

**INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION
OF UNESCO**

REPORT OF THE MISSION

TO

**THE REPUBLICS OF SOUTH AFRICA, MOZAMBIQUE,
KENYA AND TANZANIA**

ON

**THE DEVELOPMENT OF A LAND OCEAN INTERACTION OF THE COASTAL
ZONE (LOICZ)-ORIENTED REGIONAL PARTNERS IN SCIENCE PROGRAMME**

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BY

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EXECUTIVE SUMMARY

The purpose of the mission was to:

- * Collect information on South Africa, Mozambique, Tanzania and Kenya concerning the ongoing and planned developments in marine science in these countries.
- * Collect information on existing manpower, research vessels and training opportunities and to explore areas of collaboration.
- * Prepare a regional overview of the scientific problems which need to be tackled in a regional context. This overview should also contain proposals for tailor made Capacity Building activities in the eastern African countries involved.

The mission showed that the Republic of South Africa has a strong marine science community, with most of the Institutions involved in research activities at the following universities: University of Cape Town, University of Port Elizabeth, University of Rhodes, and the Institute of Oceanography in Durban. It is clear that South Africa has the best scientific infrastructure in the Eastern Africa Region. The infrastructure includes universities, scientific staff and technicians, research vessels, scientific equipment, libraries, etc. Mozambique is under developed, Tanzania and Kenya being in the middle with South Africa.

The scientific infrastructure in South Africa is of a high standard. The new political situation and the initiatives formulated in the new policy plan (1996-2000) of the Foundation for Research Development offer a unique opportunity for regional partnerships. Donor agencies from the following countries are active in South Africa: Norway, Denmark, Sweden, the Netherlands, the United States of America and the United Kingdom (through the Commonwealth Science Council). FAO and UNEP are also active in South Africa.

The University of Cape Town offers a broad variety of expertise in marine science and also has taken the lead in the sub-Saharan Capacity Building activities through initiatives such as the university science and engineering partnership in Africa (USEPIA) and UCT's Centre of Marine studies. The focus of USEPIA is staff development through attainment of jointly supervised Ph.D degrees.

The Sea Fishery Research Institute (SFRI) has a fleet of four research vessels, the *Africana*, the *Algoa*, the *Benguela* and the *Sardinops*, which are equipped with sophisticated instrumentation and sampling gear, as well as a number of smaller ski boats and dinghies, and the Antarctic supply and research vessel *Agulhas*. All research vessels of the universities in South Africa have been. An interesting opportunity might be the use of the hydrographic vessel SAS *Protea* from the South African navy.

In Mozambique the manpower available for oceanography is minimal. The Instituto Nacional de Hidrografia e Navigacao (INAHINA) is responsible for all navigation and hydrographic surveys. The institute has a well equipped oceanographic vessel RV *Basurato*. The manpower and facilities at the University Eduardo Mondlane urgently need strengthening and upgrading.

The Institute of Marine Sciences in Zanzibar is identified as the lead institute in Tanzania to co-ordinate marine research.

Most of the marine institutions in Kenya are concentrated in Mombasa and Nairobi. The Kenya Marine and Fisheries Research Institute (KMFRI) is mandated by the government of Kenya to undertake research in the marine environment. KMFRI has scientific staff and technicians who are currently involved in marine science research. It has also some equipment which can be used for research. KMFRI has taken an active role in international research projects through bilateral and multi-lateral collaboration. It also acts as a regional centre for the Regional Cooperation in Scientific Information Exchange in the Western Indian Ocean (RECOSCIX-WIO) project. KMFRI's research vessel *Maumba* needs to be replaced or upgraded.

The consultants discovered that the focus of marine science in Eastern Africa (Kenya, Tanzania, Mozambique and South Africa) is on research, training and infrastructure development. The mission also noticed the increase in tourism, and, subsequently, the need to monitor activities affecting the (coastal) environment. To ensure sustainable development, future research training and topics should reflect both local and national priorities. The interviewed scientists also emphasised the value of personnel exchange (short courses, ship-board training and long-term courses), and suggested that these be interlinked to the post-graduate training programme. Due in part to the new political developments in South Africa, there was a strong appreciation and enthusiasm for developing marine science partnerships. Accordingly, it became clear that the IOC-initiative in research and training to enhance Capacity Building in the Eastern African region is timely and is highly appreciated by universities and institutions in the region.

A number of recommendations resulted from the mission. These include the organisation of a workshop, in march/april 1996, which has to lead to a five year workplan; the identification of additional sources of funding for the Capacity Building activities in the region; and the broadening of existing bilateral co-operation to include other interested (European) universities and industries.

The mission came up with the following issues to be addressed in the near future:

- * South Africa's position as economic and scientific power in Eastern Africa
- * Coastal resources in light of growing tourism
- * Manpower in marine science
- * Infrastructure in Eastern Africa
- * The organisation of a TREDMAR-like research cruise (training through research) with a South African research vessel, every two years

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1. INTRODUCTION

This report describes the findings of a mission undertaken by dr. E. Okemwa and dr. J.H. Stel to the Republic of South Africa, Mozambique Tanzania and Kenya. The mission is a follow-up of the recommendation of the IOC/CIDA workshop on the benefits of improved relationships between International Development Agencies, the IOC and other multilateral intergovernmental organisations in the delivery of ocean, marine affairs and fisheries programmes. The workshop was held in Sydney, BC, Canada between 26 - 28 September 1995. During this workshop the use of the existing regional intergovernmental mechanisms such as the Regional Committees of the IOC, for the implementation of donor-sponsored programmes formulated through the donors for bilateral or multilateral were discussed as a follow-up of UNCED. En marge of the workshop it was agreed that the consultants would execute a mission to explore the feasibility to develop on Eastern African Partners in Marine Science Programme.

1.1 Terms of Reference of the mission

On behalf of the Intergovernmental Oceanographic Commission (IOC) and IGBP/START the objectives of the mission were to:

- * Collect information in the Republic of South Africa, Mozambique and Tanzania and Kenya concerning the ongoing and planned developments in marine science in these countries.
- * Collect information on existing manpower, research vessels and training opportunities and to explore areas of collaboration.
- * Prepare a regional overview of the scientific problems which need to be tackled in a regional context. This overview should also contain proposals for additional areas of Capacity Building activities which need to be developed.

1.2 Arrangements of the mission

Dr. E. Okemwa, attending the 32nd executive committee meeting of the Scientific Committee on Oceanic Research (SCOR) in Cape Town, South Africa (November 14-16, 1995), was joined by dr. J.H. Stel on the 17th of November to start the mission. Annex 1 gives an overview of the schedule.

During the mission, meetings were held with relevant institutes (Annex 2) in both countries. Visits were made to relevant departments and laboratories. The marine science capabilities (scientific programmes, vessels, manpower, land based facilities) were assessed.

The first part of the mission report contains the overall assessment and general recommendations. The second part is a country-by-country assessment, commentary and recommendations necessary for an effective collaboration in marine science. Where relevant a short overview of the most important institute as given. Detailed information on institutes, organisations, research programmes etc. is given in Annexes.

2. REGIONAL ASSESSMENT

2.1. Introduction

Eastern Africa comprises Kenya, Tanzania, Mozambique, the Republic of South Africa, Madagascar and Mauritius. In this report the first four countries are referred to as "Eastern Africa".

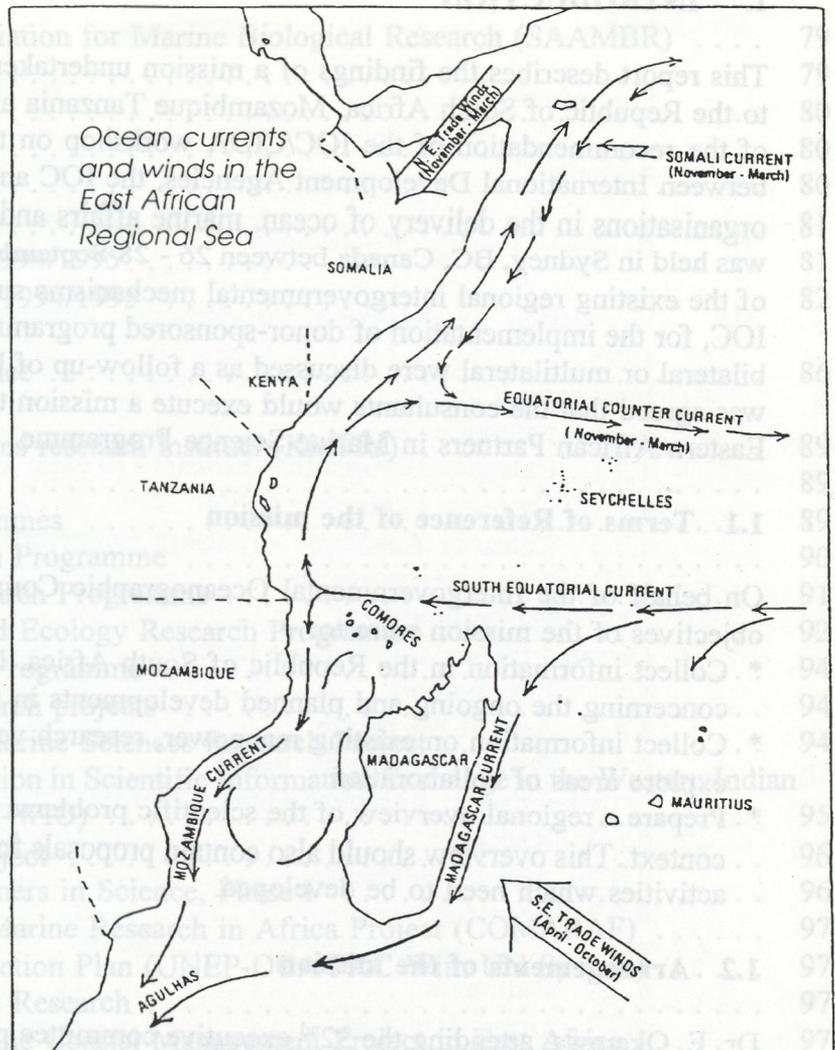
The Eastern African coastline runs diagonally from northern Kenya through Tanzania and Mozambique towards the southern tip of South Africa. As the continental shelf is almost non-existent in the northern part, the inland waters in Kenya and Tanzania are heavily influenced by the deep water of the open northern Indian Ocean. Along the Mozambican coast, however, the shelf is broader. Reefs, seagrass beds and tidal estuarine systems supporting mangrove forests have developed.

2.2 The Eastern African countries

Table 1 is based upon the 1995 World Bank Atlas presenting key social and economic information. The Gross National Product gives an indication of an economy's performance. In order to complete the overall picture of Eastern Africa the information of the countries not involved in this mission is given in italics.

Country	Population ('93)	Growth rate ('85/'93)	Life expectancy (1992)	GNP (1993; MUS\$)	Av. Inflation (1985-93)
Kenya	25,376	3.0	59	6,743	10.6
Tanzania	26,743	3.0	51	2,521	23.4
Mozambique	16,916	2.6	44	1,375	54.3
South Africa	40,677	2.4	63	11,057	13.8
<i>Madagascar</i>	<i>12,728</i>	<i>3.1</i>	<i>51</i>	<i>3,039</i>	<i>15.1</i>
<i>Mauritius</i>	<i>1,111</i>	<i>1.1</i>	<i>70</i>	<i>3,309</i>	<i>9.0</i>

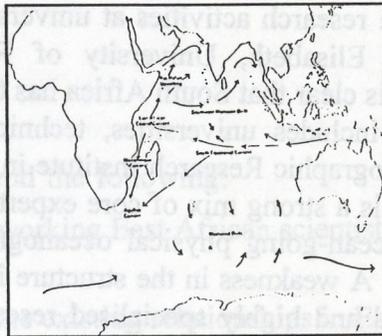
Table 1: Socio-economic indicators of some Eastern African countries



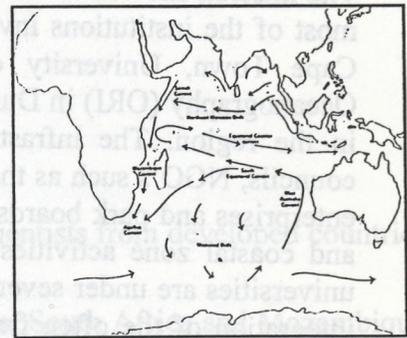
2.3 The Indian Ocean

Nearly one third of the world's population lives around the Indian Ocean. The total area of this ocean is about 75,000,000 square kilometres; a little over twenty percent of the total area of the world's sea surface. Yet it is one of the least studied parts of the global ocean. Unlike the Atlantic and Pacifics, the Indian Ocean is not directly connected with the Arctic Ocean in the north. To the southwest, the Indian Ocean meets the Atlantic at the southern tip of Africa. To the east and south-east its waters mingle with those of the Pacific through the Indonesian archipelago.

The floor of the Indian Ocean is dominated by an inverted Y-shaped mid-ocean ridge. It is a small part of an undersea ridge that winds all the way around the Earth. Here is the meetingplace of the Indian, African and Antarctic Plates. The northern stem of the Y forms the Carlsberg Ridge which divides



The South-West Monsoon current pattern in July



The North-East Monsoon current pattern in January

into a western arm that runs around the southern tip of Africa to join the Mid Atlantic Ridge. The eastern arm connects with the East Pacific Rise. When India crashed into Asia with a speed of several centimetres per year, the Himalayas were the result. This collision not only denied the Indian Ocean a northern access, it also caused the unique Indian Ocean monsoonal climate. Under the influence of the monsoon winds the surface currents of the northern Indian Ocean change its direction twice a year. The most spectacular and best-observed reversal is in the direction of the Somali current.

From April to September, a south-west monsoon blows. Due to this, the surface water in the Indian Ocean flows northwards at great speed along the coast of Kenya. In November, the wind changes to north-east. The direction of the current turns south. The half yearly change has extreme consequences for life in the sea. During the SW Monsoon large quantities of cold water, rich in oxygen and nutrients, are sucked to the surface from the deeper parts of the ocean. This happens in a relatively small zone off the coast of Somalia and the Arabian peninsula. That is the reason why a sudden, large increase in the biological activity is seen in these upwelling areas during the summer. Nevertheless, it comes to a gradual end in autumn, when the wind subsides and changes direction. The north-east monsoon starts up. The wind blows in the direction of the African continent, causing a current direction of the surface water. No more water comes up from the depths. The upwelling is over.

South of the equator the currents are dominated by the westerlies and trade winds, driving an anti-clockwise warm water gyre. The south equatorial current flows towards Africa. Near Madagascar a small part splits off and feeds the Somali current. Most of its water, however, passes south between Madagascar and Africa. It finally enters the Agulhas boundary current, which mainly feeds into the southern Atlantic.

2.4 Conclusions

The mission showed that Republic of South Africa has a strong marine science community, with most of the institutions involved in research activities at universities such as the University of Cape Town, University of Port Elisabeth, University of Rhodes, and the Institute of Oceanography (ORI) in Durban. It is clear that South Africa has the best scientific infrastructure in the region. The infrastructure includes universities, technicians, scientific and industrial councils, NGO's such as the Oceanographic Research Institute in Durban, musea, (semi)-private enterprises and park boards. There is a strong mix of core expertise in marine biology, geology and coastal zone activities. The ocean-going physical oceanographic sections of most of the universities are under severe stress. A weakness in the structure is the lack of co-ordination and integration of the often fragmented and highly specialised research efforts at the universities. Through the SFRI there might be an interesting (regional) training opportunity for marine technicians at the Cape Town Technikon. The lack of long term monitoring activities of South Africa's coastal waters is surprising and indicates an underestimation of the value (tourism) of the pristine coastal resources. On the other hand tourism is a rapidly increasing business in South Africa.

Mozambique is underdeveloped. The University Eduardo Mondlane in Maputo and the Institute of Marine Science in Mozambique lack trained staff and equipment. Despite a ten years support by SAREC, the development of a marine science capability, although steadily moving forwards, has not born many fruits. This might be caused by political constraints, which are outside the scope of the consultants view. It is suggested to give the present efforts a more tailor made accent by strengthening among others, the financial responsibilities on a scientists level. Often research activities are delayed by cumbersome administrative procedures.

In Tanzania the University of Dar es Salaam, with especially its Institute of Marine Science in Zanzibar is relevant to the mission. However, as a consequence of the recession of the last ten years, the university has suffered an extensive brain drain. Moreover, funding by donors is steadily tightening. The marine science capability mainly consist of marine biologists. There is a need to broaden the capability by expertise in physical and chemical oceanography as well as coastal zone management.

Most of the marine institutions in Kenya are concentrated in Mombasa and Nairobi. Nairobi is about 500 km from the Kenyan coast, KMFRI is located in Mombasa on the coast. In Kenya, KMFRI undertakes research in marine and freshwater fisheries, aquatic biology, environmental

and ecological studies, geological, chemical and physical oceanography, including marine meteorology. KMFRI employs about 65 scientists of nearly all marine science disciplines.

In the last few years KMFRI has carried out research in bilateral and multilateral projects in marine science. KMFRI has taken a leading role in the Eastern African region in information exchange under the RECOSCIX-WIO project. KMFRI continues to collaborate in global programmes, e.g. in world ocean circulation and climate change, and pollution programmes by participating in the collection of oceanographic data. It has participated in regional and international oceanographic and fishery programmes in the Indian Ocean. The institute is disadvantaged by not having an operational research vessel.

2.5 Recommendation

The consultants recommend the following:

- * There is a need for networking East African scientists and scientists from developed countries and donors.
- * There is a need to use the existing relationships in East Africa, South Africa and Mozambique and with EU countries to develop multilateral cooperation to carry out among others a LOICZ programme.
- * There is a need to explore the possibilities of using ships from South Africa for training and research for scientists in the region. (TREDMAR)
- * Many of the institutions are under different supervising ministries or government authorities. Although in South Africa an interagency South African Network for Coastal and Oceanic Research (SANCOR) coordinates marine research there still is a need for a better interuniversity coordination.
- * The problem of effective coordination in Mozambique needs to be addressed.
- * Participants of the Eastern African Partners in Science programme need access to internet.

3. COUNTRY REPORT

3.1 South Africa

The Republic of South Africa (1,228 million km²) is larger than Germany, France, Italy, Belgium and Holland together. Washed by the cold Benguela current on the west coast and the warm Mozambique-Ahulhas current on the east, the country has a long coastline of 2,954 km and a temperate climate. The topography ranges from highveld grasslands to bleak semi-desert to subtropical swamps. South Africa has three capitals: Pretoria is the administrative, Cape Town the legislative and Bloemfontein the judicial capital. Parliament resides in Cape Town. South Africa controls access rights to the Exclusive Economic Zone of 200 nautical miles.

A post-apartheid socio-economic policy, the Reconstruction and Development Programme (RDP), is designed to mobilise government, private enterprise and all other resources of the economy to reduce poverty and to provide opportunities in a stable, democratic society. The main targets of the RDP are to foster:

- * Democracy and institutional change.
- * Urban renewal and rural development.
- * A new mass culture of paying for services.
- * Wider opportunities in a growing economy.

The government aims to spend more than R 40 (some US\$ 12) billion on RDP before the year 2000. The state-financed part of the programme will come from:

- * Adjusting the national budget and raising loans.
- * Containing expenditure and tightening tax collection.
- * Sale of excess oil reserves.
- * Sale of state enterprises and assets.
- * State lotteries.

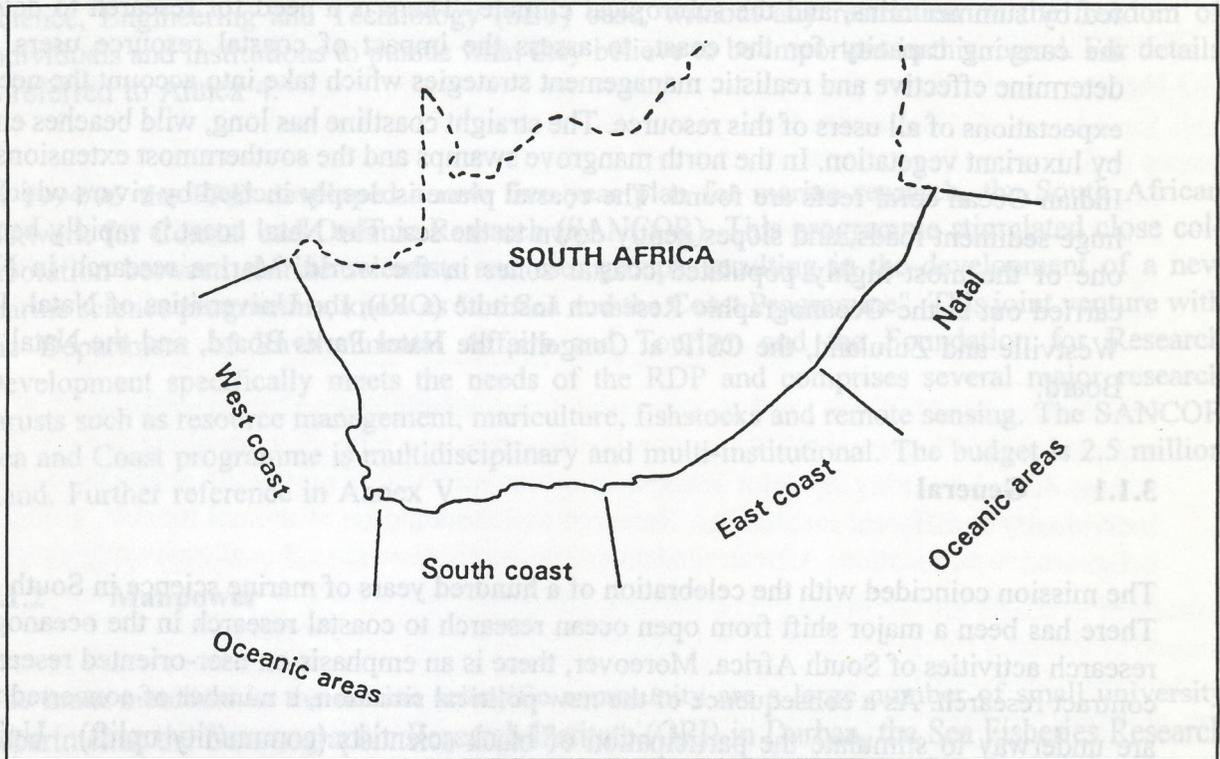
The government is coordinating foreign aid to support the objectives of the RDP. Financial institutions, commerce, industry and small business are being pressed to adapt their social responsibility efforts to the aims of the RDP. Local communities, from squatter camps to upmarket housing estates, are being pressed to cooperate actively with the RDP. The first tangible result of the national programme was a R 475 (about US\$140) million primary school feeding system introduced by President Mandela. But other RDP projects have been slow to get off the ground.

South Africa has a population of more than 40 million people, who all require access to natural resources for the provision of basic needs (employment, food, shelter, water, land and fuel). To fulfil these needs there have already been made major landscape changes such as shifting and interlinking the drainage basins of rivers. The projected population doubling time is some 30 years. At present about one third of the South Africans have an income lower than the minimum subsistence level. Of these more, than 90 percent are black and more than 70 percent are based in rural areas.

South Africa's coastline can be devised into four regions, being the:

- * West Coast, which is characterised by the cold waters of the Benguela system. Rainfall on land is minimal except in the extreme south. There are three rivers (Orange, Olifants and Berg) of significance which flow into the sea. Unlike on the rest of the South African coastline, there are few estuaries. Most of the productivity is derived from the nutrient-rich upwelled waters of the Benguela system which supports one of the richest fisheries in the world. Apart from

the high density urban environment of greater Cape Town, the coast is minimally populated, with scattered fishing villages in the south and diamond mining operations in the north. The major research organisations serving the West Coast region are the SFRI, the University of Cape Town, the Council for Scientific Industrial Research (CSIR) at Stellenbosch and the Geological Survey. Details of the Benguela Ecology Programme, which started in 1981, are given in Annex III.



- * South Coast has, apart from Mossel Bay, a low population density spread along the coast in residential towns such as Hermanus, Plettenberg Bay and Knysna. The area is influenced both by the warm Agulhas current and the cold Benguela system. The species diversity reflects both systems. The major offshore feature is the vast Agulhas bank which deflects the Agulhas current away from the coast. On land, a reasonable rainfall all year round supplies water to some fifty estuaries, including the prime holiday resorts of the Wilderness Lake System, Knysna, Hermanus, Still Bay, Plettenberg Bay and Nature's Valley. The most intensive research effort on the South Coast has been concerned with the exploitation of the offshore hydrocarbon deposits on the Agulhas Bank. The bulk of the research activities in this area are carried out by scientists from Western Cape University and scientists from the eastern province.
- * Eastern Cape Coast, which is characterised by the river-incised coastal plane and magnificent spiral beaches, some of which feed sand to South Africa's largest coastal dunefields (Alexandra and St Francis Bay dunes). The continental shelf is very narrow. The fast flowing warm Agulhas current comes close to the shore. Wind-induced upwelling can, however, bring cold water to the surface near the coast at the more prominent headlands. Urban and residential development has been concentrated around the larger of the many estuaries along this coast (Port Elizabeth, East London, Port St Johns). Marine and coastal research in this area is carried

out by the Institute for Coastal Research (ICR) at the University of Port Elizabeth, by scientists in the biologically orientated departments at Rhodes University and the University of the Transkei, at the JLB Smith Institute of Ichthyology, and the Port Elizabeth Museum.

- * Natal Coast, being one of the most sought after residential and recreational areas of the country. This is due to the warm waters of the Agulhas current, the many beautiful estuaries fed by summer rains, and the subtropical climate. There is a need for research to determine the carrying capacity for the coast, to assess the impact of coastal resource users and to determine effective and realistic management strategies which take into account the needs and expectations of all users of this resource. The straight coastline has long, wild beaches enclosed by luxuriant vegetation. In the north mangrove swamps and the southernmost extensions of the Indian Ocean coral reefs are found. The coastal plane is deeply incised by rivers which carry huge sediment loads, and slopes gently down to the sea. The Natal coast is rapidly becoming one of the most highly populated coastal zones in the world. Marine research in Natal is carried out at the Oceanographic Research Institute (ORI), the Universities of Natal, Durban Westville and Zululand, the CSIR at Congella, the Natal Parks Board, and the Natal Sharks Board.

3.1.1 General

The mission coincided with the celebration of a hundred years of marine science in South Africa. There has been a major shift from open ocean research to coastal research in the oceanographic research activities of South Africa. Moreover, there is an emphasis on user-oriented research and contract research. As a consequence of the new political situation, a number of concerted actions are underway to stimulate the participation of black scientists (community uplift). University undergraduate and post-graduate intake has increased recently to fulfill the government policy.

Foundation for Research Development (FRD)

The South African Foundation for Research Development is an independent organisation within the Ministry of Arts, Culture, Science & Technology and is charged with the development of expertise and human resources in science, engineering and technology. Its objectives include:

- * Enabling disadvantaged communities to participate at all levels in related activities.
- * Increasing the pool of human resources with technological skills.
- * Ensuring a competitive research expertise base in the country.

FRD promotes international collaboration and exchange and administers three national research facilities: the National Accelerator Centre, the South African Astronomical Observatory and the Hartbeeshoek Radio Astronomy Observatory.

The FRD is based in Pretoria. The mission statement is "to ensure the affordable and balanced provision of human resources and expertise in science, engineering and technology, through the support of research and education, for economic growth and the social advancement of all South

Africans". The FRD has formulated a new five year plan (1996-2000) which addresses the national needs and priorities of the RDP. The new research programmes in this plan fit into two broad themes, being directed and open themes. In directed themes, programme research is driven by predetermined demand. Human and capital resources are directed towards effectively creating new knowledge, ideas and human resources, all aimed at serving well-defined national needs. Programmes in open themes support research aimed at building and strengthening the national Science, Engineering and Technology (SET) base, without any restriction on the freedom of individuals and institutions to pursue what they believe to be important in this regard. For details is referred to Annex 4.

In 1994/95 the FRD developed a new five year plan for marine research, the South African Network for Coastal and Oceanic Research (SANCOR). This programme stimulated close collaboration between marine scientists and user groups, resulting in the development of a new marine science programme, know as "the Sea and the Coast Programme". This joint venture with the Department of Environmental Affairs and Tourism and the Foundation for Research Development specifically meets the needs of the RDP and comprises several major research thrusts such as resource management, mariculture, fishstocks and remote sensing. The SANCOR Sea and Coast programme is multidisciplinary and multi-institutional. The budget is 2.5 million Rand. Further reference in Annex V.

3.1.2 Manpower

The main members in the marine scientific community are a large number of small university departments, the Oceanographic Research Institute (ORI) in Durban, the Sea Fisheries Research Institute in Cape Town, the Data Centre for Oceanography in Stellenbosch and the Marine Geosciences Unit of the University of Natal and the Geological Survey. There is no government-funded oceanographic research institute in South Africa. ORI is a non-governmental institute. The data centre is part of the Council for Science & Industrial Research (CRIR).

The marine activities of the different universities are diverse and often complementary. Although jointly they more or less cover the whole spectrum of marine research, the effectiveness of the diverse activities would increase if there were more co-operation and co-ordination. The scientific infrastructure in South Africa is of a high standard. The new political situation and the policy initiatives as formulated in the RDP (Annex IV offers a unique opportunity for a regional Partners in Science programme.

University-based institutes that carry out marine research

During the mission the University of Cape Town (UCT) and the University of Natal in Durban were visited. The following information is based upon the information obtained during these visits. The consultants have the opinion that the UCT offers a broad variety of expertise in marine science. Moreover, UCT apparently has taken the lead in sub-Saharan capacity building activities through initiatives such as the University Science and Engineering Partnership in Africa

(USEPIA) and UCT's Center of Marine Studies. The latter is an interface between the university knowledge base and the industry.

University of Cape Town

The UCT strives to be a university of quality both in an international and an African context. UCT is firmly committed to use its capacity for the development of science and technology in Africa. To facilitate this UCT launched, with a grant of \$50.000 from the Rockefeller Foundation, the University Science and Engineering Partnership in Africa (USEPIA) in 1994 as a collaborative programme and network with selected universities in the sub-Saharan African region. The aim of USEPIA is to develop a science and engineering capacity to enable sub-Saharan African scientists and engineers to compete internationally and by this contribution to the uplift of Africa scientifically and technologically. At present USEPIA is funded by the Rockefeller Foundation, the Carnegie Corporation, Coca Cola and the Ridgefield Foundation.

The focus of USEPIA is staff development (capacity building) through attainment of jointly supervised PhD degrees. USEPIA partners believe that long term viability of the capacity building is best done by setting up joint research projects with viable groups of scientists (rather than individuals) at different institutions. Research topics should be of mutual interest, giving rise to collaborative publications African academics also emphasised the value of staff exchanges (lecture series and short courses), and suggested that these are linked to the post-graduate training programme. Access to USEPIA is restricted to the participating institutions. Preference is given to applicants permanently employed at their home universities. Applicants should have at least a four-year bachelor's degree and should be identified by their home universities as prime candidates for staff development. More details in Annex VI.

In South Africa, the university departments and musea relevant to the mission are:

* University of Cape Town, UCT

Department of Zoology. Sandy beaches, pollution, aquaculture, fishery management (strong thrust), utilisation of seaweed, taxonomy. Details are given in Annex 7.

Department of Oceanography. Sealevel rise, fisheries east coast, satellite remote sensing, SST and rainfall, deep-sea research, air-sea interaction.

Department of Geology. The GS-UCT Marine Science Unit is under severe stress.

Centre of Marine Studies. CMS is an interface with the industry for constancy activities.

* University of Port Elisabeth, UPE

Department of Zoology. Estuarine issues, sandy beaches, dunes, colonisation.

Department of Oceanography. (Merged with the Dept. of Geology).

* Rhodes University , Grahamstown

Department of Zoology. Estuarine energy budgets, intertidal ecology, Antarctic research

Department of Ichthyology. Aquaculture, mariculture

* University of Western Cape, UWC

Department of Zoology ?? Physiology

- * University of Transkei (UNITRA), Umtata

Department of Zoology. Interidal marine research, subsistence, artisanal fishery, pioneer communities

- * University of Natal (UND), Durban

Department of Zoology. Estuarine ecology (prawns), recruitment, mangrove physiology

Department of Geology. There is a very strong and well equipped, but under utilised GS-UNB Marine Geoscience Unit. Harbour studies, environmental impact studies, tidal sedimentation, making maps. Consultancy activities in the field of offshore mining, coastal mining, pollution.

- * University of Zululand (UZ), Empangeni (coastal inlets)

- * Museums

Museum of Port Elisabeth. Mammals, sharks, squid, birds.

Museum of East London. Shells

Museum of Natal. Malacology

Sea Fishery Research Institute

The mission of the Sea Fisheries Research Institute (SFRI) is to ensure the effective protection and sustainable use of the living resources and ecosystems of South Africa's Exclusive Economic Zone. SFRI advises on the sustainable use of living marine resources and the conservation of the marine ecosystems by conducting and supporting multidisciplinary scientific research and monitoring in the marine environment. The institute advises and interacts with decision-makers, those involved in fishing, interest groups and the local and scientific community. SFRI functions within the Department of Environmental Affairs & Tourism. SFRI employs 52 scientists, 52 qualified technicians (qualification from Cape Town Technikon) and 50 unqualified technicians (= oceanographic assistants).

SFRI has a fleet of four research vessels, namely the *Africana*, *Algoa*, *Benguela* and *Sardinops* which are equipped with sophisticated instrumentation and sampling gear, as well as a number of smaller ski boats and dinghies. (For details see Annex VIII). The institute's Engineering Services and Technical Management and Development groups have contributed to the improved efficiency and cost-effectiveness of the research vessels by developing some of the ship's technology in-house. Most progress has been made in the development of hydro-acoustic instrumentation, used in conjunction with echo-sounders to locate and estimate the size of fish schools, or to measure ocean currents. A research aquarium with the most modern facilities is currently being developed for the benefit of researchers from SFRI, educational institutions and the private sector, to be operational by mid 1996.

The institute has a library containing books, journals and archival material from around the world. SFRI publishes the "South African Journal of Marine Sciences" as a service to the scientific community. Numerous pamphlets are produced and distributed as part of a public information

campaign. The new research aquarium will include a public information centre. Hand-drawn and computer-generated artwork for these publications, as well as for conference posters and public relations purposes, is provided by an innovative reprographics department.

SFRI's research into primary and secondary production levels focuses on phytoplankton and zooplankton. In addition, monitoring and research of red tide is conducted in order to warn the public against toxic shellfish. The impact of various sources of marine pollutants are studied in order to develop sound management approaches and cleanup strategies. Although oil spills have the most visible and extensive impact, pollution from local sources such as sewage pipelines, mariculture farms, fish factories and other industries are also investigated. Harvesting strategies for stock assessments are usually assessed for single species, although each is part of a complex, ever-changing ecosystem. For an understanding of the role of the environment in the functioning of marine ecosystems it is vital to understand the variations in the physical and chemical parameters, which may cause changes in the stocks of commercially important species. Ship-based measurements and information from satellites and automatic monitoring by marine and land based instruments provide information on among others sea temperature, salinity, currents, wind speed and direction. Seasonal effects may cause fluctuations in fish survival, distribution and migration, while global climate change may alter fish stocks and the functioning of the marine ecosystems. Predator-prey relationships are also important in regulating population numbers. The result of these interactions among populations and between these populations and the environment are studied by SFRI scientists. Acoustic and trawling surveys are carried out on commercially important fish species. Much effort is devoted to develop and update the methods and technology used. Behavioural studies, which yield information on daily and seasonal variations in fish abundance, provide input in improving sampling techniques, and lead to a better understanding of the ecosystem as a whole.

Council for Scientific and Industrial Research, CSIR

CSIR is a statutory body with head offices in Pretoria and regional offices in Stellenbosch, Durban, Port Elizabeth and Nelspruit. CSIR has twelve operational divisions. It performs multi-disciplinary, market-orientated research on a broad range of subjects relating to industry and science. CSIR's activities and services are available to both public and private sectors. The CSIR Earth Marine & Atmosphere Technology Department plays an important role in coastal zone management and pollution consulting.

The CSIR Data Centre for Oceanography in Stellenbosch, which was created in 1977, plays an important role in hydrographic modelling and water quality research. The activities of the South African Data Centre for Oceanography (SADCO) has placed South African scientists at the forefront of oceanographic research. All oceanographic data collected on research cruises and by voluntary observing ships (VOS) is stored in SADCO and is available on request for specific research or management requirements. Through the IOC datacentres the data is available to the international community. SADCO has built up a 800 Gigabyte of data covering temperatures, salinities, nutrients, chemistry, pollution related data, meteorological and climatological data, ornithology and waves and current data. Historical data which go back to the 1920's are included. Every effort is made to make the data and data product available from SADCO as up to date as

possible. SADCO is widely used by the oceanographic community, who started to finance its continuation since late 1989, when the CSIR at Stellenbosch threatened to be close SADCO. SADCO is guided by a steering committee and operated by a professional data base agency for the benefit of the marine science community.

Oceanographic Research Institute (ORI), Durban

ORI was established in 1958 and is part of the South African Association for Marine Biological Research (SAAMBR), an independent, not-for-gain, non-government organisation founded in 1951. The institute carries out applied research that serves as decision support to managers and users of marine resources. Marine conservation forms the basis for all projects at ORI. The research programme of the ORI is subject to strict peer review and provides good science that has practical application. Although most effort is devoted to basic research projects, a considerable amount of time is also allocated to monitoring surveys, consultancies and decision support. In 1994/95 for instance research at the ORI was undertaken by 123 scientists supported by 11 field and technical staff engaged in 20 projects. The quality and productivity of the science output is assessed by the ORI Scientific Advisory Committee, assisted by three independent assessors. For details, see Annex IX.

ORI's objectives are to:

- * Conduct marine biological investigations.
- * Document and assess marine resource utilisation trends.
- * Interact with the resource-user community.
- * Provide decision support to resource users.
- * Produce impartial statements and opinions on marine and coastal conservation and rehabilitation.
- * Publish and disseminate authoritative documents and reports on the investigations undertaken.

The collaboration between ORI and with Mozambique institutions and other countries in the region that share fish stocks with South Africa, is successful. The joint processing and interpretation of fisheries data yields good results and assists in the joint management of stocks. The research programme of the ORI is directed by its overall mission which, more than ever, is relevant to the needs of South Africa today. The primary thrust, however, will unavoidably be directed at financially sustainable projects and those that have immediate practical application. Participation in the Sea and the Coast programme of SANCOR (Annex V) will strongly influence the research direction in the years to come.

ORI's staff plays an important role in the training of students by running a semester-long fisheries science course at Natal University. This course is becoming increasingly relevant and popular. Senior staff serve on numerous research, management, advisory and liaison committees. In doing so the ORI provides a scientific basis for many decisions that have to be made concerning marine resource utilisation. This is normally best achieved by preparing documents that form the basis

for discussion and subsequent implementation. ORI staff actively participated in the developments of the Sea and Coast programme of SANCOR.

Joint Geological Survey - University of Natal Marine Geoscience Unit

The Marine Geological Unit was established in 1989 by an agreement between the University and the Geological Survey. The unit is attached to the Department of Geology and Applied Geology at Durban. The director of the unit is prof.dr. T.M. Mason. Three geologists and one geological technician are seconded from the Geological Survey. For information on the Geological Survey we refer to Annex X. Other staff members and scientists attached to organisations outside the university are associated with the unit for collaborative research projects. The unit trains postgraduate scientists: undergraduate geology students work with unit staff on specific research projects on an ad hoc basis. The total number of people involved is nine scientists and three technicians.

The primary function of the unit is to investigate marine geology, but current projects include flood plain deposits of Namibia, diamondiferous deposits of Namaqualand, vertebrate fossils from the Natal midlands, the sedimentology of the Mkuze River and the bathymetry and geology of Lake Sibaya. Shore and intertidal projects include studies of fossil ivory and teeth, erosion and formation of wave cut platforms, and the detailed petrology of beachrocks and coral reef-derived bioclastic sediment. Projects of the offshore continental shelf include the ecology of coral reefs and their geological history, the geology and sedimentology of submarine canyons off the Zululand coast, late Pleistocene palaeocoastlines and the construction of a model for late Pleistocene sea-level changes. The unit is funded by the Geological Survey, the University of Natal, and by research contracts.

3.1.3 Equipment

Some of the university departments at UCT and UND are very well equipped and offer excellent training facilities. All research vessels of the universities are sold. SFRI is operating the larger research vessels such as *Sardinops* (small, inshore, old), *Algoa* (53 meter), *Africana* (70 meter) and the Antarctic supply and research vessel *Agulhas*. See for details Annex VIII. An interesting opportunity might be the use of hydrographic vessels SAS *Protea*, from the South African navy. (Informally it was learned that the running costs of the *Africana*, *Algoa* and *Benguala* are respectively R 12.000, R 6.000 and R 3.500 a day).

3.1.4 Comments

Donor agencies from the following countries are active in South Africa: Norway, Denmark, Sweden, the Netherlands, the United States of America and the United Kingdom (through the Commonwealth Science Council). The FAO and UNEP are also active in South Africa.

3.1.5 Recommendations

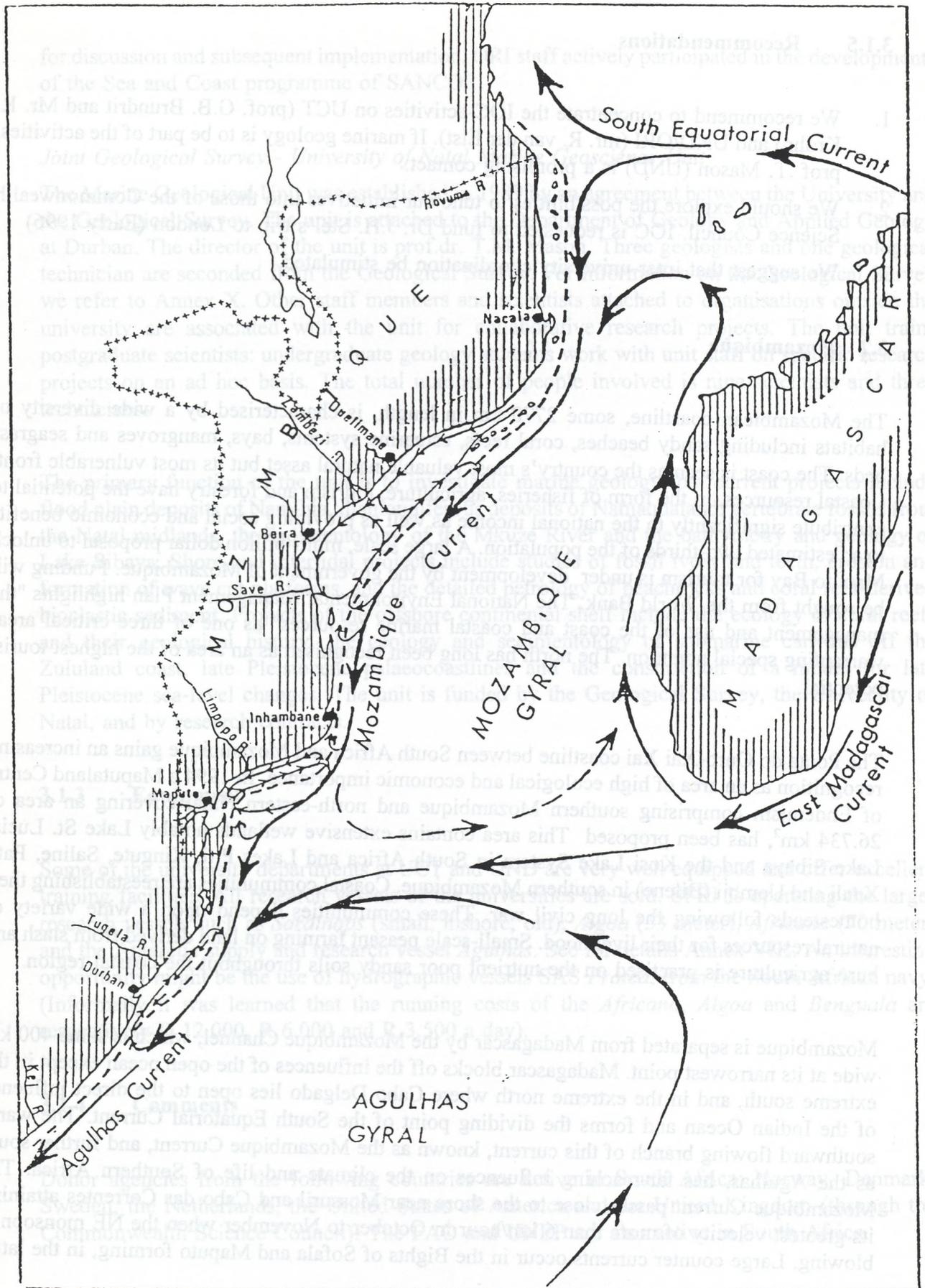
1. We recommend to concentrate the IOC-activities on UCT (prof. G.B. Brundrit and Mr. R. Krohn) and UND/ORI (mr. R. van der Elst). If marine geology is to be part of the activities, prof .T. Mason (UND) is a promising contact.
2. We should explore the possibilities to tune our initiatives into those of the Commonwealth Science Council. IOC is requested to fund Dr. J.H. Stel's trip to London (Early 1996)
3. We suggest that inter-university coordination be stimulated.

3.2 Mozambique

The Mozambican coastline, some 2770 km in length, is characterised by a wide diversity of habitats including sandy beaches, coral reefs, estuarine systems, bays, mangroves and seagrass beds. The coast is seen as the country's most valuable natural asset but its most vulnerable front. Coastal resources, in the form of fisheries, agriculture, tourism and forestry have the potential to contribute significantly to the national income as well as providing social and economic benefits to an estimated two-thirds of the population. A large scale, multi-billion dollar proposal to unlock Maputo Bay for tourism is under development by the government of Mozambique. Funding will be sought from the World Bank. The National Environmental Management Plan highlights "the management and use of the coast and coastal marine resources" as one of three critical areas warranting special attention. The north has long been recognised as an area of the highest tourist potential.

The Ponta do Ouro-Xai Xai coastline between South Africa and Mozambique gains an increasing recognition as an area of high ecological and economic importance. In 1994 a Maputaland Centre of Endemism comprising southern Mozambique and north-eastern Natal covering an area of 26.734 km², has been proposed. This area contains extensive wetlands notably Lake St. Lucia, Lake Sibaya and the Kosi Lake System in South Africa and Lakes Piti, Xingute, Saline, Pati, Xauli and Uembji (Bilene) in southern Mozambique. Coastal communities are reestablishing their homesteads following the long civil war. These communities depend upon a wide variety of natural resources for their livelihood. Small-scale peasant farming on land derived from slash and burn agriculture is practised on the nutrient poor sandy soils throughout the coastal region.

Mozambique is separated from Madagascar by the Mozambique Channel, which is some 400 km wide at its narrowest point. Madagascar blocks off the influences of the open ocean except in the extreme south, and in the extreme north where Cabo Delgado lies open to the direct influence of the Indian Ocean and forms the dividing point of the South Equatorial Current. The warm southward flowing branch of this current, known as the Mozambique Current, and further south as the Agulhas, has far-reaching influences on the climate and life of Southern Africa. The Mozambique Current passes close to the shore near Mossuril and Cabo das Correntes attaining its greatest velocity of more than 6 km/hour in October to November when the NE monsoon is blowing. Large counter currents occur in the Bights of Sofala and Maputo forming, in the latter



OCEAN CURRENT SYSTEMS, MOZAMBIQUE CHANNEL

case, the characteristically northward trending peninsulas most notably the Machangulo (Santa Maria), Inhambane and Sao Sebastiao (Bazaruto) Peninsulas. The Islands of the Bazaruto Archipelago and Inhaca Island were once peninsula headlands of the present mainland and were subsequently severed and isolated by wind and/or sea action.

The Mozambique coast can be divided into three main natural regions, being the:

- * Coral Coast (770 km) in the north. The reef-forming hermatypic corals require a mean annual sea temperature of about 21°C. Corals occur at intervals offshore from Bazaruto Island southward to South Africa but these occur in relatively deeper waters than the reef corals and play little part in modifying the direct action of the sea and storms. The southern limit for shallow water fringing coral is reported from Inhaca Island at latitude 26°S.
- * Swamp Coast (978 km) in central Mozambique with simple linear to arcuate beaches, swamps and estuaries. The sea along this coast is shallow and the waves are high but short which disturb the bottom materials close to the beach, one of the causes of the high turbidity found in this region. Twenty four rivers, including the Zambesi and Sava rivers which form deltas, discharge into the Indian Ocean along this central section of the coast, each with an estuary supporting well established mangrove swamps. The beaches between Pebane and Zambezi River mouth are of black sand and consequently fairly rich in the minerals illuminite and rutile.
- * Parabolic Dune Coast (850 km) is characterised by high parabolic dunes and north-trending capes and barrier lakes. These systems attaining heights of 120 m are considered to be the tallest vegetated dunes in the world.

3.2.1 General

In Mozambique significant changes in government structures dealing with fisheries and oceanography are occurring. Several institutions are involved in research on coastal and marine issues. These include the Fisheries Research Institute, the Departments of Biology and Geology of the University Eduardo Mondlane, the National Institute of Hydrography and Navigation (INAHINA), the Ministry of Agriculture and Fisheries and the Ministry of Environment.

The Instituto Nacional de Hidrografia e Navigacao (INAHINA) is responsible for all navigational and hydrographic surveys in the ports, as well as for the maintenance of all tide gauges and port navigational buoys. The institute has a well equipped oceanographic vessel RV Basurato. The institute also has a Department of Oceanography (4 scientists).

The Institute of Fisheries Investigations (IIP) is responsible for conducting research related to fisheries. The institute has a Department of Oceanography and it collects oceanographic data along Maputo Bay in collaboration with INAHINA. IIP does not own a research vessel.

3.2.2 Manpower

The manpower available for oceanography is minimal. The university has 21 scientists (5 expatriates from Portugal, the Netherlands and the UK). Out of the remaining 16 scientists, only one has a PhD. Some of the scientists obtained training in the former Soviet Union. All scientists are preparing for their Honours degree. The support staff at the Department of Biology exists of 81 persons. Most research is carried out in Maputo Bay, which is a key locality within LOICZ. The Marine Biological station at Inhaca Island is well situated for this research. The facilities need upgrading. The Biology Department of the University Eduardo Mondlane has few scientists who can conduct research in biological oceanography. They also need short-term and post-graduate training.

The Fisheries Research Institute has ten scientists who can carry out research on the living resources. However, there is a need for short and long term courses in fisheries and living resources management. INAHINA has some professional staff in hydrography who require short term training courses in physical oceanography.

3.2.3 Equipment

INAHINA has some equipment and staff for physical oceanography. The institutes vessel is equipped with GPS for positioning as well as current meters. It also has computers for the analysis of tidal data, INAHINA runs two research vessels being *Alcantra Santos* (16 meter) and *Basaratu* (45 meter). The vessels can be hired for the operational costs of respectively US \$ 250 and \$ 1000 per day.

3.2.4 Research

Some current research carried out in Mozambique includes heavy metal pollution in Maputo Bay, physical oceanography and impact assessment of the coastal zone of Mozambique. Planning is underway for LOICZ related research in Maputo Bay. This is a key location for LOICZ East Africa. The initiative taken by the institute (mr. Gove Domingo) to start interagency discussion on this matter is a promising one. The university also is participating in the Eastern African Action Plan of UNEP-OCA/PAC and the EEC-STD3 project on inter-linkage between coastal marine ecosystems in the Eastern African region. Most research concerns seagrasses, coral reefs, mangroves and sandy beaches. Short term (six weeks) research projects on marine mammals, plant use, limnology, fish parasitology etc. are done as a part of the postgraduation. Virtually all research in the country is funded from overseas sources such as SAREC, NORAD, IUCN and UN-agencies.

3.2.5 Recommendations

1. More emphasis should be laid on training the scientists present at the university and IIP to post-graduate level. They will form the nucleus for training and guiding future scientists in Mozambique.
2. Despite internet connections, communication problems in the eastern African region should not be underestimated.

3.3 Tanzania

Tanzania has a population of about 27 million people. Tanzania has a coastline of some 630 km, which has various types of littoral, shallow and deep-sea biotopes. The shorelines have many sandy beaches, rocky shores and mangrove forests (530 km²) which grow luxuriantly in creeks with low gradient shores. The shallow water zone supports living coral and seagrass beds. Tanzania has declared and claimed its Exclusive Economic Zone (EEZ) to the 200 nautical miles limit in line with the International law of the sea. Relevant for the mission are the University of Dar es Salaam with the Institute of Marine Science in Zanzibar.

3.3.1 General

Marine scientific research is carried out by the following institutions:

- * University of Dar es Salaam

Department of Zoology (Institute of Marine Science, Zanzibar)

Department of Botany

Department of Geology

Department of Chemistry

Department of Physics

- * Foreign collaborating universities and
- * Tanzania Fisheries research Institute (TAFRI)

3.3.2 Manpower

University of Dar es Salaam

The University of Dar es Salaam (UDS) is situated some 12 km west of Dar es Salaam in a very large compound. It has about 4,000 students and extensive buildings including staff housing, cafeterias, etc. UDS staff is 604 persons, out of which 442 hold a permanent position. An aggressive programme of "nationalisation" has occurred after the independence in 1967. Staff members tend to be well qualified and many (some 70 percent) have an overseas PhD. The UDS comprises six faculties and five research institutes. There are collaboration research projects with the Netherlands, Norway and Sweden.

The university has funding problems as most research funds comes from donors who are steadily tightening their criteria for support. Moreover, the UDS is facing staff problems as many people, trained abroad, have left the country during the recession. Areas of strenght are natural products chemistry (which receives funding from the Netherlands) and microbiology. Areas of weakness are marine biology, plant taxonomy, computer sciences and resource management.

The faculty of science comprises six departments being botany, zoology (including microbiology), chemistry, physics, geology and mathematics. The science faculty is especially hard hit by the exodus of trained Tanzanian staff during the last ten years. In this context is noteworthy that the director of the Institute of Marine Science (IMS) just recently left his post for a position at the IUCN headquarters in Geneva, Switzerland. Some 75 percent of the PhD's are from foreign universities. The development of "sandwich" post graduate degrees with research on locally relevant topics is seen as an important development. IMS has a few capable scientists in marine biology but the institute lacks capable personell in physical and chemical oceanography and in coastal marine geology.

3.2.3 Equipment

Tanzania Fisheries Research Institute

TAFRI has a few capable scientists who can carry out research and assess the living resources. However, the institute lacks capable personnel in physical and chemical oceanography and in coastal marine geology.

3.3.3 Equipment

TAFRI lacks equipment to conduct physical and chemical oceanographic surveys. Its biological laboratory badly needs upgrading.

The Institute of Marine Science (IMS) is part of the University of Dar es Salaam, but is based in Zanzibar. The IMS has build up a modern equipment pool with the assistance of foreign donors and UN-agencies. The obtained equipment is linked to the execution of specific projects funded by SAREC, DGIS, FAO and UNEP. Some of the recently obtained equipment is:

- * Atomic absorption spectrophotometer.
- * Computers with scanner, laser and dot matrix printer.
- * Video room equipemt with video cameras and recorder as well as editing equipment.
- * Current meter, echosounder and bottom grab.
- * Small boat with outboard motor.

3.3.4 Research

The research carried out in Tanzania includes nutrient exchange studies, primary production, nitrogen fixation, carbon uptake mechanism, halocarbon production, hydrodynamics and tidally induced flow, mangrove and coral ecology, socio-economic aspects of resource use. The main part of the present coastal research is supported by SAREC, NORAD, DGIS/NUFFIC, SIDA, UNEP and the EU through collaborative short term research projects. A multidisciplinary approach has been applied in implementing projects. A few disciplines have been selected to overcome the shortage of equipment and manpower. Post-graduate (M.Sc and Ph.D) students play a major role in the data collection and the execution of research.

3.3.5 Recommendations

1. The Institute of Marine Sciences in Zanzibar is the leading institute in Tanzania to coordinate marine research. Regional collaboration is seen as a necessary mechanism for strengthening the research capacity.
2. The expertise in physical and chemical oceanography as well as coastal zone management, now lacking, needs to be developed.

3.4 Kenya

Kenya has a population of some 24 million people. Its coastline is some 630 km long and has various types of littoral, shallow and deepsea biotopes. The shorelines have many sandy beaches, rocky shores and mangrove forests (530 km²) which grow luxuriantly in creeks with low gradient shores. The shallow water zone supports living coral and seagrass beds. Kenya has declared and claimed its Exclusive Economic Zone (EEZ) to the 200 nautical miles limit in line with the International law of the sea. Relevant for the mission are KMFRI and five universities. The oldest university is the University of Nairobi; the youngest one is the Jomo Kenyatta University of Agriculture and Technology.

3.4.1 General

Most of the marine institutions in Kenya are concentrated in Mombasa and Nairobi. These include departments at the University of Nairobi and the Moi University, at Eldoret-school of Environmental Studies, Coast Development Authority, the National Museum and the Tana and Athi river Development Authority. The Kenya Wildlife Services participates in coral reef research and marine conservation. The University of Nairobi has a long history in training marine scientists. Over 50 marine scientists work in the departments of zoology, botany, geology, engineering, chemistry and geography. The university does not have a diving unit, nor a boat or a coastal field station which can be used for both teaching and research. Kenya Marine and Fisheries Research Institute (KMFRI) is based in Mombasa and is mandated by the Government of Kenya to do research in the marine and freshwater environment. KMFRI is currently involved in research in physical, chemical, geological and biological oceanography, as well as in fisheries, mariculture and ecology. For details see Annex XI.

3.4.2 Manpower

University of Nairobi

The University of Nairobi was founded in 1956 as a college of the University of London, and became part of the University of East Africa at Independence. Since the 1970's it has become a fully autonomous university and has some 15,000 students. This university comprises six colleges: Architecture and Engineering, Arts and Social Science, Biology and Physical Science, Agriculture and Veterinary Science, Health Sciences, and Education and External Standards. The University had obviously been under considerable political, managerial and financial strains which has resulted in deterioration of buildings and equipment.

The Science Faculty comprises nine departments (Biochemistry, Botany, Zoology, Geology, Meteorology, Geography, Mathematics, Physics and Chemistry) of which some are relevant for marine sciences.. The Science Faculty is an established faculty awarding degrees since 1963. During the last two years, 35 to 40 Masters and 15 PhDs have been awarded. Areas of strength include :

- * Biological Sciences: Ecology, tropical plants and animals, wildlife conservation, medicinal plants, parasitology, entomology and tropical diseases.
- * Meteorology: This department has close links with WMO and prides itself on being one of the three African centres of meteorology.
- * Geology: This is the only geology department in Kenya. IGBP-START and UNDP funds have been obtained to set up a geological GIS in the department in collaboration with the University of Cape Town (Prof de Wit). The department is keen to develop partnerships outside Kenya (UCT).
- * Geography: Key areas are geomorphology and hydrology.
- * Chemistry: The environmental chemistry activities might be of interest in the context of this mission.

Jomo Kenyatta University of Agriculture & Technology (JKU)

This university developed from an agricultural college and became an independent university in December 1994. It is situated on a rural campus some 40 km northeast of Nairobi. The University comprises only Science, Agriculture and Engineering faculties and has some 2,500 students. It brings about some 200 graduates per year. At present most students are undergraduates but the University is in the process of developing Masters programmes. As yet, little research takes place on the campus, and staff who do research are also engaged at other universities, some of them being registered for higher degrees at these universities.

JKU is situated in the countryside on a pleasant, clean campus. The buildings are relatively new and the laboratories, though, as yet, sparsely equipped, are satisfactory. Thanks to financial and technical support from the Japanese government, each department is equipped with a computer

room housing 8 - 10 computers. There is also a computer training centre with 40 computers, 10 of which are 486's. A Kenyan technician works with a Japanese technician maintaining them and providing computer training.

Three departments of the Science Faculty have some relevance for this mission. These departments are:

- * Chemistry: PhD graduates are required in all areas, but top priorities are organic chemistry (natural Products) and environmental chemistry (monitoring heavy metals, nitrates, phosphates, water quality, atmospheric pollution).
- * Zoology: Priority areas identified (in order): fish and fisheries entomology and wildlife management.
- * Botany: Priority areas identified (in order): plant morphogenesis (especially in conversation), plant taxonomy, mycology and microbiology.

Kenyan Marine and Fisheries Research Institute

KMFRI is part of the Ministry of Research, Technical Training and Technology. The institute has two main divisions, the marine science division and freshwater science division. The marine science division is based at the KMFRI's headquarters in Mombasa. Here is a large block of building which houses laboratories and offices for the scientific staff as well as a store and a wet laboratory with several aquaria and tanks. There is also a newly erected office block for the supporting staff. KMFRI owns and runs one small research vessel (R/V Maumba) and some small boats with outboard engines. A library with a computerized search/retrieval system runs under the RECOSCIX-WIO project. An integrated computer section is housed on the top floor.

The inland waters division is at the Kisumu Laboratories. This division has laboratories in Kisumu near Lake Victoria, at Kalokol on Lake Turkana, at Lake Baringo; at Sango'ro on River Miriu, Kegati (River Gucha), Lake Naivasha and in Nairobi. The institute in Kisumu operates three research vessels for research at Lake Victoria.

There are 120 scientists with about half the number carrying out research on fresh water and the other half on marine waters. Out of them 85 have a B.Sc; 33 have an M.Sc and 2 have a Ph.D. Most of the scientific staff join the institute with a B.Sc. degree. The institute undertakes to train them for MSc. courses locally or by securing scholarships for training abroad. The postgraduate training is undertaken in more specialized areas to tackle specific project areas. There is need for more post-graduate training opportunities due to the recent increase in number of scientific staff at B.Sc. level. There is also need for postgraduate training locally and abroad. There is need to train supporting staff in various disciplines as well. The total number of supporting staff is about 1,300.

The following is an overview of the most relevant marine science activities in the last three to six years (see for details Annex 11):

- * Kenya-Belgium Marine Sciences research project
- * Kenya-Dutch Partners in Science Programme, Phase I
- * Eastern Africa Action plan (UNEP - OCA/PAC)
- * SAREC and IOC-SAREC Marine coastal management programme
- * Artemia project (Ghent State University, Belgium)
- * Kenya Belgium Project on Biological Oceanography (Vrije University Brussels, Belgium)
- * Dynamics and assessment of Kenyan Mangrove Ecosystems (Delta Institute of Hydrobiological Research, Netherlands; Vrije Universiteit Brussels; and European Economic Community)
- * Nile Perch Utilization Project (FAO)
- * Kenya-Dutch Indian Ocean Expedition (Netherlands Science Foundation)
- * Lake Turkana Fisheries Research Project (NORAD)
- * Fish Stock assessment on the Kenyan Coast (NORAD)
- * Regional Cooperation in Scientific Information Exchange in the Western Indian Ocean region-RECOSCIX-WIO (Limburg Universiteit Centrum, Belgium)
- * Coral Reef Conservation Project (Wildlife Conservation International, USAID)
- * Individual researchers affiliated to the institute.

The institute also participates actively in the following international projects:

- * Assessment and control of Pollution in the Coastal and Marine Environment- EAF6 (UNEP, IOC, FAO, WHO, IAEA, SAREC)
- * Protection and Management of Marine and Coastal areas-EAF5 (UNEP, FAO, IOC)
- * Coastal Marine Systems in Africa- COMARAF (UNESCO)
- * Global Sea Level Observing System-GLOSS (IOC)
- * Tropical Ocean and Global Atmosphere Experiment - TOGA (IOC, WMO)

3.4.3 Equipment

KMFRI has some equipment that can be used for research, such as gas chromatography and atomic absorption spectrophotometer. KMFRI's computer facilities, though not state of the art, are impressive. There is a need to upgrade or replace KMFRI's research vessel Maumba.

3.4.4 Research Activities

Research activities at the institute have been grouped as follows:

- i) Fisheries - identification, stock assessment and management of commercially important species in both coastal and inland waters.

- ii) Marine Biology and Biological Oceanography - studies of primary and secondary production (phytoplankton, zooplankton), benthos, invertebrates, marine bacteriology, fish biology, marine macrophytes (macro-algae, seaweeds, seagrasses), dynamics of mangrove and coral ecosystems, biodiversity.
- iii) Physical and Chemical Oceanography - nutrient cycles, biogeochemical cycles, chemical composition of sea water, water-air interactions and water-sediment interactions; hydrography and dynamics (including currents, waves) of coastal and inshore waters, hydrodynamics, sea level monitoring. Use of modelling as a tool for studying and predicting the behaviour of marine systems.
- iv) Pollution Studies - studies of dissolved and suspended hydrocarbons, heavy metals, trace metals, PCB's: their distribution and effects. Ecotoxicology.
- v) Aquaculture - identification and development of culturable fish species (both marine and freshwater), development of hatchery for restocking of lake and adjacent waters; prawn and oyster culture techniques; artemia culture; and farming of important algae species.
- vi) Marine Geology - study of stratigraphy, sedimentology and applied technology; evolution of beaches and development of coastal defense. Impact of climate change.
- vii) Fish Processing and Preservation - development of cheap methods for processing and preserving different types of fish, changes in nutritional value with different storage and processing methods.
- viii) Marine resource assessment - compilation of a marine resource data-base and regional atlas.

In the report of the LOICZ-workshop (august 1995) organised in Nairobi, Kenya, it is stated that research related to LOICZ in Kenya is carried out by local scientists in co-operation with regional and international scientists through programmes such as UNEP's Regional Seas Programmes, SAREC funded programme on physical oceanography, the Western Indian Ocean Marine Science Association (WIOSA) activities, Kenya-Belgium project in Marine Sciences, EEC-STD2 project on the structure and function of mangrove ecosystems in Kenya (1990 - 1992), EEC-STD3 project on inter-linkages between coastal marine ecosystems in the Eastern Africa region (if approved), and the Netherlands Indian Ocean programme (Kenyan Dutch cooperation in Marine Research, Partners in Science. Phase II if funded.) Other research activities include IOC's programmes of monitoring the sealevel and coastal erosion, GLOSS, OSNLR, OSLR and GOOS.

3.4.5 Recommendations

1. The Kenya Marine and Fisheries Research Institute is identified as the lead institution in Kenya to coordinate marine research.
2. There is a strong need to strengthen regional institutional Capacity Building for sustainable development and utilization in the region.
3. KMFRI's research vessel *Maumba* should be upgraded or replaced.
4. KMFRI could be developed into a regional training centre and equipment pool.

4 FOLLOW-UP

The consultants think that the time is right for a regional, Eastern African, Partners in Science programme. It is clear that a tailor-made approach in a bilateral (donor) context is a condition sine-qua-non for such a programme. The capacity and capability in Kenya, Tanzania, Mozambique and the Republic of South Africa is rather diverse and at different levels of development. Because of the existing infrastructure we expect that South Africa and Kenya will play a leading role in this partnership.

The emphasis in all four countries in marine activities is research of the coastal environment. It is, therefore, suggested to develop the Partners in Science plan in relation to the LOICZ initiative of IGBP. Because of, among others, the direct link between the local/regional climate and the Indian Ocean current system, this research has to be embedded in research in the Eastern African EEZ. The state of the art infrastructure of especially the universities at Cape Town and Durban as well as the Ocean Research Institute in Durban, offer excellent training and research facilities. Initiatives such as USEPIA and the UTC Center of Marine Studies are promising vehicles for future cooperation. Moreover, the research fleet, operated by SFRI, offers excellent opportunities for training of technicians (at the Cape Town Technikon) and regional TREDMAR-like initiatives (training through research) .

The capabilities in Kenya, such as KMFRI's computer section, offer a promising start for developing the "northern part" of the Eastern African region. To allow for this, feasibility of a refit or replacement of RV *Maumba* should be investigated.

As a way forward, the consultants suggest to organize a workshop with the following objectives:

- * To develop an integrated Eastern African Partners in Science Programme (1997-2001) based upon the LOICZ initiative.
- * To set up detailed bilateral workplans between the Eastern African and non-African partners.
- * To develop a training programme for Eastern African scientist and technician (including technicians for computer support).
- * To give an outline of a two-yearly TREDMAR-like (training through research) Eastern African Research cruise in the EEZ of the participating countries.

We suggest that the workshop be held in Mombasa, Kenya, march/april 1996. In table 2, potential participants are suggested. The cost of such a workshop will be US\$ 60.000. Finally, it is strongly suggested that a small number of science managers and representatives of key donor organisations will participate and discuss in a parallel session, the fine tuning of the different donor activities and the funding possibilities of the Capacity Building elements of the partnership.

Table 2. Proposed Participants

Country	Person	Expertise	Organisation
Kenya	Dr. E. Okemwa Dr. Ntiba	Management Oceanography	KMFRI, IOC UON
Tanzania	Prof. Semesi	Coastal Research	UOD
Mozambique	Mr. D. Gove	Coastal research	
South Africa	Prof. G. Brundrit Dr. R. Krohn Mr. R. Van der Elst Dr. T. Mason	Oceanography Management Coastal research Marine geology Coastal Research	UTC UTC, FRD ORI UND CSIR
Netherlands	Prof. C. Heip Dr. J.H. Stel	Coastal research Management	CEMO, EU GOA, IOC, EU
UK		Management	
Norway		Coastal Research	
Sweden	Dr. A. Granlund	Donor Coastal Research	SIDA/SAREC
Belgium	Prof. N. Daro	Coastal research	VUB

Invitations to participate in the workshop should be extended to the donors/organisations: SAREC/SIDA; CIDA; Commonwealth; DGIS; EU; NORAD; DANIDE; ICELAND; IOC; UNEP; IUCN. Also to scientists from the following countries: Germany, France, Belgium, UK, U.S.A., Portugal and any other.

5 ACKNOWLEDGEMENT

The consultants wish to thank Dr. Gunner Kullenberg (Executive Secretary IOC-UNESCO) for enabling them to undertake this task. Sincere thanks go to all those who assisted the consultants in one way or the other in Cape Town, Durban, Maputo, Zanzibar and Nairobi during the mission. We hope that this report will be useful towards the overall objective of the mission and create new initiatives to solidify the re-entry of South Africa in the international community.

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17 November 1995, University of Cape Town

12.00 Arrival in Cape Town (Dr.J.H. Stel)

14.00 - 15.00 Prof. J.C. Field (President IGOFS), Mike Lucas

15.00 - 16.00 Dr. R. Krohn

18 November 1995

10.00 - 18.00 Trip with Prof. G.B. Brundrit

19 November 1995

Day off

20 November 1995

08.45 Department of Zoology

09.00 - 10.00 Prof. G.M. Branch

10.30 - 11.00 Prof. B. Davies

11.00 - 12.00 Prof. J.R.E. Lurjeharnis (Chemical Oceanography)

12.00 - 14.00 Lunch

14.00 - 16.00 Prof. G.B. Brundrit (LOICZ), L.Y. Shackleton, J.L. Largier

21 November 1995

09.00 - 10.00 Dr. J. Rogers (Geology)

13.15 - 14.15 Dr. A.I.L. Payne, dr. A. Badenhorst

14.15 - 14.45 Visit to the SFRI facilities

14.45 - 16.00 Visit to Research Vessels

18.00 Flight to Durban

20.00 Arrival in Durban

22 November 1995

09.00 - 17.00 Mr. R.P. van der Elst, Dr. L. Beckley, Institute of Oceanography

23 November 1995

09.00 Departure by car to University of Natal, Durban

10.00 - 12.00 Prof. T.R. Mason, prof. J.R. Krynauw

13.00 - 14.00 Prof. A.T. Forbes, Miss. N.T. Demetriades

14.00 Departure to Johannesburg

16.15 Arrival in Johannesburg

21.30 Departure to Maputo, Mozambique

22.30 Arrival in Maputo, Mozambique

24 November 1995

09.00 - 12.15 Mr. Domingos Gove (Head Marine Science Institute)

14.30 - 15.00 INAHINA

15.00 - 15.30 Fisheries Institute

25 November 1995

10.00 Departure to Nairobi, Kenya

ANNEXES

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- * *Transkel Coastal Fisheries Resources*, Oceanographic Research Institute, Special Publication No. 3, November 1994.
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- * *Council for Geoscience, Annual Report 1994-1995, 1 April 1994 to 31 March 1995.*

Annex I Programme

- 11 November 1995
Departure from Mombasa to Nairobi (Dr.E. Okemwa)
- 12 November 1995
Departure from Nairobi (Dr.E. Okemwa)
Arrival in Cape Town (Dr.E Okemwa)
- 16 November 1995
Departure from the Netherlands (Dr.J.H. Stel)
- 17 November 1995, University of Cape Town
12.00 Arrival in Cape Town (Dr.J.H. Stel)
14.00 - 15.00 Prof. J.C. Field (President JGOFS); Mike Lucas
15.00 - 16.00 Dr. R. Krohn
- 18 November 1995
10.00 - 18.00 Trip with Prof. G.B. Brundrit
- 19 November 1995
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- 20 November 1995
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12.00 - 14.00 Lunch
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13.00 - 14.00 Prof. A.T. Forbes, Miss. N.T. Demetriades
14.00 Departure to Johannesburg
16.15 Arrival in Johannesburg
21.30 Departure to Maputo, Mozambique
22.30 Arrival in Maputo, Mozambique
- 24 November 1995
09.00 - 12.15 Mr. Domingos Gove (Head Marine Science Institute)
14.30 - 15.00 INAHINA
15.00 - 15.30 Fisheries Institute
- 25 November 1995
10.00 Departure to Nairobi, Kenya

- 20.00 Arrival in Nairobi, Kenya
 22.00 Arrival in Mombasa (Dr.E. Okemwa)
 26 November 1995
 Day off
 27 November 1995
 11.00 - 12.30 Mr. J.J. Hooft, the Netherlands Embassy
 14.15 - 16.00 Mr. P.K. Akiwumi, UNEP, OCA/PAC
 28 November 1995
 23.15 Departure to the Netherlands
 29 November 1995
 06.00 Arrival in the Netherlands
 2 December 1995
 10.15 - 11.30 Departure from Mombasa to Zanzibar (Dr. E. Okemwa)
 2 December 1995
 2.00 - 3.00 pm Dr. J. Francis and Mr. Salm (Institute of Marine Science Zanzibar)
 4 December 1995
 3.00 - 6.00 pm Arrival in Mombasa (Dr. E. Okemwa)

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Annex III Benguela Ecology Programme, Phase III

The Benguela Ecology Programme (BEP) is an inter-disciplinary, ecological research programme which coordinates and facilitates research into selected living resources of the Benguela ecosystem and their environment, with particular emphasis on the southern areas.

The Benguela ecosystem

The Benguela ecosystem consists of the shelf sea environment off the South and West coasts of southern Africa. The prevailing southerly wind results in the upwelling of cold, nutrient-rich water which supports high level of biological production. This productive ecosystem maintains important commercial fisheries. In the southern parts of the system young anchovy *Engraulis capensis* and sardine *Sardinops sagax* are carried by currents from the spawning grounds in the south to the West Coast where there is abundant planktonic food for growth. On their southward journey back to the spawning grounds, on the Agulhas Bank, they are available to the purse-seiners of the pelagic fishery.

The shallow waters of the Agulhas Bank in the south are warmer but less productive than the west coast. The Bank also includes the spawning grounds of the commercially important chokka squid *Loligo vulgaris reynaudii*.

The objectives of the BEP

The BEP, which started in 1981 and entered its third five-year phase in 1992, has focused increasingly on the pelagic environment, where the important, relatively short-lived fish species such as anchovy and sardine, as well as the chokka squid, are found. Because of their short life-spans, the abundance of these species can fluctuate considerably from year to year, particularly in response to environmental changes.

The specific objectives of Phase III of the BEP can be summarized as follows.

- * To make a measurable contribution to the optimal utilization and management of anchovy, sardine and squid through the following research.
- * To describe the characteristics and variability of the physical environment, primary production and their impact on the key resources.
- * To improve existing knowledge of the nature and causes of long-term changes in the ecosystem.
- * To supplement the existing knowledge on resource dynamics required for immediate resource management.
- * To encourage national and international cooperation among marine scientists.
- * To provide opportunities for appropriate training for young marine scientists.

Participating organisations

- * Foundation for Research Development
- * Port Elizabeth Museum
- * Sea Fisheries Research Institute
- * South African Museum
- * University of Cape Town
- * University of Port Elizabeth

International cooperation

International collaboration and exchange are a high priority. Through the Programme itself or through local scientists associated with BEP III, close ties are maintained with international programmes such as GLOBEC, IGBP, JGOFS, LOICZ, TOPEX-POSEIDON and WOCE.

Research structure of BEP phase III

The research programme of BEP III is highly diverse, covering many aspects of the Benguela ecosystem. However, for convenience BEP III has been split into nine distinct but inter-related projects, these are:

- * **Physical processes and remote sensing**
This project aims to investigate, through on-going shipboard sampling, analysis of existing data and remote sensing, the vertical and horizontal circulation, stratification and mixing of the coastal waters of the Benguela ecosystem. The information generated by remote sensing and processed in this project is important to several components of the Programme.
- * **Biogeochemical processes**
This project is examining the primary production of phytoplankton, which underlies all other production. Using direct measurements and remote sensing, it focuses particularly on the relative quantities of "new" production arising from the introduction of nitrogen from upwelling, and "regenerated" production from nitrogen cycling within the system.
- * **Zooplankton and the recruitment of pelagic fish**
Initial results have suggested that the number of anchovy recruits each year may be closely related to the availability of food, particularly copepod zooplankton, on the spawning grounds. The project aims to test this hypothesis through studying zooplankton production and pelagic fish feeding and their variability between and within different spawning seasons.
- * **Factors affecting the distribution and variability of anchovy and sardine**
This project is aimed at determining the distribution, abundance and availability to the commercial fishery of sardine and anchovy. Aspects such as the patterns in commercial catch positions, spawning activity and recruitment are being measured with particular emphasis on their variability.
- * **Factors affecting the abundance and distribution of chokka squid.**
The overall objectives of the project are to increase knowledge of the biology of the species to improve upon the current management procedure, and to link the distribution of squid and its availability to the South Coast jig fishery to environmental parameters. This project involves localized environmental studies, research cruises and simulation modelling.
- * **Long-term trends in the abundance of dominant resources in the Benguela Ecosystem.**
Upwelling ecosystems are not stable assemblages of species. For example, anchovy and sardine abundances have been found to have fluctuated over decades, with the species alternately dominating the pelagic ecosystem. This project is attempting to identify the environmental parameters regulating changes in dominance, and is investigating the feasibility of predicting such changes.
- * **Stock assessment**
Variability in stock abundance and uncertainties associated with measuring abundance and key production parameters require sophisticated modelling techniques to ensure stocks are properly utilized without undue risk of adverse depletion. This project is exploring possible improvements to the way stocks are assessed, and how the results can be translated into the best management advice.
- * **Variability of pelagic fish and squid and the environment**

This project is integrating the results from the Programme to identify those abiotic and biotic factors which drive the spacial and temporal variability of pelagic fish and squid. The relationships between these factors and the resource populations are being quantified. Coupled physical-biological models are being used to simulate the interactions between the driving variables and the dependent populations.

Resource management

BEP III is attempting to supplement some of the stock assessment models currently used for management by helping to reduce important uncertainties. This work aims to incorporate results from the Programme into resource assessment and management procedures.

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Annex IV Foundation for Research Development: Announcement of new programmes, July 1995:

4.1 Introduction

The mission took place just before the phasing in of a new five year plan (1996-2000) of the Foundation for Research Development (FRD). The new plan was developed after a wide and intensive consultation process of several years and led to a strategy document "Facing the Challenge". The information in this annex is gathered from the new programmes implementation document "Announcement of new programmes" (July '95).

The new programmes in this plan are strongly directed to address the needs of the Republic of South Africa. The expected contribution of the scientific community in addressing national needs and priorities is laid down in the government's Reconstruction and Development Programme (RDP). All FRD funded activities have to support:

- * competitive research in science, engineering and technology (SET);
- * corrective action and;
- * research at the academic-industry interface.

All new FRD programmes fit into two broad themes, being Directed and Open Themes.

In Directed Themes programmes, research is driven by predetermined demand. Human and capital resources are directed towards effectively creating new knowledge, ideas and human resources - all aimed at serving well defined national needs. DT-programmes have been developed in the following themes:

- * **Competitive Industry:** to develop expertise and to produce appropriately qualified people to assist South African Industry to compete effectively in the world.
- * **Sustainable Environment:** to develop experts with the necessary skills to address the environmental challenges presented by the country's development programme.
- * **Improved Quality of Life:** to promote, facilitate and support the development of research capacity with a focus on high quality and relevance, as well as the effective education at tertiary level of enough people with relevant expertise to contribute to an improved quality of life for all South Africans.

Programmes in Open Themes support research aimed at building and strengthening the national SET base, without any restriction on the freedom of individuals and institutions to pursue what they believe to be important in this regard.

- * In the Open Research Programme researchers can look beyond and pursue opportunities of interest and importance outside the more focused thrusts of the programmes in the Directed Themes.
- * The Institutional Research Programmes for Technikons and Universities focus on the creation of an environment conducive to the maturation of a research culture. This will necessitate special support measures customised to the needs, strategies and research missions of the individual institutions concerned.
- * The Equipment Programme in the Open Theme "National and Regional Research Equipment" is designed to meet the needs of all researchers in higher education. Although grants are ultimately made to the institutions that will take responsibility for the equipment, initiation of the process of applying for resources from this programme is open to all researchers in SET.

- * Within the Bursary and Fellowship Programme the students/fellows are offered the opportunity and freedom of association and supported in their own right. This programme therefore complements the grant-holder-linked and institution-linked bursaries of the other programmes.

4.2 A new approach

A new approach within the FRD will allow for the integration and synchronisation of activities designed to achieve the corporate goals. This approach will focus on three categories, each of which has specific characteristics. All activities within programmes should promote and contribute to the objectives of these categories.

4.2.1 Category Competitive Research in SET

The challenge is to maintain and enhance leading-edge expertise in SET in South Africa, and to ensure that the country has leaders in SET who can apply their knowledge to the challenges and objectives of RDP and national development needs. The objectives of the "Competitive Research in SET" category are to:

- * Sustain and enhance the strategic knowledge base in SET according to national development needs.
- * Develop the capacity to recognise and exploit scientific and technological advances for the benefit of the nation.
- * Encourage participation in international research initiatives and programmes.
- * Encourage team work at disciplinary interfaces and in multi-disciplinary areas.
- * Develop present and future generations of internationally acknowledged researchers in SET.
- * Develop high level human resources with relevant SET expertise and enterprise.

4.2.2 Category Corrective action

Capacity building at tertiary institutions and the involvement of disadvantaged communities and women in all the programmes of the FRD is one of the greatest challenges. This category supports activities that will enable disadvantaged communities to participate fully at all levels of SET research and education. Correcting the imbalances of an educational history which under-emphasised technological and technical education, and promoting at all levels of society an awareness, appreciation and understanding of SET, are priorities. The objectives of the "Corrective Action" category are to:

- * Contribute to an increase in the number of black engineers, scientists and technologists to a level reflective of the demographic composition of society.
- * Foster a research culture in SET at historically black universities and all technikons.
- * Contribute to staff development programmes in SET at historically black universities and all technikons.
- * Improve the quality of science education in schools and colleges of education.
- * Promote public awareness, appreciation and understanding of SET.
- * Provide a framework for collaboration and linkages between historically black universities, technikons and other educational and research institutions in the public and private sectors.

4.2.3 Category Academic - Industry Cooperative Research

In building the economy of South Africa, it is important for industry to be internationally competitive. Wealth and job creation will lead to more employment opportunities and an improved quality of life. This category supports activities to develop human resources capable of effectively developing and employing new technologies that enhance the competitiveness of South African industry. These activities will be driven by the needs of industry. The objectives of the "Academic - Industry Cooperative Research" category are to:

- * Promote the technological advancement of industry, based on and driven by the need of industry to be competitive.
- * Ensure a balanced supply of human resources with the desired technological and managerial skills for industry.
- * Establish effective technology transfer processes between educational institutions and industry.
- * Improve the quality of academic staff in SET at higher education institutions through significant exposure to industry.
- * Encourage synergistic collaboration between higher education and industry in the development of new technologies.
- * Foster entrepreneurship by developing an entrepreneurial culture within higher education institutions.
- * Promote a culture of innovation through the support of relevant and challenging projects.

4.3 FRD-programmes principles

In the design, implementation and management of FRD Programmes, the following principles will be adhered to. An important general consideration of every programme will be the overall contribution of the proposed research to the three categories of the FRD, i.e. Competitive Research in SET, Corrective Action and Academic-industry Cooperative Research. In the management of all programmes relevant expertise and information will be accessed, through consultation, for transparency and rational decision-making (*consultative programme management*). The development of an understanding of *innovation*, and fostering *entrepreneurship* amongst researchers and research students in higher education, are important elements of programmes. This will focus research and human resource development on the advancement of business enterprises. Finally, partnerships and cooperation are important for the:

- * Involvement of local and international leaders in SET.
- * Development of appropriate partnerships between higher education, industry, labour, science councils and government.
- * Teamwork and the formation of networks of expertise across disciplines and institutions.
- * Interdisciplinary, multidisciplinary and trans-disciplinary research. Where it is necessary to involve other disciplines of science, outside the traditional mandate of the FRD, to make a success of its programmes, the FRD will interact with other research funding bodies in the development of activities and to mobilise mutual support. The level of support for research programmes incorporating these disciplines, will depend on the joint commitment of other funding bodies and the availability of FRD funds.
- * Funds available as a result of agreements between the FRD and other countries or organisations, will be channelled to the relevant FRD programmes.

4.4 New FRD Programmes

DIRECTED THEMES		
THEME	PROGRAMMES	THRUSTS
Competitive Industry	Primary Resource Beneficiation	Minerals and Materials Forestry Natural Materials
	Manufacturing Advancement	Product Design for Manufacturing and Marketability Discrete and Continuous Process Manufacturing Management and Manufacturing Systems
	Information and Infrastructure Systems	Information Technology Communications Systems Industrial Electronics Control Systems Logistic Systems
Improved Quality of Life	Rural and Urban Development	Water and Sanitation Waste and Pollution Management Housing Transport Energy Land-use and Rehabilitation
	Food Production and Food Security	Farming Systems Sustainable Use of Natural Resources for Food Production Animal Production and Management Crop and Horticultural Production and Management Innovation in the Food and Beverage Industry
Sustainable Environment	Inland Resources	Biodiversity and Conservation Indigenous Species Utilisation Systems Management Restoration and Rehabilitation Weather and Climate (also Marine Programme) Ecotourism (also Marine Programme)
	Marine and Coastal Resources	Coastal Communities and Living Resources The Coast as a Resource Offshore Living Resources and Society Mariculture Biodiversity and Conservation Ocean Dynamics and Coastal Geomorphology
Effective SET Education and Awareness	Innovation and Change in Education	Appropriate Curriculum Development Assessment Criteria SET and Industry/Business/Higher Education Cost-effective and Quality Delivery of Teaching Educational Materials Language and Learning (Programme to be developed for implementation in January 1996)
	Public Understanding of SET	(To be developed during 1996)
	Preparation and Development of Educators	

OPEN THEMES	
THEME	PROGRAMMES
Building and Enhancing Research Capacity	Open Research Programme
Developing Institutional Research Culture	Technikon Programme
	University Programme
National and Regional Research Equipment	Equipment Programme
Bursaries and Fellowships	Bursary and Fellowship Programme

4.5 Directed theme: Competitive Industry

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4.5.1 Introduction

Competitiveness is the degree to which a country can, under free and fair market conditions, produce goods and services which meet the demands of international markets, while simultaneously maintaining and expanding the real incomes of its people over the long-term. Competitiveness in industry is the ability of entrepreneurs to design, produce, market and distribute goods and services, the price and non-price characteristics of which form a more attractive package to customers than that of competitors. The key to success seems to be in innovation - in process and product, in productivity and quality - and in a skilled workforce.

For countries and companies that have grown complacent with the existing state of affairs, adapting to a changing global environment may be painful. South Africa is not very competitive according to recent World Competitiveness Reports. If South African industry does not become more competitive economic growth will remain a dream.

In a world economy which is becoming increasingly technology-based, skills and knowledge are the only sources of sustainable competitive advantage. Better cooperation between industry and the educational system must play a key role. Creating a climate where science, engineering, technology and industry are unified and work together is a major element in enhancing competitiveness.

Being internationally competitive does not only imply success in exporting products, it also means that domestic markets are catered for by supplying the products that are needed. In South Africa the domestic needs spelled out in the government's Reconstruction and Development Programme (RDP) provide excellent guidelines for the kinds of goods and services needed in the near future.

Many of these goods and services require innovation and development to allow them to be successfully delivered to consumers and clients.

4.5.2 Aim of the theme

The aim of the three programmes in this theme is to develop expertise and to produce appropriately qualified people, to assist South African industry to compete effectively in the world.

- * In these programmes university and technikon undergraduates will be sensitised to the issues of competitiveness while postgraduates and staff will obtain specialised knowledge in partnership with industry.
- * The programmes aim explicitly at developing the expertise required for wealth creation and sound industrial entrepreneurship. They address the employment issue through the promise that South Africa needs wealth to create the jobs its people need to ensure sustainable socio-economic growth.
- * Through their products, the programmes furthermore aim to strengthen and expand small and large, black and white industry in South Africa.
- * Finally they address both the competitiveness and the employment issues in that the awareness they generate should permeate the entire South African educational and industrial communities.
- * There are some industries which could logically be included in the Competitive Industry Theme, but which are being accommodated in other themes, e.g. Tourism and fisheries in sustainable environment and the Food industry and agribusiness in quality of life.

Mechanisms will be put in place to ensure coordination.

4.5.3 Programmes in the theme

Within the DT Competitive industry three programmes are formulated. The programmes Primary Resource Beneficiation and Manufacturing Advancement are not related to the objective of this mission. The programme Information and Infrastructure Systems offers some interesting interfaces with the objective of this mission. Information, communications and electronic technologies are essential drivers of competitiveness in most sectors of the economy. The IIS-programme aims to qualify people to design, implement, apply and manage these infrastructure technologies across the broad spectrum of the total South African endeavour. The programme addresses five areas:

Information Technology

South Africa cannot afford to, nor needs to, import all the information technology (IT) systems it needs for all the development it requires. Moreover, there is a real opportunity to develop export quality systems in niche markets. The goal is thus to develop the capabilities of a major producer of niche computer software and systems, in addition to the considerable IT user capabilities which exist and have to be maintained.

To train the necessary people means giving them education and an apprenticeship in a computing environment where the following areas and their applications are emphasised:

- * Database systems.
- * Advanced integrated information systems.
- * Decision support systems.
- * Computer system security and privacy.
- * Software engineering.
- * Software quality assurance and process assessment.
- * Distributed and real-time processing.
- * Computer supported cooperative work.
- * Visualisation, multi-media and virtual reality.
- * Knowledge and information based industry models including object and agent approaches.
- * New applications of high speed microprocessors e.g. signal and information processing.
- * Safety-critical systems.

The training must be linked to real world applications and the honing of skills to proliferate the new knowledge and technology created.

Communications Systems

The communications industry is an economic sector in its own right and a key element of the infrastructure supporting other sectors. The goal is to train people to deploy and operate communication networks and develop innovative ways to use modern communications technology to maximum benefit.

Universal service poses a unique challenge to evaluate, acquire and use new telecommunication technologies to install and maintain an efficient and affordable infrastructure as quickly as possible.

Technologies include: digital coding, compression; high capacity cellular telephony; management and performance evaluation of the rural telecommunications infrastructure; distribution of medical and educational tele-services; satellite technology; integration of computing and telecommunications networks.

Competitive modern communications systems also require sophisticated network technology for both local and wide area application. This cuts across telecommunication and information technology and requires expertise in: network management, protocols, dimensioning, optimisation, security, signalling; traffic analysis and forecasting; broadband technologies; intelligent services; the Internet and its applications.

Collaboration between academic institutions

Collaboration between the natural sciences and engineering disciplines as well as with social and management disciplines will be encouraged, sought and achieved. The FRD's funding will predominantly be employed in natural science, engineering and technology aspects. Partnerships with other funders in South Africa and abroad will actively be sought to augment money available from the FRD and also to ensure that the necessary inputs from disciplines outside the FRD's purview can be accommodated adequately.

4.6 Directed theme: Improved Quality of Life

4.6.1 Rationale

Past inequalities have created major social and economic problems in South Africa. Approximately one third of South Africans have an income lower than the minimum subsistence level. Of these, more than 90 percent are black and more than 70 percent are based in rural areas. These communities do not have easy access to an income, infrastructure and education that can assist them in improving their quality of life. This diminishes self-confidence and pride and often leads to despair, lethargy and crime.

The programme of Reconstruction and Development (RDP) of the South African government proposes that this critical situation be alleviated as a matter of the greatest urgency. Science and technology are essential instruments through which many of these legacies can be addressed, in addition to creating competitive industries for economic growth. The mandate of the FRD requires it to assist in these efforts by focusing on the education of people with the expertise to identify, develop, adapt and maintain systems, processes and products that will improve the quality of life of especially the poor communities in South Africa.

4.6.2 Aim of the theme

The aim of this theme is to contribute to an improved quality of life for all South Africans, by promoting, facilitating and supporting:

- * the most effective education at a tertiary level and,
- * research capacity development, focusing on high quality, relevant research.

Within this theme seven projects are promoted, out of which four are relevant for the mission.

Targeted human resource development

The development and use of advanced educational technology and innovative education methods (such as interactive, multi-media, distance education systems) will be encouraged.

Research capacity development

Research will be used as a vehicle to train high-level human resources. Strategic and applied research, as well as basic research aimed at understanding and eventually solving a problem encountered in the industry or in community upliftment projects, will be supported and promoted. Researchers will be encouraged to find innovative, cost-effective and simple solutions to problems, and to grasp opportunities. This implies an understanding of the socio-economic complexities and real needs of target or end-user groups and will in many cases require a holistic and/or multi-disciplinary approach to projects, including a strong component of social sciences.

Researchers will be encouraged to continuously seek ways to adapt their scientific endeavour to practice. They should thus be sensitive to potential applications of their research results, even if they are not involved in applied research. In addition, they will be encouraged to adopt a culture

of continuous improvement of imported or locally developed technologies, in addition to searching for new knowledge.

The concept of considering national and international experiences and technologies as a point of departure in every project, will be promoted. Therefore, comprehensive feasibility studies and literature surveys will be encouraged. Funds for this purpose can be requested before a fully motivated request is submitted to the FRD for funding. Support can also be provided if the feasibility study concludes that no new research is necessary but that there is a need to collate and process available research and other information into a report that will be of benefit to the potential recipients.

Individuals and single research teams will be supported, but collaboration between different research groups will be greatly encouraged from the start. Self-initiated projects within the stated thrusts can be identified and presented to the FRD in response to a call for proposals. In addition, the FRD will identify specific problems or opportunities and put them out to tender or identify, link and support individuals or teams to collaborate on such identified projects.

Knowledge transfer

Research projects at academic institutions will be linked to potential development and implementation opportunities and systems. This can be done *inter alia* through collaboration with the industry and community-based organisations and the innovative dissemination of research results. While the FRD cannot be an implementing agency, it should play a role in the chain ensuring that, where possible, research results are not lost to potential developers and implementers. In addition, intellectual property rights and patenting expertise should be made easily accessible to researchers and this can be facilitated by the FRD if required. There will be limited support for pilot projects to expose academic scientists to practice, and then only in partnership with relevant industries or other partners.

4.6.3 Research projects

Most of the activities in the DT Improved Quality of Life have an indirect relation to the objectives of this mission. An important thrust, however, within the programme Food Productions and Security is "sustainable use of natural resources for food production." Research in this thrust has to provide a better understanding of the nature, direction and degree of change in the natural resource base that impacts on food production and food security. Climate research is one of the important issues to be addressed. (See University of Cape Town UCT, oceanography)

4.7 Directed Theme: Sustainable Environment

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4.7.1 Rationale

As part of its development strategy, the Government of National Unity launched the Reconstruction and Development Programme (RDP) in July 1994 with the objective of uplifting the quality of life of the country's disadvantaged people. This will be achieved via improvement of employment opportunities, education, housing, water supply, sanitation and electrification. As recognised by the RDP and in order for it to succeed, development should be paralleled by appropriate protection of the environment and the country's valuable natural resources.

Poor management of renewable natural resources and damage to basic life support systems, such as soil, water and air, are considered to be some of the biggest barriers to improving the long-term quality of life for all South Africans. South Africa, with a population of over 40 million people and a projected population doubling time of only 30 years (denoting a real increase of about one million people per annum), has enormous environmental and other challenges with which to contend. For example, it is estimated that the current level of damage caused to the country's natural environment by development is as much as R 40 billion per annum. Therefore, innovative approaches to the sustainable use of natural resources will have to be developed in order to support the goals of the RDP.

The Earth is almost totally dominated by the activities of humans. Indeed, so great is the impact of anthropogenic activities that the environment has begun to display symptoms of breakdown in many of its basic life support systems, especially in poorly developed areas. The source of the problem originates at the local environment level where uncontrolled consumption of natural resources has led to modification of the land- and seascapes, as well as to the deterioration of environmental quality. If the RDP is to succeed, this trend has to be addressed. These activities and their impacts have also acted in a cumulative way to influence the global environment resulting in potential threats such as global warming, climate change and loss of the uv-light protective ozone layer.

South Africa is endowed with a rich and diverse flora and fauna that must be wisely utilised for the benefit of all South Africans. It thus makes sound strategic sense to ensure that future development is in harmony with the natural environment. Particular attention needs to be given to renewable natural resources, their wise utilisation, and the potential impacts of humans on the long-term (sustainable) survival of species, populations, habitats and ecosystems. Only humans have the ability to control what is occurring and to manage the Earth in a sustainable way, making the generation of environmental knowledge and the development of expertise of paramount importance.

Sustainable development has been defined as 'improving the quality of human life while living within the carrying capacity of supporting ecosystems'. For South Africa to optimally utilise and maintain or improve the condition of its natural environment it is important to ensure that the following needs are addressed:

- * Appropriate high quality environmental expertise (especially in the country's disadvantaged communities, universities and technikons) and relevant information systems need to be deve-

loped and maintained to serve the full spectrum of South African society. This will ensure that decisions are made by people who are in touch with community needs and are well informed.

- * Appropriate environmental management systems are required to ensure that there is a balance between socio-economic development and sustainability of the natural environment, and the wise utilisation of renewable natural resources.
- * New and innovative ways of sustainably utilising the renewable natural resources within our environment, to the benefit of all need to be developed.
- * The natural environment is a common heritage linking all of South Africa's diverse people. South Africans need to recognise and protect their natural heritage with its environmental assets. This will require a massive educational and awareness campaign with high quality information and expertise as the basis of input.

The FRD, in collaboration with other stakeholders and partners, through support of expertise-generating activities within the Theme of "Sustainable Environment", intends to make a major contribution to each of these areas and ultimately to the protection, wise use and management of the country's natural resources and the environment.

4.7.2 General approach

The stakeholders of environmental research are multiple and it is impossible for any one organisation to support all the research required. The FRD should be viewed as one of many sponsors and supporters of environmental research. The programmes will thus actively seek partners and sponsors, many of whom have similar interests to the FRD and should therefore be involved in the respective Programmes and their thrusts. It is desirable to involve as many of the stakeholders as possible in the planning, funding and management of Programmes and projects.

4.7.3 Theme aim and objectives

The Theme on Sustainable Environment aims to develop experts with the necessary skills to address the environmental challenges presented by the country's development programme. This will be done by generating and transferring knowledge on the natural environment, with special reference to natural resources, their wise utilisation and the potential impacts of human activities on the sustainability of biodiversity and life support systems.

The objectives of the programmes in this theme are:

- * To establish the needs of the country's environmental managers and decision-makers and identify priorities which require FRD support.
- * To undertake high quality relevant research on the natural environment and its resources.
- * To develop, mobilise and/or involve appropriate interdisciplinary networks of people and institutions which can contribute to the development of required expertise.
- * To evaluate, assess and encourage the contributions which individuals and institutions can make to the theme's activities.
- * To initiate and support relevant projects by mobilising and/or allocating appropriate resources.

- * To generate human resources (especially from historically disadvantaged communities) with appropriate environmental skills.
- * To facilitate the transfer of information and to evaluate the quality and impact of Programme outputs.
- * To promote the activities of the programmes and their participants.
- * To facilitate collaboration between individuals, teams and institutions involved in the programmes.

4.7.4 Outputs

Dynamic and interactive research programmes will lead to numerous outputs and outcomes. The most significant will be:

- * The development of experts and expertise, particularly from historically disadvantaged higher education institutions.
- * Ensuring a balance between specialists and multi-disciplinary skilled individuals and teams;
- * The advancement of environmental science and the provision of a sound scientific basis for sustainable resource usage and environmental management.
- * Leadership in focusing society on priority environmental issues.
- * Development of interactive participation in research and management of the environment.
- * Improved environmental and natural resource decision-making and management.
- * Generation of research priorities.
- * Evaluation of environmental science, through the evaluation of projects, programmes and their outputs.
- * Information and technology transfer.
- * Improved coordination and cooperation on research initiatives.
- * Involvement of international networks.
- * Generation of opportunities for South African scientists both locally and abroad.
- * Ensuring relevance of environmental research.
- * Development of networks of excellence.
- * Development of capacity in historically disadvantaged communities.
- * Production of high quality informative publications. (Peer reviewed scientific publications, reports etc.).
- * Meaningful involvement of partners and stakeholders.
- * Leveraging of resources - financial, institutional and intellectual.
- * Transfer of information to the public.

4.7.5 Inland Resources Programme

Superimposed on this landscape is a population of more than 40 million humans who require access to natural resources for the provision of basic needs such as employment, food, shelter, water, land and fuel. There have already been major landscape changes as humans have

developed the land for industrial, recreational, domestic, agricultural and military purposes. Increases in economic growth and consumption patterns can be expected to place further pressures on an already fragile environment. New conservation thinking is needed to ensure that landscape integrity is maintained.

South Africa, as signatory to most of the major international environmental treaties and conventions (Biodiversity, Climate change, Ramsar, Migratory species etc.), has committed itself to developing and implementing a programme on sustainable development in relation to its natural resources. Consequently, this research programme, which focuses on the country's inland natural resources, their wise utilisation and the potential threats to sustainability, has a major national role to play.

4.7.6 Marine and coastal resources programme

Rationale

Coastal and marine resources contribute substantially to the economy of the country via fisheries and numerous non-consumptive uses. The value of marine resources to the country is enormous, ranging from the primary fishing industry (employing 22,000 people and with a wholesale value of R 1.5 billion p.a.) to eco-tourism, transport and trade.

Communities which make use of marine resources have an important role to play in ensuring that they are utilised in a sustainable way. It is also essential that these communities are provided with a sound expertise and information base upon which wise policies on and practices of resource management can be built. Inputs from the scientific workforce need to be developed in collaboration with appropriate communities, user-groups and management agencies. Participatory approaches are needed to develop appropriate strategies and methods for the wise use and management of all coastal and marine resources. Under the current changing patterns of access and usage this will ensure that local and national economies benefit from marine resources. It is intended that this programme will have strongly coordinated links with the *Sea and the Coast Research Programme* which has already been launched by the South African Network for Coastal and Oceanic Research (SANCOR), a joint venture of the FRD and the Department of Environmental Affairs and Tourism (DEA & T). The Sea and Coast Programme comprises the first four thrusts listed below, but the FRD recognises that marine science is much broader than these topics and will also consider funding research on the additional thrusts outlined here.

Coastal Communities and Living Resources

Coastal and marine ecosystems contain a rich and diverse flora and fauna which support a range of socio-economically important activities. The demand for these resources is increasing rapidly; many are already fully exploited and some have been over-exploited. There is a need to develop new and innovative techniques, and strategies to sustain the multiple use of coastal living resources, especially by those communities which depend on them for a living.

Some project areas likely to be supported:

- * Involvement of coastal communities in resource management.

- * Patterns and methods of resource utilisation.
- * Identification of new resources and development of improved methods of utilisation.
- * Sustainable utilisation of key resources.
- * Evaluation of techniques and strategies for multiple resource fisheries.
- * Impacts of developments on coastal living resources.
- * The role of marine reserves in fisheries management.

The coast as a resource

South Africa has one of the longest seaboards in Africa. With stretches of long open coast, numerous estuaries, harbours, bays and dunes, the coast has great potential and sensitive development. It is anticipated that the pressures of development and utilization of the coastal area will be enormous, particularly from industrial, urban and tourist perspectives. Management of development in this area is critical. It is necessary to ensure that developments are well planned, user conflicts are resolved, and ecological damage and impacts are minimised.

Some project areas likely to be supported:

- * Determination of human needs.
- * Identification of opportunities for better use of the coast.
- * Identification and description of sensitive areas in need of protection if resource base is to be maintained.
- * Techniques in habitat restoration or enhancement.
- * Methods of improved planning.
- * Carrying capacity of key areas.
- * Management of waste.
- * Habitat degradation and restoration.
- * Information required for coastal zone management.
- * Ecotourism studies (see description of ecotourism thrust).

Offshore living resources and society

South Africa's offshore fishing activity currently generates more than R 800 million per annum and employs approximately 10,000 people. These resources have limited scope for expansion, but require increased attention to ensure that the yields are sustainable. It is important to ensure that the stocks of species such as hake, sole, kingklip, horse mackerel etc., are optimally and sustainably utilised.

Some project areas likely to be supported:

- * Ecology and biology of key demersal fish, cephalopod and crustacean species.
- * Methods of assessment and utilisation of by-catch.
- * Methodology in stock assessment, especially multispecies.
- * Environmental influences on offshore resources.
- * Scope for enhanced utilisation of currently under-utilised species.

Mariculture

Farming of organisms in seawater (mariculture) is a recent initiative in South Africa. The potential is enormous. This industry grew by 800 percent over the last decade. It offers potential for alleviating pressure on natural stocks of marine organisms, as well as for their replenishment. The practice must thus be viewed as a sound conservation approach to sustainability of threatened organisms. In addition, the approach creates employment and opportunities for entrepreneurship for the coastal communities and industries that are involved.

Some project areas likely to be supported:

- * Selection of potential candidate species for mariculture.
- * Stock enhancement of threatened marine species.
- * Performance and potential of small- and large-scale farming system.
- * Evaluation of geographic locations and sites.
- * Anthropogenic effects on mariculture and vice versa.
- * Evaluation of the effects of disease on stocks.

Biodiversity and Conservation

Maintenance of biodiversity and the conservation of representative ecosystems are important for tourism, to protect resources, to enhance exploitable stocks, and to maintain international obligations and treaties. In particular, marine reserves have an important role to play in research, because they provide pristine ecosystems in which base-line studies can be undertaken. They also present an important opportunity for education. Resources that are as yet unused need to be identified and relevant taxonomic studies need to be undertaken to promote their utilisation and conservation.

Some project areas likely to be supported:

- * Identification of representative areas in need of conservation, and the criteria by which the relative value of such areas can be assessed.
- * The role, value and optimal design of reserves.
- * Development of policies for marine reserves.
- * Taxonomic studies on poorly studied organisms which have practical applications.
- * Processes influencing biological diversity.
- * Effects of biodiversity on the resilience of ecosystems to disturbance.
- * Perceptions of human communities about marine reserves.

Ocean dynamics and coastal geomorphology

Oceanographic variability, for example waves, currents and temperature, at sea and inter-annual time scales, and extreme events affect all aspects of man's actions in the marine environment, the coastal zone and to a certain extent, inland. Coastal ocean dynamics affect the dispersal of eggs and larvae of economically important marine species. Coastal currents and geomorphology affect many processes and developments. It is important for the sustainable use and development of the

coast that these processes and features are thoroughly understood to enable the maximum economic benefit to be gained from the utilisation of the coast.

Some project areas likely to be supported:

- * Coastal impacts of specific episodic events e.g. ENSO.
- * The impacts of ocean circulation on transportation of eggs and larvae of economically important species.
- * Characterisation of economically important coastal geomorphological features.
- * The "environmental fingerprint" of the South African marine environment parameters, such as winds, waves and currents, and derived combinations of extreme events.

4.7.7 Cross-cutting thrusts

The following two thrusts have applications in both the marine and terrestrial programmes.

Weather and Climate

Variations in weather and climate provide some of the major influences on the environment and economy. This applies to global, regional and local environments. Knowledge of the climate, its variability and predictability is crucial for the management of the southern African region's agriculture, infrastructure development health services and sustainable use of the environment. It provides insight into how these systems should be managed to cater for what cannot be controlled by man.

South Africa occupies an interesting geographic position where oceanic circulation patterns have a major influence on the weather and climate of the southern Africa sub-continent and ultimately determine the way in which land and biodiversity is managed.

Some project areas likely to be supported:

- * Patterns of weather and climate variability.
- * Marine influences on continental climate.
- * Climate modelling.
- * Factors influencing climate change over southern Africa.
- * Linkages between climate, biodiversity, land-use and pollution.
- * Long-term rainfall predictability.

Ecotourism

Tourism is one of the world's fastest-growing industries. In South Africa, tourism already ranks fourth in terms of income generated (R 6 billion in 1992). Over 90 percent of the tourists visiting South Africa state that it is the country's climate, wildlife and biodiversity which attracts them. It is projected that the pressure of tourism on natural resources by both local and international visitors as well as tour operators will increase. The country, therefore, has to ensure that the quality and features of its natural heritage continue to be attractive. Tourism is often perceived

Annex V South African Network for Coastal and Oceanic Research (SANCOR)

Introduction

A post-apartheid national socio-economic policy, the so-called Reconstruction and Development Programme (RDP), is designed to mobilise government, private enterprise and all other resources of the South African economy to reduce poverty and to provide opportunities in a stable, democratic society. The main targets of the RDP are to foster:

- * Democracy and institutional change.
- * Urban renewal and rural development.
- * A new mass culture of paying for services.
- * Wider opportunities in a growing economy.

Based on the RDP objectives marine resources such as fisheries, must be managed and controlled for the benefit of all South Africans, especially for those communities whose livelihood depends on resources from the sea. The fishing stock must be managed in a way that promotes sustainable yield and the development of new species. The government will assist people to have access to these resources (Table 6). At present some 25,500 people are employed in the fisheries industry. Legislative measures will be introduced to establish democratic structures for the management of sea resources. In the RDP (ANC, 1994) the coast is seen as a valuable asset and opportunity for the creation of jobs in tourism and allied industries. The promotion of ecotourism and the incorporation of the environmental consequences in the development plans are issues within the RDP policy framework.

Sector	Landings (1000T)	Value (millions US\$)
Demersal	165.6	168.6
Pelagic	448.0	73.2
Rock lobster	2.9	37.4
Mollusca	3.7	19.3
Line & small nets	20.5	25.7
Seaweed	2.1 (dry)	1.0
<i>Total</i>	642.8	325.2

Table 3: South African fisheries values in 1992

The Sea and the Coast Programme

The Sea and Coast Marine Development Programme was initiated by the Foundation for Research Development (FRD) and the Department of Environmental Affairs and Tourism (DEAT). It is FRD's and DEAT's answer to the RDP objectives in meeting basic needs (food, employment, recreation); development of human resources (education, training, capacity building and; building the economy (improved use of resources, new resources, non-consumptive use). The Sea and the Coast Programme is developed by the whole marine research community after much consultation.

It aims to address the needs of the country with respect to the RDP in the coastal and marine environment.

The aim of the programme is to promote the wise use of marine and coastal resources through appropriate marine science, engineering and technology. The emphasis on applications is intentional. The programme has to make meaningful contributions to national or regional economies through enhancing the information support available for decision-makers in the public and private sectors. The Coast and Sea programme is human-centered, leads to social and economic benefits for all develops and trains experts and expertise, builds capacity and scientific excellence with a particular emphasis on the historically disadvantaged people. The programme is multisectoral and involves all expertise needed for a sustainable use of the coastal and marine resources.

Scientific objectives

Six thrusts are formulated within The Sea and Coast Programme. These are:

- * **Communities and Living Marine Resources.** The aim of this thrust is to develop appropriate techniques and strategies to manage the sustainable, multiple use of coastal living marine resources and to investigate ways in which the utilisation of these resources can be optimised for the socio-economic good of society, especially those communities whose livelihood depends on them.
- * **The Coast as a Resource.** The aim of this thrust is to provide the scientific support needed for the sustainable development and wise management of the coast and its resources. It will investigate all opportunities for the better use of coastal resources (e.g. ecotourism) and ways that they can be utilised for the economic benefit of the users of the coast. Methods to minimise or ameliorate adverse impacts on the coast will also be developed.
- * **Offshore Living Resources and Society.** This thrust aims to provide an improved scientific basis for the management and sustained, efficient utilisation of the multiple species making up the offshore living resources, leading to the optimisation of economic benefits to society, job creation and capacity building.
- * **Ocean Impacts.** This thrust aims to describe, monitor and predict those aspects of South Africa's ocean environment critical to advancing the ability to sustain and enhance economic development (Ocean impacts on climate and fisheries).
- * **Impacts of Mineral Exploitation.** This thrust aims initially to network the various stakeholders and if required, to later expand its activities in various directions. The thrust could form the basis for the collaborative investigation of both the ecological and human impacts on the coast of near- and offshore mineral exploitation. It could also actively investigate the opportunities created by these activities for the socio-economic upliftment of those communities affected by these operations and at the same time build capacity.
- * **Mariculture.** This thrust will closely network with current and prospective stakeholders regarding future requirements and opportunities. It aims to enhance human capacity to provide the scientific and appropriate technological basis and strategies for the development of mariculture and to enhance human and institutional capacity to provide the environmental guidelines and framework required for sustainable growth and development of the mariculture industry for the socio-economic benefit of coast-dependent communities.

Contact for further information:

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Annex VI University Science and Engineering Partnerships in Africa (USEPIA)

The University of Cape Town (UCT) strives to be a university of quality both in international and African context. UCT is firmly committed to use its capacity for the development of science and technology in Africa. To facilitate this UCT launched the University science and engineering partnerships in Africa (USEPIA) in 1994 as a collaborative programme and network with selected universities in the Sub-Saharan African region. The aim of USEPIA is to develop a science and engineering capacity to enable Sub-Saharan African scientists and engineers to compete internationally and by this contributing to the upliftment of Africa.

In 1992 UCT initiated discussions with the Rockefeller Foundation to obtain funding for USEPIA. Using a launching grant of US\$50,000 UCT was able to bring 21 vice-chancellors and deans of science and engineering of African universities to UCT for discussions. These discussions resulted in signing a Memorandum of Understanding supporting mutual collaboration to strengthen science and engineering capacity in Africa. The Rockefeller Foundation then provided a US\$ 200,000 Challenge Grant to UCT to develop USEPIA. In 1995, matching funds were obtained from the Carnegie Corporation, Coca Cola and the Ridgefield Foundation.

The focus of USEPIA is staff development (capacity building) through attainment of jointly supervised Ph.D degrees. USEPIA partners believe that long term viability of the capacity building is best done by setting up joint research projects with viable groups of scientists (rather than individuals) at different institutions. Research topics should be of mutual interest, giving rise to collaborative publications. African academics also emphasised the value of staff exchanges (lecture series and short courses), and suggested that these are linked to the post-graduate training programme. Access to USEPIA is restricted to the participating institutions. Preference is given to applicants permanently employed at their home universities. Applicants have at least a four-year bachelor's degree and should be identified by their home institutions as prime candidates for staff development. Ideally they already work as part of a research team on projects of national priority where UCT has expertise. In order to minimise disruption to participating faculties, the programme will be flexible, allowing for study and supervision visits of varying lengths. In addition to providing support for foreign post-graduate students at UCT, there will be the opportunity for UCT and foreign supervisors to travel between UCT and the student's home university. Every effort will be made to rationalise facilities and build on areas of strength in the participating universities.

In November 1995 the first round of eleven fellowships was awarded. The fellowships funds cover fees, travel, research costs and infrastructural development and living costs while the students are at the UCT. The funds are managed by UCT.

Structure and membership

USEPIA is guided by an International Steering Committee. This Committee will determine criteria for awards, monitor progress, and select applicants. Day-to-day management fall under a Management Committee comprising a UCT Deputy Vice-Chancellor, a Vice-Chancellor of another participating university (at present the Vice Chancellor of the University of Zambia); the Deans of Science and Engineering at UCT, and the Programme Manager.

Table 4: Present USEPIA partners

Country	Institute
Botswana	University of Botswana
Kenya	Jomo Kenyatta University of Agriculture and Technology Nairobi University
Tanzania	University of Dar es Salaam
South Africa	University of Cape Town University of Fort Harare
Zambia	University of Zambia <i>Coppert University</i>
Zimbabwe	University of Zimbabwe <i>National University of Science and Technology</i>
Malawi	<i>University of Malawi (Zomba)</i>
Uganda	<i>Makerere University</i>

Universities to be included in the next phase are in italics.

Approach

USEPIA builds on existing activities to develop a network of African scientists and engineers capable of addressing the development needs of Sub-Saharan Africa. This will be achieved by:

- * Identifying areas of strength on which to build.
- * Concentrating research in fields particularly appropriate to Africa's needs.
- * Ensuring mutual benefits in any collaboration.
- * Developing sustainable research collaboration.
- * Emphasising staff development.
- * Sharing access to specialised facilities.
- * Producing joint scientific papers in quality journals.

The mechanism

Participating universities will raise funds from the international community for:

- * Post-graduate fellowships for staff development.
- * Sandwich M.sc and Ph.D degrees where students work on topics of local concern jointly supervised by their home university and UCT.
- * Lecturing exchanges for semester periods.
- * Short courses.
- * Joint research projects of mutual interest.
- * Exchange of external examiners.

Criteria for awards

- * Preference will be given to staff development awards for study for higher degrees, but which may also include awards for research collaboration and other forms of training.
- * Awards must contribute to capacity-building in science or engineering at the participating universities. Attention will be given to sustainability, and to the consequential development of mutual links between these universities.
- * The level of funding of individual awards will aim to allow for capacity-building in the country of origin. Particular attention will be paid to projects which will strengthen local research efforts and capabilities in areas of national priority, and which are of mutual interest to participating institutions.

Applications

Application should be made by the Dean or Head of Department and forwarded by the Dean or relevant officer in the academic division of the participating institution on behalf of candidates.

Applications should:

- * Identify a specific post-graduate candidate or staff member who wishes to study further at UCT, clearly indicating his/her availability to participate in the programme over the next two years.
- * Give details of the applicant's academic record, position in the institution, age and marital status.
- * Show how the applicant might gain from a period of study at UCT, and enrich his/her home institution on return.
- * Where possible, identify a supervisor/sponsor for the candidate in his/her home institution for possible co-supervision of the research the candidate will undertake at UCT.
- * Provide details of the existing infrastructural and human capacity in the candidate's home institution in his/her research field.
- * Give an indication of the infrastructural capacity which would be required as part of the award to enable the candidate to continue research in his/her home institution after a period of study at UCT. (For example, computer hardware and software, journals, etc.).
- * Show how important the applicant's proposed field of research would be for national development.

Applications should be sent to:

Lesly Shackleton, USEPIA Programme Director

University of Cape Town

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South Africa

Tel:+27(21),650-2173

Fax:+27(21)683-5785

e-mail: LYS@iafrica.com

Annex VII University of Cape Town, Research Activities

7.1 Marine Biology

Scientists:

A.C. Brown, J.G. Field, G.M. Branch, C.L. Griffiths, P.A. Cook, M.O. Bergh, P.A.R. Hockey, M.I. Lucas, T.A. Probyn, E.R. Trueman, R. Bustamante, F. Odendaal, A. Barkai, B.A. Bennett, M. Waldron, J. Harris, B. Tibbles, D. Glassom, J.M.E. Stenton-Dozey, C. Attwood, J.H.M. David, P. Wickens, C. Villacastin-Herrero, A. Cohen, S. Tugwell, Y. Dempster, D. Gianakouras, M.I. Branch, M. Lipinski, L. Kruger, S. Webb, B. Kallejta, W. Steele, S.J. Painting, R. Krohn, R. Crawford, K. Cochrane, E. Plaganyi, J. Korrubel, K. Dower, J. Mantel, C. Parkins, A. Leeb, B.M. Clark, S. Lamberth, B. Emanuel, K. Prochazka, G. Cliff, I. Hampton, N.A. Sweijd, C. Velasquez, Y.A.R.G. Lechanteur, S. Mayfield, A.J. Richardson, L.J. Shannong, S.F. Bloomer, N.R. Henry, J.A. Huggett, S.F.J. Dudley, N. Sharratt, S. Tolosana, C. Verheye, D. Durholtz, D. Miller.

Ecosystem modelling:

Network analysis is being used to compare carbon and nitrogen budgets of sandy beach and plankton ecosystems. Simulation models have been built to explore the size-basis of plankton food webs, the influence of water column stability upon plankton primary production, and the effects of seal-culling. Time series analysis has been used to relate historic fish catches to environmental data. Squid life histories are also being modelled. Expert systems are receiving attention for marine fisheries management, and rule-based modelling is being developed to predict ecological scenarios. Stable isotope ratios are being used to trace marine food webs.

Ecology and physiology of sandy-shore organisms:

The swash climate and penetrability of the substratum of sandy beaches are being investigated and related to the burrowing abilities of intertidal invertebrates. Nutrition is being studied in a number of bivalves with regard to food clearance rates, assimilation and scope for growth: this follows the finding that much previous work is suspect, being based on algal mono-cultures instead of natural food. The behaviour and energetics of the isopod *Tylos* are receiving attention, as is the ecophysiology of spatial separation in talirid amphipods.

Ecology of mixed rock and sand:

Shores of mixed rock and sand constitute some 26% of the South African coastline, yet have been almost totally neglected from an ecological point of view. Attempts, are being made to remedy this with particular reference to mixed shores in False Bay.

Intertidal and shallow-water rocks shores:

Interest in rocky shores centres around biological interactions, requirement patterns, community structure and its explanation and human exploitation and its consequences. The effects of creating marine reserves have been monitored and studies done on the patterns of human utilization of the shore. Mussels have been the focus of work on comparative physiology and aquaculture. Predator-prey interactions have received attention, particularly in terms of avian predation, kleptoparasitism in gulls, and the effects of an alien crab, *Carcinus maenas*. The ecological effects of a second introduced species, the mussel *Mytilus galloprovincialis*, are also being studied. Potential commercial harvesting of limpets is being researched on the west coast, and has led to a broad-

based study on other aspects of intertidal ecology, including adaptations to physical stresses, larval dispersal, competitive interactions, sex-change and recruitment patterns. Wave action, the role of offshore kelp, and the magnitude of local productivity all appear important. Anti-herbivore defence mechanisms in kelps are being researched. The genetics of marine snails is being studied in relation to their evolution and taxonomy. The role of marine reserves and criteria for their selection are being researched. A project on the hydrodynamic properties of colonies of the reef worm *Gunnarea* has been completed. A substantial amount of work has been undertaken to model the consequences of reducing the legal size of rock lobsters and has led to changes in legislation.

Line fish research:

Research is aimed at the rational conservation and management of angling fish. The abundance, distribution patterns, diets, growth rates and reproductive cycles of important species are being studied and the effects of angling and trek netting assessed. A series of studies in progress on the structure of intertidal, shallow reef and surf-zone fish assemblages and the factors determining their abundance and composition.

Mariculture:

The farming potential of the South African abalone *Haliotis midae*, is being investigated. A successful spawning and larval research facility has been set up at the Sea fisheries Sea Point Laboratory and growth rates on different food types are being determined. An experimental pilot plant has been established at Danger Point, near Gansbaai, where additional projects, including genetic experiments are being undertaken.

Pelagic ecosystems:

Plankton research ranges from studies on bacteria, to phytoplankton, zooplankton, and the foodwebs leading to fish production. Microbial studies are directed at the microbial loop in the recycling of nitrogen. Processes such as nitrogen fixation denitrification and the physiology of nitrogen assimilation by bacteria are also being addressed. Research on the relative importance of biological and physical agents of nutrient supply for primary production is in progress. Protozoan grazing on the smallest plankton has come under investigation. Adult copepod growth, feeding and egg production are being quantified. Surveys of standing stocks and studies on krill feeding and energetics are in progress. Estimates of carbon flux are linked to new studies concerned with global climate change.

Estuarine ecology:

Experimental manipulations of the infauna of estuaries have included the sand prawn *Callinassa*, bloodworm *Areicola*, and the snail *Assiminea*. Work has now been completed on the ecological consequences of bait-collecting of sand prawns and further studies continue on bloodworms and on the microbiology of nitrogen cycling in the sediments. A project has been completed on the effects of bioturbation by flamingos. Much work has been done on the effects of avian predation on estuarine organisms, and the significance of this for avian migration.

Antarctic and sub-Antarctic research:

The Marion Island offshore Ecological Study (MOES) has been completed. The major objective has been understanding of the trophodynamics of the plankton and benthic food webs which support some 1.5 million seabirds. Size-fractionated studies have been coupled with physical oceanographic studies. Studies on bacterial activity, microzooplankton, macrozooplankton and

kelp production have yielded information on energy flow. The composition of the benthos has been studied by photography and dredging. Food webs are being synthesised using network analysis and simulation models. Future work will move towards carbon flux studies as part of the international research effort to understand the role of the Southern Ocean in global climate change. Illustrated keys for the identification of the benthos of Marion Island are near completion, papers on Mollusca, Brachiopoda, Crustacea, Pycnogonida, Echinodermata and Cnidaria have been published.

Antarctic marine ecosystem and global change:

A science programme in Antarctica and the southern ocean, funded primarily by the Department of Environment Affairs, is now in place. Some University of Cape Town funding is also available. The primary objective is the provision of scientific information to SCAR in terms of the Antarctic Treaty of which South Africa is an original signatory. The research programme addresses global climate change and has as its principal components a study of the southern ocean hydrology and fronts: a study of carbon flux processes and a whole system modelling project. The programme's major goal is to understand ocean heat transport and ocean-atmosphere CO₂ exchanges which are relevant to global climate change. The programme has strong and formal links with other international climate change programmes through its links with the Joint Global Oceans Flux Study (JGOFS) and through the World Ocean Circulation Experiment (WOCE), Professors Field and Lutjeharms and Dr. Lucas are members of international scientific planning groups which integrate the activities of various national programmes. The Department of Oceanography, UCT, and the Zoology Department, Rhodes University, are joint partners in this programme which has already seen successful international collaborative cruises with the Germans, British and Canadians.

Pollution studies:

The effects of various types of pollutants on rocky-shore mussels are being investigated and the question of whether parasite load renders them more vulnerable is being addressed. A pollution monitoring technique based on the rate of transport of inert particles over the gill surfaces of bivalve molluscs is being developed.

Coral reef biology:

The most southerly coral reefs in Africa occur at Sodwana Bay, and concern has been expressed that increasing use by divers threatens this grafile ecosystem. On site experimentation and ecological investigations have been completed, in conjunction with the Natal Parks Board, in an attempt to assess the condition of the reefs and to suggest possible management options.

7.2 Freshwater Research

Scientists:

B.R. Davies, J.A. Day, J.M. King, J. Adams, A. Baxter, C. Brown, H. Dallas, S. Ekhout, A. Fourie, B. Gale, C. Griffiths, D. Hall, W. Harding, P. Hurley, A. Joubert, M. Luger, M. Meadows, M. Meador, J.H. O'Keeffe, G. Pech, M.D. Picker, S. Pollard, G. Ractliffe, C. Shaeffer, R. Skoroszewski, D. Stevens, K. Snaddon, R. Tharme, M. Thoms, S. Tian, G. Walters, D. Weeks.

Special programme on South African rivers:

An FRD Special programme on South African rivers is developing training programmes at postgraduate level linked to river ecology and to river functioning across a very wide variety of disciplines, including analytical chemistry, microbiology, river engineering, palaeo-geography, geomorphology and minimum flow requirements. The programme is in the final year of a five year cycle and has developed 21 projects.

River regulations by dams:

Collaborative programmes between the Freshwater Research Unit and the Centre for Water Research, Rhodes University, have established the way in which reservoirs regulate and impact the running reaches of rivers below reservoirs, and are presently undertaking a catchment-wide study of the Sabie and Mareti Rivers in the Kruger National Park. Linked to this work is a study of the ecological impact of farm dams on rivers, a greatly neglected area of river regulation.

Ecological impacts of inter-basin water transfers:

B.R. Davies and C.D. Snaddon have commenced work on an inter-basin transfer, the first study of its type in the southern hemisphere. It has led to a major project funded by the Water Research Commission to be carried out during the next four years.

River ecology:

The group is involved in the first long-term river research undertaken in South Africa. Based in the Jonkershoek mountains, this research also involves manipulative and experimental field ecology. The effects of atmospheric pollution on streams are being examined in the Eastern Transvaal.

Riverine organisms:

Studies are proceeding on the autecology and/or systematics of crabs, amphipods and stonefly nymphs. Amphipods are being studied with a view to using them as standard laboratory test organisms.

Wetland research:

Wetlands are critically important environments that are fast disappearing. A preliminary assessment of the distribution and biota of south-western Cape wetlands is being finalised.

Urban coastal lake ecology:

Studies on urban-impacted coastal lakes of the Cape Flats include the role of invertebrates, marina management, pollution control, and the biology of bulrushes and phytoplanton.

Management of rivers:

Many of the rivers of South Africa are under stress as a result of water abstraction, damming and pollution from various sources. They are examining the effects of trout farms, road construction, damming and water abstraction on downstream stretches of rivers, as well as methods for assessing instream flow needs of regulated rivers, the effects of water quality variables of riverine biotas, the environmental implications of the Water Act and methods for the rehabilitation of canalised urban rivers. A classification of rivers is being developed for conservation and management purposes. Various aspects of the biology and environment of the Berg River are being studied for management purposes.

Xenopus hybridization and ecophysiology:

The response of embryonic stages of two species of *Xenopus* to low pH and naturally-occurring humic compounds has been investigated. The role of cannibalism in *Xenopus gilli* is being examined. The importance of tadpoles as grazers in mountain streams is being studied.

Other research activities of the Zoology Department are in the field of ornithology and are outside the scope of this mission.

7.3 Oceanography

Head of department: Prof. G.B. Brundrit

Research in Progress

Research in the Department of Oceanography falls broadly into three areas, the South African oceanic environment, ocean atmosphere interactions and the South African coastal environment. A number of climate and weather related projects are under way. Individual members of the academic staff have established a series of research projects and attracted postgraduate students and research staff to form personal research groups.

The Ocean Climatology research group (J.R.E. Lutjeharms, H.R. Valentine, R.C. van Ballegooyen, M. Rouault, O.G. Malan, L.A. Staegemann, J. Cooper, R. Philips, G. Rigg, I. Ansoorge, C.P. Mathysen, A. Lee-Thorp) focuses its attention on ocean processes and sea-air interaction of south of Africa. This region is characterised by the greatest level of ocean variability in all the world's oceans. A greater knowledge of these processes will play a critical role advancing understanding of Southern African as well as global climate.

The Physical Processes and Remote Sensing group (F.A. Shillington, L.V. Shnnon, J.J. Agenbag, C.R. Duncombe Rae, H.N. Waldron, T.A. Probyn, G. Nelson, S.J. Weeks, A. McLachlan, S. Bernard, S. Courtney, J. Tauntan-Clark, S. Childs) forms part of the Benguela Ecology Programme. The group is concerned with research in the waters overlying the continental shelf of the greater Benguela region. Such research has great importance in establishing the nature of the physical environment and its relevance to the fisheries of South Africa's west and south coasts. There is close collaboration with associated research groups at the Sea Fisheries Research Institute.

The Marine Weather Systems and Rainfall Variability Group (M.R. Juri, B. Pathack, A. Makarau, A. Nassor, T. Kabanda, J. Barclay, K. Levey, B. Parker, S. Courtney,) is assessing the association between changes in the large scale ocean environment and patterns of Southern African rainfall, with a view to providing an improved predictive capability. Collaborative studies with senior scientists from neighbouring African countries form an important part of these activities. The group is also concerned with the identification of those short term meteorological events such as troughs and tropical cyclones which make significant contributions to drought and floods in southern Africa, to coastal air pollution and to nuclear emergency risk assesment.

The Sea Level research group (G.B. Bundrit, P.Hughes, A. Wijnberg, S. Searson, J. Courtney, M. Stander) is concerned with sea level as an indicator of the ocean climate and with the impacts of sea level rise on the coastal environment of southern Africa. The related estimates of

temperature change in the world's oceans through global underwater acoustic propagation is being studied through model and field studies.

Oceanographic research depends critically upon access to research vessels and this is provided locally by the SA *Agulhas* and FRS *Africana*, and internationally by the growing number of research vessels using Cape Town.

River regulations by dams:

Collaborative programmes between the Freshwater Research Unit and the Centre for Water Research, Rhodes University, have established the way in which reservoirs regulate and impact the running reaches of rivers below reservoirs, and are presently undertaking a study of the Sabie and Maren Rivers in the Kruger National Park. Linking to this work is a study of the ecological impact of damming rivers in the southern African

Research in the Department of Oceanography falls broadly into three areas, the South African oceanic environment, ocean-atmosphere interactions and the South African coastal environment. A number of estimate and weather related projects are being undertaken by members of the department. There have also been a number of research projects and related postgraduate students and research staff have been established to form a research group.

The Ocean Climatology research group (U.R.R. Lujshams, H.R. Valentine, R.C. van Ballegooy, G.G. Malm, I.A. Stegmann, J. Cooper, R. Phillips, G. Risig, I. Ashore, C.P. Johnson, A. J. (ed.)) focuses its attention on ocean processes and sea level rise in the world's oceans. This research is characterized by the greater level of ocean-atmosphere interactions. A greater knowledge of these processes will play a critical role in understanding the climate of Southern Africa as well as global climate.

Riverine organisms:

The Physical Processes and Remote Sensing group (F.A. Schimberg, J.V. Stiller, J.S. Reynolds, C.R. Danabasoglu, H.N. Waldron, T.A. Fryday, G. Walsh, S.J. Walker, A. McIsaac, S. Bernard, S. Courtney, J. Tanton-Clark, S. Childs) forms part of the Biological Ecology programme. The group is concerned with research in the waters overlying the continental shelf of the greater Benguela region. Such research has great importance in establishing the nature of the physical environment and its relevance to the fisheries of South Africa's west and south coast. There is close collaboration with associated research groups in the Sea Fisheries Research Institute.

Urban coastal lake ecology:

The Marine Weather Systems and Remote Sensing group (M.K. Carr, S. Tammak, A. Makarau, A. Nassor, I. Kabanov, J. Balcov, K. Lave, B. Tarkenton, S. Courtney) is assessing the association between changes in the large scale ocean environment and patterns of Southern African rainfall, with a view to providing an improved predictive capability. Collaborative studies and a number of other projects from neighbouring African countries form an important part of these activities. The group is also concerned with the identification of those short term meteorological events such as large scale tropical cyclones which make significant contributions to drought and flooding in southern Africa. Areas of coastal air pollution and industrial effluent discharge to the sea are also being investigated.

The sea level rise on the coastal environment of southern Africa. The related estimates of M. Stander) is concerned with sea level rise as an indicator of the ocean climate and with the impacts of sea level rise on the coastal environment of southern Africa. The related estimates of

Xenopus hybridization and ecophysiology:

Annex VIII South African Research Vessels

8.1 FRS *Algoa*

(Most of the information given below was received in november 1995 from the former SFRI director, dr. A. Robertson.)

The *Algoa* was purchased in late 1991 at a cost of US\$ 1.280.000. The vessel was selected by A. Robertson and Captain Richardson, after an extensive tour and detailed inspection of 18 vessels. The final offer to purchase was made after sea trials, during which some hydroacoustic tests were made. The purchase price of the former *Ludovic Jego* included a pre-delivery dry docking, sufficient bunkers to sail non stop from Lorient, France to Cape Town and a French crew to assist on the delivery voyage.

The first phase of the conversion included the:

- * Conversion of forward factory check into scientist accommodation.
- * Conversion of fishhold into a new mess deck area, computer room, sonar room, etc.
- * Creation of all the laboratories and structural modifications to fit scientific winches and devits.
- * Complete reconstruction of lower deck accommodation.
- * Replacement of all life saving and fire-fighting appliances to conform to South African standards.

The total cost of phase 1 was approximately US\$ 1.800.000. Phase 2, carried out during 1994, included the fitting of two 295 KVA generator sets and new switchboard. Total cost was US\$ 100.000. Phase 3, just completed, was the fitting of a retractable bow thruster unit at a cost of US\$ 550.000.

The *Algoa* is owned and operated by the Sea Fisheries Research Institute (SFRI) in the SE Atlantic and Indian Ocean. The vessel was built in 1975 and has a Bureau Veritas classification. *Algoa*, at 53.00 m length and with a Gross Registered Tonnage of 759 tons, can accommodate 14 scientists and 6 officers and 16 crew. With an endurance of 16 days, a range of 5.000 nautical miles, a cruising speed of 11 knots and a maximum speed of 12 knots, she is suitable for research in most Eastern African waters. The vessel is, however, partly air conditioned and has a stabilised energy system (220VAC AMP 50Hz) for scientific equipment.

8.2 FRS *Africana*

The *Africana* is the flagship of Sea Fisheries' fleet of oceanographic research ships. Her main role is as platform for research and monitoring undertaken to guide the management of South Africa's offshore fisheries. The vessel was built in Durban and commissioned in 1982. *Africana*, at 77.85 m long and with a gross registered tonnage of 2,452 tons, can accommodate 19 scientists and 33 officers and crew. With an endurance of 45 days and a range of 20,000 nautical miles, as well as an ice-strengthened hull, she can undertake voyages as far afield as Antarctica, where she is used for krill research surveys. The vessel is specifically designed to carry out fisheries and environmental research. Equipped with rugged trawling gear and sophisticated echosounders, *Africana* conducts both trawling and hydroacoustic surveys for resource monitoring. The activities concentrate on pelagic resourced (anchovy and pilchard) and demersal resources (hake, sole, horse mackerel and kingklip), as well as squid and a variety of linefish. The results of these surveys

and information on other indices such as commercial catch rates provide the basis for the Total allowable catch (TAC) for each species to be set each year, ensuring that the exploitation of fish stocks will be sustainable for the future.

As each species is part of a complex, ever-changing ecosystem, it is important to understand the influence of the environment on commercially exploited species. In the physical-chemical environment, ocean currents are measured using an Acoustic Doppler Current Profiler (ADCP), mounted on the hull of *Africana*, as well as by current meters moored on the sea bed. These instruments provide information on the currents that transport fish eggs and larvae from the spawning areas on the Agulhas Bank to the nursery areas of the west coast. On board ship is a CTD (conductivity-temperature-depth) unit, which is lowered through the water column to record temperature and salinity, coupled to a 12-bottle rosette sampler. Each bottle can be individually triggered to close at any depth down to 5,000 m collecting samples that are used for chemical and biological analyses.

In the biological environment, experiments are conducted to measure primary production by phytoplankton, the microscopic plants of the sea. Phytoplankton is a source of food for the zooplankton, such as copepods, which are in turn eaten by pelagic fish. Zooplankton are collected with a variety of towed nets to determine how much food there is for spawning fish and their offspring. The number of fish eggs and larvae (ichthyoplankton) is also assessed to estimate the quantity of fish that could be available to the commercial fishery the following season.

8.3 SA *Algulhas*

The largest ship in the fleet is the polar supply ship SA *Algulhas*. This 110m, ice-strengthened ship, was commissioned in 1978 and has a crew of 41. The vessel carries 93 scientific or base station staff. Having a range of 12,000 nautical miles the *Algulhas* services the SANAE base each year, the weather station on Marrion Island twice a year and Gough Island once per year. In addition to transporting the weather teams and equipment to the various bases, the ship also conducts deep oceanographic and marine biological research in the Southern Ocean. Two Puma helicopters are carried, to provide assistance in both cargo handling and research work. The vessel is well equipped for navigation in ice and can deploy temperature/depth-profiling and water-sampling equipment to 6,000 meters. In addition, the ship is fitted with a coring winch housing 9,000 m of steel-wire rope. Facilities also exist for deploying small research trawls for the afterdeck.

8.4 FRS *Benguela* and *Sardinops*

The 45m *Benguela* was constructed in 1968 by the then South West Africa Administration. Currently operated by the Sea Fisheries Research Institute, this transom stern trawler research ship has five laboratories and can accommodate seven scientific staff. She is used mainly for fisheries research in Namibian waters. Regular updating of the ship's scientific systems ensures that *Benguela* remains a modern, efficient research ship. The *Sardinops* was built in 1958 to supplement the pelagic fish research programme of the Sea Fisheries Research Institute. Despite her 35 m length, this sturdy little vessel has conducted environmental research between the Kunene River and Durban, up to 250 nautical miles offshore. Due to limited facilities on board, the ship is now used mainly for surveying coastal resources and inshore environmental research.

Annex IX The South African Association for Marine Biological Research (SAAMBR)

9.1 Introduction

The South African Association for Marine Biological Research (SAAMBR) is an independent, non-profit, non-governmental organisation founded in 1951. SAAMBR is a member of the International Union for the Conservation of Nature (IUCN), the International Union of Zoological Gardens (IUZG), The Pan African Association of Zoos, Aquaria and Botanical Gardens (PAAZAB) and many other national and international learned societies.

SAAMBR fulfils its mission through the following divisions:

- * Oceanographic Research Institute (ORI).
- * SeaWorld Aquarium and Dolphinarium.
- * SeaWorld Education Centre.

The oceanographic research institute (ORI)

ORI was established in 1958 to carry out applied research that serves as decision support to managers and users of marine resources. ORI is staffed by experienced marine biologists and the research undertaken is subject to strict peer review. Marine conservation forms the basis for all projects at ORI, and ever escalating demands on our marine resources call for new and innovative research programmes. Those envisaged by ORI involve marine reserves, artificial reefs, fish-aggregating devices and the restocking of over-exploited species. Pilot studies on several such projects are underway at ORI. Essential decisions about the future of our marine environment have to be made now! The scientific information ORI provides will ensure food for our people and the conservation of our seas well into the next century.

SeaWorld

SeaWorld has a dual function. Firstly, through its aquarium and dolphinarium, it brings people into close contact with a wide range of sea creatures, their biology, habitat and the importance of marine conservation. Secondly, SeaWorld generates much of the funding that makes the vital work of ORI and the SeaWorld Education Centre possible. A visit to SeaWorld is an experience similar to a journey in a submersible. The variety of sea creatures in the displays constantly excites the mind and kindles the imagination. A visitor can have a first-hand experience of living creatures which range from tiny jelly fish and sea horses to large sharks and dolphins. Every year, many turtles, seals, penguins and dolphins are stranded on Natal's beaches. These animals are usually ill, emaciated and, with caring attention from SeaWorld staff, are nursed back to health and returned to the sea.

The SeaWorld Education Centre

The SeaWorld Education Centre, and its marine environment education programme, is extensive and reaches children, teachers and marine resource users from all sectors of the community. Children are the future custodians of the environment. They cannot be expected to meet this challenge without the necessary expertise and yet the majority of our young people have never come into contact with ocean life. Programmes run by the SeaWorld Education Centre are varied and comprehensive and provide an introduction to the reality of life beneath the breakers while encouraging marine environmental awareness. Because SAAMBR believes that the effectiveness of these educational programmes should not be limited to only those who can afford to visit SeaWorld, a highly successful Outreach Programme was initiated in 1994.

9.2 History

In 1947, the Natal Society for the Preservation of Wildlife undertook a scientific expedition to Tongaland, a pristine coastal region just south of the Mozambique border. Impressed by the diversity of the marine creatures on that stretch of coast, and struck by the complexity of their fragile and unresearched ecosystems, those present recognized the need for more knowledge. One night, around a campfire, they resolved to establish a marine biological station in Natal. The idea was nurtured by a small group of enthusiasts which included Dr George Campbell, Prof. Bush and Mr. Len Chiazzari. In 1949, Dr Campbell announced that a committee investigating the feasibility of establishing a marine biological station in Natal had expressed their intention of working towards the building of a public aquarium, the profits of which would go towards marine research. On January 30, 1951 the South African Association for Marine Biological Research (SAAMBR) was founded, following a great deal of work by conservationists, academics and anglers. The Oceanographic Research Institute (ORI) was established in 1958 and in June 1959 the Durban Centenary Aquarium was officially opened. Today, SAAMBR plays a leading role in ensuring the wise utilisation and conservation of our precious marine resources.

9.3 Mission statement

The South African Association for Marine Biological Research (SAAMBR), a nongovernment, not-for-gain association, plays a pivotal role in stimulating community awareness of the marine environment through education and ensuring wise, sustainable use of marine resources through research.

9.4 Objectives

Oceanographic Research Institute:

- * To conduct marine biological investigations.
- * To document and assess marine resource utilisation trends.
- * To interact with the resource-user community.
- * To provide decision support to resource users.
- * To produce impartial statements and opinions on marine and coastal conservation and rehabilitation.
- * To publish and disseminate authoritative documents and reports on the investigations undertaken.

SeaWorld:

- * To provide the nation with a world class "exhibition" of living creatures representative of our waters.
- * To develop new and innovative aquarium technology that will attract a growing patronage, create a memorable experience for our visitors, and provide quality facilities for education and research.
- * To optimise the benefits derivable from our prime location in the attainment of our goals and to the benefit of the community.
- * To assist the conservation aims of the South African Association for Marine Biological Research by maintaining a dedicated facility to rehabilitate stranded and injured marine animals.

- * To use whatever resources at our disposal to generate support for the benefits of marine conservation.

SeaWorld Marine Education Centre:

- * To establish and equip a centre for marine environment education.
- * To offer an interpretive experience for visitors to SEA WORLD.
- * To promote education extension services through public lectures, displays and collaboration with other agencies.
- * To provide an enriching learning experience to young people through guided tours and field courses.
- * To provide a guidance and resource material service to scholars.
- * To provide support for curriculum development by teachers and professional education bodies.
- * To collaborate with tertiary institutions in the furthering of marine environmental education.

9.5 Governance

SAABR is controlled by a Council of 26 members of whom two are nominated by the University of Natal and two are nominated annually by the City Council of Durban. The executive functions of the Council are carried out by an Executive Committee, the members of which are the president, chairman, vice-chairman, honorary treasurer, honorary secretary, the director and four other elected members of Council. The chief executive officer of the Association is the director who is an *ex officio* member of both the Council and the Executive Committee.

9.6 ORI's research projects 1994/1995

Research projects

- * Ecology and management of Kwazulu Natal coral reefs.
- * Reproductive strategies of Kwazulu Natal corals.
- * Ecology, population dynamics and fishery of ghost crabs (*Ocypode spp.*).
- * Exploitation of the burrowing prawn, *Callinassa kraussi*, in Kwazulu Natal.
- * Stock assessment and fisheries management of the rock recreational lobster, *Panulirus homarus*.
- * Distribution and dispersal of fish larvae.
- * Stock assessment and biology of Serranidae.
- * Applied modelling of selected fisheries off the Kwazulu Natal coast.
- * Multiple usage of St Lucia's fish resources.
- * Evaluation of linefishery participation and management in Kwazulu Natal.
- * Assessment of Vetch's Pier seine netting.

Monitoring projects

- * Kwazulu Natal coastal invertebrate fisheries: Catch statistics.
- * National Marine Linefish System: Kwazulu Natal recreational data.
- * Marine linefish tagging.

Ancillary projects

- * Lake St Lucia juvenile fish.
- * Artificial reefs.

- * Biology and fishery for billfish in Southern Africa.
- * Fish identification services.
- * Alternative fish resources of the Kwazulu Natal shelf region.
- * Abundance and seasonality of whalesharks in Kwazulu Natal.

Surveys

- * Natural history of Bazaruto Island: Coral reef survey.
- * Survey of *Scylla serrata* in Eastern Cape estuaries.

Consultancies

- * Transkei coastal resources.
- * Mozambique linefishery.
- * Recreational angling in the Port of Durban.

9.7 ORI's research overview 1994/1995

The research programme of ORI provides good science that has practical applications. Although most effort is devoted to basic research projects, a considerable amount of time is also allocated to monitoring surveys, consultancies and decision support. In 1994/95 research at the ORI was undertaken by 123 scientists supported by 11 field and technical staff engaged in 20 projects as well as three consultancies and two surveys. Field activities amounted to a total of 86 excursions with 468 person-days spent sampling. Considerable use was made of volunteer assistance to reduce the field load on ORI staff. As usual, the quality and productivity of the science output is assessed by the ORI Scientific Advisory Committee, assisted by three independent assessors.

Table 5: Research productivity in 1994/95

Refereed scientific papers	27
Conference papers	10
Unpublished reports	15
Special publications	1
Contributions to book	2
Popular articles	10
Data reports	4
Others	15
Total	84

Research highlights

The study on the population dynamics of the estuarine sand prawn *Callinassa kraussi* was completed. The comprehensive final report provides essential information for management decisions as originally requested by the Natal Parks Board. The distribution and abundance of sandprawn population in Kwazulu Natal estuaries was found to have altered significantly over

the past decade. This was as a result of the drought and low river flow having closed estuaries. This reduced saltwater intrusion and led to lowered salinities which impaired breeding success of the prawns. Comparisons between heavily exploited and non-exploited areas suggest that present harvesting levels are having a negligible effect on stocks.

The study of the dynamics and fishery for ghost crabs *Ocypode* spp. was also completed. Based on extensive and regular population assessments along the coast, the present levels of harvesting were found to be sustainable. Although vehicular beach traffic kills crabs in high numbers, this does not appear to interfere with new recruits to that beach.

Another major study completed was that dealing with the multiple use of St Lucia's estuarine fish resources. Although started four years ago, this pioneering project adheres strongly to RDP initiatives in providing a scientific basis to accommodate local communities on a sustainable basis in a fishery that was previously closed to them. The management recommendations that have emanated from this study will allow for fair allocation of resources to subsistence users, recreational anglers and the piscivores of the system such as crocodiles, birds and fish. The next phase of this project will involve a pilot study with community involvement to assist in monitoring and management.

The coral reef studies progressed well in several areas of activity, especially topics of application to reef management. Community structure, species composition and the effects of divers on reefs were all under scrutiny. Although the coral reefs appear generally robust, diver and fisherman induced damage was detectable and will be further quantitatively evaluated. Of concern was the sudden appearance of the Crown of Thorn starfish on Tow Mile Reef, the extent and implication of which will be further investigated. Coral studies also expanded to include the Bazaruto Archipelago in Mozambique.

Research on the rock lobster stock in Kwazulu Natal is becoming increasingly important. Based on population analyses and catch rates derived from experimental and diver fishing activities, the east coast rock lobster stock in Kwazulu Natal was seen to be in a satisfactory condition.

Several projects dealing with linefish populations and their management continued to make good progress. The project evaluating linefish participation and management has expanded its sampling techniques to include detailed questionnaire and creel surveys, mail questionnaires and aerial surveys. Early results at hand reveal a surprisingly positive disposition of anglers to research and management.

Studies on the rockcods of Kwazulu Natal proceeded as planned with a special focus on the endemic species. The larval fish research project continued to produce good scientific papers and provide insight into the dispersal mechanisms of many fish species along the South African coast. The low-key projects investigating billfish, juvenile fish recruitment to St Lucia and alternative resources of the Kwazulu Natal shelf were continued. Many projects at ORI focus on the informal fishing sector.

Various monitoring activities continued. In most cases the data are collected by statutory conservation agencies or by fishermen themselves and subsequently processed and interpreted by the ORI. Thus, the National Marine Linefish System (NMLS) processed catch information from

more than 80,000 angler outings, involving 43,000 km of coastal patrols and numerous boat inspections. Extensive feedback was given to anglers in the form of brochures indicating trends in landings. The fish tagging project also contributed to monitoring activities as well as providing a data source for scientific analyses. More than 9,600 fish were tagged during the year and many valuable recaptures processed. Catch returns submitted by holders of invertebrate harvesting licences again provided good insight into the status of stocks. While several sites along the Kwazulu Natal coast are heavily exploited, especially in the case of mussels, generally, most harvesting remains within sustainable levels. This project provided ongoing decision support, especially to the Fisheries Licensing Board in projecting harvest levels.

Regional and international cooperation

The collaboration with Mozambique and other countries in the region that share stocks continued successfully. The joint processing and interpretation of fisheries data yielded good results that will assist in joint management of stocks. In Mozambique significant changes in government structures dealing with fisheries are occurring but our scientific collaboration and liaison will continue. Considerable technology transfer took place and Capacity Building amongst Mozambique fisheries research staff also occurred.

Post graduate training

ORI staff plays an important role in the training of students by running a semester-long fisheries science course at Natal University. This course is becoming increasingly relevant and popular and a growth in participation is predicted, especially from other universities in the province. Supervision of two M.Sc and two Ph.D students also occurred.

Advisory and consultancy services

Senior staff serve on numerous research, management, advisory and liaison committees. In doing so the ORI provides a scientific basis for many decisions that have to be made concerning marine resource utilisation. This is normally best achieved by preparing documents that form the basis for discussion and subsequent implementation.

In 1994/95 the South African Network for Coastal and Oceanic Research (SANCOR) stimulated intense collaboration between marine scientists and user groups, resulting in the development of a new marine science programme for the nation, known as "The Sea and the Coast Programme". This joint venture with the Department of Environmental Affairs and Tourism and the Foundation for Research Development specifically meets the needs of the RDP and comprises several major research thrusts. ORI staff actively participated in these developments and are major participants in this programme. The SeaWorld education officer, assisted by ORI, library and secretarial personnel provided extensive technological information to conservation staff, scholars, students and members of the community. This was achieved through the holding of formal education courses, lectures, seminars and contributions to the media.

Funding

Poor availability of funds remains a serious impediment to research on, and development of, coastal resources. Marine resources underpin much of the socio-economic fabric of the region, yet disturbingly few users are prepared to commit funds to marine research. In particular, development of marine-based tourism could be impeded if research cannot play the necessary role in its planning and development. The issue of user-pay contributions to research and development

will be actively pursued, especially as other important needs in the new South Africa are likely to receive greater priority for some years to come.

Future plans

The research programme of the ORI will continue to be directed by their overall mission which, more than ever, is relevant to the needs of South Africa today. However, the primary thrust will unavoidably be directed at financially sustainable projects and those that have immediate practical application. Participation in the national Sea and the Coast programme will strongly influence research direction over the next three years.

Annex X The Council for Geoscience

The council

The Geoscience Act (Act 100 of 1993) was approved by Parliament during 1993 and implemented on the 1st of November 1993. The Act provides for the establishment of a Council for Geoscience which operates on the principles of Framework Autonomy. The Council for Geoscience is the natural successor of the Geological Survey of South Africa, which had its origins in the Geological Commission of the Cape of Good Hope (1895), the Geological Survey of the Transvaal Republic (1898) and the Geological Commission of Natal and Zululand (1899). The Geological Survey of the Union of South Africa came into being in 1913 without provisions having been made in terms of an Act of Parliament and without its statutory functions ever having been determined by Parliament. The promulgation of Act 100 of 1993 thus establishes this function for the first time as a statutory responsibility for South Africa and defines the functions which the Council must perform.

The main functions of the Council for Geoscience include:

- * The systematic documentation of the earth's surface within the territorial boundaries of South Africa, the compilation of the geological, geophysical, geochemical and other earth-science information and the publication of this information in the form of maps and documents.
- * Geoscientific research on the rocks, ores, minerals, formations, fossils, etc. in South Africa and the publication of this information in national and international publications.
- * The collection and preservation of all geoscientific data and information of the Republic of South Africa in national data bases. This information also includes confidential data from companies which may only be released in accordance with the provisions of existing laws.
- * The rendering of geoscience information and advice to the State to enable it to make informed decisions on the use of the earth's surface.

These functions are performed with four national objectives in mind, which are:

- * To reduce the geological and scientific investment risks for national and international entrepreneurs in the South African mining sector. The geological risk rating of a country, i.e. the quality of its available geological data, accounts for some 61 per cent of the investment risk of a country.
- * To provide the basic geological data to permit the country to develop a safe, cost-effective physical infrastructure which avoids sterilization of usable mineral resources.
- * To provide the basic knowledge to ensure safe, cost effective and environmentally acceptable urbanization and housing development. In this regard the inherent dangers resulting from sinkholes in dolomitic terrains, seismic activity as a consequence of mine-related earthquakes, and flood hazards are particularly relevant. The identification of construction materials, waste disposal sites and cemeteries is also an important facet of these functions.
- * To carry out research on the raw materials which are necessary to cloth and feed the nation. These include agro-minerals, ground water and the mineral commodities which our industries need.

The economic and social integration of the Republic of South Africa into Africa and the world also dictate that the country must have access to the basic geological information of the African continent and the world as a whole. With this long-term need in mind the Council also acts as a repository for African and Global Earthscience data. These data are made available to the South

African public, the State and to African Governments. It is foreseen that basic knowledge of the geology and the mineral resources of Africa would be a critical consideration in the economic integration and development of the African continent.

The Geoscience Act makes it mandatory that the Council performs specific statutory functions on the principle that public funds, as allocated by Parliament, must be used to establish public benefits. The compilation and publication of geoscience maps and documents for public use constitute a direct public benefit resulting from the statutory functions of the Council. The system of Framework Autonomy also permits the Council to render services to individuals, communities and companies on a client-pay basis. The Council accepts the principle that specific individuals, companies and/or communities, who require specific services from the Council for their exclusive benefits, have the responsibility to pay for these services.

Marine geoscience unit at University of Natal

The Marine Geoscience Unit was formed in 1989 by contractual agreement between the University and the Geological Survey. The unit is attached to the Department of Geology and Applied Geology at Durban and a member of staff heads the unit: three geologists and one geological technician are seconded from the Geological Survey. Other staff members and scientists attached to organisations outside the university are associated with the unit for collaborative research projects. The unit trains postgraduate scientists: undergraduate geology students work with unit staff on specific research projects on an ad hoc basis.

The primary function of the unit is to investigate marine geology, but current projects include flood plain deposits of Namibia, diamondiferous deposits of Namaqualand, vertebrate fossils from the Natal midlands, the sedimentology of the Mkuze River and the bathymetry and geology of Lake Sibaya. Shore and intertidal projects include studies of fossil ivory and teeth, erosion and formation of wave cut platforms, and the detailed petrology of beachrocks and coral reef-derived bioclastic sediment. Projects of the offshore continental shelf include the ecology of coral reefs and their geological history, the geology and sedimentology of submarine canyons off the Zululand coast, late Pleistocene palaeocoastlines and the construction of a model for late Pleistocene sea-level changes. The unit is funded by the Geological Survey, the University of Natal, and by research contracts.

Staff of the joint GS-UN Marine Geoscience Unit (situation 1995):

Advisory committee

* Geological Survey:

Dr C J van Vuuren; Mr A du Plessis

* University of Natal:

Professor F G Bell; Professor T R Mason; Dr M K Watkeys

Research staff

* Director:

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Annex XI Kenya Marine and Fisheries Research institute (KMFRI)

11.1 Introduction

The institutions undertaking marine science research in Kenya are the Kenya Marine and Fisheries Research Institute (KMFRI), the national universities in Kenya i.e. Nairobi, Kenyatta, Moi, Egerton, and Jomo Kenyatta University of Agriculture and Technology, the Kenya wildlife services and the national museums of Kenya. KMFRI was founded in 1979 through an Act of Parliament as a governmental, non-profit national organization, after the collapse of the East African community (EAC) and consequently, the dissolution of then existing East African organizations for fisheries research. KMFRI is part of the Ministry of Research, Technical Training and Technology.

The Institute has two main divisions, the marine science division and the freshwater science division. The marine science division is based at KMFRI's headquarters in Mombasa. KMFRI owns and runs a research vessel, *the R/V Maumba*, and some small boats with outboard engines. A library with computerized search/retrieval system runs under the Regional Co-operation in Scientific Information Exchange in the Western Indian Ocean (RECOSCIX-WIO) project. An integrated computer section is housed on the top floor. The freshwater science division is at the Kisumu Laboratories. This division has laboratories in Kisumu (near Lake Victoria), at Kalokol on Lake Turkana, at Lake Baringo; at Sango'ro on River Miriu, Kegati, Lake Naivasha and in Nairobi.

There are 120 scientists, half of them carrying out research on fresh water and the other half on marine waters. Out of them 85 have a BSc.; 33 an MSc and 2 a PhD. Most of the scientific staff join the institute with a BSc degree. The institute undertakes to train them for M.Sc. courses locally or by securing scholarships for training abroad. The postgraduate training is undertaken in more specialized areas to tackle specific project areas. There is need for more post-graduate training opportunities, locally as well as abroad, due to the growing number of scientific staff at B.Sc level. There is need to train supporting staff in various disciplines as well. The total number of supporting staff is about 1,300.

11.2 Marine research programmes

The research programmes described below only concentrate on the activities of the Marine Science division at Mombasa. The lacustrine research activities of KMFRI are outside the scope of this mission.

KMFRI conducts applied and basic research, which is organized in four major programmes

- * Fisheries Research Programme
- * Aquaculture Research Programme
- * Environment and Ecology Research Programme
- * Natural Products Research Programme

Detailed research projects are prepared by the participating scientists or group of scientists in various research disciplines. When a major regional effort or international project is planned, both local and overseas scientists prepare a joint project proposal. A memorandum of understanding

(MOU) is then drafted and agreed upon by the collaborating institutions and/or governments and/or sponsoring agency.

11.2.1 Fisheries Research Programme

Most of the catch is by artisanal fishermen who use low technology gear and fish mainly in shallow waters inside or close to the fringing reef. The potential yield of the reef fisheries varies between 8,000 and 10,000 tonnes. For proper management of the fishery there is need to continue stock assessment and studies on ecology and biology giving relevant advice on the use of appropriate fishing gears and where to fish. The objectives of this programme are:

- * To undertake stock assessment of fishery stocks with an emphasis on prawns, lobsters, crabs, commercial pelagic and demersal fish stocks.
- * To study biology and ecology coral fishes.
- * To study fish marketing and socio-economics of fishing communities.

Proper industrial exploitation of fishery resources requires the knowledge of the magnitudes that can be economically harvested without depleting the resource. This is dealt with as stock assessment, which is described as the search for the exploitation level which in the long-run gives the optimum sustainable yield in weight from the fishery. It further deals with important aspects of fish which are used in models to estimate the optimum sustainable yield such as growth, exploitation rate, natural and fishing mortalities, recruitment, reproductive biology, gear selectivity, food consumption and catch effort assessment. So far, KMFRI has undertaken research to provide these parameters for modelling and application in stocks assessment.

Fish Stock Assessment

Under the KMFRI, FAO and NORAD projects, the distribution of fisheries resources along the coast of Kenya was studied. The Ungwana Bay-Sabaki Complex and the North Kenya banks were shown to constitute the fishing grounds for fin fish and shellfishes. The area was found to be suitable for trawler-fishing. The yields obtained here were higher than in other areas of the Kenyan Coast.

The Kenyan coral reefs were also found to be rich fishing grounds for the artisanal fishermen. The fishing gear recommended for these untrawlable habitats are gill-nets, longlines and traps. These areas should be protected from pollution and impacts of tourism. Lack of an appropriately equipped oceanographic research vessel has greatly limited the confirmation of monitoring research on this aspect of our research programmes.

Fish Biology Studies

Scientific papers and theses on fish biology have described the fisheries of different areas along the Kenyan Coast with information on reproduction, age, growth, food and feeding habits of species of commercial interest. Under the Kenya-Belgium Project, the mangrove fishery studies resulted in:

- * A compilation of a species list of fishes in mangrove creeks such as Gazi Bay, Tudor, Mtwapa, Mida and Ungwana Bay where a total of 53 families belonging to 129 species were encountered.

- * Information which linked the mangrove creek to fisheries was obtained. Among the total fish encountered in the mangrove creek, 90% were juveniles. This further demonstrated the importance of the mangrove ecosystem on the early life of fish and other marine organisms.

Penaeid prawn fishery study

Under this study, penaeid prawn recruitment and growth patterns were studied. The role played by mangrove creeks in the prawn fishery was demonstrated. The prawns were shown to recruit into mangrove creeks during their early life stages and thereafter migrate offshore. It is therefore important to protect the fragile mangrove ecosystem and curb overfishing of prawn fry in order to sustain the prawn stocks in our waters. Similar studies were conducted on the lobster fishery. An inventory and taxonomy of lobsters along the Coast was documented. These work should diversify into mariculture productivity and further monitoring studies. A number of papers have been published on this subject in referred journals.

11.2.2 Aquaculture Research Programme

The aquaculture research programme is targeted on organisms to be cultured and will emphasize studies on their genetics, biology, ecology, pathology, nutrition, farm/pond production technology, and seed production and culture technology. The objective of the programme is

- * To enhance food production in the country through aquaculture
- * To popularize aquaculture through integrated agro-aquaculture practices in irrigation systems.
- * To find ways of producing organisms of threatened species for ranching or stocking water bodies and to research into the extraction of natural products, for use as fish feeds for freshwater and marine cultured fishes.

As a result of the "eat more fish"-campaigns throughout the country by the Fisheries Department, fish consumption has become popular in communities which previously found fish strange to eat. Due to the increasing local fish consumption and the flourishing tourist industry, the demand for freshwater and marine fish, prawns and oysters has greatly increased. In Western Kenya, the popular tilapia is not easily available and a way of making it easily available is through aquaculture. Apart from production for human consumption, aquaculture can be used for production of ornamental products and also for feed, bait or sport; production of animals for biological control, production of organisms for natural products extraction, and production of organisms of threatened species for ranching or stocking in lakes, rivers and dams.

Aquaculture activities are undertaken in order to supplement wild fishery production especially for those species whose natural production in the wild cannot support the demand. The Kenyan coastline has several sites that are suitable for aquaculture practises. Research on aquaculture of prawns, oysters, algae and fish is being undertaken and there are attempts to integrate salt farming activities with culture of the Brine shrimp *Artemia*.

Oyster culture and research

Oyster research has been conducted by the Institute for many years. Research intensified in 1989 with a study on the ecomorphological aspects of the oysters. This study was awarded the MacLeod Price (of the Royal Academy of Sciences in Belgium). The study aims to formulate a new theoretical model on oyster feeding and culture.

Seaweed research

KMFRI conducts research on agar producing algae aimed at reducing the cost of importation of agar into Kenya. Currently, Kenya depends on imports for all her agar requirements. Investigations have shown that two of the *Gracilaria* species, which are an agar producing rhodophytes, *G. verrucosa* and *G. crassa* found growing in Kenya marine waters yield agar that is comparable in quality to the commercial agar imported into the country. *G. verrucosa* has been found to give the highest agar yield of 30% dry weight, whereas *G. crassa* has a yield of 24 percent dry weight. *G. verrucosa* in particular has a morphological structure which is conducive to cultivation on commercial basis. Trial cultivation has also proved positive. One local researcher has been awarded a Ph.D. in this subject.

Artemia

Artemia has been introduced successfully in the saline waters of the Kenyan Coast. Bioassay analysis was also done using marine mysid *Mysidopsis bahia* (Melenoc) with very good growth results. A small bioassay laboratory has been set up and uses local fish (tilapia) and crustaceans (*Macrobrachium*) for quality tests. A healthy algal culture stock has been established with five different algal species, namely *Chlorella* (fresh water and marine), *Tetraselmis sp.*, *Dunalliella sp.* and two diatoms of the genus *Chaetoceros*.

11.2.3 Environmental and Ecology Research Programme

Kenya has a long history of a strong interest in preservation and conservation of her wildlife resources and protection of critical habitats through creation of marine parks. Coastal marine parks in Kenya are also a major attraction to tourists. Kenya has also gained financially in creating parks as thousands of tourists and local visitors are attracted by the high diversity of life in the parks. As regards health, there is every need to monitor pollution in order to avoid diseases and possible elimination of intolerant species. Thus KMFRI undertakes keen research on environmental aspects. The environmental problems range from increased sediment loads from the land to sea, sewage and solid waste disposal from urban areas, overexploitation of reef resources and overcutting of mangroves, and oil pollution to wastes disposed from industries.

There is substantial information on the coastal marine waters from research undertaken by KMFRI, universities (especially University of Nairobi); bilateral projects e.g. Kenyan-Belgian Project in Marine Sciences; UN-sponsored projects e.g. through UNESCO, UNEP, FAO and non-governmental societies whose aim is to protect the environment from being degraded.

This is a broad programme containing limnology and oceanography (physical, chemical, biological, and geological oceanography). The objectives are:

- * To study the natural state of the physical, geological and chemical characteristic of the water bodies so that anthropogenic changes can be discerned;
- * To study the interrelationships between aquatic organisms and their environment;
- * Investigate the impacts of use and abuse of the aquatic environment.

Optimal utilization of resources depends on the practical knowledge of the environment, the organisms therein and the interrelationships among them and the environment. Knowledge of the habitat preferred by a species has various practical applications in aquaculture, fisheries, conservation and planning. For example, in aquaculture the information has practical application in choice of material to be used such as clutch size or in creating the right type of bottom

conditions in ponds. In fisheries, such information is used in the making of fish aggregating devices (FAD), identification of nursery/spawning and fishing grounds. In conservation, such knowledge is important in the location and preservation of habitat refuges.

While water circulation patterns are necessary for pollution studies as well as understanding the functions of various biotopes, larval and fish dispersal patterns and water mass distribution rely on the hydrodynamics of the given system.

Oceanography

Covers biological, chemical and physical oceanography. This includes primary production, nutrient cycles and general hydrographic changes.

Marine Geology

The evolution of the coastal marine and inland features is of major interest in Kenya. The geology section is currently involved in a comprehensive study of the Kenyan coastal systems especially the distribution and expanse of mangrove areas vis-à-vis the oceanographic processes.

Coral reefs

Surveys have been carried out on the major groups of organisms occurring on Kenyan reefs that are directly utilized by the local population, for example fin fish or for collection for example, shells and corals. To date, surveys have been carried out on reefs in Kiunga, Malindi, Watamu, Vipingo, Bamburi, Kanamai, Diani and Shimoni. Many of these reefs are landing bases for the local fishermen whose landings constitute more than 80 percent of the total fish catches on the Kenyan coast. Detailed studies of the major reef builders, the hard corals, have been carried out including the species composition, distribution patterns and percent cover a reefs in Malindi Marine National Park, Watamu marine National Park, Vipingo, Bamburi, and Diani. These studies show that protected areas have a richer fauna than unprotected ones and that protection of Kenya's coral reefs is an important management undertaking as these areas do act as breeding grounds for the fish and other organisms from adjacent reefs. Studies have also been carried out on the fin fish resources of Kenyan coral reefs with a view to studying the problem of overfishing. There is an important relationship between the level of fishing activity and the numbers of sea urchins and fin fish on Kenyan reef lagoons. Reef lagoons that are heavily exploited have low numbers of fin fish and very high numbers of sea urchins. Sea urchins have the potential, to greatly affect the reef by bio-erosion.

Benthos research

The benthos research addresses both the macro- and meio-benthos. Studies have been concentrated in the mangrove area at Gazi though several other sandy areas along the coast have been studied. In the beginning of 1989, several short programs on the comparison of the meio- and macro-benthos of several mangrove species were executed.

Zooplankton research

Research on zooplankton has been going on since 1985 under the Kenya-Belgium Marine Science Project. Sampling has been done in Tudor and Gazi creeks. Several papers, M.Sc theses and one Ph.D. thesis have been published on the zooplankton community of Tudor creek. These works have been undertaken by both Kenyans and foreigners.

Mangrove research

Within the framework of the biotopes studies, the real cover of mangroves at Gazi was reviewed and found to be 661 ha. Eight species occur in the area: *Ceriops tagal*, *Rhizophora mucronata*, *Brugueirra gymnorhiza*, *Avicennia marina*, *Lumnitzera racemosa*, *Xylocarpus granatum*, *Heritiera littoralis* and *Sonneratia alba*. *C. tagal* and *R. mucronata* are the most common. On Chale Island, isolated stands of extremely tall *B. gymnorhiza* were found growing in the natural mangrove forest.

Standing biomass is known for two plots (*Ceriops tagal* and *Rhizophora mucronata*) vegetation. The contribution of under growth to total production and success of seedlings in natural (wild) and artificial (planted) sites have been tested. Carbon and nitrogen analyses conversion to dry weight are available for computer modelling of the mangrove ecosystem.

11.2.4 Natural Products Programme

The objective is to isolate active ingredients substances from various types of aquatic flora for use in making products of commercial importance such as feeds, fertilizers, medicine and for improvement of industrial products.

There is a world-wide practice to find out ways of incorporating extracts from aquatic organisms into foods, fertilizer or in making medicines and drugs for use by mankind. Both the marine and inland water bodies have abundant resources which are reservoirs of various active ingredients. Research has shown that marine algae, crustaceans, echinoderms, sponges etc, provide useful active ingredients which can be incorporated into feeds, fertilizers and medicines in order to improve their quality. The red algae, (Rhodophyta) are important sources of agar which is used as culture medium for bacteria and fungi in various medical and institutional researches, and are used in the fertilizer, food, cosmetics and leather tanning industries. Other types of algae called brown algae or Phaeophytes are sources of alginic acids and alginate which are used in the preparation of products for human consumption e.g. soups, antibiotics; as thickeners in cosmetics, textile and pharmaceutical industries and emulsifying agents in the preparation of polish and paints. Alginic acid has a high specificity for binding or strontium, a fact that can be utilized in the inhibition of internal absorption of radioactive strontium. Shells and pigments (carotenoids) of shrimps have useful active interments. There is therefore a need to strengthen research in the study of aquatic flora and fauna with a view to develop a viable industry producing products from sea animals and plants of commercial value.

11.3 International research projects

11.3.1 Kenya-Belgium Marine Sciences Research Project

This is a bilateral project supported by the Kenyan and Belgian governments and based on co-operation between KMFRI and the Free university of Brussels (VUB), Laboratory of Ecology and Systematics. The project was started in 1985. The objective of the Kenyan-Belgian Project (KBP) in Marine Sciences is to link training and capacity building (research, equipment, operational funds and marine science literature). The marine research activities are undertaken in Kenya while the Belgian government gives fellowships for Kenyans to undergo specialized training in Belgium leading to M.Sc.s or Ph.D.s. On the other hand, students from Belgium also come to Kenya for

undertake research for their Post-graduate theses. This has greatly enhanced the establishment of a marine research information infrastructure on Kenyan marine waters. The provision of essential equipment and reference literature has indeed facilitated to create an enabling environment at KMFRI for conducting research. The KBP focuses research on the biological oceanography of shallow water ecosystems. Scientific data on plankton, reef ecology, macro-flora and fauna, meiobenthos, oyster culture, bacteriology and ecology of mangroves continues to be gathered. With the cooperation of the University of Limburg in Belgium, KBP received valuable marine literature for various disciplines. To date a total of 14 Belgian professors and 30 scientific experts (50 percent with Ph.Ds) have worked in Kenya. Many research papers in fundamental and applied research have been published as a result of the joint research activities. Moreover, a large number of theses for obtaining higher degrees have been prepared or are in progress by Belgian and Kenyan students.

The project has been expanded to involve cooperation with other universities and institutions in Belgium, the Netherlands, and Italy as well as with the University of Nairobi and the Kenyatta University in Kenya. The research activities of the project are done in close collaboration with the on-going project on the "Dynamics and Assessment of Kenyan Mangrove Ecosystems". The project was started in November 1989 and is based on collaboration between scientists from Kenya (KMFRI), University of Nairobi, and Kenyatta University, the Netherlands (the Delta Institute and the Catholic University of Nijmegen), Belgium (VUB and University of Gent) and Italy (University of Florence).

11.3.2 Regional Cooperation in Scientific Information Exchange in the Western Indian Ocean (RECOSIX-WIO)

The computer section of the Kenya-Belgium Project originated the IOC/RECOSIX/WIO project. The project was initiated by Intergovernmental Oceanographic Commission IOC in February 1989 and chose the KMFRI-KBP computer section as the Regional Dispatch Centre (RDC) in view of the available equipment and trained staff. The RECOSIX Project is now funded by the Belgian government through the University of Limburg. The main objective of the project, which is an information network within ASFIS, is to promote communication between marine scientists in the Western Indian Ocean Region, and between them and scientists and institutions outside the region including international organizations.

At present, fifteen marine science institutions in eight countries of the region and eight marine science libraries outside the region are participating in the project. Since its inception, the project has provided the following services:

- * Requests received by RDC for information on specific topics were satisfied by sending abstracts, diskettes, or papers after searches in local (ASFA CD-ROM) and remote (on-line DIALOG) data bases.
- * Hard copies of scientific literature were supplied upon request, through the network of libraries in and outside the region.
- * Special bibliographies have been prepared for special occasions such as symposia, training courses etc.
- * A directory of Marine Scientists, Western Indian Ocean (WIODIR) was produced (first release, December 1990). This valuable directory gives a listing of scientists from fourteen institutions in eight countries according to: (a) their institutions (stations) and (b) their disciplines using

ASFA subject category. These are followed by individual data sheets. The directory is available in three formats: printed version, Faxbase/dBase version, Micro CDS/ISIS version. WINDOW is a quarterly newsletter printed in 1500 copies of which 140 are mailed to scientists within the region. Five issues have been published since 1990.

11.3.3 EU Mangrove Project

This project began in 1989 and was an offshoot of the Kenyan-Belgian Project. The general objective of this project is to describe the structure and functions of mangrove ecosystems along the Kenya Coast in order to provide a basis for their rational exploitation and management. The study includes:

- * Mangrove primary production litter fall.
- * Mangrove litter decomposition and its role as nutrient source.
- * Nutrient concentration and salinity.
- * Phytoplankton and zooplankton composition and production.
- * Seagrass and macro-algae composition and primary production.
- * Meio-macrobenthos composition, distribution and biomass.
- * Fish communities.

The institutions involved are: KMFRI (Kenya), University of Nairobi (Kenya), Free University of Brussels (Belgium), Delta Institute for Hydrobiological Research (Netherlands), Catholic University of Nijmegen (Netherlands), University of Florence (Italy) and Center for study of Tropical Faunistics and Ecology of the Italian National Research Council (Italy).

11.3.4 Kenya-Dutch Partners in Science, Phase I

The programme is linked to the Dutch Indian Ocean Programme (1990-1995), of which an expedition in 1992-1993 was the most visible part. In this partnership Kenyan, Dutch and Belgian scientists jointly planned the research objectives of the programme. Within the programme a modest fellowship programme was financed by the Dutch partners, the Netherlands Marines Research Foundation (SOZ). Moreover, a training course at KMFRI and on board of the Dutch RV *Tyro* was organised. Infrastructure for the landbased research camp was also donated by SOZ. One part of the expedition programme concerns the effect of the monsoon on coastal ecosystems in Kenya. Both offshore studies on board of the Dutch research vessel *Tyro*, and studies of the coastal fringe (mangrove, seagrass and coral reef ecosystems), using a land-based camp, were executed. The *Tyro* covered three transects perpendicular to the coast and one of these had its starting point near Gazi. In addition, the land-based crew carried out research in Gazi Bay, in collaboration with scientists involved in the EU-mangrove project. Topics that were studied jointly include:

- * The sediment and plankton transport in undisturbed and exploited parts of the mangrove.
- * Food chains in the coastal fringe (using stable isotopes).
- * Emission of greenhouse gases by the mangrove sediments.
- * The function of the extensive seagrass meadows in the bay as nutrient and seston traps between mangrove and coral reefs.

The integration of the EU-project and the expedition was scientifically profitable to both projects. Five topics related to global ocean flux studies were covered:

- * Coastal ecosystem studies off Kenya
- * Coral reef research centred in the Seychelles
- * Late quaternary productivity and dynamics of the oxygen minimum zone near Pakistan
- * Paleoecology in relation to the Somali and Omani monsoonal upwelling systems
- * Productivity of the Somali and Omani upwelling systems

11.3.5 The Coastal and Marine Research in Africa Project (COMARAF)

The Coastal and Marine Research in Africa (COMARAF) Project started in 1986, but Kenya officially accepted to participate in the project in 1988. In brief the objectives of the project are:

- * To promote the development of a comprehensive framework for a better and more appropriate understanding of coastal systems in view of their rational management for the coastal states of Africa.
- * To establish a scientific basis for understanding the characteristics and functioning of the coastal systems with a view to integrate management of the Coastal zone.
- * To reinforce the capacity of countries in terms of utilization, management and protection of their marine and coastal zones through appropriate training and the dissemination of information of research activities (1992-1996).

The COMARAF project comprises three phases, at present the second phase has not been entered yet. As part of COMARAF, Kenya undertook the project "Ecology of coral reefs along the Kenyan Coast". To fit into the objectives of the COMARAF project, the Kenyan project focused on describing the range of coral reefs with respect to and in comparison with other ecosystems present (mangroves, seagrass beds etc.); study the taxonomy of various groups and examine different types of human and natural aggression and steps that could be taken to limit their consequences.

11.3.6 Eastern African Action Plan (UNEP-OCA/PAC With UN System)

Similar to other UNEP Regional Seas Action Plan, the Eastern African Action Plan is designed to link assessment of the quality of the marine environment and the causes of its deterioration with activities of the management and development of marine and coastal environment, and to promote the parallel development of regional conventions and legal agreements. Participating countries are: Comores, Kenya, Madagascar, Mauritius, Mozambique, Seychelles, Somalia and Tanzania.

11.3.7 Support to Marine Research

The Swedish Agency for Research Cooperation with Developing Countries (SAREC), has supported development research since 1975. At the beginning, most of the support was channelled to research activities within UN systems and other international organizations. Over the years, the emphasis has shifted towards bilateral cooperation with a number of developing countries, particularly in Africa, Asia and Latin America as well as Swedish development research. Although important, this support to Swedish development research constitutes only a minor part (less than 10 percent) of SAREC's total activity (SAREC Project Catalogue, 1987).

11.3.8 SAREC-IOC Marine Coastal Management Project in East Africa

In addition to the direct support by SAREC for the development of marine sciences in East Africa, SAREC concluded an agreement in 1990 with IOC for a joint regional programme based on the main elements of the IOC programme in IOCINCWIO region, as well as SAREC Action Plan for East Africa, with a view to ensure the maximum coherence between, and mutual reinforcement of the activities carried out through IOC, and those carried out directly through SAREC.

11.4 Institutional capacity and other facilities

The emergence of new perceptions in the national research system demands a re-examination of the science and technology infrastructure in Kenya. In particular, basic research in physical and chemical oceanography, marine geology, limnology, aquaculture and fisheries which cannot be suitably accommodated in KMFRI's main biological laboratory requires attention. One possibility is to strengthen the existing laboratories in KMFRI and construct more new buildings with fully equipped research laboratories.

Kenya would like to strengthen centres of excellence in marine sciences, at Mombasa laboratories, allowing the manpower of the different universities and Institutes in Kenya, East Africa and from abroad to work in optimal conditions. Collaboration between Kenya and developed countries in developing marine and freshwater fisheries research in Kenya will be beneficial to Kenyan scientists. The institute will continue the collaborative research in marine and freshwater sciences with regional and international institutions, universities and organizations interested in the development of aquatic sciences.

The rapid growth of KMFRI's decentralized, collaborative activities in recent years has created an intense need for additional central facilities to carry out research tasks. In the long run, the expansion of strategic research may require increased investment in more sophisticated facilities. Immediately required are laboratories for biological, chemical and physical oceanography and an additional building at Mombasa to serve as the headquarter.

The success of research output depends also on the infrastructure and facilities to enable the research work to be undertaken. In any strategic plan, therefore, this aspect cannot be overlooked. The item Infrastructure and facilities embraces buildings, equipment, jetties and transport facilities.

Since KMFRI inherited facilities from EAMFRO and EAFFRO in 1979, the staff has expanded but the facilities have not been adequately expanded to accommodate the increasing staff. This has resulted in overcrowding in offices. The situation can be alleviated by building extra office blocks at KMFRI Mombasa. The Institute frequently receives guest scientists and students who come to carry out research in the inland or marine waters. There is need to build guest houses in every station. Mombasa station requires a guest house capacity for 60 guests.

Annex XII The Eastern African/Indian Ocean region LOICZ project proposal

12.1 Introduction

The Eastern African region between Cape Town and the upwelling zone in Somali and in particular the coastal zone, presents unique and interesting challenges to the study of land-ocean interactions for several reasons: it is a monsoon shelf with characteristic coastal ecosystems such as mangroves, seagrass meadows and coral reefs; it is subject to dramatic oceanic influences such as those associated with the boundary between the East African coastal current and the Somali current; and it is also a zone where major rivers such as the Tana, Sabaki, Rufiji, and Zambezi enter the Western Indian Ocean. The catchment and basin dynamics and sediment delivery are therefore important factors influencing change in coastal environments. Typically the ecosystems in this zone exhibit high productivity which is largely due to river inputs and an efficient recycling of nutrients, which tend to limit production in coastal ecosystems. Consequently these ecosystems are expected to also show a strong response to current reversals and to climatic and anthropogenic forcing through modification of freshwater input, sediment transport and carbonate flux, nutrients and pollutants.

Since limited research work has been done in this region, important basic questions are yet to be answered:

- * How do the mangrove seagrass meadows and coral reefs interact with the physical environment?
- * What is the response of these systems to the human influence?
- * Does the biological and nutrient enrichment seen during part of the monsoon season result from river input, seeping, or invasion of remnant water from the Somali current? and,
- * What are the causes of observed shoreline erosion?

12.2 Proposal

To address these questions, we propose to study the following with the aim of understanding better the interactive role of coastal ecosystems in the land-ocean zone.

12.2.1 Project title: Coastal Ecosystem Health, Implications for Sustainable Development and Economic Uses of East African Coral Reefs and Mangroves.

Objectives:

- * Identify the major functional biotic components of mangroves, coral reef and sea grass communities.
- * Evaluate the role of mangroves in trapping and stabilising sediments.
- * Identify and quantify the major anthropogenic factors stressing these systems.
- * Quantify the contribution of mangrove and sea grass systems to the emission of greenhouse gases (methane, DMS).
- * Identify and quantify the economic value of these ecosystems.
- * Develop a sound scientific basis for forecasting change under different social, cultural and environmental conditions.

Activities:

- * Identification will be made of the major components of the flora and fauna of mangrove reefs and sea grass communities at specific sites which represent both pristine and impacted areas. Examples of selected sites are Mafia Island, Rufigi Delta, Malindi, Ungwana Bay, Maputo Bay and Inahaca Island, Bazaruto, Kismayo, Comoros and Mauritius.
- * Studies of sediment trapping in and by mangroves will be undertaken in sites near river mouths and on open coastlines such as the Tana River and Rufigi Deltas and Karanga Island.
- * At the selected sites identified in the first activity above, the effect of different species of mangrove trees and sea-grasses on sedimentation and erosion rates and processes will be established. Special attention will be given to the effects of episodic events.
- * The role of the different ecosystem components in nutrient and carbon cycling (sources and sinks) will be determined.
- * Surveys will be undertaken in selected areas to determine the nature and extent of human impacts on the composition and functioning of these ecosystems. Special attention will be given to mangrove clear-felling, salt production, dynamite fishing, tourism, urbanisation and land-use in watersheds.
- * Measurements will be made of the gradients of methane and DMS in the anaerobic sediments of mangroves and sea grasses at selected sites in Kenya and Tanzania.
- * Studies will be undertaken to determine the value in economic terms of the various ecosystem functions in mangroves, coral reefs and sea grasses.
- * In order to facilitate the collection, compilation and exchange of information, a common data base will be established to service the various activities carried out within the context of the project. This data base will include data from all participating countries within the region.
- * Ecosystem models of these components will be developed on the basis of the data collected and will be used to study their interrelationships.
- * Determine the response of mangroves and coral reefs to environmental forcing including changes in climate and sea level.

Potential participants:

Table 5: Potential lead organisations Eastern Africa

Country	Institute	Contact person
Tanzania	University of Dar es Salaam	A. Semesi
Kenya	KMFRI University of Nairobi National Museum	E.N. Okemwa M.J. Ntiba H. Oyieke
Mozambique	University of Maputo	D. Gove
South Africa	University of Cape Town Oceanographic Research Institute	G. Brundrit L.E. Berkeley

Table 6: Collaborating European Institutions

Country	Institute	Contact person
Sweden	University of Stockholm University of Uppsala	R. Johnston Pedarsen
Belgium	Free University of Brussel	De Haas
The Netherlands	Netherlands Institute of Ecology Netherlands Institute for Sea Research	C. Heip H. Lindeboom

12.2.2 Project title: Coastal changes in Eastern Africa: sedimentation erosion processes in relation to global change.

Preamble

Most of the shorelines of the region are undergoing change and erosion. Affected environments include: beaches, mangrove areas and some wetlands. The causes of the erosion process and its future trends are not well understood. However, increasing human pressure, especially on mangroves and reefs that play an important biogeomorphic function in stabilising shorelines, is apparent along the entire coast of the region.

Objectives

- * Characterise and determine the vulnerability of different coastal environments to erosional and accretional changes driven by natural and anthropogenic forcing.
- * Quantify the capacity of individual coastal systems to supply and retain sediments.
- * Assess the contribution of rivers to the coastal sediment budgets.
- * Determine shoreline evolution trends.
- * Determine the quantities and physicochemical characteristics of sediments delivered to the coastal zone and their temporal variations.

Justification

Coral reefs, mangroves and seagrass beds form important ecosystems in the Eastern African region. Available baseline studies indicate that these ecosystems are undergoing rapid change, due to natural and anthropogenic influences.

Methodology

- * Carry out visual assessment and characterisation of the major coastal types.
- * Sample coastal deposits along predetermined transects perpendicular to the shoreline at selected representative sites.

- * Analyse samples for textural, physical and chemical parameters.
- * Determining accretion rates from cores and direct measurement of sedimentation flux.
- * Taking shore profiles on seasonal basis.
- * Measure flow velocity, hydraulic radius and channel width in order to compute discharge at the river mouth.
- * Determine sediment load at river discharge.
- * Measure salinity, temperature, and current velocities at various stations at the study sites and obtain coastal meteorological data.

Outputs

At the end of the investigation period the following shall have been achieved:

- * Thematic information on the different coastal types indicating their relative vulnerability to shoreline change.
- * Data on factors responsible for erosion/accretion processes.
- * Data on the functional roles of mangrove, sea grass beds and coral reefs in relation to shoreline stability.
- * Data on sediment contribution from the major rivers.
- * Data on distribution and nature of sediments brought into the coastal ecosystems.
- * Data on temperature salinity and current velocity.
- * A descriptive model on the erosional and deposition processes.
- * Information on the response of coastal ecosystems to changes in climate, land use, and geographic factors.
- * Quantification of erosion and accretion rates within the different coastal systems.

Country	Institution	Principal Investigator
Tanzania	University of Dar es Salaam	A. Semesi
Kenya	KMFRI	E.N. Okemwa M.J. Ntiba
Mozambique	University of Maputo	H. Ouyake
South Africa	University of Cape Town Oceanographic Research Institute	G. Brundrit L.E. Berkeley

Input

Scientific staff from each Eastern Africa institution carrying out LOICZ related activities available research equipment, and laboratory space.

Country	Potential lead institutions
Kenya	* Kenya Marine and Fisheries Institute * Nairobi University * Kenyatta University * Moi University * Coast Development Authority * Kenya Wildlife Service
Tanzania	* University of Dar-es-Salaam (Institute of Marine Sciences)
Mozambique	* University of Eduardo Mondlane, Marine Biological Station at Inhaca
South Africa	* Oceanographic Research Institute, Durban * University of Cape Town
Mauritius	* Ministry of Environment and Quality of Life
Comores	* INRAPE, Ministère de l'Agriculture, Pêche et Environnement

Table 7: Potential Participants

12.2.3 Project title: Socio-economic impacts of Global and Regional changes on coastal ecosystems along the Eastern Africa coastline.

Rationale

The Eastern African Coastal Zone resources have been and continue to be modified by global change with socioeconomic drivers of change such as population growth, increasing rate of urbanisation, increasing industrialisation and intensification of agriculture causing stress and degradation to the resources. However, information on global change impacts is quite limited in the region.

Objectives

Short-term:

- * To conduct economic valuation of resources within selected study sites in the Eastern Africa coastal ecosystems.
- * To establish a collaborative multidisciplinary regional research teams to collect and analyse data.
- * To investigate the socioeconomic relationship between people and coastal resources.

Long-term:

- * Developing models for the Eastern African Coastal processes.
- * Forecasting of future anthropogenic coastal changes based on models developed in the above.
- * Develop a database for model building and validation.
- * Develop modalities for data and information exchange.
- * Assessment of the future impacts and development of mitigation strategies.

Outputs

- * Economic valuation of coastal ecosystems particularly: mangroves, beaches and coral reefs.
- * Data on socioeconomic forces driving change in coastal ecosystems.
- * Database on socioeconomic processes including relationships between community dependence on coastal resources and rates of change in coastal environment.
- * Conceptual and semi-quantitative models of the coastal processes.
- * Forecasts of anthropogenically induced coastal changes.

Methodology

- * Economic assessment of coastal resources using *inter alia* contingent valuation method - (CVM) and travel cost method (TCM).
- * Surveys will be undertaken in selected study sites to determine the nature and extent of human impacts on coastal ecosystems. Specifically the following techniques will be applied:
 - * Participatory approaches including participant observation.
 - * Key informant interviews.
 - * Resource survey inventory.
 - * Focus group discussions.
 - * Secondary data analysis.
 - * Ethnographic methods.
 - * Social mapping of critical resources.
 - * Case studies.

Table 8: Study sites

Country	Site
Kenya	Mombasa
Tanzania	Zanzibar
Mauritius	Grand Bay
Mozambique	Maputo
Comoros	Moroni
South Africa	Port Elizabeth
Seychelles	Mahe
Madagascar	Nosy be'
Reunion	Port St. Denis
Somalia	Mogadishu

Table 9: Proposed duration: 10 years divided into phases

Phase I	3 years
Phase II	3 years
Phase III	4 years

Table 10: The total estimated budget for all three project elements is as follows:

Budget item	ECU	ECU
Equipment	500,000	500,000
Chemicals	250,000	250,000
Transport	100,000	100,000
Expert exchange and services	150,000	150,000
Field allowance	180,000	180,000
Salaries (scientists, PhD's, assistance)		1,800,000
Miscellaneous	20,000	20,000
Total		3,000,000

From: Report of the IGBP workshop LOICZ IN AFRICA (7-9 August 1995, Hotel Panafric, Nairobi, Kenya.