



The Southern Ocean- South African Cooperative Research Programme

SANCOR

Programme developed by an *ad hoc* working group for
the South African National Committee for Oceanographic Research and
the South African Scientific Committee for Antarctic Research

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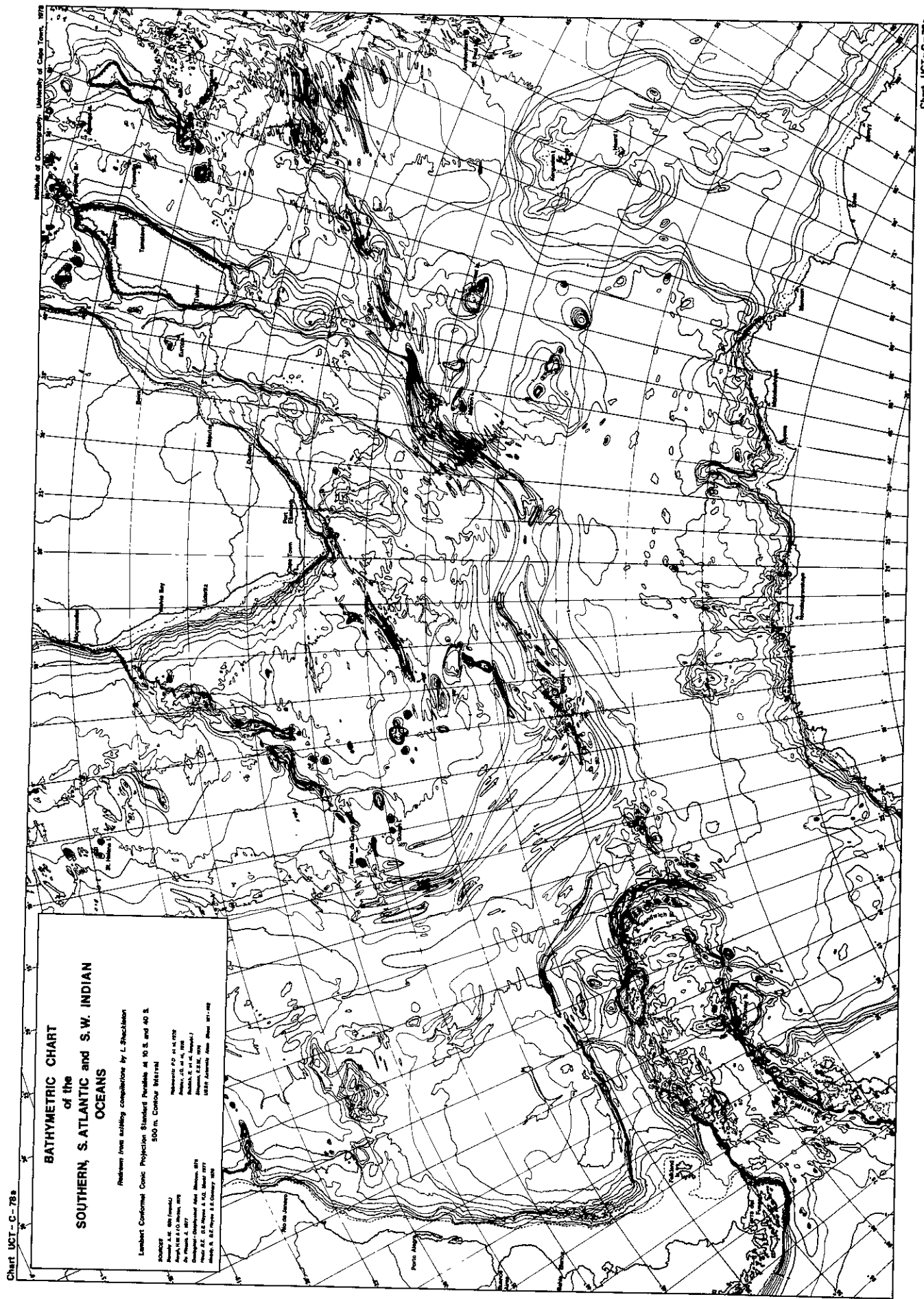
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BATHYMETRIC CHART
of the
SOUTHERN, S. ATLANTIC and S.W. INDIAN
OCEANS

Revisions from sailing computations by L. Shackleton

Lambert Conformal Conic Projection Standard Parallels at 10 S. and 40 S.
500 m. Contour Interval

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Chart UCT-C-78a

Chart UCT-C-78a

PREFACE

At the 27th meeting of EXCOR (the Executive Committee of the South African National Committee for Oceanographic Research) held on 2 November 1976 it was decided to review and clarify South African involvement in Southern Ocean research. A Working Group was appointed, which in consultation with the research groups in the country with an interest in Southern Ocean research, formulated the programme contained in this document.

In subsequent negotiations it has been agreed to recognize the programme as a joint activity of the South African National Committee for Oceanographic Research (SANCOR) and the South African Scientific Committee for Antarctic Research (SASCAR). It will be directed by a Steering Committee which will report to both SANCOR and SASCAR.

SUMMARY

South African research in the Southern Ocean has already produced some important and illuminating results. Most of these efforts, however, were of an individual and uncoordinated nature. Due to increasing interest in this ocean - in South Africa and elsewhere - and to ensure the most efficient possible utilization of limited manpower and facilities, a national programme had to be formulated to achieve the required coordination and cooperation.

Such a programme is presented in this report, compiled in cooperation with all interested parties. It briefly outlines the motivation for South African research in the Southern Ocean and indicates the research objectives of each marine discipline within a coordinated programme. The report also contains a more elaborate list with details and descriptions of each proposed research project.

SAMEVATTING

Suid-Afrikaanse navorsing in die Suidelike Oseaan het tot op hede belangrike en insiggewende resultate gelewer. Die meeste van hierdie werk was egter van 'n individuele, ongekoördineerde aard. Vanweë die toenemende belangstelling in hierdie oseaan - in Suid-Afrika en elders - en om beperkte mannekrag en fasiliteite so voordelig moontlik aan te wend, moes 'n nasionale program saamgestel word om die nodige koördinasie en samewerking te bewerkstellig.

So 'n program is vervat in hierdie verslag, saamgestel in samewerking met alle belanghebbende instansies. Dit skets kortliks die motivering vir Suid-Afrikaanse navorsing in die Suidelike Oseaan en dui die navorsingsdoelwitte vir elke dissipline binne 'n gekoördineerde program aan. Die verslag bevat ook 'n uitvoeriger lys met besonderhede en omskrywings van elke beoogde navorsingsprojek.

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INTRODUCTION

The Southern Ocean is one of the least explored, least exploited, least accessible and least polluted areas of the world ocean. However, this no-mans-ocean surrounding Antarctica has in recent years become the subject of ever-increasing international activity - scientific, economic and political - and international mechanisms for the stimulation of scientific investigation and control of economic exploitation are now being formulated.

In the light of these developments, and with the advent of sophisticated global and local data collection possibilities, including the new research and Antarctic relief ship, SA Agulhas it was necessary for South African research plans in the Southern Ocean to be reviewed and clarified.

Definitions of the Southern Ocean are legion. For the purposes of this document the Southern Ocean - in the Atlantic and Indian sector at least - is accepted in terms of ocean processes as extending northwards to Cape Agulhas and embracing Tristan da Cunha and Amsterdam Islands (say south of 35°S between 20°W and 80°E).

Examination of the objectives of the South African Cooperative National Oceanographic Programme shows that research in this ocean area is justified on grounds of scientific interest, the evaluation of resources and their conservation and for the improvement of weather forecasting.

SCIENTIFIC INTEREST

Scientific study of the Southern Ocean and particularly the area defined above, will yield results of broad general significance. Investigations have already been started by both South African and foreign research groups, often in coordinated programmes. All indications are that the research level will increase and it is incumbent upon this country to maintain and expand its presence in this multi-national effort.

The Antarctic Circumpolar Current is the only ocean current that circumscribes the globe. It has the largest mass transport of any current on earth and affects the flow patterns of South Africa's west coast Benguela Current and the terminal region of the east coast Agulhas Current, which are indeed type examples for analogous currents in the other major ocean basins. Also on a global basis, air-sea interactions near the Antarctic continent produce the Antarctic Bottom Water, which flows north to cover the floor of all the earth's major ocean basins. Because of this unique coupling between ocean and atmosphere it is believed that the Southern Ocean acts as a controlling factor on long term climatic change for the Southern Hemisphere. For these reasons, major research efforts are being directed toward measuring flow and variability of the Antarctic Circumpolar Current and the production of deep water masses.

The ocean segment south of South Africa is dynamically the most active of any portion of the Southern Ocean and the strong oceanographic gradients here make the area particularly conducive to shipboard and satellite study.

Satellite pictures over the last decade have shown very clearly that weather in the Southern Hemisphere is largely dominated by processes in and over the Southern Ocean. Local weather forecasting, particularly for periods longer than one or two days will not improve significantly until more data are acquired.

In the field of marine chemistry, the formation of Antarctic Bottom Water and its subsequent sinking presents a rare opportunity to study the injection and dispersal in ocean water of key trace metals such as nickel and cobalt. These elements are important in metabolic processes and may be of economic interest. Because of the very high surface productivity of siliceous plankton such as diatoms, the Antarctic is also one of the best areas in the world to study the flux of silica between bottom sediment and water. Perhaps of paramount importance, the relatively unpolluted Southern Ocean will serve as a baseline indicator for worldwide studies of the level and transport of pollutants.

Biologically the Southern Ocean is one of the most productive areas on earth. Krill Euphausia superba which is already regarded by many as a fishable resource, is at the heart of a complex ecosystem of other commercially valuable animals. Although krill has a circumpolar distribution, major concentrations are known to occur in areas accessible to South Africa. Adequate conservation of resources will require inter alia information on the impact of exploitation of such organisms as krill on stocks of their predators. South Africa is well-placed to study certain populations of whales, seals and seabirds that are krillpredators.

The Southern Ocean south of Africa has evolved during the past 200 million years through relative movement between Africa, South America, Australia and Antarctica. The marine geoscience programme seeks to gain an adequate understanding of the complex nature of these movements and those of sea-floor sedimentation and igneous activity. These studies are expected to yield important evidence for investigations of exploitable resources and changing oceanographic and climatic conditions.

ECONOMIC IMPORTANCE

When viewing South Africa's economic interest in the Southern Ocean, cognisance should be taken of the status of the Republic's traditional marine resources, the magnitude of the living resources of the Southern Ocean, the possibility of the existence of minerals and fossil fuels, our geographic situation and our expertise in the fields of harvesting and processing of marine resources.

All South Africa's major fisheries are at present maximally exploited and are controlled by means of quotas and other limitations. Any new resources, e.g. in the Southern Ocean, could lead to diversion of fishing effort with the resultant decrease of pressure on and recovery of traditional resources.

Apart from whales and tunas, catch statistics for the Southern Ocean are not readily available, but other exploitable stocks include small mesopelagic fish, cephalopods, seals and crustaceans (including krill). Current estimates are that the annual yield of krill may be as high as 100 million tons - almost double the world marine fish catch recorded in 1975.

At this stage one can but speculate about the potential mineral wealth and the possibility of finding fossil fuels in the Southern Ocean. The implications of such developments are self-apparent.

Geographically the Republic is placed most advantageously to harvest Southern Ocean resources, with possibly only Chile and the Argentine better located. In a world facing severe resource crises, the value of our relative proximity to some of the remaining untapped resources cannot be over-emphasised. Our considerable expertise in the field of marine exploration and the capture, processing and marketing of fishery products is another important consideration.

PAST AND CURRENT RESEARCH ACTIVITIES

This document is aimed specifically at providing a framework for future South African research activities in the Southern Ocean and its scope does not permit a review of the history of research in the area.

Suffice it to say that South African oceanographers have been involved in most major international research programmes in the Atlantic and Indian sectors of the Southern Ocean in the recent past, and are participating or planning to participate in current or future programmes.

In spite of limited facilities, South African scientists have already achieved results of international importance in the fields of marine geophysics, acoustic studies of krill, palynology, and studies of seals, birds, whales and fish.

Past research effort has been constrained by the lack of suitable deep sea research vessels but this situation has already improved with the commissioning of the S A Agulhas and is expected to improve further when a new deep sea fisheries research vessel is acquired. Opportunities also exist for working on foreign vessels or for foreign groups to participate in programmes undertaken off South African vessels. It may, for example, be possible for South African scientists in contact with groups from other countries to use the S A Agulhas to fill the data gap left in the South Atlantic and South West Indian Oceans through the circumpolar programme of the USNS Eltanin not being completed.

Furthermore the numerous satellites already operational or planned for the near future provide a valuable tool for studying the Southern Ocean, and South African oceanographers have made use and are planning to make increased use of satellite data. However, such data are confined to the surface of the sea and will not eliminate but complement the need for shipborne data.

FUTURE RESEARCH

OBJECTIVES

This multidisciplinary programme has been designed to concentrate on work which, because of available expertise or because of geographical position, is particularly suited to be undertaken by South African groups. It takes due regard of international programmes in the area and aims specifically at complementing and not duplicating the efforts of other nations. The agreed objectives within each of the major disciplines are:

BIOLOGY

- To contribute to knowledge of standing stocks and population dynamics of selected living resources in the Southern Ocean, their interaction with other elements of the ecosystem and to help establish systems for monitoring these resources.
- To undertake research designed specifically to complement but not duplicate the efforts of other nations, within the framework of BIOMASS and other relevant international studies in the Southern Ocean.
- To contribute scientific information required for the conservation and rational utilization of the living resources of the Southern Ocean.

PHYSICAL OCEANOGRAPHY

To reach a better understanding of selected physical processes within the Southern Ocean and their relation to the ocean adjacent to the South African coast and the weather and climate affecting the sub-continent.

MARINE CHEMISTRY

To obtain an understanding of the distribution of chemical elements in the Southern Ocean by studying the variability of the trace element content of sea water, sediment and particulate matter including plankton.

MARINE GEOSCIENCE

To contribute to an understanding of the structure and history of development of the Southern Ocean floor through geological, geophysical and geochemical studies.

RESEARCH REQUIREMENTS

The remainder of this document contains statements on the most important scientific problems within each of the major disciplines, and suggestions as to which organizations or institutes have an interest in these problems and where funds could be sought.

BIOLOGY

WHALES

In the sixty years since Antarctic whaling started, a considerable amount of data on the distribution, abundance, movements and biology of baleen whales within the Antarctic has accumulated, mainly as a by-product of the industry-associated research. It is therefore unlikely that the relatively small temporal and spatial coverage that could be provided by South African vessels visiting the Antarctic would contribute much that is new. It would be preferable to investigate baleen whale stock units, their size and migration routes to the Antarctic, by conducting research outside the Antarctic during winter, coincidental with the breeding season and migration of baleen whales. Such investigations would be facilitated by the higher densities, predictable locations of whales on the breeding grounds and the better weather conditions, so that a limited temporal and spatial coverage might prove sufficient to monitor population size and trends in abundance. Counts of calves would also provide a direct measure of recruitment. The success of such an approach has been demonstrated by the annual right whale surveys carried out by the Sea Fisheries Branch, and comparable monitoring of a protected krill-eating species (such as the blue or humpback whale) would provide an interesting comparison with the copepod-eating right whale. South Africa is particularly well-placed to make a unique contribution in this field as her research vessels will usually be based closer to the breeding grounds of southern baleen whales in winter than those of northern hemisphere nations.

South African research on killer whales is concentrated at Marion Island and focuses on studies of the behaviour of the whales.

Survey of possible breeding grounds of blue and humpback whales in the southwestern Indian Ocean

Organization: Sea Fisheries Branch
Funding: Institutional

Reports suggest that a concentration of blue and humpback whales may exist south of Madagascar during the austral winter. It is proposed that this area should be searched, in a grid fashion, for whales during June-July and that all whales encountered be marked and photographed. If the initial survey is successful, then future annual surveys should allow estimates to be made of population size and trends in abundance.

Annual surveys of right whales along the coast of South Africa

Organization: Sea Fisheries Branch
Funding: Institutional

Annual surveys of right whales along the coast of Southern Africa are carried out using aerial counts and various behavioural and other biological studies. These observations provide more reliable information on population changes than observations in the Antarctic feeding grounds where they are dispersed.

Population and behavioural studies of killer whales at Marion Island

Organization: Mammal Research Institute
Funding: SASCAR

Killer whales occur regularly at Marion Island during the austral summer, their occurrence being very closely synchronized with the occurrence of southern elephant seals. The population of elephant seals at Marion Island has been declining since 1965, possibly even since the late 1950's and killer whale predation is at least one of the responsible factors for this decline.

The seasonal occurrence of the killer whales at Marion Island, and aspects of their behaviour have been studied. The next phase of the project entails the estimation of the actual number of killer whales occurring there during the austral summer, more detailed behavioural studies, and regular monitoring to determine whether or not the population that visits the island is increasing, displaying strong fidelity to the island hunting ground and has synchronized its occurrence at the island with the occurrence and breeding cycle of penguins and fur seals.

Most of these studies will be conducted from the shore, but if individual marking is required, it may be necessary to operate on occasions from the ship and a high speed dinghy.

Studies of Southern Ocean cetaceans reaching the coasts of South Africa

Organization: Port Elizabeth Museum, Sea Fisheries Branch,
South African Museum
Funding: Institutional

Stranded cetaceans and other marine mammals appearing on the coasts of South Africa are collected and studied. The biology of almost all of the smaller whales and dolphins of the Southern Ocean is very poorly known. Studies of series of stranded specimens can provide information on morphology, variability, range, reproduction and feeding.

SEALS

South African research on Southern Ocean pinnipeds was initiated on Marion and Prince Edward Islands in August 1973, in the pack ice in the King Haakon VII Sea

off the Fimbul Ice Shelf in January 1974, and on Gough Island in November 1974. From 1973 to 1978 five years of continuous fieldwork was conducted on the Prince Edward Islands (mainly Marion Island), one complete year plus two summers (October to March) on Gough Island and four seal censuses in the pack ice in the King Haakon VII Sea (January and February). Considerable basic biological data have been accumulated and published (or are in press and/or in preparation). In summary, these data concern estimates of total population sizes, seasonal changes in terrestrial distribution and seasonal changes in numbers hauled out on the islands, pup growth, local movement (e.g. around Marion Island and between Marion and Prince Edward Islands), population dynamics, reproductive potentials and population trends. The overall seal programme is now well poised to focus in on specific aspects necessary to complement national programmes (e.g. Marion Island terrestrial mineral and energy cycles) and international programmes (e.g. BIOMASS).

Temporal and spatial distribution and trophic relationships between seals (*Mirounga leonina*, *Arctocephalus tropicalis* and *A.gazella*) which occur at the Prince Edward Islands and their mineral and energy inputs to the terrestrial ecosystem of Marion Island

Organization: Mammal Research Institute
Funding: SASCAR

Since 1973 the following quantitative data have been obtained; sex and age specific seasonal changes in terrestrial distribution and numbers hauled out, total population sizes, population trends, reproductive potentials, life tables, and age and sex specific local movement (i.e. around Marion Island and between Marion and Prince Edward Islands), growth and development of pups, stomach contents and some behavioural aspects. An estimate of total seal biomass by species occurring on Marion Island each month has been obtained, and this has enabled a theoretical projection of total food consumption by the populations concerned. Further research is necessary to provide quantitative data to replace these theoretical considerations, to investigate in greater detail terrestrial and oceanic spatial and trophic competition between the populations of each species, and to quantify the terrestrial energy and in particular mineral output from these populations. Biochemical and genetical studies are necessary to understand the relationship between the two fur seal species and to determine whether such techniques can be used to identify separate populations of the same species.

Biology of the Ross seal (*Ommatophoca rossi*)

Organization: Mammal Research Institute
Funding: SANCOR

The Ross seal is the rarest of the four Antarctic seal species, and therefore probably has the most specialized environmental requirements.

It is therefore also likely to be amongst the most sensitive species to environmental perturbations and a useful indicator and monitor species of changes in the environment, in particular changes in its food supply and the food chain. Virtually

nothing is known about this species, and no Ross seal pups have ever been seen. For as yet unknown reasons, one of the highest densities of Ross seals ever recorded occurs in the pack ice adjacent to SANAE (between 1°E and 6°W), and therefore South Africa is in a unique position to conduct this study. Four censuses already conducted in this area provide all the necessary background data and practical experience. The main objectives of this study are to determine the size and trend of the local population, its distribution, to investigate in depth its trophodynamics and ultimately to determine why such a unique population occurs in this area. (Aspects of physical and chemical oceanography are involved in these investigations).

Spatial and temporal distribution of seals in the pack ice

Organization: Mammal Research Institute
Funding: SANCOR

Seals in the Southern Ocean, in particular the four pack ice inhabiting species, appear to have overtaken the baleen and toothed whales as major consumers of krill and also possibly squid and fish. It has been estimated that seals in the Southern Ocean consume 80 million tons of food annually, of which krill comprises about 80%, squid 9% and fish 8%, with penguins and young seals comprising the remainder. Seals may be the largest consumers of krill, fish and squid in the Southern Ocean, and therefore it is necessary to monitor their population sizes and distribution since they may be among the best indicators of changes in the status of these food resources. In the area adjacent to SANAE (1°E to 6°W) which is readily accessible to South Africa, censuses have indicated a relatively large population of crabeater seals (krill consumers), and small populations of Weddell seals (fish, squid and krill consumers), and leopard seals (fish, penguin, seal consumers), in addition to the uniquely high population of Ross seals (thought to be squid consumers). This study entails marking of as many seals as possible, and routine aerial censusing once every two to four years. It can be carried out at the same time as the Ross seal project above, both studies complementing each other.

Spatial and temporal distribution of seals in the sub-Antarctic

Organization: Mammal Research Institute
Funding: SASCAR

This project is aimed at following the dispersal of pinnipeds from Gough, Marion and Prince Edward Islands, and as was done in 1977/78, Crozet and Kerguelen Islands as well, in collaboration with TAAF. Immigration and/or emigration may be influencing the observed changes in population sizes of fur seals (A. tropicalis and A. gazella) and elephant seals (M. leonina) at all these islands.

Tagging is conducted at each island and together with investigations of genetical and biochemical markers, the amount of immigration/emigration or the discreteness of each population will be estimated. The Mammal Research Institute has been asked to process some eight years of tag resighting data collected by TAAF on Kerguelen, and together with five years worth of its own data from Marion, Gough and Prince Edward Islands this represents a unique sample. This is

a long term project, with tagging conducted on an opportunistic basis at Gough and Prince Edward Islands, and on a planned basis at the other islands.

BIRDS

South African ornithological research in the Southern Ocean has concentrated on elucidating the roles played by selected species of sea birds in the transport of minerals and energy to, and in, the ecosystems at Marion Island. The species chosen for study include all the abundant, surface-nesting, diurnal species. Guano, feathers, eggs, egg-shells and corpses of birds remaining on the islands form an increment to the island's energy and mineral systems. The project has been designed to provide quantitative data on the avian-derived contributions of energy and chemical elements (P, N, S, Ca, Na, K, Zn, Mn) to the island. The ultimate objective is to provide estimates of these 'inputs' in relation to both time and space. Thus, it is intended to reveal how much calcium, for instance, is contributed by birds (at individual, species' population and community levels) and when (month) and where (1 km² quadrates) the calcium is deposited. Estimates of annual 'inputs' will be available for most of the diurnal, surface-nesting birds at the conclusion of the 1973-1978 phase of the project.

Population dynamics and general biology of sea birds on Marion and Prince Edward islands with particular reference to their mineral and energy input in the ecosystem

Organization: Percy FitzPatrick Institute, University of
Cape Town
Funding: SASCAR

There are at least 13 species of burrowing petrels (*Procellariidae*) at Marion Island. These birds are nocturnal and many breed inland at relatively high elevations. They will, therefore, be much harder to 'work with' than the species studied in 1973-1978. It is likely that a period of ten years of study will be necessary before our state of knowledge will be roughly equivalent to that gathered for the diurnal species in 1973-1978.

Spatial and temporal distribution of Antarctic sea birds

Organization: Percy FitzPatrick Institute, University of
Cape Town
Funding: SASCAR and SANCOR

Biological information on sea birds which breed at Marion Island and elsewhere in the Antarctic and sub-Antarctic, is almost lacking for that portion of the year when the birds are at sea away from their breeding grounds. Studies of sea birds at sea are now sponsored by most of the developed maritime nations and South Africa has been asked to cooperate with, and to contribute to, a programme of research involving sea birds at sea. The project will be designed to supplement and complement the land-based studies of sea birds breeding at Marion Island. The present land-based studies at Marion Island cover only about 40% of the life cycles of the sea birds breeding there; perhaps less when we consider that at any time, a

large part of the population is away at sea collecting food or does not return to land for several years. A primary aim is to discover the feeding grounds and to describe the food of the avian populations which breed at Marion Island.

Sea birds as indicators and monitors of krill and other marine living resources

Organization: Percy FitzPatrick Institute, University of
Cape Town
Funding: SANCOR

The primary objective is a series of feasibility studies of techniques, such as satellite imagery, for monitoring selected bird populations potentially useful as indicators mainly of the dynamics of krill distribution and abundance. It has been estimated that seabirds in the Southern Ocean consume about 30 million tons of food annually, of which 20 million tons are taken in the sub-Antarctic region. The amount of food consumed is equivalent to about 10% of the amount of krill available in summer. About 23%, 30% and 11% of the world's sooty albatrosses, King penguins and Macaroni penguins respectively are based at the Prince Edward islands. The sooty albatross feeds mainly on squid and the Macaroni penguin feeds on krill. Thus these two birds can be regarded as potential candidates for indicators for monitoring changes in availability of krill and/or squid in an area surrounding the Prince Edward islands.

FISH

There are about 160 species of fish known from south of the Antarctic Convergence of which about 99% are endemic. They may be broadly divided into benthic species and pelagic species. Exact data on the annual catch rate of fish in the Southern Ocean are not available, but it has been estimated that 700 000 tons were caught in the first six months of 1973. Benthic fishing is necessarily limited to the shelf and slope regions of oceanic islands but, because of the nature of the ground, it presents problems. The pelagic ichthyofauna around the sub-Antarctic islands, is poorly known, could be sampled with relative ease and would form a part of the nekton sampling programmes which have been proposed both by SASCAR and the Southern Ocean programme.

Studies of pelagic fishes of Antarctic and sub-Antarctic areas

Organization: South African Museum and J L B Smith Institute
of Ichthyology
Funding: SANCOR

Lantern fishes (fam Myctophidae) are the most important group of pelagic fishes in Antarctic water, but the 'Antarctic herring' (Pleurogramma antarcticum) may represent a further exploitable stock in the region of the East Wind Drift. Most pelagic species in the Southern Ocean are circumglobally distributed and extensive sampling has taken place in certain regions, but not south of South Africa. Material from this region would be forthcoming from krill sampling cruises.

Possible investigations in the Haakon Sea area could be keyed into the mammal research proposals. Because of the multidisciplinary nature of the proposal, costs can be shared with other programmes. Stations to be run during the relief cruises to Marion and Gough Islands and to SANAE. Star transects to be run around the islands and sampling stations in the King Haakon VII Sea. Opening/closing nets to be employed, as per macroplankton and krill programmes.

KRILL

A general picture of the distribution and life-history of Euphausia superba has been built up over the years, but specifics are lacking. Four problems require urgent attention:

- identification of stocks and races
- hydrological features of high as well as low population densities and swarm behaviour
- transport of early larval stages
- changes in abundance

Two 'populations' have been recognized in the region to the south of South Africa and between approximately 10°E and 40°E, namely the suspected Scotia Arc-Weddell Sea and Enderby populations. The Weddell Sea and Weddell Drift are two of the most biologically productive areas of the Southern Ocean, and the ones most likely to be exploited. Maintenance of the stock is little understood, but the key may lie in the region 20°E - 30°E, where the Weddell Drift dissipates itself and a southward flow has been suggested. The productive region off Enderby Land, which extends further to the west in austral summer, is separated from the Weddell Drift region by an area of low productivity.

Krill assessment programme

Organization: Department of Oceanography, University of Cape Town, Sea Fisheries Branch and South African Museum

Funding: SANCOR, Sea Fisheries Branch, UCT

As krill occupies a central position in the Southern Ocean ecosystem and is potentially the largest single species fishery known, the development of methods for population census are of the highest priority. Acoustics offer the best means to accomplish this end in the next five to ten years at least, and the results of the 1978 Protea cruise indicate that the manpower and equipment resources are available for meaningful research to be accomplished.

It is proposed to conduct fundamental research into problems of hydro-acoustics theory, hardware specification, data processing, survey strategy and to conduct one cruise per year until 1980/81 when a major review will be undertaken.

A role has been accepted in the design of the BIOMASS krill assessment programme, which implies a measure of influence on the way in which the international multiship research cruises and surveys will be implemented.

The specific research programmes envisaged are:

- Working-up all data from Protea 1978;
- The development of a real-time software echo-integrator for national and international use;
- The development of a towed multitransducer underwater vehicle for national and international use;
- The development of theories of krill survey strategy;
- The conducting of fundamental research into echo- integration theory;
- The conducting of research with computer simulation models on the influence of transducer design on the detection and quantification of multiple target sound scatterers;
- The conducting of survey work on krill to test theory, hardware and software developments on a real population.

PLANKTON AND PELAGIC INVERTEBRATES

In view of the limited facilities and manpower that will be available it seems desirable to concentrate marine biological studies in a few fields of special importance. The preliminary marine biological studies that have been carried out, indicate the vital significance of plankton and pelagic invertebrates to the overall ecology of the Antarctic seas and sub-Antarctic Islands. Research is required, particularly on:

- the distribution and biomass of plankton and pelagic fauna in relation to the feeding of sea birds and seals
- the identification of food items consumed by sea birds and seals
- the marine component of the Marion Island ecosystem including the primary production of phytoplankton and macrophytes and fluctuations of abundance of marine fauna on and around the coasts of the islands
- primary productivity of phytoplankton in the Southern Ocean.

The sophisticated work which is already in progress in South Africa on the Southern Ocean sea birds and marine mammals makes studies of their pelagic food resources important. Data on pelagic food chains in the Southern Ocean will be significant in the overall understanding of Southern Ocean ecosystems.

Primary productivity and phytoplankton

Organization: University of Cape Town, Rhodes University, Sea Fisheries Branch /
 Funding: SASCAR and SANCOR

It is suggested that the methods of Prof S El Sayed be followed to provide results that will be comparable with the large amount of data he and his colleagues have already established. Water samples must be collected at various depths in the water column for cell counts and the determination of total chlorophyll and phaeophyton pigments. The contribution of nannoplankton to the total standing crop must be determined by filtration. Primary production of total phytoplankton and nannoplankton must be determined with water samples from depths corresponding to various percentages of surface light intensity. Incubation should be in situ where possible for at least two hours in flasks suspended on frames at the collection depths. Vertical phytoplankton net hauls must be made between to determine the species composition of phytoplankton. The depths to which various percentages of surface light intensity penetrates must be determined. Environmental data including temperature, salinity, pH, alkalinity, oxygen and nutrient profiles will be required.

Ocean colour-phytoplankton relationships

Organization: Department of Oceanography, School for Environmental Studies,
 University of Cape Town and Department of Zoology, Rhodes
 University
 Funding: SASCAR and SANCOR

Phytoplankton is the food of krill, and this predator/prey relationship is the subject of considerable research effort overseas. In particular, the Nimbus-G experiment will cover the Southern Ocean to describe circum-Antarctic chlorophyll distributions in space and time, but the only work on ocean colour in that area was conducted from the Protea in 1978.

It is therefore proposed to continue to investigate phytoplankton, plant pigments and ocean colour relationships through analysis of ground truth and satellite data collected synchronously. In addition, as the proposed ocean colour research could be conducted in the same area as acoustics studies, it becomes possible to relate large-scale krill distributions to chlorophyll distribution. Primary production studies have an important role and should be accomplished during the same cruise.

Distribution and biomass of plankton and pelagic fauna in relation to the food of sea birds and seals

Organization: School of Environmental Studies, University of Cape Town
 and South African Museum
 Funding: SASCAR and SANCOR

If an understanding of the biology of seals and sea birds in the Southern Ocean and around the Islands is to be achieved, it is essential that studies of the marine organisms which form their food, be carried out. This involves studies of plankton

and other pelagic fauna. Plankton studies will include zooplankton standing crop. Other pelagic fauna will be sampled quantitatively as far as possible by means of pelagic trawls and neuston nets. These studies must be carried out not only in the major areas of interest such as immediately around Marion Island and in the King Haakon VII Sea, but also elsewhere in order to provide comparative data.

A knowledge of the distribution and biomass of plankton and pelagic fauna in relation to the food of sea birds and seals is important if an overall understanding of the biology of seals and sea birds in the Southern Ocean is to be achieved.

Identification of food items consumed by sea birds and seals

Organization: School of Environmental Studies, University of Cape Town
and South African Museum
Funding: SANCOR and SASCAR

This research is required as a service to the programmes on marine mammals and marine birds. The identification of food items is often difficult particularly when they are fragmentary or partially digested so it is desirable that this work should be carried out by biologists familiar with the particular species or organisms concerned. Identifications may depend on parts such as fish otoliths, squid beaks and crustacean appendages. As most of the organisms will be the pelagic and planktonic species being studied in the project on the distribution and abundance of food organisms it is logical that this service to the mammal and ornithology programmes should be carried out by the same marine biology group.

Quantitative studies of the coastal fauna and flora of Marion and Prince Edward Islands

Organization: School of Environmental Studies, University of Cape Town
Funding: SASCAR

If an understanding of the ecology of Marion Island is to be achieved, it is important that quantitative studies of the coastal fauna and flora be carried out. The primary production and biomass of phytoplankton and marine macrophytes and fluctuations of biomass of marine fauna require study. Up to the present, work has been limited to taxonomic descriptions presented in the Marion monograph, descriptive intertidal ecology published recently and studies of hydrology, plankton and benthic fauna around the Islands carried out during a cruise of the Marion Dufresne. Shore based studies to provide quantitative data on coastal phytoplankton and macrophytes, marine invertebrates and fishes are now required. A good basis for this work has been provided by the abovementioned preliminary descriptive studies. Work on marine mammals, sea birds and plants is now at a sophisticated level, so more intensive marine biological work is required to reach a comparable level for a balanced ecosystem study.

Studies of planktonic Copepoda in the Southern Ocean

Organization: South African Museum
Funding: Institutional

Studies of planktonic Copepoda collected in the Southern Ocean by ships of the Sea Fisheries Branch and the South African Weather Ship are in progress.

ASSESSMENT OF COMMERCIAL POTENTIAL

Krill

Organization: Sea Fisheries Branch
 Funding: Institutional

It is unlikely that commercial exploitation of krill by South Africa will be initiated without a trial fishing operation. This operation is likely to be expensive, and a decision to implement it would depend on the outcome of a review which is designed to establish the probability of a successful krill fishery by South Africa. This will be conducted in 1979, and representatives from the Fishing Industry Research Institute, the Fisheries Development Corporation, Department of Industries, Council for Scientific and Industrial Research as well as other organizations will be asked to participate. If the outcome of this review indicates that such a fishery is indeed feasible, some form of subsidy will be required, to send a vessel to the Southern Ocean with the objective of testing gear and vessel suitability as well as to provide material for investigations into processing and marketing problems.

A large trawler with freezing and limited meal producing facilities would be suitable, but at the present it is premature to speculate further about such a trial. In addition to research aimed at establishing the viability of a South African krill fishery, certain studies can be conducted which would contribute towards determining more rational fishing methods or aid in assessing stocks.

Assessment of other exploitable resources

Organization: Sea Fisheries Branch
 Funding: Institutional

Apart from krill, South African scientists have conducted fisheries assessment research on other important species in the Southern Ocean and these efforts should continue. Certain important whale stocks in the Southern Ocean have been harvested by South Africa on their annual migration to more northerly latitudes. South African whaling has ceased, but could well recommence as stocks improve. In addition, attempts to harvest krill will probably have to be defended on the ground that this activity is not adverse with regard to whaling operations. At present South Africa plays an active scientific role in the International Whaling Commission and this should be continued.

Research on whaling is funded by the Sea Fisheries Branch. Rock lobster stocks occur at Gough Island and Tristan da Cunha Island and are currently being monitored by South African scientists. Each year complete fisheries data are collected and management advice is provided. This work will continue in the future. There is also a need to establish whether rock lobster or crab stocks occur off other islands such as Marion. Such information could be collected by short-term experimental fishing by ships of opportunity. Other exploitable resources in the Antarctic include fish and possibly cephalopods. Effective evaluation of these would require trial fishing and probably acoustic surveys.

INFORMATION MANAGEMENT

Specification of information management system for BIOMASS

Continuation by: Department of Oceanography, University of Cape Town
 Funding: SANCOR, Sea Fisheries Branch and UCT

BIOMASS identified the need for biological, chemical, physical and catch statistics research, as well as the use of unconventional systems such as acoustics and remote sensing methods, but did not propose the development of a fisheries information management system to integrate these diverse data types into a single coherent unit. Instead, it was proposed that a central organization should catalogue, compile and process information derived through national and world data centres using established arrangements for data exchange.

This proposed system relies heavily on the exchange of data between institutes with the result that no data system would have a full set of the relevant information, and that different centres will continue to treat their data in different ways. An alternative approach is for all data to be acquired from all sources by a regional data centre where the input of data to a data base is rigorously controlled. At routine intervals the updated information in the regional data base can be transmitted to local data bases in other countries. In this way all data will be available to all users in a common format, regardless of the way the data were presented to the data base. The specification of such a system would be a useful contribution to BIOMASS or successor organization and to the needs of developing Southern Ocean fisheries.

PHYSICAL OCEANOGRAPHY

AGULHAS RETROFLECTION AREA

Organization: NRIO and Weather Bureau
 Funding: Institutional

The importance of the area in which the Agulhas Current interacts with the Agulhas Return Current, the Sub-tropical Convergence and sharply varying bottom topography has been shown to be of particular importance for the energy balance of the Southern Ocean. The key to the understanding of the dynamics of this part of the Southern Ocean, eddy formation in the area and their influence at greater distances, lies in the retroflection area south of Cape Agulhas.

Studies of the area with satellite remote sensing techniques are in progress while the addition of drifting buoy measurements is also envisaged. A number of three week cruises, preferably in summer, should be undertaken to establish the dynamics in depth.

BOTTOM CURRENTS

Organization: NRIO
Funding: Institutional

The distribution through the world ocean of bottom water formed off the Antarctic coast is only partially understood. Especially in the Southern Indian Ocean with its many ridges and plateaux, our knowledge is very limited and the potential for a research contribution with global impact exists.

It is proposed that two two-week cruises, preferably during summer, be undertaken with lines of stations running from Cape Town, one over the Agulhas Plateau to the Mid-Indian Ridge, (southwest of Marion) and the other across the Mozambique and Madagascar Ridges, measuring physical oceanographic parameters to the bottom. The first cruise could form part of a Marion relief cruise. Results should be obtained comparable with those in the eastern Indian Ocean and east of Madagascar where it was found that bottom water moves northwards in narrow western boundary currents.

EDDY FORMATION AND MESO-SCALE PHENOMENA

Organization: NRIO
Funding: Institutional

The formation of meso-scale eddies and their energy transfer potential is of major importance in the understanding of ocean dynamics. Important work has already been done on eddies in the Sub-tropical Convergence, the retroflexion area and the south west Indian Ocean.

It is proposed that studies of these three areas with XBT's and remote sensing techniques be continued. One XBT line between Cape Town and SANAE has already been undertaken and will be repeated together with CTD work within the ISOS programme. The other areas are traversed by the SA Agulhas during its relief voyages to Marion and Gough Islands. The Cape Basin with its near flat bottom topography is of even greater importance for theoretical physical oceanography, but here a three week, two ship cruise in summer will be necessary.

POLAR FRONT

Organization: NRIO
Funding: Institutional

The dynamics and spatial variability of the Antarctic Polar Front is one of the gaps in knowledge of the Southern Ocean and is being investigated within the ISOS programme through XBT's and remote sensing techniques.

It is proposed that South African involvement in this study, through the XBT line between Cape Town and SANAE and the interpretation of satellite data, be continued and supplemented by CTD data in future. Through a cooperative project the work may be extended in future to include a line to Kerguelen.

WEDDELL GYRE

Organization: NRIO
Funding: Institutional

The eastern boundary of the Weddell Gyre is incompletely described and of great biological importance due to a sharp transition which has been found between the Weddell Sea current, well populated with krill larvae and the relatively barren conditions further to the east.

This area is situated south of South Africa, is regularly crossed on relief voyages and lends itself to multidisciplinary (physics, chemistry, biology) cruises in summer which can be complemented by remote sensing data to provide insight into the problem.

CIRCUMPOLAR CURRENT VOLUME TRANSPORT

Organization: NRIO
Funding: Institutional

Within the ISOS programme attempts are being made to determine the volume transport of the ACC through the measurement of deep sea pressures north and south of the current. Suitable sites for such measurements exist south of Africa and a joint project deploying deep sea pressure gauges off the SA Agulhas in summer is being planned.

REMOTE MONITORING OF PHYSICAL PHENOMENA

Organization: NRIO and University of Cape Town
Funding: Institutional and SANCOR

Many multidisciplinary problems will become tractable only if a long-term study of the physical factors and variability in the Southern Ocean has been accomplished. Towards this end a study of this area, making use of NOAA-5, Nimbus-G, Meteosat and Tiros-N remote sensing satellite products and satellite tracked drifters, is being undertaken. A study of atmospheric storm-ocean surface interaction as evidenced by changing wave spectra on the South African coastline also continues.

MARINE CHEMISTRY

DISTRIBUTION OF CHEMICAL ELEMENTS IN THE SOUTHERN OCEAN

Organization: NRIO and University of Cape Town
Funding: Institutional and SANCOR

Earlier physical and biological studies acquired data on oxygen and nutrients (phosphate, nitrate, silicate), but there is almost no information on other chemical constituents. The high primary productivity of the Southern Ocean suggests that

very extensive uptake and subsequent release of micronutrients must occur. The limited data available for silicate indicate a large flux from sediment to ocean, enriching bottom water, and it is probable that similar large fluxes of other elements take place across the sediment-water interface, influencing Bottom Water and then entering the deep basins of the world ocean. The effects of ice formation and melting on chemical constituents are not known. Any effort to construct a geochemical balance in the world ocean must consider the element contributions from the Southern Ocean - at present these are poorly understood.

It is proposed that samples be collected initially at ten stations spaced about 200 nautical miles apart on the line between Cape Town and SANAE. Standard oceanographic parameters (T, S, O, Nutrients, CTD or XBT) will be measured at standard depths at each station to establish the physical oceanographic framework and samples for trace elements (Pb, Cd, Cu, Ni, Fe, Co, Zn, Mn - both 'particulate' and 'soluble') collected at a number of selected depths.

Plankton tows, using a non-metallic closing net, will be done at selected stations at selected depths for trace element analysis of the bulk plankton and sediments will be sampled for interstitial water chemistry and general mineralogy.

AGULHAS INTERACTION AREA

Organization: NRIO
Funding: Institutional and SANCOR

The Sub-tropical Convergence zone is noted for an increase in surface trace element concentration and this area is considered to be a source for the water upwelling along the west coast which supports South Africa's major fisheries. The use of chemical tracers to delineate penetration of Agulhas water into the Atlantic has already been demonstrated and should be of assistance in understanding this complex region.

METEOROLOGY

ACQUISITION OF REAL-TIME METEOROLOGICAL DATA FROM THE SOUTHERN OCEAN

Organization: Weather Bureau, NRIO and NITR
Funding: Institutional

With the computerization of its telecommunication system and the introduction of numerical methods of analysis and prognosis in 1976 the Weather Bureau acquired a capability to collect and process large quantities of data in real-time. Since then all available conventional as well as satellite derived temperature and wind data for the Southern Hemisphere have been processed on a routine basis. With the launching of Meteosat valuable additional data became available for the African sector of the hemisphere and full use is also being made of these data.

One of the very encouraging features of the numerical system has been the degree of success attained with it in spite of the fact that the real-time data base is still

completely inadequate in an important respect. To determine the three-dimensional mass structure of the atmosphere it is necessary to specify the pressure at a reference level. Sea-level is normally used as a reference level but conventional sea-level data in the Southern Hemisphere are completely inadequate for this purpose.

One of the most important objectives of the South African Southern Ocean cooperative research programme is therefore to promote the acquisition of real-time meteorological data from the Southern Ocean by means other than fixed, manned land stations e.g. buoys, fixed automatic weather stations and satellites. An NRIO-Weather Bureau feasibility study which took place during 1975-1976 showed that small, expendable drifting buoys have the potential to provide meteorological data at sea-level and it is planned to launch about 20 similar buoys for the FGGE.

Regular pressure data from a network of drifting and anchored buoys will improve the Weather Bureau's routine analysis markedly and will result in more accurate numerical prognoses and numerical predictions of ocean waves.

RESEARCH ON LONGER TERM VARIATIONS IN THE INTENSITY OF THE CIRCUM-POLAR VORTEX OF WESTERLY WINDS

Organization: Weather Bureau
Funding: Institutional

Variations in weather conditions on a time scale of one to two or three weeks are usually attributable to planetary scale waves in the circum-polar vortex of westerly winds. The Southern Hemisphere atmospheric circulation is more intense and its mean monthly circulation more zonal than that of the Northern Hemisphere.

It has been known since the International Geophysical Year, however, that planetary scale waves, with amplitudes comparable to those in the Northern Hemisphere, also occur in the Southern Hemisphere. Planetary scale waves can be studied only with the aid of hemispherical analyses and the routine numerical, hemispherical analyses of the Weather Bureau are providing a valuable data base for research of this nature.

MARINE GEOSCIENCE

SOUTHWEST INDIAN RIDGE

Organization: Bernard Price Institute of Geophysical Research,
University of the Witwatersrand
Funding: SANCOR

The sea floor north and northwest of Marion Island and a swathe between Cape Town and SANAE have now been mapped and dated in some detail using marine

geophysical techniques. Most of this increase in knowledge has been a result of surveying carried out on the RSA. A qualitative model for the plate tectonic motion between Africa and Antarctica over the past 180 million years has been developed (SANAE was near southern Mozambique 180 million years ago). The area south and west of Marion is poorly mapped but is of considerable interest because one of the biggest transform faults in the world passes through the area. The structure and age of the Africa-Antarctic Basin and of the Southwest Indian Ridge and its relationship with the Antarctic continental margin is also not known in detail. Future studies will focus on these areas with the ultimate goal of fitting Antarctica to Africa as parts of Gondwanaland. When dredging and coring capabilities are available on the Agulhas it is also proposed that studies be carried out on aseismic ridges and plateaux such as the Agulhas Plateau, Maud Rise, Ob and Lena Seamounts, in an effort to understand their evolution.

STRUCTURE AND ORIGIN OF CAPE BASIN AND AGULHAS BASIN

Organization: Geological Survey
Funding: Institutional

South African institutions, notably the Bernard Price Institute of Geophysical Research, have been active in the study of the sea-floor spreading history of the 'Southern Ocean' (Southwest Indian Ridge) for more than 10 years and have made many advances in our knowledge of the past motion of Antarctica relative to Africa. A major remaining problem is an understanding of the motion of this Antarctica/African system relative to the Africa/South American system. The key to its solution lies in the study of the age and origin of the sea floor and various plateau, ridges and seamounts located in the Agulhas and Cape Basins.

The two most important techniques to be employed in the study of the basins will be magnetometric traversing and continuous seismic reflection profiling. The first technique will be used to map the spatial distribution of dateable Cenozoic and Mesozoic magnetic lineaments and the seismic profiles will be used to study sedimentation. Deep-sea sedimentation is complexly influenced by sea-floor topography and bottom-water flow and it is possible that an understanding of the past sedimentation in the Basins will lead to an insight into past climates and the pattern of present Antarctic Bottom Water circulation.

The intention is to acquire data on all regular voyages of the SA Agulhas to Gough Island and SANAE. Over a period of years a library of systematic, problem orientated, geophysical lines will be built up across the Basins.

Close collaboration will be maintained with other institutions in the execution of the programme.

OCEAN BASIN AND CONTINENTAL MARGIN GEOLOGICAL PROCESSES

Organization: Geological Survey and University of Cape Town
Funding: Institutional and SANCOR

Sedimentation on the continental margins around South Africa has been controlled by two main factors: original tectonic style produced by continental separation,

and sediment supply characteristics. The interaction of these two factors determines the disposition of marginal sediment basins, and the nature and sediment process on the continental slope, rise, and adjacent ocean basins. To understand the development of these and hence their economic potential, it is necessary to take every opportunity to acquire sediment samples and geophysical data across the margins and adjacent ocean basins. Detailed stratigraphic control can only be achieved by deep drilling, but sea floor and shallow penetration studies can result in a wealth of data which the drilling results cannot provide. In addition, the sedimentary process in the adjacent ocean basins can be investigated by modelling sediment dispersion patterns using water movement and lithofacies data collected by coring and current metering.

SEDIMENTS OF THE SOUTHERN OCEAN FLOOR SOUTH OF THE SOUTHWEST INDIAN RIDGE

Organization: Not identified
Funding: SANCOR

In the southern oceans, sedimentation can be expected to have resulted from a combination of high biological productivity and glacial detritus. A shallow seismic/picton coring study of the area would provide valuable data on the palaeoclimatic fluctuations that have affected the southern oceans in the recent past (Neogene), as revealed by lithofacies interfering caused by the shift in the polar front and advance and retreat of the ice sheets.

In addition, the dispersion patterns of Antarctic Bottom Water could be usefully investigated by the study of sediment bedforms and lithofacies along the southern side and within the SW Indian/SE Atlantic ridge system. The identification of these dispersion routes would be of great interest to sedimentologists studying the geology of the Cape, Agulhas and Madagascar Basins, as well as for those scientists investigating the dynamic oceanography of these basins.

SOUTHERN MID-ATLANTIC RIDGE

Organization: University of Cape Town
Funding: Institutional and SANCOR

Owing to its remote geographic location, almost nothing is known about the morphology, constitution, structure and age of the southernmost Mid-Atlantic Ridge between Tristan da Cunha and Bouvet Island, and its tectonic relationship with the subduction zone of the adjacent Scotia Arc. Detailed information on the Ridge crest and flanks is of particular importance to understanding relative motions between the African, South American and Antarctic plates, and hence to the evolution of South Atlantic ocean basins.

It is proposed that initially reconnaissance traverses (bathymetry, magnetics and seismic reflection profiling) be undertaken using ships of opportunity, followed by more detailed geophysical studies of areas and features shown to be of particular significance.

LIST OF ACRONYMS

ACC	Antarctic Circumpolar Current
BIOMASS	Biological Investigations of Marine Antarctic Systems and Stocks
FGGE	First GARP Global Experiment
GARP	Global Atmospheric Research Programme
ISOS	International Southern Ocean Studies
NITR	National Institute for Telecommunications Research
NRIO	National Research Institute for Oceanology
SANCOR	South African National Committee for Oceanographic Research
SASCAR	South African Scientific Committee for Antarctic Research
SFB	Sea Fisheries Branch
TAAF	Terres Australes et Antarctiques Francaises
UCT	University of Cape Town

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