

South African Marine and Antarctic Research Strategy Version 4.5 June 2016

The research themes in this strategy were developed primarily using as input research plans developed by the marine and polar research community. These themes were consolidated with current initiatives and commitments of Government such as Operation Phakisa. The focus of this strategy has been aligned with current research support instruments and strategies, including those presently being processed. National Policies and plans also served as key drivers for the development of this strategy.

EXECUTIVE SUMMARY

South Africa is located at the confluence of three major, but very poorly understood, ocean systems and the Antarctic, and this confluence is increasingly believed to have a major impact on global weather patterns. Consequently, South Africa enjoys a considerable geographic advantage with respect to oceans, Antarctic and climate change research. For many years, extensive national research effort has been invested in this domain, across various programmes, government departments and public science institutions, and significant investments made in a range of research infrastructures, including research vessels and Antarctic bases. However, the implementation of the national research effort in this domain has been somewhat fragmented, with strategic priorities defined across several key stakeholders in a largely uncoordinated manner. This strategy seeks to enhance alignment in this regard.

The need for coordinated, extensive and targeted research in the marine ¹and oceanic domain has also recently been underwritten in the Operation Phakisa initiative, whose key purpose is to maximise the socio-economic return accruing from South Africa's proximity to massive ocean resources. Coordination has become important as there has been a shift in marine science from resources and process studies that could be carried out by small groups or individuals to very large scale regional climate and ecosystem studies, where the success, nooses and benefits lie in the coordination.

The Marine and Antarctic Research Strategy was constructed from the bottom up by consolidating separate research plans for the marine and Antarctic domains, respectively, drawn up by the relevant research communities, under the guidance of the National Research Foundation and with the involvement of researchers from the Department of Environment Affairs (DEA). The consolidation was brought about by identifying overlap and synergy between the two research plans, and prioritising research themes identified jointly between the DST and DEA. In addition, research-related expectations and deliverables emerging from the Operation Phakisa initiative also informed the focus of this strategy.

The strategy is constructed around six strategic objectives:

¹ Includes coastal and estuaries

- provision of a well-coordinated governance system for marine and Antarctic research activities;
- ensuring sustainability of marine and Antarctic resources;
- development of high-level skills to support research and development in the marine and Antarctic domains;
- improving the quality of life for South Africans derived from the oceans economy;
- creation of a society informed on the value of marine and Antarctic research initiatives; and
- contribute towards the creation of employment derived from innovation in the marine and Antarctic environments.

The following five thematic (vertical) areas were prioritised for research programmes, and are briefly outlined in the Strategy, more details on them being located in the relevant research plans:

- Oceans and marine ecosystems under global change
- Earth systems observations
- Ecosystems, biodiversity and biodiscovery
- Innovation and development
- Human Enterprise

In addition, six cross-cutting (horizontal) support interventions are identified and discussed, outlining possible specific activities under each:

- Coordination and governance
- Human capital development and transformation
- Research capacity development
- Public awareness and engagement
- Infrastructure and research platforms
- Data management

The strategy will mainly be implemented through existing instruments and institutional platforms, including a range of DST, NRF and DEA programmes and facilities. In

conjunction with relevant stakeholders and agencies, especially the NRF and DEA, existing marine and Antarctic research programmes and activities will be reviewed for alignment with the strategy, in order to assess the extent to which the two research plans that served as inputs into the strategy need to be modified to reinforce the objectives of this strategy.

PREFACE

(Same preface to be signed by the respective Ministers)

1. SOUTH AFRICA'S GEOGRAPHIC ADVANTAGE

South Africa is a maritime nation, surrounded on all but its northern boundaries by the sea. Its geographical position at the southern tip of Africa has been a major factor determining its natural and human history as much as its climate past, present and future.

We have a strong geographic advantage for conducting research in Antarctica and the oceans (Atlantic, Indian and Southern Ocean). We are the closest African point to the South Polar region, separated from the continent of Antarctica by about 4000km of open ocean. This distance allows for a regionally unique configuration of ocean circulation to occur. South Africa as the only African nation with a foothold in Antarctica and the Southern Ocean, carries a regional responsibility and obligation to serve as a channel for broader African scientific research interests in the Antarctic region.

The South African coast, from the border of Mozambique in the east, to the border with Namibia in the west, spans some 2800 km. The eastern Indian Ocean seaboard, under the influence of the southern drift of warm tropical waters (the Agulhas Current), is rich in biodiversity. By contrast the cold western South Atlantic seaboard, cooled by the coastal upwelling within the Benguela Current, is comparatively poor in biodiversity but productive and rich in biomass.

South Africa, is a founding member of the Antarctic Treaty System (ATS), and has a long-term track record and commitment to undertaking research in Antarctica and the Southern Ocean. The Treaty System is the overarching international legal framework by which nations conduct their presence and interests in the region, which is defined as the area south of 60° S. Signatories undertook to ensure that the Antarctic region will be used for peaceful and scientific purposes only and to protect and preserve the environment. There are three core principles enshrined in the Treaty System, viz. (1) the region may be used only for peaceful activities, all military activities are prohibited, (2) scientific research is encouraged, and (3) territorial claims are suspended. Our strategy to capitalise on our geographic advantage in respect of research in the marine and Antarctic domains must be informed by these commitments. In the absence of the absence of recognized land claims, scientific activity is one of the most important measures of a nation's role in the ATS.

2. THE POLICY CONTEXT

South African scientific investigations of the adjacent surrounding seas and its physical, chemical and biological nature emerged in the late 19th century, with significant investments made from the 1960s onwards, starting with the establishment of a South African base in Antarctica, followed by bases on the Prince Edward and Marion Islands, and the procurement of several research vessels over the last 3 decades.

After 1994, the South African Government developed the National Research and Development Strategy (NRDS, 2002) that focused on innovation, human capital development and the building of an effective government system for science and technology. This document also explicitly outlined the Department's intention to capitalise on South Africa's geographic advantage in respect of marine, Antarctic, astronomy and palaeoscience research. Whereas the NRDS focussed strongly on organising our national approach to basic, applied and strategic research, the Ten-Year Innovation Plan (TYIP) of 2008 was intended to complement the former by focussing more strongly on the aspects of technology development and commercialisation, as social outcomes of research. Specifically, it identified five 'Grand Challenges' as priority research areas for science and technology (S&T) programmes to drive the country towards a knowledge-based economy.

Since then, Government has adopted the National Development Plan (NDP) as an overarching, high-level framework for the formulation of sectoral development plans and strategies, and on priorities for implementation. The Plan identifies education, training and innovation as being at the centre of South Africa's long-term development, and specifically states that "inadequate capacity will constrain knowledge production and innovation unless effectively addressed". The NDP also considers science and technology as some of the key drivers of change in the country's economic situation. In 2014, as part of implementing the NDP, President Zuma launched Operation Phakisa as platform to unlock the potential of South Africa's oceans to contribute to national economic development.

In other words, there exist two key ambitions with respect to South Africa's marine and Antarctic environments: the first, deriving from the NRDS, is to maximise the benefit of this strategic geographic advantage to South African research and science, and the second, deriving from the NDP and Operation Phakisa, is to increase and maximise the socio-economic benefits derived from the oceans.² Both these strategic objectives are dependent on the development of knowledge and human capital to be able to take advantage of the potential that is provided by the oceans and Antarctica. These imperatives are clearly aligned with the DST's mandate of knowledge production and high-level human capital development, but a strategy is necessary if the DST's various marine and Antarctic research and development initiatives are to be coordinated and guided with this strategic intent in mind. Consequently, there exists a need for a consolidated Marine and Antarctic Research Strategy (MARS).

3. RESEARCH AND INSTITUTIONAL CONTEXT

South Africa already supports an extensive suite of research programmes in the marine and Antarctic domains, and hosts a long list of active research platforms and organisations, most of which are organised around policies, strategies and plans developed in the specific context of those research activities. For example, in the DST's remit there is the South African National Antarctic Programme (SANAP) and the African Coelacanth Ecosystems Programme and the CSIR's ocean and climate research programme, while the DEA hosts several environmental management and weather modelling research programmes each with their own strategic and/or planning documents.

The same is true for several other government departments and agencies. Consequently, a major purpose of this strategy is to provide an over-arching policy framework for a wide range of pre-existing programme and project-level plans, policies and strategies, and in this context the Marine and Antarctic Research Strategy constitutes to some extent a codification of existing research programmes and activities.

² Incidentally, the need for extensive research and knowledge production, as well as high-level skills development has been recognised across numerous Operation Phakisa initiatives.

4. SOCIO-ECONOMIC CONTEXT

South Africa is a country with complex socio-political structures and a large population whose lives are prioritised by day-to-day requirements. These primarily include food security, water resources, health and education. These makes it imperative for the broader scientific research community to focus on these needs to ensure national investments towards marine and Antarctic initiatives.

As indicated in the policy context section, that the South African government launched Operation Phakisa as platform to unlock the potential of South Africa's oceans to contribute to national economic development, four key priority areas were identified: marine transport and manufacturing; offshore oil and gas exploration; fisheries and aquaculture; and marine protection and governance. Research is considered to be central in the aspirations towards attaining the targets set in Operation Phakisa Oceans Economy. The research focus of this strategy will also ensure that the expectations and deliverables emerging from the Operation Phakisa Oceans Economy initiative are attainable through provision of a research agenda as indicated in the aspirations.

All the research themes of this strategy will broadly address the requirements of the Operation Phakisa Oceans Economy set targets that are will ultimately address national socio-economic challenges. Some of these would be e.g. through fisheries and aquaculture research, marine technology research that would contribute in marine protection and governance, and disaster management.

The move in this strategy will be towards trans-disciplinary, collaborative, solution-oriented research that mirrors a number of national and international initiatives. South African marine and Antarctic sciences are well placed to make substantial and important contributions to such research. South Africa has a long history of inter-disciplinary and inter-institutional collaboration in marine and Antarctic sciences and the country is geographically located in an area where ocean dynamics are dominated by processes at the spatial scales from tens of kilometres to metres and temporal scales from months to hours.

5. PURPOSE OF THE STRATEGY

The focus of this strategy is purely meant to address the scientific research, and technological imperatives. There is a clear need to strengthen South Africa's marine and Antarctic research and its research capacity through strong leadership and coordination. Marine and Antarctic research is considered in this strategy to encompass all research that is performed in the estuaries, coasts, oceans, islands and Antarctica. Activities in these areas are managed in different government Departments with a plethora of legislations impacting activities in the estuarine, coastal, marine, ocean and Antarctic environments.

While many strategic imperatives will be unique to the marine and Antarctic environment, others are generic in nature in the context of South Africa's national science and innovation system, and its historical bias that has skewed development of research capacity at both institutional and demographic levels; this strategy must seek to rectify this bias.

In addition, the strategy needs to respond to a wide range of other strategic and operational challenges in this domain, which include the need to:

- Promote fundamental and applied research in order to increase human knowledge and develop multidisciplinary links between basic and applied research and knowledge;
- develop the necessary human capital base aligned with national plans and instruments;
- breed innovation and links to relevant industry to exploit commercial opportunities; and
- grow general public awareness and engagement that is aligned with national plans and instruments.

Superimposed onto the above elements, is a wide scope of particular research needs and interests of various government departments, relevant to their specific administrative and regulatory mandates; in this context, this strategy is an over-arching framework that is intended to align all national research needs in the marine and Antarctic domains.

Furthermore, the strategy provides government with a platform to develop a comprehensive funding framework for research that addresses national imperatives in the marine and Antarctic domains, while the research community is provided with clarity on priority research themes that would be funded in line with national priorities.

6. VISION AND MISSION

Vision: A high-quality marine and Antarctic research system that is responsive to relevant national strategic imperatives and has both regional and global reach.

Mission: To build the national marine and Antarctic research system in order to develop human capital, maximize South Africa's international profile for research in this domain, bring about transformation in the sector, and contribute to innovation and economic growth around the oceans economy.

7. STRATEGIC OBJECTIVES

The high-level objectives of this Marine and Antarctic Research Strategy are aligned with the current national imperatives such as the National Development Plan and specifically the Ten Year Innovation Plan grand challenges:

- *provision of a well-coordinated governance system for marine and Antarctic research activities;*
- *ensuring sustainability of marine and Antarctic resources;*
- *development of high-level skills to support research and development in the marine and Antarctic domains;*
- *improving the quality of life for South Africans derived from the oceans economy;*
- *creation of a society informed on the value of marine and Antarctic research initiatives; and*
- *contribute towards the creation of employment derived from innovation in the marine and Antarctic environments.*

8. SCOPE OF THE STRATEGY

The scope of the Antarctic and marine environment is very broad, the list of stakeholders is long and varied, and opportunity for valuable outputs is massive – this broad scope brings with it the risk that the strategy's focus can become diluted by the multitude of expectations, and for this reason its crafting needs to be informed by clearly enunciated priorities and

imperatives, and its basic scope well defined, spanning programmatic organisational, and scientific considerations.

The MARS also considers current international trends and priorities, of which understanding the role of biodiversity and regional climate systems in maintaining ecosystems functionality, the relationships between human pressures and ecosystems, and the impact of Global Change on marine ecosystems and their services are fundamental. In addition several urgent actions are required to address current problems, namely, assessing marine ecosystems health in an integrative way; sustaining valuable long term observations, delivering ecosystems services by conserving and protecting our seas; recovering ecosystem structure and functioning through restoration/mitigation, managing the seas using the ecosystems approach and spatial planning; and modelling ecosystems for better management.

The content of this strategy has been constructed from the bottom up, guided by detailed research plans for the marine and Antarctic domains, respectively, these plans having been compiled by the relevant research communities. The strategy presented herewith constitutes a top-down a strategic consolidation of the two plans, driven by the National Research Foundation in consultation with the DST and DEA.

6.1 Programmatic scope

The following types of cross-cutting programmes are required to address the national research development needs for the marine and Antarctic domains:

Sector-specific programmes: Sector-specific research will be driven by the respective line departments and be designed to meet their mandated reporting and management responsibilities. The following examples serve to illustrate the point: the Department of Agriculture, Forestry and Fisheries (DAFF) mainly focus on research that assist in fisheries management and stock assessment; the Department of Environmental Affairs (DEA) specific focus within marine and Antarctic research is on the protection and management of the environment and conservation of natural resources; and the Department of Water Affairs (DWA) will focus on estuarine reserve determinations.

Individual or small-consortia competitively-won fundamental and applied programmes: These programmes would address fundamental and applied research from

individual projects to collaborative ventures. The key characteristics would be that they would be open competitive calls aimed at meeting certain research priorities. Examples include programmes to support NRF-rated researchers and unrated researchers; Blue Sky and Thuthuka candidates; the South African Research Chair Initiative; Centres of Excellence; Belmont Forum actions; the Applied Centre for Climate and Earth Systems Sciences, SeaKeys (a programme aimed at unlocking marine biodiversity knowledge through the coordinated capture and distribution of genetic and species data as well as ecosystem information on South African marine environment and benefit the country as a whole through the exploration and understanding of genetic diversity within the South African marine environment) , etc. The SANCOR Society Ecosystems and Change (SEACChange) programme was a successful framework and elements could be extended.

Infrastructure linked programmes: The NSI has invested heavily in marine infrastructure such as research bases, ships, coastal craft, ocean robotics, remotely operated vehicles (ROVs), oceanographic arrays, data centres, collections, and laboratories. Flagship programmes such as the African Coelacanth Ecosystems Programme are required to ensure that research infrastructure is made accessible on a competitive basis to researchers within the system.

Larger interdisciplinary specific issue driven programmes: There are some new regional scale or Earth - Climate Systems scale research needs which may require immediate attention through dedicated large-scale inter- and trans-disciplinary approaches which are demanding with respect to human capacity and infrastructure, and are expensive to run. These programmes will require multiple agencies' input, but should be retained in an open competitive research framework.

Dedicated transformation programmes: Dedicated programmes are required to develop and enhance marine and Antarctic research at Historically Black Universities (HBUs) and drive transformation.

6.2 Organisational scope

There are a number of interested and affected groups, many of which are already established as sectors in government Departments (e.g., the Department of Environmental Affairs [DEA]: Oceans and Coasts branch; and the Department of Agriculture Forestry and Fisheries [DAFF]: Fisheries branch) and the Department of Science and Technology (DST)

through the National Research Foundation (NRF) National Facilities and agencies such as the South African Institute for Aquatic Biodiversity (SAIAB); the South African Earth Observation Network (SAEON); the Council for Scientific and Industrial Research (CSIR); Council for Geoscience; and forums such as the South African Network for Coastal and Ocean Research (SANCOR), which represents both bottom-up interests (through individual researchers) and top-down guidance and direction (through the funders; currently the NRF and DAFF: Fisheries Branch). There is also the DST and DEA-funded South African National Antarctic Programme (SANAP) which provides for a consolidated management of Antarctic research. All this provides a good platform from which to develop a suite of new research programmes and projects, including flagship projects that maximise South Africa's geographic advantage.

Since the inception of the Antarctic Treaty System (ATS), South Africa has been at the forefront of a number of major international oceanographic, astro- and bio-physical projects in which African partnerships are well embedded. These projects seek to develop not only the infrastructure for global oceanographic, astro- and bio-physical research but also to train and develop African human resources in these most advanced physical science realms. The thrust now extends to space research in which South Africa's recently established National Space Agency is rapidly developing the physical and human resources required for space research.

The South African Government has indicated its commitment to continued research in the Antarctic and the oceans through major financial investments in new state-of-the-art platforms including a new base on Marion Island and the refurbishment of SANAE IV, a state of the art research and supply vessel, the *SA Agulhas II*, ocean robotics, small vessels such *uKwabelana* and other investments that provide a sound platform for scientific endeavour. The establishment of SAEON, and Centres of Excellence – e.g., the Centre for Invasion Biology at the University of Stellenbosch, and the Percy FitzPatrick Institute of African Ornithology at the University of Cape Town (UCT) – and the CSIR's Southern Ocean Carbon - Climate Observatory (SOCCO) Programme, have facilitated outstanding academic research at several South African institutions, some of which has been focused on the Antarctic and the Southern Oceans. This research excellence has helped to keep South African scientific research at the forefront of international research in Antarctica and the

Southern Ocean; most importantly, it is linked to the vital development of high-quality human capital.

South Africa has a diverse and active marine science community, with areas of excellence in ecology and ecosystem research, fisheries biology and marine biodiversity. Institutions that house the above, together with government agencies and research units will be the focal points for implementing any policy on marine and Antarctic research. Active laboratories and researchers exist at several institutions and the majority of them serve as training facilities as well as research centres. The major challenge is the lack of coordination to ensure that they all operate in synchrony and there is no duplication of effort and resources – it is the purpose of this strategy to enhance that coordination.

6.3 Scientific scope

The Marine and Antarctic Research Strategy will enable exploitation of the opportunities for increased economic and energy security from marine and sub-sea resources. The geographical advantage derives from the peninsular position of South Africa (Figure 1) separating the northerly deflected, cold South Atlantic waters via the Benguela Current on the West Coast, from the southerly directed warm Agulhas Current along the East Coast. The relatively sharp interface and contrast between the two systems provides its own dynamic for research, but each system will be subject to different spectral changes due to global change dynamics, and all can be observed and researched ideally from South Africa.

The country is situated at a globally-important climate site, where warm, salty Agulhas eddies transport heat and salt from the Indian Ocean to the Atlantic Ocean, forming an important link in the so-called 'Global Ocean Conveyor Belt' for salt and heat transfer. Furthermore, this combination of physical, chemical and biological oceanographic processes in the waters bordering and surrounding South Africa provide unique advantages for science in advancing the understanding of the regional marine environment, which is influenced by global scales of variability and change and provides feed-backs into the Earth System

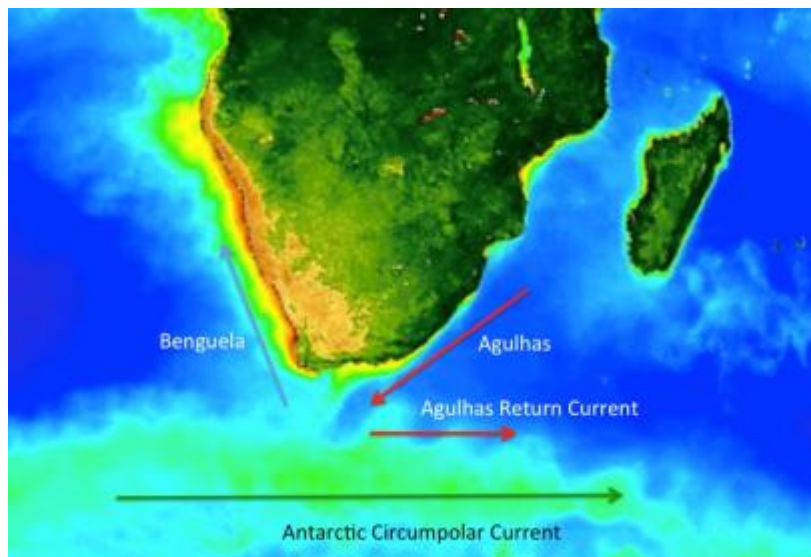


Figure 1: South African Geographical Advantage for coastal and marine research – a crossroads of ocean dynamics, with a rich ecological diversity within easy reach of the major centres where research capacity is present. Image depicts Chlorophyll concentration on a scale from low to high through the colour spectrum blue-light blue-green-yellow-red. Current systems are depicted by arrows as: red – Agulhas and Agulhas Return current; blue – Benguela Current; green – Antarctic Circumpolar Current. (Source: <http://oceancolor.gsfc.nasa.gov/SeaWiFS>).

Antarctica and the Southern Ocean offer other vital opportunities that include, but are not restricted to, the following key points which highlight the thrusts of the DST Ten Year Innovation Plan (2008):

- Predicting global change in the Southern Ocean and Southern Africa because the region plays a key role in global heat and carbon exchange through, e.g., the formation of intermediate and bottom water and ocean/atmosphere carbon fluxes.
- Managing global change (through, e.g., carbon sequestration);
- Food security (new and existing fisheries), given that the production of polar marine living resources surpasses that of all other oceans, with at least 5 million tonnes of krill, fish and squid in the Antarctic Ocean;
- Antarctica as a possible future source of fossil fuels and other strategic minerals; and
- The many opportunities for biodiscovery and biotechnology – fuelling the bio-economy.

The large Exclusive Economic Zone (EEZ) around the Prince Edward Islands, South Africa's Sub-Antarctic territory, supports important marine resources, most of which currently are not exploited. The extended Prince Edward Inlands EEZ claim will exceed that of mainland South Africa in area. The islands have been declared a Marine Protected Area under the National Environmental Management: Protected Areas (NEMPA) Act, and there are obligatory research, monitoring and conservation responsibilities that come with this

declaration. The islands also fall within the Convention for the Conservation of Antarctic and Marine Living Resources area, and are globally important breeding sites for several marine top predators, which South Africa has undertaken to conserve as part of its international obligations (e.g., through Agreement on the Conservation of Albatross and Petrels). As it happens, the location of the PEI is considered to be strategically critical to the island's ecosystem, and could enable the monitoring of the impacts of global change on the surrounding dynamic marine current systems.

The South African Government's commitment to continued research in the Antarctic and Southern Oceans and the significant investment in research infrastructure provides a sound platform for scientific activity. Furthermore, the establishment of Centres of Excellence and other entities at various institutions facilitated outstanding research which contributed to the country's research profile internationally. More importantly, this also leads to the development of highly skilled human capital. This strategy will integrate all these investments to capitalize on the emerging global prominence of the Southern Ocean and South Africa's comparative geographic advantage.

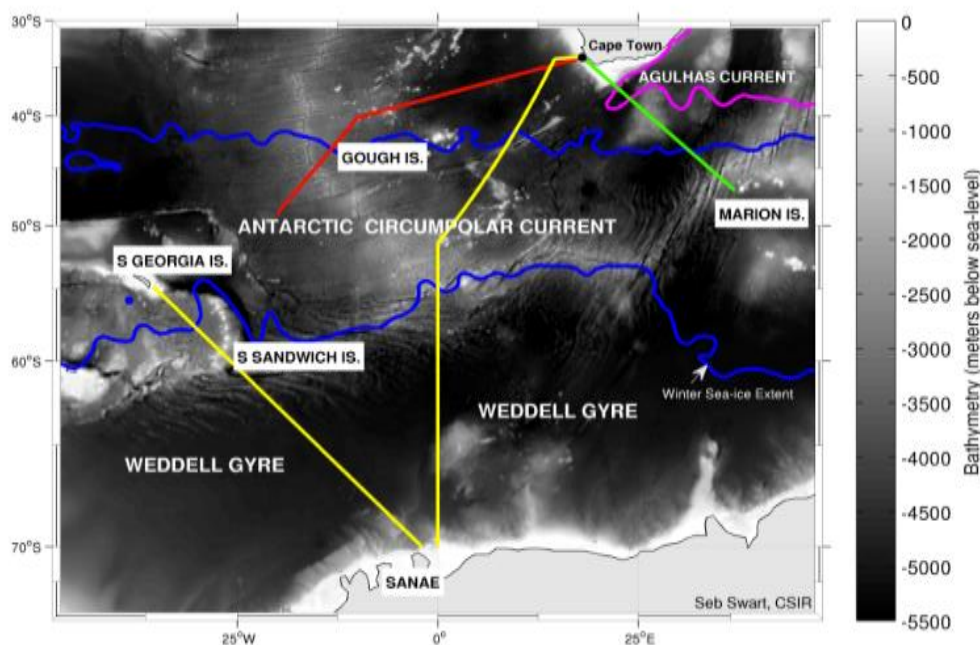


Figure 2: South Africa's geographical coverage of the Southern Hemisphere oceans and access to the Antarctic region. The coloured lines represent the domains covered by annual South African research and logistical voyages (carried out by the *S.A. Agulhas II*): Marion Island, Gough and Tristan du Cunha Islands, SANA E base, South Georgia Island and South Sandwich Islands. The blue lines represent the northern and southern extent of the Antarctic Circumpolar Current, while the magenta line represents the position of the Agulhas Current and Retroflexion. The maximum winter sea-ice extent is indicated. The background shading represents the ocean depth (meters below sea-level).

9. RESEARCH THEMES

Regional and large-scale oceanographic processes underpin aspects of South Africa's marine environment that link research directly to significant societal benefits. These include sustained environmental observations and maritime safety linked to extreme weather events, employment and food security linked to fisheries and aquaculture, bio-prospecting linked to marine biodiversity, oil, gas and other exploration, and mining linked to non-renewable marine resources, and ecotourism linked to the country's beaches and coastal waters and the biodiversity they support. The key research questions are addressed in the research plans and the sector plans.

Prior to this strategy, South Africa was guided by the following broad research themes to promote and maintain the South African National Antarctic Research Programme activities: Antarctica – a window into geospace; Climate Variability – Past, Present and Future; Biodiversity responses to Earth System variability; Engineering and a sustainable presence in Antarctica; History, Sociology and Politics of Antarctic Expeditions and Research. These research themes addressed environmental variability within the context of human quality of life and sustainable interactions, and are adopted in this strategy to provide a continuum of opportunity for SA researchers from the far reaches of outer space to the ocean bed.

Within the Ten Year Innovation Plan Grand Challenge for Global Change, four priority areas were identified for research in South Africa, namely (i) understanding the ocean as part of a coupled (ocean/atmosphere) regional system, (ii) the risks and responsibilities of ecologically sustainable coastal development, (iii) the response of coastal and marine ecosystems and ecosystem services to Global Change, and (iv) operational capabilities, marine science for society.

The key research questions that should be tackled within the research themes are addressed in detail within the research plans and the sector department's plans. The figure below lists the five overall themes and their respective subthemes, as they emerged from the research plans developed in consultation with the broader research community, and as they have been adapted to the current national priorities in this broad field; each of the themes is then discussed in more detailed subsequently.

Oceans and marine ecosystems under global change

- Understanding modes of ocean variability across temporal and spatial scales
- Developing a regional observations network.
- Developing end-to-end modelling and operational prediction capabilities
- Establishing global, regional and coastal system indicators
- Delivering robust & useful information to society
- Reconstructing past climate changes

Earth Systems Observations

- Usage of South African space science in Antarctica, as a window into geospace
- Understanding the links between ocean-atmospheric physics, ocean iron availability, trace element biogeochemistry and ocean productivity
- Understanding large scale ocean circulation and global climate
- Geology of onshore terrestrial Antarctica

Ecosystems, Biodiversity & Biodiscovery

- Understanding scales of biodiversity from molecular to ecosystem
- Understanding the connectivity between terrestrial, coastal and marine systems
- Understanding natural and anthropogenic drivers of change
- Development of capacity in biodiscovery & biotechnology
- Marine Spatial Planning and Marine Protected Area Expansion and Optimisation

Innovation and development

- Sustainable coastal and ocean development: vulnerability, risks and responsibility
- Oil & Gas, Fisheries, Mining and Mariculture
- Energy management
- Development of technology and vessel design
- Development of energy exploration capacity
- Development of links to ecotourism
- Antarctic Waste management

Human Enterprise

- Geopolitics, international and national law and policy;
- Usage of the resource and to develop and refine human History and Palaeosciences;
- Explore from a research perspective the Antarctic arts, architecture and literature;
- Social Adaptation and Human Impact

8.1 Oceans and marine ecosystems under global change

It is important that South Africa further develop the capacity for understanding and predicting the state of the ocean and its ecosystems, and the capacity and systems to incorporate such knowledge into policy and management. To do this requires multi-, inter- and cross-disciplinary approaches to marine science with explicit links to stakeholder requirements.

Global change pressures include climate change, increases in sea-level rise and wave heights, and the impact that these changes will have on coastal ecosystems, towns and cities and major port infrastructure. Increasing water pollution within the coastal zone and reduced river flow to estuaries and the coastal zone are issues to be researched. Coastal bio-invasions, particularly by alien plant and invertebrate species, require attention. Management of coastal ecosystems under global change scenarios requires scientific and socio-economic information for wise management decision making.

8.2 Earth Systems Observations

Gaining a better understanding of the generation and impacts of space weather is crucial to efforts to meet the TYIP Grand Challenge of Space Science and Technology. The national space strategy has prioritised ocean and coastal marine management as one of the instruments to leverage the benefits of space science and technology for socio-economic growth and sustainable development. Data obtained from satellite observations can be used with increased accuracy to monitor ocean current circulation, wind velocity and wave height and direction. The use of satellite platforms have spawned a number of new applications, such as providing information for climate and weather forecasting, fishing, ensuring the safety of shipping vessels and monitoring pollution. This ensures sustainability and the protection of coastal and marine wildlife.

The Southern Ocean is an important component in the global carbon cycle and understanding the links between ocean and the atmosphere will improve the reliability of regional climate forecasting.

The sector of Antarctica between $\sim 25^{\circ}$ W and $\sim 35^{\circ}$ E, comprising a major component of Dronning Maud Land, was adjacent to the southern African coastline prior to the breakup of Gondwana. Aerial geophysical surveys over parts of both continents in the last decade have facilitated a re-interpretation of the geological evolution of both continents, particularly in the broader areas inland and adjacent to the contact along which the two continents separated.

Interest in the ocean floor geology is also mandated by the United Nations Convention on the Law of the sea which has a ten-year period for countries to make claims to an extended continental shelf which, if validated, gives it exclusive rights to resources on or below the seabed of that extended shelf area. Study of the seafloor is also an important aspect of Operation Phakisa. In addition to the extended continental shelf and its possible

resources, current interdisciplinary (geophysics, geology, geochemistry and palaeontology) studies of the ocean floor around Antarctica are providing valuable insights into paleoclimate evolution of the Antarctic Ice cap. Such studies are needed recognising the limited rock exposure on the continent; due to ice cover; and the limited preservation of material on the continent, resulting in the ocean floor sediments being important settings for preservation and study of earth history. Such studies will also gather valuable information on possible resources on the Antarctic ocean floors, in the event of the moratorium of possible exploitation of such resources being lifted when the Antarctic Treaty expires.¹

8.3 *Ecosystems, Biodiversity and Biodiscovery*

Over the past decade the South African marine community has reviewed the state of marine science through a series of interactive consultative exercises. These reviews identified gaps, threats, human skills capacity and the link between the functioning ecosystem and management.

An understanding of the ocean dynamics is essential to predicting and adapting to global change. The Antarctic region is remote, sparsely inhabited and still very poorly explored as far as natural (fixed and renewable) resources are concerned. South Africa must take advantage of its presence and participation in the ATS by an active programme of research into human impact, biodiscovery and biotechnology in the region.

8.4 *Innovation and development*

Studies have indicated that Coastal ecosystems are considered to be highly vulnerable to human-mediated drivers of global change because they are located at the land–ocean interface and often host centres of urbanisation and development. At present the physical development of coastal areas is intense and pressures on coastal and marine environments are rising rapidly. Research that focuses on the interface between resources, society and development is of high priority. With regards to issues specifically pertaining to Antarctica, the infra-structure and logistics supporting research is constantly in need of re-design, maintenance and improvement. This would then require that innovation to be encouraged.

The maintenance of the long-term prosperity and sustainability of marine fisheries is not only of political and social significance but also of economic and ecological importance, and as such innovation in this area will be important.

There has been an upsurge in offshore exploration within the South African EEZ and extensive mineral exploration concessions have been granted for large parts of South Africa's EEZ marine sectors. The development of ocean energy is inherent with diversifying the supply of renewable energy. Ocean energy offers the potential for long-term carbon emissions reduction but is unlikely to a significant short-term contribution before 2020 due to its early stage of development.

Operation Phakisa has prioritised a need to develop skills and capacity that would enable South Africa to protect its exclusive economic zone (EEZ) (e.g., for oil drilling), maintain safety in the EEZ and exert influence beyond the EEZ (e.g., in terms of search and rescue). South Africa also needs to build on existing technologies (such as marine remote sensing and biotechnology) to provide mitigation instruments to assist in management of disasters such as oil spills.

Operation Phakisa has also highlighted a requirement for technology development plans focused on ship repairs, aquaculture and offshore oil and gas exploration. Many scientific projects and programmes are actively developing and using 'marine technologies'. This important sphere of activity is at present largely in the hands of industry and international academia, and in South Africa it is unfocused and un-coordinated at present, and therefore requires further attention.

8.5 Human Enterprise

South Africa is one of the twelve founding members of the 1959 Antarctic Treaty and therefore was a player right from the inception of what was later to become the Antarctic Treaty System (ATS). The ATS is a set of 'living' treaties where parties, including SA Government delegations are active participants in attending international scientific and governance meetings and decision making processes on a regular annual basis. A key on-going research need is to provide academic support to the South African delegations attending these meeting. South Africa has enacted a number of statutes that are directly or indirectly relevant to the area. A second on-going research activity will be to monitor and ensure that the South African domestic legislative and regulatory framework keeps up with international law developments.

There is a rich history of human enterprise in the Antarctic and Southern Ocean. Whilst some of this history is available in the literature there is a wealth of interest that remains to be researched and published.

There is little information on artistic, literary and architectural artefacts which reflect the human endeavours of the Southern African Antarctic region, whose oceans and adjacent landmasses have both ancient and modern human histories. The challenge for this research project is to open up a field of research into the production of art, literature and architecture in this region that engages with the far South.

The Antarctic and Southern Ocean is a harsh inhospitable region where any human activity can be extremely stressful and unforgiving. As such the region provides a natural laboratory for studying the human condition under stress. There have been and continue to be significant human impacts in the region. These impacts need to be elaborated, monitored, and mitigation measures established where necessary.

10. DELIVERING THE STRATEGY

The general nature of marine and Antarctic research renders the work expensive in a country where there is competition for resources with basic needs. There is a requirement for extensive inter-departmental collaboration and co-ordination funding and other resources to ensure cost effective research activities.

Operation Phakisa has unearthed a number of potential industrial stakeholders whose relations would need to be managed to be able to derive equitable benefits. These include the oil and gas industry, fishing industry and the broader maritime industry that all have the potential to benefit research through data collection and access to their vessels. These industries have the potential to absorb a composite of skills that are required to drive the economy from marine research practices.

The MARS strategy consolidates research and provides a platform for the national marine and Antarctic research agenda. The strategy is aligned with the TYIP through the alignment with all four grand challenges. The implementation of the strategy will also provide a research base that will assist in the implementation of the White Paper on the National

Environmental Management of the Ocean (NEMO). The strategy will also provide a platform to enable scientific research to contribute towards policy decisions.

To ensure that there is alignment with current developments, the Steering Committee will organise forums where government and the research community will participate to share development that could yield policy briefs.

In the section above, the thematic priorities of this strategy have been outlined in some detail, and these can be thought of as *vertical* priorities. In addition, however, several critical supportive and cross-cutting interventions also need to be serviced for the successful implementation of the strategy – these may be thought of as *horizontal* priorities or interventions critical to delivering on the strategy.

10.1 Intervention 1: Coordination and Governance

The White Paper on the National Environmental Management of the Ocean (NEMO) declared that responsibility for ocean governance will reside within the Economic Cluster of Cabinet. The Department of Science and Technology (as the Department mandated to coordinate research and development) will lead the establishment of a marine and Antarctic research steering committee (MARS Com) that will be appointed for the implementation of this strategy in partnership with the DEA, DAFF and other key stakeholder departments to drive the implementation of this strategy.

The MARS Com will also establish a system that would ensure that logistical needs for researchers are managed to be in line with receptive capabilities of the line departments and research entities. The DEA has the responsibilities of managing the logistics for Antarctica and the Islands. The DEA also manages access to the SA Agulhas and the FRS Algoa vessels. Operation Phakisa has yielded the possibility of research access to industrial vessels as well and this process needs to be managed effectively in a coordinated manner. Coordination of logistics will alleviate the huge financial strain that is associated with provision of logistical support. The MARS Com coordination will ensure that research grants awarded by the funding agencies are aligned with available logistical support. This has been a major challenge for researchers and government administrators alike, where research and logistics were not seen to be aligned, particularly for Antarctic related research.

10.2 Intervention 2: Human Capital Development and Transformation

The DST has finalised its Human Capital Development strategy in response to the urgent need in South Africa to develop high-level capacity in sciences, and to ensure transformation in the demographics of the national research system. (Women have only been allowed onto South African polar research ships and to reside at SANAP bases within the last 20 years.) This strategy provides a platform for demographic transformation, while ensuring training and first-hand experience for both researchers and technical support personnel.

The scope and the emphasis of the HCD strategy's high-level objectives are informed by the need to develop postgraduate research training and research and development outputs, consistent with the mandate of the DST and its entities. As the HCD strategy is not discipline-specific, the HCD requirements in marine and Antarctic research will be implemented in alignment with the instruments of this strategy. A MARS HCD programme will be developed to utilise and customise (as relevant) the instruments of the HCD strategy, including the Professional Development Programme (PDP), the Internships Programme, Post-doctoral Fellowships, the Freestanding NRF Bursary programme, and the grant-holder linked bursary programme. The DST incentive programmes will also be adapted to attract academic partnerships with industry. International collaborations will also be used as a vehicle to increase expertise and research partnerships.

Ongoing and improved government support of peer-reviewed research programmes will provide future opportunities for all young, early career and established researchers working in the Antarctica and marine environment. The creation of sustainable programmes will enable the establishment and strengthening of international and national networks, which will play a crucial role in revitalising science and developing skills, knowledge and expertise in this important research area. This is critical if South Africa is to take full advantage of her comparative geographic advantage, retain her top-class scientists, attract international partnerships, and continue to produce top quality research outputs.

Strategic transformation interventions should be implemented to provide redress and they could include the following:

- focused recruitment and training of black students in broad Antarctic and marine research programmes;
- strong support for existing transformation programmes at historically disadvantaged institutions such as the Phuhlisa Programme for marine sciences that is implemented through the African Coelacanth Ecosystems Programme; and

- development of a mentoring programme to provide support young researchers.

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10.3 Intervention 3: Research Capacity Development

Research groups and consortia are critical for development and maintenance of research excellence. These would enable South Africa to focus, develop and broaden our research strengths as well as provision of various platforms to train the new generation of researchers. There are several pockets of expertise that already exist that need to be nurtured to be able to attract the new generation of researchers. Several challenges have been raised to enable the country to address national needs and they would require the consolidation of current expertise for them to be addressed. The economic challenges that have been raised through Operation Phakisa are an example of a requirement for capacity development that would need to be used for South Africa to optimally raise the economy with our resources through a knowledge based solutions without compromising the environment.

The DST and NRF have developed research development instruments to develop and expand research excellence, and these could also be customised specifically for marine and Antarctic research. The following programmes fall into this category: emerging researcher development programmes, post-doctoral fellowships, the Career Advancement programme, the Thuthuka programme, and the unrated researcher programme. For established researchers there is the South African Research Chair Initiative (SARChI), the Centres of Excellence (CoE) programme, the rated researcher programme, SANAP grants, ACEP grants and the SANCOR grants. Prestigious grants such as the SARChI and the CoE would be used to prioritise development in identified areas to advance national priorities.

10.4 Intervention 4: Public Awareness and Engagement

Countries and marine bodies generally do advocate for the development of strategies for the sustenance and management of environments, but these strategies are based on information acquired from expert groups and are rarely linked to the general public as key stakeholders. In South Africa and globally there is limited research that is performed on ocean literacy and on public understanding of marine and coastal issues. From existing literature two key themes emerge: firstly, that public awareness of marine and coastal issues is difficult to distinguish, making definitive statements about this issue difficult; and secondly that much of the existing research suggests a very low level of understanding of basic concepts and principles related to the marine environment.

The marine environment is considered by the public to be a very complex and emotive subject. South Africa is currently moving towards deriving economic benefits from the ocean through Operation Phakisa initiatives. It is thus important for the strategy to also focus on improving public understanding and awareness in marine and Antarctic sciences, as this is important in moving towards a more holistic and sustainable approach to obtaining buy-in from the public on the large investments required in these initiatives.

As South Africa is in the process of implementing activities of Operation Phakisa towards unlocking the economic potential of the ocean, it is important to take note of socio-economic consequences in coastal areas and in the ocean. The human impact on climate change and on the ocean environment renders the need to engage the broader South African public as a key stakeholder on issues of the ocean and the impending challenges. Instruments have to be developed to educate the general public on the environmental status of the oceans and how research, exploitation and other activities have an influence on their lives and how their general behaviour could impact the marine ecosystems.

A key action here will be to develop platforms to engage with the public in discussion forums that are geared towards Antarctic and marine sciences. This will also involve two-way exchanges that would raise the importance of Antarctica and the ocean the impact of our actions on them. Public engagement plans would need to be developed that are specific to the sector in partnership with industry.

10.5 Intervention 5: Infrastructure and Research Platforms

A rich suite of platforms and infrastructure is available for Antarctic and broader marine research. There is a requirement to coordinate access to research platforms and infrastructure to avoid duplication of resources. Coordination will also ensure that research is aligned with logistical needs and support. The state of observations and modelling south of Africa is not as developed as it is in other regions of the world's oceans. This is largely due to limited logistic support, the lack of available technical support and the lack of sufficient funds to establish a long-term mooring array and improved local research and development of buoy and sensor prototypes suitable for these energetic conditions. Even with the enhanced sampling to adequately address key challenges; year-round, full-depth, multi-disciplinary monitoring of the oceans around South Africa is essential.

As a consequence, South Africa's participation in, and contribution to, international programmes is limited. Governmental support and appropriate funding for both science and the necessary logistic support will provide future national and international opportunities for all young, early career and established researchers working in the region.

Since Government has invested heavily in provision of research infrastructure platforms, coordination of their deployment is critical to maximise the outputs that could be derived from them.

Technical support is an additional requirement that is essential in ensuring that scientific research in the region functions effectively. The effective management of training, logistics support and technical support should be considered for attention and development. Building of the technical expertise is also crucial in the ability to provide maintenance to the various instruments. This has the potential to also make significant economic contributions as South Africa is also used by most countries as an entry point to access Antarctica. A strong technical capacity will ensure that these countries do not use South Africa as a point to ship-out their equipment for servicing, but could utilise South African expertise to provide the services at a significantly reduced costs. This is in line with the projections of Operation Phakisa where the ocean is a significant contributor to the economy

10.6 Intervention 6: Data Management

Data transfer, access and reliability remain a challenge when working in this research sector. Proper centralized management of data emanating from the ocean, Antarctica and the Islands is required to meet both national and international data requirements. Systems that make the data available to national and international users are required. This would require appropriate management, so as to guarantee the integrity of the data. Obviously, reliable access to this data would also be critical. This situation is not unique to marine and Antarctic research as this is also important for South Africa to successfully host the Square Kilometre Array (SKA) telescope. The current SKA commitments have propelled the DST to start initiating the establishment of a big data centre and also increase the computing capabilities. Operation Phakisa has also indicated a need for big data capabilities. The current thinking towards the development of a big data centre is sure to also benefit the marine and Antarctic community as well.

Such centralized data management would be invaluable in sustaining and advancing scientific inquiry, and would undoubtedly increase opportunities for learning and innovation. As part of the data dynamics of the ocean and Antarctic Research, the Antarctic and Ocean Data Management System should be established aligned with the big data centre that will be established. This will enable tracking of all relevant data and information sources, and in so doing serve as a virtual central information portal to the various digital and physical material available. This virtual centre will coordinate the management of all the data and information collected and produced by South African researchers. With the advent of Operation Phakisa, industry is also interested in assisting in data collection and access to infrastructure, and this will require a coordinated process that also has the potential to reduce duplication that tends to put a strain on the already limited available resources.

The centre will act as a single portal to all ocean and Antarctic related data, so as to ensure that such data can be found, shared, and interpreted efficiently and effectively. A database only proves its worth after assessment and evaluation, and if the data therein is utilised to its full extent. A central point of access to all South African oceans and Antarctic related data sources will facilitate the use of databases that might otherwise have been overlooked. The centre will function primarily to:

- identify and manage existing databases, and keep record of their content, purpose and restrictions of use; and
- identify gaps, and in so doing initiate processes to address such gaps, either through new collection efforts, or through new database creation.

The centre will verify that databases listed comply with various national and international standards for data collection format and documentation. The centre will also ensure that copyright law and policies are upheld. The centre will also function as a platform to provide the necessary information for the marketing of South African activities in the oceans and Antarctic regions.

11. Resourcing the Strategy

The strategy will mainly be resourced from coordination of currently existing instruments and it will also be embedded in new instruments that are being developed such as the South African Infrastructure Roadmap Initiative. Through comprehensive evaluation of new requirements that emerge once the coordination structures are in place, new directed

instruments would be developed through a reprioritisation exercise and national Treasury submissions.

12. CONCLUSION

The South African Government generally has expectation that the research that is supported will be on programmes that will have major benefits for country as a whole. The research would broadly fall within four categories: long-term observations that would involve more basic concepts and studies of national importance; short-term projects that address specific challenges of the time; large scale multi-year, multidisciplinary and cross-disciplinary research that has the potential to cut across different sectors; and sector specific research whose priority is determined by a particular sector.

This Strategy expresses the national intent of developing and advancing Marine and Antarctic research in South Africa. Current and previous investments highlight the importance of this sector in turning around the South African economy. In an effort to fast track the process, government initiated Operation Phakisa and this has yielded positive commitments by various sectors. The implementation of this strategy will assist in the establishment of a foundation. There are limited resources that are available and as such coordination of implementing this strategy will ensure that these resources are optimally utilized.

The strategy will also be periodically reviewed to ensure that new developments are adapted for the benefit of the country. The role that will be played by the MARS Com and the broader research community is central to the implementation of this strategy. The challenges that are faced by the sector are significant but there is an urgent need to deliver the appropriate science to meet the current national and future needs. There is an urgent requirement for South Africa to make significant contributions towards the understanding of impacts and benefits that can be derived from the marine and Antarctic environment. This strategy will contribute in ensuring that a knowledge based economy is developed in line with policies of the South African government. The economic turnaround strategy of South Africa which is embedded in the NDP identified the oceans economy as one of the initial steps that had to be prioritized. Building of capacities in these areas is an integral part of implementing this strategy to produce the desired outcomes.