A compendium of SOUTH AFRICAN MARINE RESEARCH

in the Western Indian Ocean

ACEP

COMPILING AUTHORS

Dr Angus Paterson
Prof. Juliet Hermes
Dr Tommy Bornman
Tracy Klarenbeek
Dr Gilbert Siko
Rose Palmer

Report design: Rose Palmer

science & technology
Department:
Science and Technology
REPUBLIC OF SOUTH AFRICA

NRF National Research Foundation | RISA Research and Innovation Support and Advancement

NRF National Research Foundation | SAIAB South African Institute for Aquatic Biodiversity

NRF National Research Foundation | SAEON South African Environmental Observation Network

A COMPENDIUM OF SOUTH AFRICAN MARINE RESEARCH IN THE WESTERN INDIAN OCEAN

CONTRIBUTING AUTHORS

Prof. Janine Adams
Prof. Isabelle Ansorge
Dr Björn Backeberg
Prof. Paulette Bloomer
Dr Thomas Bornman
Dr Hayley Cawthra
Geremy Cliff
Prof. Rosemary Dorrington
Dr Thembinkosi Steven Dlaza
Prof. Ken Findlay
Prof. William Froneman
Dr Enrico Gennari
Dr Issufo Halo
Dr. Jean Harris
Prof. Juliet Hermes
Dr Jenny Huggett
Tracy Klarenbeek
Prof. Mandy Lombard
Neil Malan
Benita Maritz
Meaghen McCord
Tammy Morris
Ms Maryke Musson
Mr Mduduzi Mzimela
Mr Ashley Naidoo
Dr Larry Oellermann
Ryan Palmer
Dr Angus Paterson
Dr Brilliant Petja
Nicole du Plessis
Dr Anthony Ribbink
Prof. Chris Reason
Prof. Michael Roberts
Prof. Mathieu Rouault
Prof. Ursula Scharler
Dr Gilbert Siko
Dr Kerry Sink
Dr Gavin Snow
Johan Stander
Dr Neville Sweijd
Prof. Peter Teske
Dr Niall Vine
Prof. Sophie von der Heydem

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INTRODUCTION

South Africa is blessed with a remarkable marine and coastal environment that includes two contrasting boundary current systems, a range of zoogeographic zones, over 300 estuaries, deep-water and continental shelf regions, and a range of habitats that include rocky shores, sandy beaches, kelp forests, mangroves, and coral reefs. In order to best manage and understand these systems, South Africa has a vibrant marine research community which has steadily grown since the pioneering research started by Dr John Gilchrist in the late 19th century. This community involves researchers at Universities, Government Departments, National Research Facilities, Science Councils and Non-Governmental Organisations (NGOs).

Many fundamental marine science questions of the 21st century require multi-, inter- and transdisciplinary approaches which will demand increased collaboration between scientists, managers and policy makers nationally and internationally. In the last decade, the number of regional and international marine research programmes in the Western Indian Ocean (WIO) in which South African researchers can collaborate has increased. Activities run by programmes and initiatives such as the Agulhas Somali Current Large Marine Ecosystem (ASCLME) Programme, Western Indian Ocean Marine Science Association (WIOMSA), Indian Ocean Rim Association (IORA), and International Indian Ocean Expedition 2 (IIOE - 2) call for high levels of interaction and co-operation.

In order to foster collaborative opportunities, the South African Department of Science & Technology (DST) requested that a compendium of South African marine research activities being conducted in the WIO should be produced and periodically updated. This compendium includes information on key institutions and research programmes and is cross-indexed according to discipline. The compendium is the result of voluntary submissions by the various institutions and does not purport to be a comprehensive overview of all WIO marine research activities. The first version of the compendium focuses primarily on the natural sciences. If the result is deemed helpful, the scope will be broadened in the next version.

The editors hope that the compendium will enable researchers to identify possible research partners and agencies and thus enhance collaborative research throughout the Western Indian Ocean.

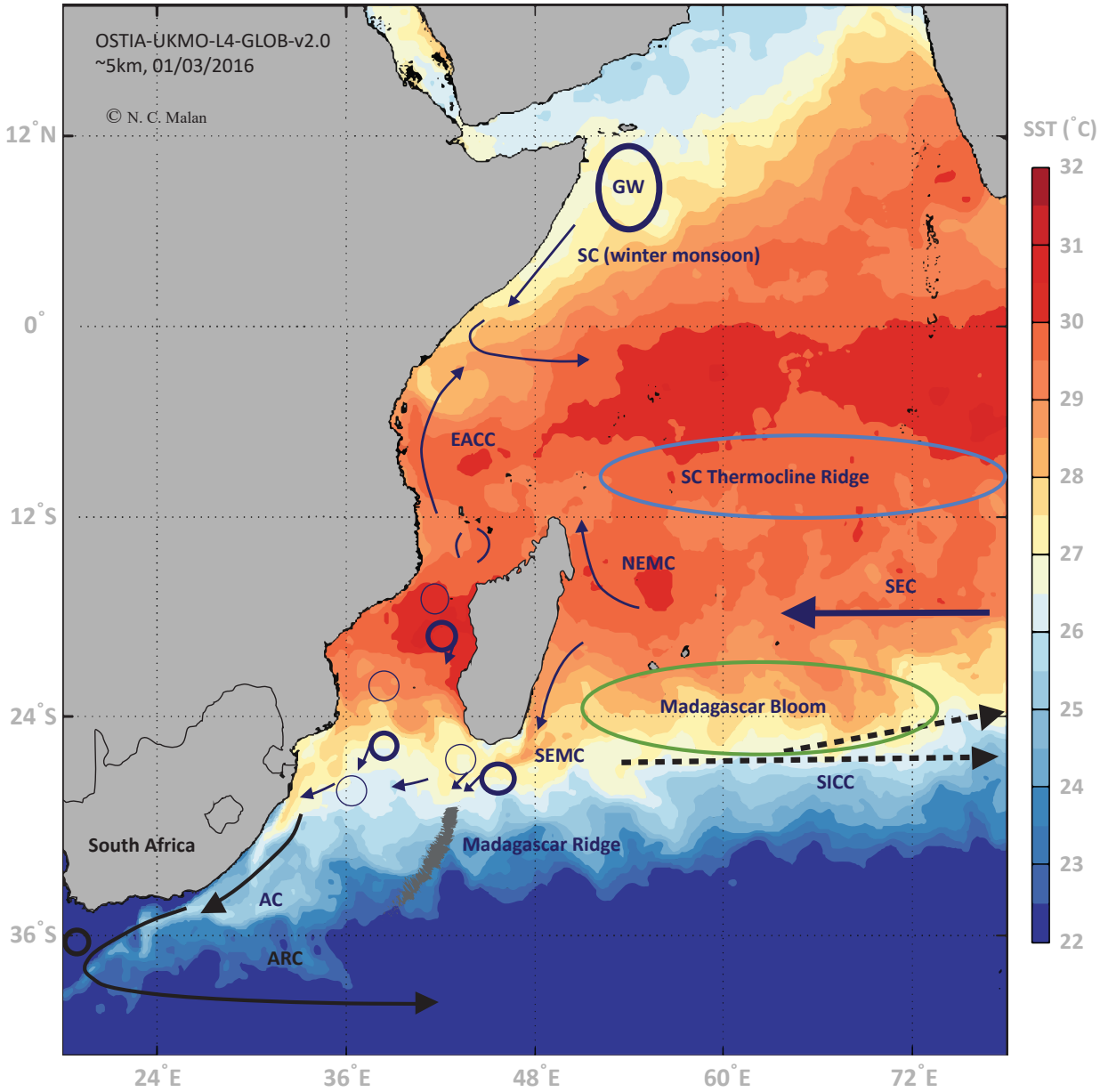
THE WESTERN INDIAN OCEAN

The Western Indian Ocean (WIO) region stretches from the southern tip of South Africa to the northern Red Sea, the Persian Gulf, Sri Lanka, and a line south from the tip of India. It harbours diverse habitats with both tropical and subtropical regions stretching along the coastline of continental Africa: Somalia, Kenya, Tanzania, Mozambique, and South Africa, and surrounding the island states of Madagascar, Seychelles, Comoros, Mauritius, and French Territories. The WIO region is characterised by high biodiversity, both in terms of species and ecosystems, which places it as one of the most rich and interesting ocean regions of the world.

Unlike the Pacific and the Atlantic, the northern boundary of the Indian Ocean (Asia) is at a low latitude and hence the North Indian Ocean cannot export heat to high latitudes via a western boundary current like the Kuroshio or the Gulf Stream. Most of the Indian Ocean, except the Agulhas Current and Leeuwin Current systems, gain large amounts of heat from the atmosphere, as well as from the tropical Pacific via the Indonesian throughflow.

The landmass configuration leads to a very strong boreal monsoon and a weaker austral monsoon. It is the only ocean where annual mean winds near the equator are westerly, causing a flat and deep equatorial thermocline. This limits anomalies in SST via upwelling variability, creating a dry Equatorial East Africa compared to Indonesia.

The wind stress curl between these westerlies and southeasterly trades creates an anomalous upwelling in tropical SW Indian Ocean: the Seychelles-Chagos thermocline ridge, which is important for tropical cyclone modulation, Madden-Julian-Oscillations (MJOs), and the monsoon, and potentially influences El Niño Southern Oscillation (ENSO) signals.



The South Indian Ocean has strongest curl between mid-latitude westerlies and trades, resulting in the Agulhas Current being the strongest western boundary current in the Southern Hemisphere. A poleward flowing warm current (Leeuwin) is also found off the Australian coast, on the eastern boundary of the South Indian Ocean, unlike any other subtropical eastern boundary.

The Somali Current (SC), in the WIO, crosses the equator within a narrow zone during the boreal summer monsoon and is closely connected with upwelling and high levels of eddy activity in the Great Whirl (GW). The Somali Current is reversed during the boreal winter monsoon and, along with the South Equatorial Current (SEC), feeds into the South Equatorial Counter Current (SECC). The SEC reaches Madagascar and bifurcates, with a northward flowing North East Madagascar Current (NEMC) which feeds the East African Coastal Current (EACC) and a poleward flowing South East Madagascar Current (SEMC), linked to strong upwelling on the south coast. The EMC breaks away from Madagascar forming dipole pairs which generally head to the southwest and the east coast of South Africa. Some of the SEMC heads eastwards and feeds into the South Indian Ocean Countercurrent (SICC) which heads back towards Australia. This current is linked with one of the largest phytoplankton blooms in the world, the Madagascar bloom. The flow through the Mozambique Channel is associated with mesoscale poleward eddy features and upwelling along the continental margin.

The southward-flowing Agulhas is associated with upwelling, large eddies, and strong temperature gradients, which are of vital importance to the adjacent coastal and open ocean ecosystems. The Agulhas Current connects the Indian Ocean with the Atlantic Ocean and, through its leakage, plays an important role in the global overturning circulation. While a huge amount of research has been undertaken on the Agulhas Current on account of this global significance, its dynamics, instability, and multi-scale variations are still open to be addressed in depth. The Agulhas Return Current (ARC) travels back eastwards. forming the Indian Ocean's connection with the Southern Ocean.

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Pic: ACEP Spatial Solutions

GOVERNMENT DEPARTMENTS

Department of Science & Technology (DST)

science & technology
Department:
Science and Technology
REPUBLIC OF SOUTH AFRICA

Mandate

The DST derives its mandate from the 1996 White Paper on Science and Technology which created the policy framework for the then Department of Arts, Culture, Science and Technology (DACST) to establish key enabling policies and strategies to inform the strategic development of science and technology in South Africa. In 2002, Cabinet approved the National Research and Development (R&D) Strategy as the basis for the National System of Innovation (NSI). The National R&D Strategy requires performance and responses in three key areas:

1) enhanced innovation;
2) providing science, engineering and technology (SET), human resources and transformation;
3) creating an effective government science and technology system.

It is in this context that the DST was established as a separate department to ensure greater coordination and integration as well as better management of all government-funded science and technology institutions, and to provide a holistic overview of public expenditure on science and technology. Much of the Department's work is ultimately carried out through various agencies such as the National Research Foundation (NRF), which receives a substantial proportion of the DST budget to carry out various research support tasks, including supporting key national research infrastructure (National Research Facilities), scientific research grant administration, a student grant scheme, and the Council for Scientific and Industrial Research, which acts as a quasi-privatised research and development agency with a specific focus on research applicable to industry.

Key WIO Partnerships

The DST has established a number of partnerships through formal bi-lateral agreements with WIO countries such as Kenya, Madagascar, Mauritius, Mozambique, Seychelles, and Tanzania. These links are extended by institutional partnerships established by entities reporting to the DST, and programmes that are supported by the DST.

Key Research Areas

In consultation with national stakeholders, the DST developed the National Marine Research Plan (2014+) which steers the scope and direction of South African marine science. This research plan forms part of the larger DST-led Marine and Antarctic Research Strategy (MARS). The Marine and Coastal Research Plan contributes to MARS through research in the following themes:

- Oceans and marine ecosystems under global change
- Ecosystems, biodiversity and biodiscovery
- Coastal and marine resources, society and development

This research is conducted through nationally supported programmes implemented as competitive and directed research calls at national research institutions and academic institutions.

Within the DST/NRF National Facilities there are dedicated WIO research and research infrastructure provision programmes:

- South African Institute for Aquatic Biodiversity (SAIAB)
  - National Fish Collection – Considerable WIO holdings
  - National Coastal Craft Fleet – Vessels based at Durban and Port Elizabeth.
  - National Acoustic Telemetry Array Platform (ATAP) – 100 *in situ* stations between Cape Town and Sodwana
  - Marine Remote Imagery Platform (MA-RIP)
- South African Environmental Observation Network (SAEON)
  - Elwandle Coastal Node
  - Egagazini Offshore Node
  - Agulhas Somali Current Array
  - Sentinel Site Programme
- African Coelacanth Ecosystem Programme
  - Open Research Call
  - *Phuhlisa* Development and Transformation Programme
  - Marine Research Platform Provision

Key Researchers

The DST marine programme is managed by Dr Gilbert Siko - Director: Marine & Polar Research, Palaeosciences

Department of Environmental Affairs (DEA)

environmental affairs
Department:
Environmental Affairs
REPUBLIC OF SOUTH AFRICA

Mandate

The core business and mandate of the DEA is derived from the Constitution of the Republic of South Africa. Chapter 2 (Bill of Rights) and section 24 of the Constitution of the Republic guarantee everyone the right to an environment that is not harmful to their health or well-being; and to have the environment protected for the benefit of present and future generations, through reasonable legislative and other measures that

- prevent pollution and ecological degradation;
- promote conservation, and
- secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development.

In giving effect to these fundamental environmental rights, Parliament has enacted a number of key environmental legislation and regulations which guide the work of the Department. The enacted legislation, regulations and other approved policies deal with specific sub-sectors of environment, such as biodiversity and conservation management; oceans and coastal management; climate change and air quality management, and waste and chemicals management.

The DEA Branch: Oceans and Coasts (DEA: O&C) delivers on the mandate with respect to protecting, conserving and managing the coastal and ocean environments, including the Southern Ocean and Antarctica, with the specific purpose to promote, manage, and provide strategic leadership on oceans and coastal conservation.

Key WIO Partnerships

The DEA has several key partnerships with national, regional and international institutions. The branch: O&C has entered into strategic Memorandums of Understanding (MoUs) with South African Universities, including Nelson Mandela University, University of the Western Cape, Cape Peninsula University of Technology, the Nansen-Tutu Centre at the University of Cape Town, and the Walter Sisulu University.

The branch cooperates closely with the Department of Science and Technology and its various entities to promote marine sciences and improve the knowledge base for environmental management. These include joint research arrangements with the Council for Scientific and Industrial Research (CSIR), the South African Environmental Observation Network (SAEON), and the South African Institute for Aquatic Biodiversity (SAIAB).

At the regional level, key partnerships exist with the Nairobi Convention, the Western Indian Ocean Marine Science Association (WIOMSA), the Nansen Programme of the Food and Agricultural Organisation (FAO) of the United Nations, the Intergovernmental Oceanographic Commission (IOC) of UNESCO's sub-Commission for Africa and Adjacent Island States (IOCAFRICA). The DEA also engages in several bi-lateral partnerships with countries that share ocean research interests in the Western Indian Ocean and other ocean areas adjacent to South Africa.

The research agenda for O&C informs management decisions that require input from fields that range from physics to chemistry, as well as biology, across the spectrum from plankton to benthic biodiversity and top predators.

The UN Second International Indian Ocean Expedition (IIOE-2) was launched in Goa, India, in December 2015. The IIOE-2 seeks to revisit and advance from the first International Indian Ocean Expedition which took place 50 years ago. The DEA will undertake research and training cruises on *SA Agulhas II* in the south Western Indian Ocean in 2017 and 2018, as a national contribution to the IIOE-2 effort. Each cruise will have a duration of about 30 days, undertaking research of regional significance around South Africa and neighbouring countries.

The Second International Indian Ocean Expedition is envisaged around the following themes:

- Theme 1: Human impacts
- Theme 2: Boundary current dynamics, upwelling variability and ecosystem impacts
- Theme 3: Monsoon variability and ecosystem response
- Theme 4: Circulation, climate variability and change
- Theme 5: Extreme events and their impacts on ecosystems and human populations
- Theme 6: Unique geological, physical, biogeochemical and ecological features of the Indian Ocean

The current draft DEA plan is to address Themes 2 and 4 by undertaking oceanographic measurements in the northern part of the Agulhas Current in Replications of the Agulhas System Climate Array Line (RASCAL) and along the shelf edge between Port Edward (the ASCA line) and north of Durban to measure volume transport variability along the length of the current, and interaction with the coast and inshore shelf. There is expected to be time available to do associated surveys south of Madagascar and in the Mozambique Channel and to make diplomatic visits in neighbouring ports. During the first cruise from 15 Oct–15 Nov 2017, the focus was on regional capacity building and multi-disciplinary sampling off the

Mozambican and Tanzanian shelves, with a port call in Dar es Salaam during the WIOMSA symposium. Closely associated in time and space are the South African ACEP-IV cruises, investigating upwelling and other shelf processes on the Agulhas Bank shelf edge between Cape Agulhas and Port Alfred. Other ongoing programmes and projects in the branch may address one or more of the six science themes of the IIOE-2. The South African IIOE-2 research cruises in the Western Indian Ocean are a contribution to combined work of the countries of the Indian Ocean Rim Association (IORA).

Key Research Areas

The DEA manages two research vessels, namely the *RV Algoa* and *SA Agulhas II*. The *RV Algoa* spends about 200 days per year at sea undertaking specific research required by the DEA within the entire Exclusive Economic Zone of South Africa. The *SA Agulhas II* undertakes a mix of research and logistics cruises to Antarctica and the Southern Ocean islands.

Additionally, the DEA undertakes numerous shore-based and inshore research programmes, including satellite telemetry, and boat and dive operations. The areas of research include physical oceanography, chemical oceanography, biological oceanography, biodiversity, top predators, and coastal research.

Key Researchers

The DEA: O&C employs research staff in all of the above fields. Researchers currently participating in the planning of the IIOE-2 research cruises on the *SA Agulhas II* are listed below.

Dr J Huggett
Dr H Verheye
Mr M Tsanwani
Dr T Lamont
Ms Z Philander
Dr T Samaai
Dr A Makhado
Mr M Seakamela
Dr C Duncombe Rae
Mr M Gulekana
Mr N Devanunthan
Mr Ashley Johnson
Dr Alan Boyd
Mr Ashley Naidoo
Bukeka Bandezi

DEA Research and Supply Vessel *SA Agulhas II* Dedicated to Miriam Makeba

Department of Agriculture, Forestry & Fisheries (DAFF)

Branch: Fisheries Management

Mandate

The Department of Agriculture, Forestry and Fisheries' legal mandate covers the agriculture, forestry and fisheries value chains: from inputs, production, and value adding to retailing. The strategic goals and associated objectives of the Department of Agriculture, Forestry and Fisheries (DAFF), are effective and efficient strategic leadership, governance and administration; enabling environment for food security and sustainable agrarian transformation; and enhanceing production, employment and economic growth in the sector, and are a response to achieve the National Development Plan's (NDP) objectives and targets. The goals and associated objectives have been reviewed to address the priorities identified in the NDP.

The role of the Chief Directorate for the Fisheries Management branch is as follows:

To advise on and promote the sustainable utilisation of fisheries resources and ecosystems, and the sustainable development of aquaculture by leading, managing, and supporting appropriate natural science and fisheries research.

This means that we

- provide scientific and strategic leadership for natural science research on fisheries resources and scientific advice to support the sustainable and optimal management of aquatic resources;
- provide scientific and strategic leadership for ecosystem research and scientific ecosystem-related advice to support the sustainable and optimal management of aquatic resources and the management of aquaculture;
- provide scientific and strategic leadership for aquaculture natural science research and scientific advice to support the management and development of aquaculture;
- create an enabling environment for research;
- ensure cooperative governance, enhance service delivery and stakeholder relations through participation;
- oversee the management of the resources of the Chief Directorate.

DAFF has responsibilities to

- undertake research on living marine resources and advise on and promote sustainable resource utilisation, including commercial, recreational and small-scale fisheries;
- apply an ecosystem approach to sustainable utilisation of living marine resources & conservation of marine ecosystems;
- advise on the development of under-utilised or new living marine resources and rebuilding of depleted stocks where necessary;
- undertake long-term monitoring of resources;
- undertake environmental and climate change research relevant to fisheries;
- promote the development of marine aquaculture through appropriate research;
- understand the dynamics and functioning of the marine environment as they impact on ecosystem variability;
- provide decision-makers with the best scientific advice available, taking into account international best practice;
- build capacity in Fisheries and Marine Sciences within the Department, in government, and in South Africa, through collaboration with institutions within and outside of government;
- ensure that South Africa's regional and international commitments with regard to Marine Science are effectively met.

The responsibility of Resources Research is to advise on, and promote the sustainable utilisation of coastal and living marine resources and the conservation of marine and coastal ecosystems by conducting and supporting appropriate research. This involves, inter alia:

- conducting scientific research into exploited resources;
- performing resource assessments;
- making Total Allowable Catch and Total Allowable Effort recommendations for management;
- capturing and verifying catch data;
- investigating the potential for new fisheries.

The Department has recently prioritised aquaculture and established a new Directorate: Aquaculture Research. Aquaculture is a technology-driven industry which relies heavily on research to develop new species and the appropriate technology for commercial production. The responsibility of the aquaculture research division is to conduct research in support of a competitive and sustainable development of aquaculture in South Africa, more specifically to

- research and develop culture technology for finfish and invertebrate species;
- improve biosecurity of aquaculture activities through targeted surveillance, development of diagnostic methods, epidemiological research, and the development of preventative measures for promoting and maintaining a healthy culture environment;
- promote understanding of the interactions between environment, economics and aquaculture.

Key WIO Partnerships
Indian Ocean Tuna Commission (IOTC)
Convention for Conservation of Southern Bluefin Tuna (CCSBT)
Indian Ocean Rim Association (IORA)

Key Research Areas
Resources Research: Fisheries resources research, covering 22 fishery sectors spanning hundreds of resources, is primarily aimed at determining the status of fish stocks, and the levels of harvesting which will remove the largest volume of fish possible without causing undue risk to the long-term future of the resources. Where fish stocks are depleted to an extent where they are unable to provide the maximum harvest possible, recovery plans are developed, as per the agreement signed at the World Summit on Sustainable Development in 2002 to rebuild depleted fish stocks by 2015. These recovery plans trade off short-term reductions in catches against sustained higher catches in the medium- and long-term. In order to increase South Africa's fisheries production, research is also conducted to establish the feasibility of new fisheries to utilise previously unharvested resources. Currently under investigation are octopus, white mussels, whelks and hagfish, to name a few.

Aquaculture Research
In South Africa, aquaculture has been identified in the National Aquaculture Strategic Framework (NASF) as a sector requiring attention in respect of promoting expansion and diversification of activities. More specifically, the NASF identified development of aquaculture technology, particularly for indigenous species, as a key strategy for growing the local aquaculture sector. Related to this is a need to make South African producers more internationally competitive by reducing costs through improved aquaculture technology innovations. Accordingly, development of an ecologically sustainable aquaculture sector has the potential to bestow significant economic and social benefits on South Africa. Aquaculture research areas:

1. Species diversification and competitiveness
2. Animal health & diseases
3. Interaction between the environment & aquaculture

Research Support
Vessels: Fisheries research is conducted by gathering information from the fisheries themselves, and by dedicated surveys conducted either from the shore, with the use of small crafts, or with the Department's research vessels *RV Africana* and *RV Ellen Khuzwayo*.

Engineering Support
This unit comprises electronic and mechanical workshops and the function is to provide specialized engineering and technical support to the Department's marine research activities.

African Journal of Marine Science
The African Journal of Marine Science is the Fisheries Branch's flagship publication, recognised as the best natural science journal on the African continent. The journal publishes articles on a wide variety of marine science topics from around the world. For further information, including subscriptions, online access, and instructions to authors, see http://www.nisc.co.za/journals?id=10.

Key Researchers
Rob Anderson
Lutz Auerswald
Doug Butterworth
Andrew C Cockcroft
Janet Coetzee
Charlene da Silva
Deon M Durholtz
J Dzierkwa
Tracey P Fairweather
Yonela Geja
Jean Githaiga-Mwicigi
Derek Kemp
Sven Kerwath
Stephen Lamberth
Rob Leslie
Angus Mackenzie
Genevieve Maharaj
Sekiwe Mbande
Jean Michigwi
Denham Parker
Kim IM Prochazka
Mark Rothman
Larvika Singh
Rob JQ Tarr
Nandipha Twatwa
Carl van den Lingen
Wendy West
Henning Winkler
Chris G Wilke

SCIENCE COUNCILS & RESEARCH INSTITUTIONS

National Research Foundation (NRF)

The National Research Foundation is an independent statutory body established through the National Research Foundation Act (Act No 23 of 1998).

As a government mandated research and science development agency the NRF funds research, the development of high-end human capacity and critical research infrastructure to promote knowledge production across all disciplinary fields. The goal of the NRF is to create innovative funding instruments, advance research career development, increase public science engagement, and to establish leading-edge research platforms that will transform the scientific landscape and inspire a representative research community to aspire to global competitiveness. The NRF promotes South African research interests across the country and internationally, and together with research institutions, business, industry, and international partners we build bridges between research communities for mutual benefit.

The National Research Foundation supports research in the Western Indian Ocean through the provision and management of a number of programmes. The key point of contact at the NRF is through the Knowledge Fields Development Division (KFD) and the officer in charge of marine programme (Ms Tracy Klarenbeek).

- **National Facilities** – The NRF has two National Facilities which provide marine and coastal research infrastructure. The South African Institute for Aquatic Biodiversity (SAIAB – pp 24) and the South African Environmental Observation Network (SAEON – pp 22).
- **Research Programs** – The key NRF programme in the Western Indian Ocean is the African Coelacanth Ecosystem Programme (ACEP pp - 34).
- **Open Directed Research Calls** – The NRF has an open research call that targets marine research in support of the Marine and Antarctic Research Strategy.
- **Open Research calls** – The NRF runs a range of calls which support research within South Africa. While not specifically aimed at marine research a number of research programs and researchers active in the WIO are supported:
    - Foundational Biodiversity Information Programme (FBIP).
    - Thuthuka Programme for early career research support.
    - Blue Sky Research Programme for cutting edge research.
    - Rated Researcher Open Call.
    - Unrated Researcher Open Call.
- **South African Research Chairs Initiative (SARChI - pp. 42**) – The SARChI programme has a number of research chairs which are actively involved in research in the WIO.

The other key marine research coordinating body funded by the NRF is the South African Network for Coastal and Oceanic Research (SANCOR). The South African Network for Coastal and Oceanic Research (SANCOR) is a non-statutory body that generates and communicates knowledge and advice in order to promote the wise and informed use and management of marine and coastal resources and environments (https://sancor.nrf.ac.za).

SANCOR

- Provides a forum for interaction, collaboration and communication about marine science in the marine and coastal environment (SMCE), and to generate debate on current issues.
- Contributes to planning for future demands on marine and coastal environments and resources.
- Co-ordinates and integrates activities by stimulating appropriate inter-disciplinary and inter-institutional collaboration.
- Contributes pro-actively to policy development.
- Advises on the optimal use of financial, technical, and logistic resources.
- Helps develop capacity in all sectors.
- Markets the benefits and promotes the use of research findings.

Council for Geoscience (CGS)

Location: Western Cape Regional Office, Cape Town

Overview of Marine Research

The CGS has a Marine Geoscience Unit which specialises in coastal and marine geology. Coastal geological investigations include studies of beach nourishment and erosion, investigations of coastal vulnerability (to extreme events and geo-hazards), investigations into coastal geological structures such as caves and sea-level indicators, and coastal engineering projects (around harbours, jetties, pipelines, seafloor cables). The Marine Geoscience Unit maps the seafloor using a suite of instruments including multi- and single-beam echo sounders, side-scan sonars, boomer and pinger sub-bottom profilers, and marine magnetometers. The scientists are qualified Class IV commercial divers and conduct geological mapping on the seafloor, as well as carry out vessel-based sampling (coring, sediment grab sampling). In addition to marine geophysical and geological mapping, the CGS archives, manages and curates seafloor hydrographic and geophysical data. There is a particular focus on geographic information systems (GIS) applied to continental shelf bathymetry and geology.

In the Western Indian Ocean (WIO), the CGS has mapped sections of continental shelf in KwaZulu-Natal, the Eastern Cape and the Western Cape. Previous continental shelf work of relevance in the WIO was carried out (from north to south) in Sodwana Bay (geophysical mapping, geological investigation, sea-level studies and coral coring), the Thukela Banks (sedimentary setting and shelf evolution), offshore of Durban (geophysical mapping and geological investigations of the Durban Bight and Blood Reef), Aliwal Shoal (geophysical mapping, geological investigation), limited parts of Algoa Bay (geophysical mapping), Thyspunt (geophysical mapping), Mossel Bay (geophysical mapping, geological investigation, sea-level studies and sediment analysis) and a broad study of the entire south coast (Cape St Francis to Cape Agulhas) (geophysical mapping, multi-proxy work towards the reconstruction of the palaeoenvironment during times of lowered sea level).

Bi-lateral/Multi-lateral Funded Work

Palaeoscape/SACP4 (South African Coast Palaeoclimate, Palaeoenvironment, Palaeoecology, Palaeoanthropology) Project

Rationale: To test dynamic connections between hominin resources and the environment as a means to progress to a fuller understanding of hominin origins. The offshore shelf plays a major role in this endeavour and has been mapped and the marine geology interpreted.

Methods and goals: We use marine and coastal datasets for the southern coastal plain on the south coast (archaeology (Pinnacle Point), geology, botany (across the Cape Floristic Region), continental shelf marine geophysics) to understand the nature of the palaeoscape. Minimally, we seek to generate four model states of palaeoclimate and palaeoenvironment (strong inter-glacial, moderate inter-glacial, moderate glacial, and strong glacial) to represent the Late Pleistocene.
Partner institutions: Arizona State University (ASU), Centre for Coastal Palaeoscience at Nelson Mandela University (NMU), CGS
PI: Curtis Marean (ASU, NMU)
Project partner at CGS: Hayley Cawthra
Funded by: The National Science Foundation (NSF), USA – approved until 2018; supported by NMU and CGS into the long term

RAiN (Regional Archives for Integrated iNvestigations)

Rationale: RAiN aims to expand the current state of knowledge on the drivers and dynamics of South African Late Quaternary climate change by directly comparing marine and terrestrial proxy records. The ultimate aim is to be in a better position to project future models based on solid palaeodata.
Methods and goals: Sediment cores (vibrocores and gravity cores) as well as sediment samples from more than 30 locations on the South African margin (from Sodwana Bay to the Orange River).
Partner institutions: Bremen University (MARUM), UCT, CGS, UKZN, Jena University
PI: Matthias Zabel (MARUM)
Project partner at CGS: Hayley Cawthra
Funded by: The BMBF/SPACES Programme (German Government) and Phase 2 is approved until 2019; supported by CGS

P5 (Pondoland Palaeoclimate, Palaeoenvironment, Palaeoecology, Palaeoanthropology)

Rationale: To find coastal archaeological sites adjacent to the narrow Pondoland continental shelf which contain records of coastal foraging into the glacial maxima.
Methods and goals: We use marine and coastal datasets for the Pondoland region: archaeology (at four selected locations), geology, botany, and continental shelf marine geophysics to understand the nature of the palaeoscape.
Partner institutions: ASU, Centre for Coastal Palaeoscience at NMU, Wits University, CGS

PI: Erich Fisher (ASU)
Project partner at CGS: Hayley Cawthra
Funded by: The NSF, USA and the John Templeton Foundation, USA; supported by CGS

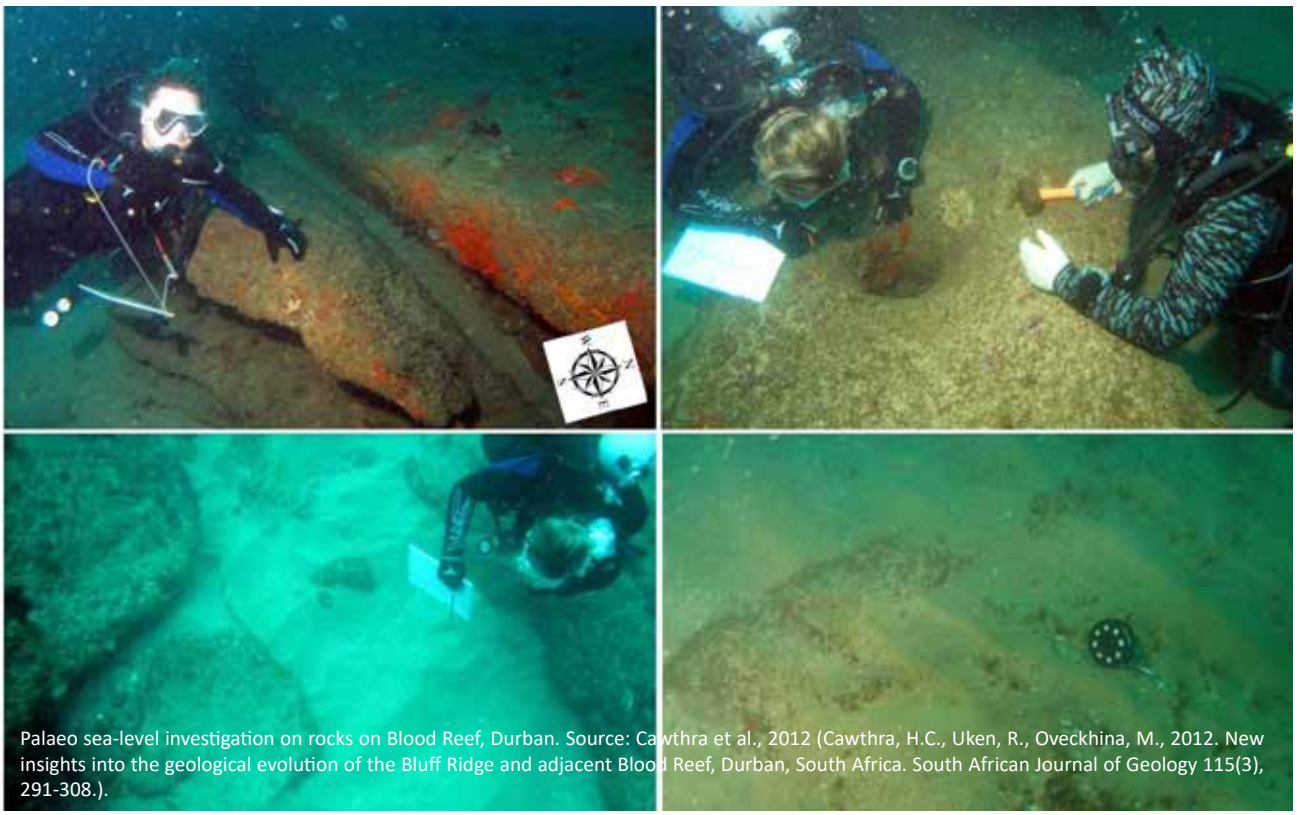
Key Programmes
The South African Nearshore Mapping Programme (SANMAP)
Rationale: The SANMAP aims to map the entire continental shelf with the objective of boosting the blue economy in South Africa. This programme is designed to incorporate six key focus areas: technology, innovation in mapping, capacity building and training, data management, knowledge and research and ocean governance; and to create and develop a marine geoscience programme at the CGS. The rationale encompasses various strategic areas, aiming to address environmental stewardship (for example, renewable energy, hazard mitigation and climate change), sustainable resource management (both geological and biological), archaeological and historical heritage management, infrastructural development, and most importantly, cutting-edge scientific research in marine geology and coastal palaeoscience through analysis of good quality data.

Methods and goals: The scientific aims are as follows:

1. Create a series of seamless onshore-offshore maps on scales of 1:250,000 and 1:50,000.
2. Map the continental shelf using marine geophysical methods (multi-beam bathymetry, side-scan sonar, boomer sub-bottom profiling, pinger sub-bottom profiling, marine magnetics) from the shoreline to the continental shelf break.
3. Design a methodology for marine geoscientific data management (historical and current).
4. Develop a high-resolution geophysical/geomorphic/palaeoenvironmental database for key sections of South Africa's continental shelf, embracing technological development and innovation in the manipulation of high-resolution data.
5. Generate computer models of offshore geological and palaeoenvironmental settings under various climatic/sea-level scenarios.
6. Create habitat maps for living marine resources, to be applied in sustainable marine planning.
7. Develop capacity and train young scientists in marine geoscience in South Africa.

Funded by: CGS
PI: Hayley Cawthra

Key Researchers
Dr Hayley Cawthra Mr Michael MacHutchon Mr Wilhelm van Zyl



Palaeo sea-level investigation on rocks on Blood Reef, Durban. Source: Cawthra et al., 2012 (Cawthra, H.C., Uken, R., Oveckhina, M., 2012. New insights into the geological evolution of the Bluff Ridge and adjacent Blood Reef, Durban, South Africa. South African Journal of Geology 115(3), 291-308.).

Council for Scientific & Industrial Research (CSIR)

Location: Cape Town, Western Cape

Overview of Marine Research

The CSIR has unique research and development (R&D) capabilities spanning South Africa's highly dynamic and productive Exclusive Economic Zone (EEZ) and shelf sea domains, with a focus on developing state-of-the-art marine observation, together with integrated modelling and forecasting capabilities that have high impact potential for Operation Phakisa-related blue economy developments.

South Africa's EEZ encompasses the coastal ocean and shelf sea waters, which support thousands of jobs and contribute millions of rand to the national economy each year, with coastal and ocean goods and services estimated to contribute 35% to South Africa's gross domestic product. Globally, the oceans have been estimated to contribute a total of US$24.2 trillion (R327.6 trillion) per year to human welfare, and provide 60% of the total economic value of the biosphere. The economic potential of the South African ocean is recognised through Operation Phakisa: Ocean Economy, which is a major South African policy initiative, expected to contribute R20 billion to the economy by 2019.

CSIR's R&D and capabilities support marine and maritime environmental activities (including research) in the EEZ across several sectors, including environmental management, safety and resources, fisheries and aquaculture, marine transport, offshore oil and gas, climate and weather forecasting. This is achieved by improving our ability to observe, model and predict the 3D ocean state, thereby providing routine, timely and actionable information on the marine and maritime environment – which is critically important to these initiatives – across the South African EEZ. Such information has significant and well-recognised economic value, and provision thereof is wholly dependent on coupled and cohesively focused earth observation and ocean modelling capabilities. The CSIR drives this scientific development through strongly application-focused end-user needs specifically tailored for the South African shelf seas which, in turn, will advance our quantitative understanding of ocean processes affecting the marine and maritime environment.

The CSIR's expertise includes regional physical and biological oceanography, satellite remote sensing and *in situ* measurement technologies (including autonomous robotics), numerical ocean modelling and data assimilation, as well as bio-optics and modelling. Combining this expertise with a strong network of national and international collaborators with a wide range of complementary skills enables the development of actionable and marketable decision-support tools, for example:

- high-resolution 3D numerical modelling of essential ocean state variables supports marine and maritime operations;
- data assimilative 3D ocean state re-analysis products of South Africa's EEZ support marine research and environmental management;
- improved shelf-scale boundary conditions enable more accurate downscaling for very high-resolution coastal ocean models;
- passive tracer tools using satellite-derived ocean current fields to estimate the advection and distribution of passive particles in the ocean;
- tailored satellite remote sensing analyses support sector-specific marine and maritime operations;
- capability to detect phytoplankton community composition from satellites to observe marine ecological shifts, with direct operational application to climate change, fisheries, harmful algal blooms, aquaculture, and water quality monitoring;
- experimental acquisition of high-resolution bio-chemical and physical data in the SA EEZ through the Gliders In the Agulhas (GINA) experiment.

Key Programmes

CSIR Thematic Programme: Towards an Integrated, Predictive, High-resolution Ocean Observing Network (TIPHOON)
PIs: Dr Björn Backeberg, Dr Stewart Bernard, Dr Kobie Smit
The project focusses on the development of new high-resolution monitoring and prediction capabilities for both the Operation Phakisarrelated Oceans and Coastal Information Management System (OCIMS), and the CSIR Earth System Model (ESM). This will, in turn, allow greatly enhanced observational and predictive ability across bay to open ocean scales, based on the integrated use of ocean models, remotely sensed earth observations, and autonomous *in situ* observations.

The National Oceans and Coastal Information Management System Project (OCIMS)
PI(s): Dr Lee Annamalai
The National OCIMS is the result of collaborative partnerships led by the Department of Environmental Affairs (DEA) and managed by the CSIR. The project has drawn from the expertise of government, labour, business, academia and other

sectors. It serves under the aegis of Operation Phakisa, a national government project. The National OCIMS is a product that will provide access to interactive spatial information which can be used as a tool for improved decision-making, predictive modelling, research, and public information. The National Oceans and Coastal Information System forms part of the Operation Phakisa Oceans Economy Programme Action Plan, endorsed by Cabinet.

The outcome of Operation Phakisa Initiative 6 are to:

1. establish Earth Observation Technology Capacity for the South African EEZ and continental shelf by 2019/20;
2. deliver the National OCIMS by 2019/20 and
3. establish and implement the Data and Earth Observation Infrastructure required of the National OCIMS.

This will be achieved through the development of an Information Management System (IMS) that will integrate current and future systems, and information and expertise into a user-friendly and cost-effective National OCIMS for the benefit of relevant stakeholders.

GINA

PI(s): Dr Marjolaine Krug, Dr Juliet Hermes

The GINA project (http://socco.org.za/gina/) is a multi-institutional observational effort led by the CSIR and co-funded by the CSIR-NRE (CSIR-Natural Resources and the Environment), Southern Ocean Carbon and Climate Observatory (SOCCO), Coastal Systems and Ecosystem Earth Observations groups, SAEON Egagasini and Elwandle nodes, SAIAB, University of Gothenburg (Department of Marine Science), DAFF, DEA, ORI, UCT (Oceanography Department), and the Nansen-Tutu Centre for Marine Environmental Research. Ocean gliders are well suited to monitor the complex and rapidly varying ocean environment in the EEZ. From their earliest conception, gliders were viewed as components of observing/modelling systems, and progress over the past decade has proven the efficacy of this approach. GINA aims to develop a sustainable glider observing network for monitoring and studying South Africa's coastal and shelf regions. GINA complements and enhances existing observing networks such as the Agulhas System Climate Array (ASCA) or the coastal monitoring network managed and maintained by SAEON. Data collected through this initiative will be used to improve and validate observations from satellites and numerical model simulations. GINA is integrated within the OceanGliders Boundary Ocean Observing Network (OceanGliders BOON).

Key Researchers

Dr Lee Annamalai
Dr Björn Backeberg
Dr Stewart Bernard
Dr Marjolaine Krug
Dr Kobie Smit

Pic: Olivier Pasnin (SU)

Institute for Maritime Technology (IMT)
a Division of Armscor SOC Ltd

Overview of Marine Research

The Institute for Maritime Technology provides scientific and engineering technology support to our primary client, the South African Navy, to carry out its seaward military operations. IMT conducts relevant research and capability-building to:

- develop an understanding of technology areas to provide the client with educated and objective advice
- support the client in resolving operational deficiencies with applied technology and research
- conduct independent maritime test and evaluation

IMT services are also available to non-Department of Defence clients on a selective basis. Spin-offs from techno-military activities are developed into commercial products through joint ventures with industry.

Although the work conducted at the IMT falls mainly into the defence realm, the skill set developed at IMT in the fields of ocean engineering cuts across domains. The ability to use engineering solutions to provide operational answers is present throughout IMT key programmes. Most of the current programmes are not focused on the Western Indian Ocean (WIO), but the research principles used by IMT can be applied anywhere.

Key Research Areas

IMT work is currently focused in the coastal areas around South Africa not limited to the WIO. Work includes:

- ocean survey research (capabilities) in underwater security
- oceanographic and atmospheric research with specific application on the affect thereof on sensors and platforms
- electro-magnetic propagation experiments (currently only in False Bay)
- underwater sound signature research
- general test and evaluation capabilities
- maritime domain awareness work across the country
- GIS research in maritime decision support

Key Researchers

Mrs Benita Maritz Mr Russell Egypt Mr Claude Ramasami

Divers inspecting a deployed OTN receiver off Mozambique. Pic: Ryan Daly

KwaZulu-Natal Sharks Board (KZNSB)

Location: KwaZulu-Natal, South Africa

Overview of Marine Research

The KZNSB is a public entity under the KwaZulu-Natal Department of Economic Development, Tourism and Environmental Affairs (EDTEA). Since 1964 it has been legally mandated to provide protection against shark attacks at popular swimming beaches in KwaZulu-Natal. Currently the Board services 37 locations between Richards Bay and Port Edward by year-round deployment of shark safety gear in the form of two fishing devices, large-mesh gillnets (since 1952) and drumlines (a single, large baited hook suspended from a large float; since 2005). These devices are anchored directly off the popular beaches. The gear is checked approximately 20 times per month, when any catches are removed and the drumline hooks rebaited. Approximately 550 sharks from 14 species are caught each year, along with about 350 other individuals, chiefly rays and smaller numbers of turtles, cetaceans and teleosts. A number of interventions have been adopted to reduce these catches. Every catch is identified, measured and recorded. Any animals found alive are released, and tagged where possible. Dead animals, unless badly decomposed, are kept for scientific examination. Routine biological information on reproduction and diet is collected and a variety of tissue samples are kept for further studies such as genetics, fatty acids, stable isotopes, heavy metal and organic pollutants. All shark attacks in South Africa are recorded and, where possible, investigated to ascertain the species responsible and the circumstances surrounding each incident.

Key Programmes

As one of the world's leading shark research organisations, the KZNSB runs numerous projects investigating various aspects of shark biology (particularly reproduction and diet), population dynamics, and shark attack. In addition, the organisation works in close collaboration with other research organisations, both locally and internationally. Currently, the KZNSB provides a variety of samples from dissected sharks, including DNA, liver, skin, parasites, teeth, and eyes to over 20 scientists and 15 projects worldwide. Some key projects include:

Shark Repellent Cable (SRC)

The KZNSB has long been investigating the use of new technology to provide more environmentally acceptable alternatives to its current programme of shark nets and drumlines deployed along the KwaZulu-Natal coast. In the 1990s it developed the SharkPOD, a personal electrical shark repellent, designed for scuba divers. This technology is now used in the SharkShield®, a highly successful personal shark repellent, developed in Australia. In 2012, the Institute for Maritime Technology (IMT) was contracted to design and build an SRC, which generates a similar electric field, but which could enclose an entire swimming area. The system has been tested at both Glencairn (Cape Town) and Mossel Bay and results have shown it to be extremely effective at repelling white sharks. The next step is to conduct tests against other potentially dangerous species such as bull and tiger sharks. If successful, this device has the potential to form a barrier system that can protect bathers without killing sharks or any other marine animals.

Acoustic Monitoring of Sharks

A key research objective is to gain a better understanding of the movement and residency patterns of potentially dangerous sharks along the KZN coastline. This information is crucial to reduce the risk of shark attack and to make informed decisions on the deployment and location of shark safety gear to reduce bycatch. In the last two years, an array of 28 'listening stations' has been deployed at both netted and non-netted beaches between Richards Bay and Mzamba (a short distance south of Port Edward). The stations are able to 'listen' for any acoustically tagged sharks that have been tagged by researchers anywhere in the world. Data are downloaded annually. The recipients are part of a bigger network (the OTN) on the east and south coasts of South African maintained by several researchers who are tagging a variety of different fish species.

Shark Tagging

The KZNSB has been a member of the Oceanographic Research Institute Co-operative Tagging Programme since its inception in 1984. All live sharks that are strong enough are released. Whenever possible, these animals are tagged with an external dart/spaghetti tag.

Hook Timers and Accelerometers

Very little information exists on the time of day an animal is caught in the shark safety gear, or how long it can survive after capture. To answer these fundamental questions, hook timers and accelerometers have been attached to selected drumlines and nets, respectively. Hook timers record the time a bait is taken from a hook. An accelerometer is an electromechanical device that measures the force of acceleration and records the struggle pattern (acceleration of net movement) of any animal caught in the net. In this way, time of capture and survival time can be determined, as can the number of animals that were caught, but escaped.

Aerial Surveys

The KZNSB conducts regular aerial surveys of the northern KZN coast to determine the number and distribution of whale

sharks. The project was initiated in 2001 following a request from DEA to assess the potential for dedicated whale shark diving on the KZN coast. The KZNSB also conducts regular aerial surveys of the annual sardine run to monitor movements of the sardine shoals and associated predators in order to facilitate the timely removal of shark safety gear.

Growth and Ageing of Sharks
Knowledge of shark age and growth is fundamental in determining the impact of this programme on shark populations. The KZNSB injects any shark released alive with oxytetracycline (OTC), which marks growth rings in the vertebrae. In this way, the number of rings deposited after the shark was injected can be counted. Through international collaboration, bomb-carbon ageing of species is also undertaken.

Genetics
The Elasmobranch Molecular Ecology Laboratory (EMEL) facilitates investigations into the genetic structure of sharks and rays commonly caught in the shark safety gear. These studies are aimed at ascertaining genetic diversity, effective population size, population connectivity, reproductive and nursery philopatry, and demographic history of these species. Post-graduate students at a number of South African universities have made use of this facility.

Scientific Advisory Service
Advice has been provided on an *ad hoc* basis to Kenya, Madagascar, Seychelles, Mozambique and Reunion in response to shark attacks and appropriate mitigation options. This service is available on request. Several regional shark species assessments have been compiled for a number of organisations (e.g. IUCN), including a South Western Indian Ocean Sharks and Rays Status Report Validation.

Key Researchers

Geremy Cliff
Dr Matt Dicken
Sabine Wintner
Paul von Blerk
Dr Lucas Mmonwa
Nomfundo Nkabi

Zambezi shark in a state of tonic immobility. Pic: Barry Skinstat

South African Environmental Observation Network (SAEON) Egagasini node

Location: Cape Town, Western Cape

Overview of Marine Research

Bi-lateral/multi-lateral Funded Work

In collaboration with the University of Cape Town, Nelson Mandela University, the University of the Western Cape, and other international universities, SAEON hosts and co-supervises a number of students with a focus on understanding the physical and biological oceanography and biodiversity of the South Western Indian Ocean and Agulhas Current. SAEON Egagasini leads the Agulhas System Climate Array: sustained observations of the Agulhas Current, with our international partners, along with other projects not listed explicitly here. Understanding the climate variability, the physical/biological interactions, the sub-mesoscale and mesoscale variability and its impact on the weather and coastal biodiversity in the SW Indian Ocean are a key mandate of SAEON Egagasini node, and this work is achieved through both in situ measurements and the use of numerical models. We are also expanding further into a multi-disciplinary approach which includes investigating indigenous knowledge of fisheries and climate variability, as well as policy-related issues within the Indian Ocean.

Coastal to Climate: Modelling for Research

At Egagasini there are a team of professional postdoctoral and PhD students working specifically on modelling the SW Indian Ocean with physical and coupled biogeochemical models and a variety of scales from submesoscale through to ocean basin (1/36 degree through to ¼ degree). This is in collaboration with the University of Cape Town and the Nelson Mandela Metropolitan University, the CSIR, the IRD and the University of Brest, and GEOMAR through SPACES. In collaboration with UCT, NMU, the CSIR and the Department of Agriculture, Forestry and Fisheries (DAFF), and IRD, we are also investigating the impact of various physical phenomena in the SW Indian Ocean and the impact on the biology through Lagrangian drifter tracking.

Offshore Invertebrate Monitoring

Established in 2011, SAEON Egagasini collaborates annually with the DAFF to monitor offshore benthic invertebrate species, abundance and biomass. The area monitored stretches from the Orange River mouth in the north to Port Alfred in the east, includes the southern temperate region of the WIO, and ranges from 30 m inshore to 1000 m in depth. All epibenthic invertebrates retained by the demersal trawl net are identified, counted ,and weighed with the approximately 17 000 records being captured in both SAEON and DAFF databases. More than 400 taxa identified to either genus or species level have been compiled into a field guide through collaborations with taxonomists and researchers from 14 institutions. Through this initiative thus far, 14 new species distributions have been recorded in South Africa, and 20 species new to science have been discovered that are in the process of being described. Data and specimens collected through this research have supported several student research and long-term impact assessment projects. Aside from contributing to foundational deep-sea taxonomy and biodiversity knowledge, information from this long-term monitoring initiative is being used to identify and map potentially vulnerable marine ecosystems, define and characterise offshore ecosystems, assess potential impacts of trawling, and has the capacity to enable quantification of future species or habitat changes that may occur as a result of a changing environment.

Algoa Bay Offshore Biodiversity Research

Through funding received from the Department of Science and Technology (DST) Innovation Grant, post-doctoral and post-graduate research conducted by the Egagasini team includes characterising patterns of habitat types and epibenthic biodiversity offshore of Algoa Bay in the Agulhas eco-region. Photographic surveys were conducted at depths between 30 m and 300 m over the shelf and upper slope. Optimal protocols for effective visual surveys are being developed, incuding sampling intensity requirements, and image processing workflow for long-term monitoring. The project aims to describe and improve knowledge of benthic habitats in the Agulhas eco-region, define habitats, determine science-based biodiversity targets, and assess the present ecological state in the study area. The effects of upwelling intensity and habitat type on species turnover and functional ecology are being investigated. The offshore region of Algoa Bay is a priority area of biodiversity interest as a result of the influences of the Agulhas current and widening of the shelf area. This research employs novel techniques of deep-water seabed photographic surveys which also provide excellent education outreach material to build knowledge of deep-sea ecosystems.

Classification and Mapping of Shelf Ecosystems in KwaZulu-Natal

In collaboration with the South African National Biodiversity Institute (SANBI) and the University of the Western Cape, post-graduate research is underway in the KwaZulu-Natal offshore region to investigate the suitability of epifaunal biota to serve as surrogates for ecosystem classification. Visual imagery of the seabed enabled quantification of epifauna in sand and reef habitats between 48 and 85 m depth offshore of Durban (both north and southwards). This study provides empirical information to support refinement of existing habitat classifications of the study region and builds knowledge

towards appropriate habitat protection objectives.

Key Programmes
Through the DST and NRF, SAEON Egagasini hosts the secretariat for the Indian Ocean Rim Association Academic group, with the programme coordinator, Nicole du Plessis and Juliet Hermes as the chair of the SA IORAG. Egagasini also hosts the secretariat for the South African Marine and Research Exploration Forum.

Key researchers
Dr Juliet Hermes
Dr Lara Atkinson
Dr Charles von der Meden
Dr Charine Collins
Dr Jennifer Jackson-Veitch
Ms Tammy Morris
Nicole du Plessis
Neil Malan
Grant van der Heerver
Katherine Hutchinson

South African Environmental Observation Network (SAEON) Elwandle node

Location: Port Elizabeth, Eastern Cape

Overview of Marine Research
The mandate of the South African Environmental Observation Network (SAEON) in the coastal zone is to establish, maintain and provide access to *in situ* coastal observation networks, innovative marine research platforms, and information management systems for long-term, multi-disciplinary, multi-institutional and participatory ecosystem research. The collection of physical, chemical, and lower trophic biological observations falls under the five key programmes indicated below. In addition, SAEON provides a platform for the collation, archiving and dissemination of coastal data through information management systems, e.g. SAEON observations database, South African Estuaries Database, Coastal Temperature Database, etc. SAEON is a member of the International Long-Term Ecological Research Network (LTER), WIOMSA, and participates in several bilateral agreements with international partners on a per project basis.

Key Programmes

- *Coastal Temperature Network* (see Shallow Marine and Coastal Research Infrastructure (SMCRI). This network is currently limited to South Africa, but there are plans to extend it up the east coast to Mozambique.
- *National Estuaries Monitoring Network*. Although a South Africa-wide initiative, SAEON's involvement is restricted to selected estuaries in the Western Cape and Eastern Cape, i.e. Knysna, Keurbooms, Kromme, Gamtoos, Swartkops, Sundays and Kariega estuaries.
- *Marine Protected Areas Network.* LTER activities are restricted to the Table Mountain Marine Protected Area (MPA); Betty's Bay MPA; Tsitsikamma MPA, and Bird Island MPA. Short-term projects are conducted at most other MPAs along the South African coastline.
- *Sentinel Sites for LTER Network (Sentinel Sites).* All Sentinel and Satellite Sentinel Sites are restricted to the South African mainland and sub-Antarctic territories.
- *Coastal Information Management Systems*. The information systems have been designed to accept certain data types and formats from the rest of the West Indian Ocean (WIO) region.

Key Researchers
Dr Thomas Bornman
Dr Shaun Deyzel
Dr Wayne Goschen
Dr Lucienne Human
Dr Albrecht Götz
Mr Tim Parker-Nance

South African Institute for Aquatic Biodiversity (SAIAB)

Location: Grahamstown, Eastern Cape

Overview of Marine Research

Estuarine Ecology

Current research by Prof. Alan Whitfield is centred on a study of the structure and functioning of micro-estuaries and micro-outlets in the Eastern Cape Province. He is also working on a synthesis of all past and present ichthyological work in southern African estuaries that will result in a monograph entitled *Fishes of Southern African Estuaries: From Species to Systems*, due to be published in late 2018. A bi-lateral/multi-lateral project has been commissioned by Wiley-Blackwell (UK) to produce a global book on fish in estuaries with Professor Mike Elliott (UK), Steve Blaber (Australia) and Kenneth Able (USA). The book has been provisionally entitled *Fish and Fisheries in Estuaries*.

Dr Nikki James's estuarine research involves assessing the connectivity of estuarine and marine nursery habitats along the south-east coast of South Africa. Although it is well understood that estuaries serve as important nurseries for fish and invertebrates, with many species in South Africa thought to be estuarine dependent, comparative data on the degree of estuarine and marine nursery habitat use by marine species is lacking. A mixed-method approach assessing habitat quality and settlement stage larval and juvenile fish and invertebrates concurrently in estuaries and nearshore coastal habitats is being conducted in the warm-temperate coastal region from St Francis to Kenton. Results from this study will help fill knowledge gaps critical to the understanding of nursery habitat use by several economically and ecologically important fish and invertebrate species.

Remote Imagery

The marine remote imagery platform undertakes research on reef ecology and conservation across the continental shelf in the Western Indian Ocean (WIO) marine environment of South Africa. The research projects cover the temperate reefs at the WIO's south-western boundary at Cape Point to the tropical coral reefs on the border between South Africa and Mozambique. Additional research projects are being conducted in southern and northern Mozambique and Madagascar.

Pic: ACEP

The research focuses on the assessment of fish communities and species population structure from the shallow subtidal (5 m) to the edge of the continental shelf (240 m) using baited remote underwater stereo-video systems. Integral to this research are studies investigating the role that marine protected areas (MPAs) play for biodiversity conservation and as experimental controls, or baselines, from which to measure the impacts of direct anthropogenic disturbances. Further research is directed towards the development and advancement of sampling methods to better survey fish and invertebrate populations associated with deep reefs (200–2000 m).

Coastal and Ocean Sciences Team (COST)
This is led by Dr Porri, funded through the DST-NRF, and focuses on intertidal and nearshore processes. The research tackled by the team uses an organismal-to-population approach to highlight individual mechanisms that underline the dynamics of assemblages. Larval ecology and connectivity constitute the bulk of the research done within the team, with a focus on the nearshore coastal waters, and a range of intertidal systems, including natural rocky shores and man-made seawalls, mangroves and sandy beaches. Understanding mechanisms driving larval dispersal is pursued multi-disciplinarily, by examining the possible bio-physical (and more recently, molecular) coupling between hydrodynamics, larval distribution, physiology, behaviour and supply to the adult benthic habitats. Since the taxonomy of most larval stages (invertebrate and fish) remains largely unknown, dedicated recent research tackles this issue through a foundational diversity information programme and aims at producing positive identification of a range of larval taxa through DNA barcoding. Through a broad international partnership (World Harbour Project, www.worldharbourproject.org), members of COST are also tackling the role of green engineering for the preservation/restoration of biodiversity in urbanised marine systems. Through this project, a combination of eco-friendly concrete, micro-architecture, and natural ecosystem engineers have monitored the establishment and growth of inter-tidal biodiversity on harbour seawalls.

ATAP
The Acoustic Tracking Array Platform (ATAP), led by Prof. Paul Cowley, continues to reveal new discoveries about marine animal movements around the South African coastline. To date, more than 700 animals equipped with long-life transmitters are being monitored by this platform. Long-term acoustic telemetry movement studies initiated in 2016 included new marine species such as smooth hammerhead sharks (*Sphyrna zygaena*, International Union for the Conservation of Nature (IUCN), Vulnerable), bronze whaler sharks (*Carcharhinus brachyurus*, IUCN, Near Threatened), blue stingrays (*Dasyatis chrysonota*), duckbill rays (*Aetomylaeus bovinus*, IUCN, Data Deficient), eagle rays (*Myliobatis aquila*, IUCN, Data Deficient) and diamond rays (*Gymnura natalensis*, IUCN, Data Deficient). The ATAP also installed a new monitoring site off Kei Mouth to enhance its nationwide coverage and to detect tagged animals moving up the east coast. In 2016 NRF-SAIAB's acoustic telemetry team initiated an exciting project on the Breede Estuary that will monitor how large adult dusky kob use the estuary and the neighbouring De Hoop Marine Reserve. The project is being managed by Dr JD Filmalter, a PDP post-doctoral candidate.

Climate Change
Dr Nikki James also studies the effects of climate change on the physiology of coastal fish and invertebrates. An understanding of physiological changes is needed to reliably project the effects of climate change on animals, particularly in unstable, temperate environments. SAIAB's Aquatic Ecophysiology Research Platform (AERP) provides a unique opportunity to initiate this type of research in South Africa. In this regard, a number of projects are being conducted along the south-eastern coastline of South Africa to understand the physiological impact of changing temperatures and pH on various temperate and subtropical fish and invertebrate species.

Taxonomic Studies
Taxonomic studies are underway on genetic connectivity and phylogeography/biogeography of WIO fishes, and genetic stock assessments of reef-associated fishes, following from past WIOMSA-, SWIOFP-, and ACEP-supported research. There are also a number of taxonomic projects that resulted from these that are being followed up in an *ad hoc* manner. Other work involves taxonomic work on goatfish throughout the region, with European (Franz Uiblein, IMR, Norway) and other international partners.

Key Programmes
African Coelacanth Ecosystem Programme (ACEP)
Acoustic Tracking Array Platform (ATAP)

Key Researchers
Prof. Alan Whitfield
Dr Anthony Bernard
Dr Francesca Porri
Prof. Paul Cowley
Dr Anthony Bernard
Dr Nikki James
Dr Gavin Gouws

South African National Biodiversity Institute (SANBI)

SANBI
Biodiversity for Life
South African National Biodiversity Institute

Location: Cape Town, Western Cape

Overview of Marine Research

SANBI's small marine programme was initiated in 2006 and a key aspect of the work has involved the collation and co-ordination of priority marine biodiversity science products in South Africa. The marine programme is a National Programme with most initiatives having relevance to the Western Indian Ocean. SANBI works closely with Government Departments, State-Owned Entities, Research Institutes, NGOs and Universities. SANBI's marine program works across the science policy continuum with a significant investment in foundational marine biodiversity science. This includes the research needed to classify and map marine ecosystems. The Offshore Marine Protected Area project produced the maps needed to support the first National Marine Ecosystem Map, the foundation for the marine component of the 2011 National Biodiversity Assessment. SANBI's marine programme was awarded the first large grant from the Foundational Biodiversity Initiative Programme and this large collaborative project (SeaKeys) has produced 14 national lists for marine animals, a list of marine algae, 260 marine species pages and approximately 150 000 new marine biodiversity records. This project has also produced many publications, popular articles, contributed to training 18 post graduate students, and is advancing barcoding of marine taxa. The project outputs are being used in Marine Protected Area design, to improve the National Marine Ecosystem Classification and Map, to identify and protect sensitive marine ecosystems, to support marine policy (such as the listing of marine invasive species), to support work on fisheries eco-certification, raise seafood consumer awareness, and to support management of marine ecosystems.

A key area of work for SANBI's marine programme is the support for the expansion of South Africa's Marine Protected Area Network. SANBI's Offshore MPA project catalysed the marine programme and identified a set of focus areas for offshore protection in 2011 using systematic planning based on more than 500 map layers and four years of stakeholder engagement. In 2014, SANBI scientists participated in the Presidential initiative, Operation Phakisa: Oceans Economy and advanced the MPA planning work into implementation. SANBI co-ordinates and leads the technical team working on the Phakisa Oceans Economy network of 22 proposed new MPAs, half of which are within the WIO region. SANBI also supports the identification of additional priority areas to inform the identification of the next 5% of area to be identified for future protection under a further Phakisa Oceans Economy Initiative, and is a permanent member of the Phakisa Marine Spatial Planning Working Group.

SANBI initiated the Offshore Environment Forum in 2010 to engage stakeholders from all marine sectors in marine environmental management building on four years of stakeholder engagement established through a good understanding of marine sectors, their impacts on biodiversity and their governance frameworks. Industry collaborations have included research partnerships with the fishing industry, petroleum companies and marine mining companies. Such industry collaborations have been important in supporting eco-certification for fisheries, understanding potential petroleum and mining impacts and risks, supporting MPA design and obtaining data to support the development of an improved national ecosystem map. Since 2008, SANBI has also engaged citizen scientists through the Reef Atlas Project and the SeaKeys Atlasing projects for fish, corals, seaslugs, and crustaceans.

SANBI's marine programme has been involved in monitoring South Africa's living population of iconic and critically endangered coelacanths at Sodwana Bay. At least thirty individuals have been catalogued, recognised by their distinct spot patterns, building on more than ten years of collaboration with the recreational mixed-gas divers who discovered the Sodwana coelacanths. More than 70 coelacanth sightings have been recorded in three submarine canyons and a deep reef in the iSimangaliso Wetland Park over the last ten years. SANBI's marine programme has also been monitoring coral bleaching in this World Heritage Site. In the last ten years, SANBI's marine programme has scored more than 21 000 coral colonies, identifying the most sensitive taxa and sites for long-term monitoring of this important climatic indicator.

SANBI's marine programme is involved in many initiatives to grow marine biodiversity capacity. One staff member acquired a Masters' while working for SANBI, and the marine programme collates and increases marine biodiversity knowledge through investments in many student projects. The marine programme has co-supervised 21 students (including the current cohort) over the last 10 years, cultivating skills in ecosystem classification, mapping and assessment; understanding impacts and change in marine biodiversity assessment; mapping of ecological infrastructure; Marine Spatial Planning; the identification and management of marine invasives and the taxonomy, ecology and protection of sensitive species. Three students (including two current staff) have developed skills to lead analyses for the National Biodiversity Assessment to strengthen capacity for ecosystem classification and assessment in the marine component. The NRF-funded projects led by SANBI's marine programme also include more than 20 students. Most of SANBI's marine interns have progressed to new academic levels or jobs and remain active in the marine biodiversity sector.

SANBI currently leads one and contributes to several ACEP open call projects in the WIO region. The Deep Secrets Project includes *in situ* habitat research off the south and east coast of South Africa, sampling many deep sea habitats in the region for the first time. This research is informing improvements to the national marine ecosystem map for deep habitats and future work will do the same for deep ecosystems such as deep sea soft and hard corals and offshore kelp forests and seamounts. The 2016 Deep Secrets Cruise sampled ten of the Phakisa Proposed MPAs and this was used to improve design and support implementation of protection.

SANBI produces the National Biodiversity Assessment every 5-7 years. This assessment is a flagship project that

informs national strategy for biodiversity planning and policy initiatives. The NBA 2018 is planned to include improved communication on benefits from biodiversity as well as initiate the first map of ecological infrastructure for SA's marine environment. These products form part of the SANBI mainstreaming strategy to broaden the appreciation for marine biodiversity with the general public and private sector, e.g. fisheries sectors, local coastal communities, and relevant government entities. SANBI also strives to engage other sectors that have major impacts on biodiversity, such as the minerals and oil and gas sectors.

Key Programmes

National Biodiversity Assessment: Marine Component
Foundational Marine Biodiversity Information
Offshore Biodiversity Research with a focus on ecosystem classification and mapping, ecosystem assessment, and sensitive taxa and ecosystems
Marine Invasive Species Research and Policy Advice
Research and support for work on Ecologically and Biologically Significant Areas
Marine Ecological Infrastructure Research (healthy ecosystems delivering services)
Marine Biodiversity Mainstreaming with a focus on marine mining and fisheries
Scientific support for Marine Spatial Planning, Marine Protected Area Design and Implementation
Marine Science to Policy
Marine Biodiversity Capacity Building

Key Researchers

Dr Kerry Sink
Ms Prideel Majiedt
Ms Megan Van Der Bank
Ms Siyasanga Miza

Pic: ACEP Deep Secrets

South African Weather Service (SAWS)

Mandate

The South African Weather Service draws its mandate from the South African Weather Service Act, 2001 (No. 8 of 2001 as amended), a mandate which is described in a series of objectives and functions, namely:

- to maintain, extend and improve the quality of meteorological service for the benefit of all South Africans;
- to provide public good services and commercial services to all South Africans;
- to ensure the ongoing collection of meteorological data over South Africa and surrounding southern oceans for the use by current and future generations;
- to be the long-term custodian of a reliable national climatological record;
- as the national meteorological service of the Republic of South Africa, to fulfil the international obligations of the Government under the Convention of the World Meteorological Organisation (WMO);
- as the Aviation Meteorological Authority, to fulfil the international obligations of the Government under the Convention of the International Civil Aviation Organisation (ICAO).

Further, the Weather Service must:

- provide such meteorological services, including public good services and commercial services, as are necessary to achieve its objectives, provided that it is in the interests of the Weather Service and the State;
- adhere to the intent of Resolution 40 of the Twelfth Congress of the WMO, and any other related resolutions regarding the internationally free and unrestricted exchange of meteorologically related data and products;
- perform any other function assigned to it by the Minister.

The Weather Service may, in order to achieve its objectives:

- co-operate or enter into agreements or contracts with any person, institution, government or administration;
- purchase or otherwise acquire, possess, hire, pledge, sell or let property;
- with the approval of the Minister, granted with the concurrence of the Minister of Finance, raise money by way of loans from any lawful source, on such terms and conditions and against such security as may be agreed upon;
- with the approval of the Minister, establish or assist in establishing, companies for the promotion of meteorological services or any related business purpose;
- charge fees for the provision of any commercial services;
- enter into an agreement with any other weather services to deliver services, or be of assistance with the delivery of services outside the borders of South Africa;
- enter into agreements with State departments for the delivery of services considered to be within the capacity of the Weather Service. These contract services are not deemed part of the public good services.

Importantly, only the Weather Service may issue severe weather-related warnings over South Africa in order to ensure that there is a single authoritative voice in this regard. The Weather Service must take reasonable steps to develop the skills and capacity of the Weather Service to enable it to provide for the needs of disadvantaged communities.

Key WIO Partnerships

The SAWS, responsible for the METAREA VII for weather forecasts, maintains a constant awareness of meteorological conditions extending into the Indian Ocean basin. This is primarily achieved by means Atmospheric General Circulation Models (AGCM) from the European Centre for Medium-range Weather Forecasts (ECMWF**)** and the National Centres for Environmental Prediction Global Forecast Systems (NCEP/GFS) of the National Oceanic and Atmospheric Administration (NOAA). Observational data from a range of Automatic Weather Stations and upper-air radiosondes are provided to the WMO's Global Observing System (GOS) via the Global Telecommunications Systems (GTS) for assimilation into these models, thus improving their simulations and providing a certain level of cooperation with the Global Data-processing and Forecasting System (GDPFS). Further, a regional (~ 4 km), as well as a high resolution, nested configuration (1.5 km) of the Unified Model is run in-house. In order to bolster observational data collection in the WIO itself, the SAWS partners with the South African Environmental Observation Network (SAEON) and the South African National Antarctic Programme (SANAP) in providing drifting weather buoys for deployment during Agulhas System Climate Array (ASCA) activities and annual research cruises to Marion Island. These buoys collect sea surface temperature (SST) and sea level pressure (SLP) data which are assimilated into numerical weather prediction (NWP) models, as well as recorded in climatological databases. Further, their positional data allow for the derivation of ocean currents.

The South African Weather Service also acts as the focal point for the WMO's Ship Observation Team (SOT) in South Africa. Under SOT, the SAWS facilitates South African participation in the Voluntary Observing Ship (VOS) and the Automated Shipboard Aerological Programmes (ASAP). This is not limited to the WIO, but is relevant when ships do operate within the area in question.

Finally, the SAWS maintains a coastal SST monitoring network around the coast of South Africa. Indian Ocean sites include Stilbaai, Mossel Bay, Port Elizabeth and East London. In working to rejuvenate this data collection programme, the Marine Unit of the South Africa Weather Service has partnered with the Biodiversity and Conservation Biology Programme of the University of the Western Cape to design new SST collection systems.

Key Research Areas

Meteorological forecasts cover METAREA VII; that is, the South Atlantic and Southern Oceans south of 6°S from 20°W to the coast of Africa, thence south to the Cape of Good Hope; the South Indian and Southern Oceans south of 10°30'S from the Cape to 55°E, thence south of 30°S to 80°E. Whilst forecasting is mostly operational in nature, research focused on the improvement of model accuracy does occur, primarily through adopting higher resolution global models. SAWS is considering the operational implementation of the Wave Watch III model, with boundary conditions from either the Global Unified Model or the regional (4 km) configuration. Observational research includes collaborative work on an enhanced understanding of the Agulhas Current and associated systems. Examples include investigation into the pathways of Agulhas waters into either the south-east Atlantic or south-west Indian Oceans, as well as the performance of fledgling operational ocean models in simulated Agulhas Current eddies.

The SAWS is not specifically limited in the scope of research it might be involved with, in the sense that it could provide a collaborative support role to numerous other studies, on account of the extent to which marine meteorological conditions impinge on other natural systems.

Key Researchers

Mr Johan Stander Mr Nico Kroese Mr Marc de Vos

Water Research Commission (WRC)

Location: Pretoria, Gauteng

Overview of Marine Research

The Indian Ocean plays a significant role in the continental climate of southern Africa. Among other research work, research conducted at the WRC includes examining the changing characteristics of summer and winter southern African rainfall since 1901, and the teleconnections with large-scale climate through the dominant time scales of variability; teleconnections with global sea-surface temperature and atmospheric circulation anomalies contribute to the shaping of the South African climate. The El Niño Southern Oscillation (ENSO) is the main driver of summer rainfall variability and its influence leads to shifts in the Walker circulation, which, at the regional scale, impacts the position of the Southern Indian Convergence Zone, modulating the development of deep-convection and the synoptic-scale rain-bearing systems over the north-eastern regions of southern Africa. Summer rainfall variability is also related to latitudinal shifts in the subtropical atmospheric circulation, which, for instance, generate an anomalous low-level easterly moisture flux over the Mascarene High region. Winter rainfall variability, however, is influenced more by the mid-latitude atmospheric variability; in particular, the Southern Annular Mode, but interactions with ENSO remain, especially in the subtropics. Asymmetrical changes in the mid-latitude westerlies between the Atlantic and Indian Oceans thus impact preferentially the south-western regions of southern Africa. The climate change research programme at the WRC aims to regularly assess the role of the ocean on the continental climate and its contribution to extreme disasters. Extreme climate events such as tropical cyclones, flooding, veld fires, and drought have posed severe threats to the economy, community and ecosystems in recent years. These events are closely linked to known drivers of climate variability, such as the ENSO, with possible contributions from climate change. Understanding how these global drivers have previously behaved, are behaving today, and how they will change in the future, as well as how they are influenced by climate change, will help us forecast and plan for future extreme climate events with greater confidence. Ensuring that climate models capture these processes will underpin the capacity to predict changes with greater confidence, and better understand uncertainties about future climate and accordingly advise on the appropriate responses. Improved observation, understanding the processes, and modelling the climate system will deliver more robust information on the timing, extent, and nature of likely changes to temperature, rainfall, water availability, sea level, and extreme climate events. It is upon this premise that the WRC continues to fund research to understand the role of the ocean on the continental climate.

Other Focal Areas

The response of coastal and marine ecosystems and associated services to global and climate change. Understanding the response and resilience of coastal and marine ecosystems to change requires an integrated approach.

Pic: ACEP Imida open call project

Ecologically sustainable coastal development: vulnerability, risks and responsibilities. Coastal development implies a human impact on coastal and marine ecosystems and biodiversity. The ecological costs depend on the extent of development, as well as on the robustness and vulnerability of the ecosystems. Development entails the risks raised and responsibilities carried in terms of the benefits derived from the development. Current and future developments in a variety of emerging industrial sectors such as oil and gas, sea-bed mining, etc. will require a sound scientific basis if they are to be sustainably managed. The opportunity for research is to provide solutions that maximise benefits and ensure sustainability whilst minimising the environmental costs.

Reducing uncertainty of seasonal, inter-annual and decadal climate projections in southern Africa. The most immediate societal benefit associated with this theme is the development of reliable climate projections.

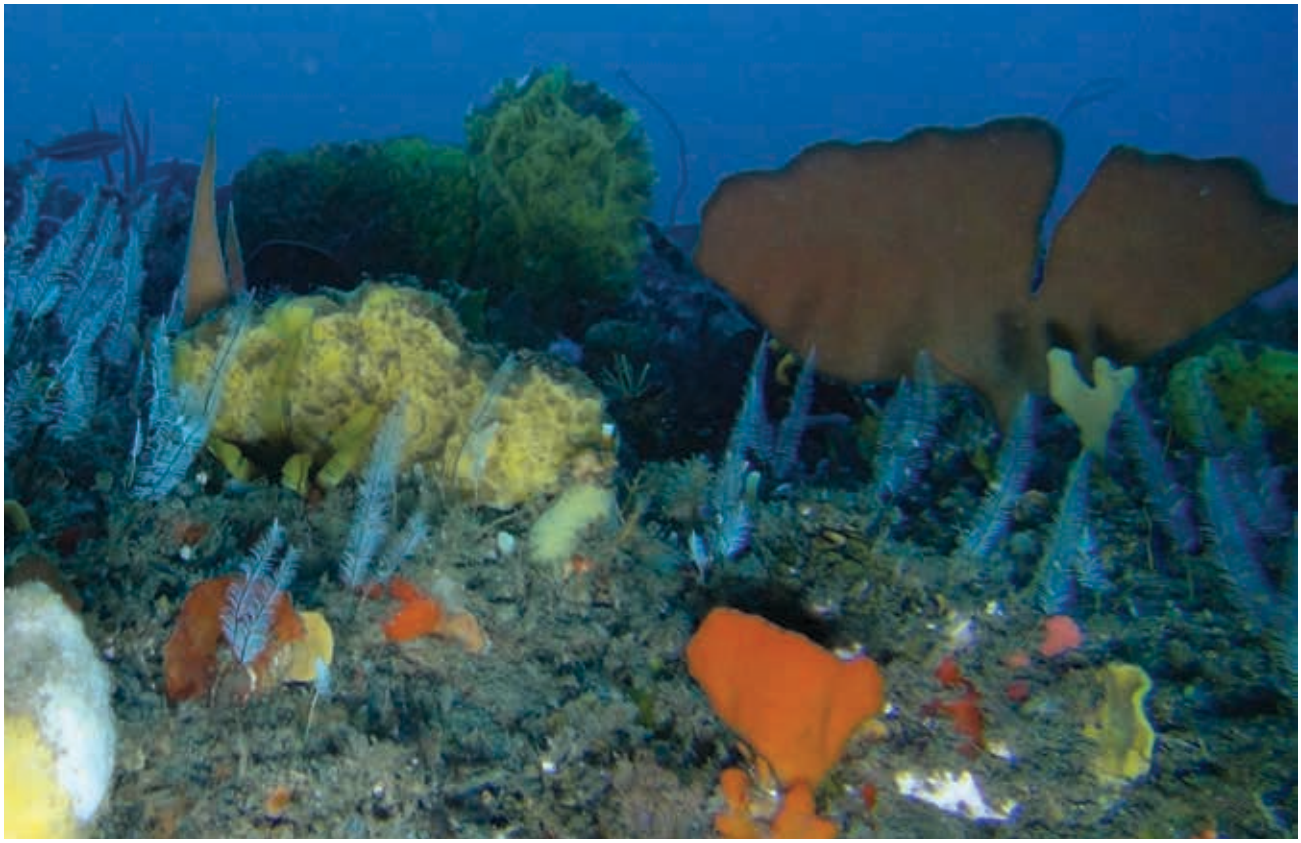
Bi-lateral/Multi-lateral Funded Work

Participation in the Indian Ocean Rim Association (IORA). The Water Research Commission, under the membership of the Republic of South Africa, participates in activities of the IORA. These activities entail, among others, a framework for exchange of researchers in member countries in the water research and development domain, and provide support in the form of technical workshops and joint collaborations in research projects. Three workshops have been conducted in member countries. The WRC organised a Business Summit during the week of the 17th Council of Ministers' Meeting scheduled on 18 October 2017 in Durban, South Africa. The WRC is also participating in the IORA-Academic Group which aims to plan and co-ordinate South African activities implemented by the academic group. WRC and the Department of Science and Technology (DST) are the Co-Chairs of the IORA-AG S&T working group which also include Water S&T (DST) and Ocean S&T (DST).

Key Programmes

Climate change and variability programme. The programme deals with aspects related to climate change and variability, and its relation to water resources and ecosystems. The research will develop knowledge about mitigation and adaptation measures. The impact of climate change on ecosystem processes, functions, and structure is given attention in this programme. The aspects such as readiness, or lack thereof, by rural and urban communities and institutions to adapt to climate change, as well as ecosystem resilience is entailed in this programme. The programme also focuses on the link between climate and resource quality, as well as the development of models to further understand, predict and develop early warning detection tools**.**

Models and early warning systems programme. This programme focuses on developing new analytical and numerical models. The development of robust and innovative early warning systems to detect environmental change will be a key focus of this thrust. Models also focus on understanding the drivers of climate.



RESEARCH PROGRAMMES

Alliance for Collaboration on Climate and Earth Systems Science (ACCESS)

Implementing Agency: Council for Scientific and Industrial Research (CSIR)
Funding Agency: National Research Foundation (NRF)
Duration: Three-year renewable cycle

Scope
The second phase of the Alliance for Collaboration in Climate and Earth Systems Science (ACCESS) programme is now being implemented via the ACCESS Secretariat hosted by the CSIR as a sub-programme of the Global Change Research Programme Management Unit (GCRMU) of the NRF and in alignment with the Department of Science and Technology (DST) Earth Systems Flagship, which is currently being developed. In Phase II, ACCESS remains an instrument of the Global Change Grand Challenge (GCGC) and will implement a research project weighted towards the earth systems science aspects of the Global Change Research Plan (GCRP) nested in the Earth Systems Science Flagship Programme.

The goal of the ACCESS research programme is to foster inter-institutional collaboration (both in South Africa, and beyond our borders), with two main outcomes sought, determined by the review of the first phase of ACCESS: a novel and well-defined research focus on a selected set of research questions to enable inter-, trans- and multi-disciplinary research addressing global change drivers and impacts; and to provide such a platform, or the development of human capacity in global change research with an emphasis on producing a generation of modern scientists geared for this wide set of challenges.

In addition to this, the ACCESS programme is mandated to maintain and further develop its education and training programme with the specific goal of contributing to the extension of the research footprint beyond traditional research partners and to the transformation of the research community. To that end, this call will maintain a focus on recruiting black and female students, and partners at Historically Black Universities (HBUs) and rural campuses.

Overview and Aims
ACCESS has recently adopted an 'Annual Cycle and Seasonality' (ACyS) concept to define its new niche and scope in the next decade or so. This is intended to become a national platform for a sustained effort in South African earth systems science which will both leverage and provide leverage for existing South African scientific research partnerships (such as the South African Research Infrastructure Roadmap, among others), and similarly, regional and international partnerships (such as the Southern African Science Service Centre for Climate Change and Adaptive Land Use – SASSCAL; Science Partnerships for the Assessment of Complex Earth System Processes – SPACES,) and Future Earth.

The scientific goal of the ACCESS research programme is to develop a predictive understanding of how the annual cycle and varying seasonality has been, is now, and will be propagated through the earth system, with reference to a changing climate future. The seasonal cycle is commonly overlooked as the strongest climatic signal that shapes and determines the composition and functioning of the biosphere, and from which the ecosystem's goods and services are derived. A global change research focus that proceeds from the above goal offers a novel approach to studying earth systems dynamics and global change pressures. It does so by providing a common conceptual framework across disciplines and domains of natural and social science research, and the opportunity for multiple tests of the predictive understanding gained with each successive annual cycle. This approach provides both a basic and applied science opportunity, with immediate policy and societal relevance. The intended outcome is to apply this knowledge to improve predictability (reduce uncertainty) about how changes to the ACyS (in terms of variability, amplitude, periodicity and trends due to both natural and anthropogenic interference in the climate system) will affect all aspects of the earth system (in southern Africa in particular) in the short-, medium-, and long-term future.

While ACCESS does not have an exclusive marine research focus, the research theme does include the marine environment in general as a component of the earth system, and specifically as a driver of climate systems and a responder to climate system dynamics. The role of the Western Indian Ocean (WIO) is critical in this, particularly in terms of sea-surface temperature at a range of space and time scales in the Indian Ocean.

Key Researchers
The programme is multi-institutional and has a range of researchers and students participating. Contact Dr Neville Sweijd for further information.

African Coelacanth Ecosystem Programme (ACEP)

Implementing Agency: South African Institute for Aquatic Biodiversity (SAIAB)
Funding Agency: National Research Foundation (NRF)
Duration: Three years (current phase)

Scope
Through an open, transparent and competitive funding call made every three years, ACEP aims to provide the South African marine research community with the means, vessels and equipment to conduct high quality, multi-disciplinary research, to foster collaboration and to provide student bursaries to facilitate training and capacity building.

Overview and Aims
The ACEP is a research platform which provides access to research infrastructure (e.g. ship time, coastal craft, remote-operated vehicles, etc.) and associated funding to the research community to undertake research along the east coast of South Africa. ACEP is a flagship programme of the Department of Science and Technology (DST) and the NRF, and its key partners are the Department of Environmental Affairs (DEA – Oceans and Coasts), Department of Agriculture Forestry and Fisheries (DAFF) and the South African Environmental Observation Network (SAEON). ACEP is managed by the SAIAB, which is a National Facility of the NRF.

The DST and DEA-O&C have identified ACEP as a leading multi-disciplinary, multi-institutional programme; one of the key platforms to be used in meeting the aims of Operation Phakisa. ACEP entered its fourth phase in 2015, and concluded it March 2018. An Open Call in April 2017 for the period 2018–2020.

ACEP Phuhlisa Programme
One third (33%) of ACEP funds is ring-fenced for establishing marine science at historically black universities (HBUs). Currently the programme reaches Walter Sisulu University (WSU) and the University of Fort Hare (UFH) in the Eastern Cape, the University of Zululand (UniZulu) in KwaZulu-Natal and the University of the Western Cape (UWC). This strategic initiative, the *Phuhlisa* programme, managed by a dedicated Human Capital Development (HCD) Coordinator, offers support to marine scientists at these universities through platform provision, logistical support for fieldwork, student bursaries, and co-supervision. The programme also offers additional academic and life skills courses, for example, academic writing, presentation skills, swimming lessons and a skipper's licence. The programme has numerous research disciplines, including marine biology, estuarine ecology, marine geology, marine microbiology, and marine biochemistry. The ACEP *Phuhlisa* Programme is a key transformation programme within the South African Marine Research Strategy and contributes directly to the Operation Phakisa Ocean Governance Laboratory.

ACEP Open Call Research
The 2016/17 ACEP continued to support six Open Call research projects. The projects were selected on a competitive basis through a peer review process and independent selection panel. The projects, and in particular the two projects which utilised the *RV Algoa* (Agulhas Current, and Deep Secrets) all made significant contributions to the Presidency-driven Operation Phakisa (Oceans Economy) research objectives. The current Open Call was finalised in December 2017 and ACEP has put out a new call for January 2018. The programme aims mirror those of the research priorities outlined in Marine Antarctic Research Strategy (MARS). With the budget available it is anticipated that four projects will be supported. The Department of Environmental Affairs (Oceans and Coasts)(DEA O&C) has once again made the *RV Algoa* available through the call, and the objectives of the Second International Indian Ocean Expedition (IIOE2) programme will form the basis of the cruise component of the call.

The open call projects scheduled for completion in March 2018 are:

- ***Imida* (Frontiers) Project**. Towards conservation planning in the Amathole area of the Eastern Cape. *Dr Sven Kerwath* (DAFF)
- **Deep Secrets**. Biodiversity and habitat description of the outer shelf and slope ecosystems of the Eastern Cape. *Dr Kerry Sink* (SANBI)
- **Larval Dispersal**. Pathways of larval dispersal: the roles of alongshore and cross-shore transport in the St Francis and Algoa Bay region of the Eastern Cape. *Dr Francesca Porri* (SAIAB)
- **Benthic Biodiversity**. Benthic biodiversity from the Agulhas Bioregion as a source of new pharmaceuticals. *Prof. Rosemary Dorrington* (RU)
- **Spatial Solutions**. Inter-disciplinary Spatial Solutions for marine conservation planning. *Prof. Andrew Green* (UKZN)
- **Agulhas Current**. Influence of the Agulhas Current oceanography on the biodiversity of the Transkei shelf. *Dr Ray Barlow* (DEA)

In 2018 ACEP moves forward into a new Open Call period with four new, innovative projects:

- **Deep Forests**: The taxonomy, phylogeny, habitat, ecology and benefits of deep coral and seaweed habitats in South Africa. *Dr Kerry Sink* (SANBI)
- **Fisheries induced evolution on fish physiology.** *Prof. Warren Potts* (RU)

- **CAPTOR** - Connectivity And disPersal beTween prOtected aReas. *Dr Sean Fennessy (*ORI)
- **Canyon Connections**. The ecological role of submarine canyons on the east coast of South Africa. *Prof. Mandy Lombard* (NMU)

Research output from this and previous ACEP open calls continues to grow, reflecting the high standard of the research being achieved. To date, 160 peer-reviewed publications have been produced, with many more expected to come from this phase of the programme.

ACEP Marine Platform Provision

A key facet of ACEP is the provision of research infrastructure to the National System of Innovation (NSI). The year 2016 saw significant growth and use of the ACEP marine platforms. Demand from the South African marine science community has necessitated the expansion of the platform, which is currently taking place.

- **Marine Remote Imagery Platform.** The Mar-RIP hosts the Remote-Operated Vehicle (ROV), the Baited Remote Underwater Video (BRUV) systems and a benthic drop camera (dropCAM) for photographing benthic macro-fauna assemblages. The ROV team spent a month in 2016 supporting the Spatial Solutions Open Call Project in KwaZulu-Natal and a three-week expedition off East London in the Amathole region for the *Imida* Open Call Project. The ROV has also been used in Algoa Bay on the Benthic Biodiversity Open Call project to collect specimens for pharmaceutical research.
- ***RV Algoa*.** The *RV Algoa* (DEA: O&C) has been used for two 30-day research cruises (Deep Secrets and Agulhas Current Projects) and continues to add a valuable offshore dimension to the programme.
- **Acoustic Telemetry Array Platform.** ATAP expanded its reach significantly and now has 13 major sites between Cape Point and Ponta do Ouro. ATAP's manager, Dr Paul Cowley, is a member of the Global Ocean Tracking Network (OTN) Steering Committee and Dr Tarryn Murray is a member of the OTN Data Management Committee.
- **Coastal Craft.** In 2017 a new coastal craft, *Phakisa,* was added to the ACEP fleet and is based in Durban, servicing the KwaZulu-Natal (KZN) community. *Phakisa* will also be available through the Open Call going forward. *UKwabelana* had a very busy year supporting two Open Call projects, as well as SAEON Sentinel Site monthly surveys, ATAP servicing, and Sentinel Site instrumentation servicing.
- **Sentinel Site Data** – ACEP is a principal partner in the SAEON Sentinel Site which provides shared platforms, integrated field operation protocols, and logistical support. The network involves six core long-term research and monitoring programmes, with no less than 40 permanent *in situ* moorings, recording the physical properties of the coastal ocean between Port Alfred and Oyster Bay. The data have already contributed to multiple post-graduate projects, been implemented in decision-making processes by local government and other agencies, and are becoming increasingly important for validating ocean- and atmospheric-based models.
- **Geophysics Platform**. This platform is a new addition to the ACEP programme and is currently being developed. The platform provides a new dimension for marine science. The high-resolution multi-beam imagery obtained using the ACEP platform, in conjunction with the University of KwaZulu-Natal (UKZN) Department of Geology, provides greater understanding of the layout of the seafloor. The geological information is then passed on to biologists who are able to determine what community compositions are linked with corresponding habitats in different depth strata.
- **Agulhas System Climate Array (ASCA)**. The ASCA is another new addition to the ACEP platforms with the objective of determining heat, salt, and volume transport along the Agulhas Current over time, and determining the regional and coastal impacts of this powerful western boundary current. The array was designed to capture the meandering and non-meandering state of the Agulhas Current. The array of moorings, along with surveys of conductivity, temperature and depth (CTD) stations and ship-borne Acoustic Doppler Current Profiler (ADCP) transects, has begun to provide a time-series of the Agulhas Current.

ACEP Outreach

ACEP hosts the National Scifest Africa's Water World exhibition at SAIAB. Water World hosts a range of institutions (Rhodes University, SAEON, Agulhas and Somali Current Large Marine Ecosystem (ASCLME), KZN Sharks Board, Southern African Foundation for the Conservation of Coastal Birds (SANCCOB)) that promote water science through stands, shows, exhibits and workshops. Water World was well attended and received good reviews.

ACEP is also a key partner on the Blue Fund Ocean Stewards programme, which is linked to the Spatial Solutions project and 'Women in mOcean' programme linked to the Deep Secrets project.

Key Researchers

Dr Sven Kerwath
Dr Kerry Sink
Dr Francesca Porri
Prof. Rosemary Dorrington
Prof. Andrew Green
Dr Ray Barlow
Prof. Warren Potts
Dr Sean Fennessy
Prof. Mandy Lombard

ACEP Manager: Ryan Palmer
***Phuhlisa* Manager:** Garth van Heerden

Agulhas System Climate Array (ASCA)

Implementing Agency: South African Environmental Observation Network (SAEON), in collaboration with the Department of Environmental Affairs, Oceans and Coasts (DEA O&C); Rosenstiel School of Marine and Atmospheric Sciences (RSMAS), University of Miami; The Royal Netherlands Institute for Sea Research (NIOZ)
Funding Agency: Department of Science and Technology (DST), through the National Research Foundation (NRF), in collaboration with: DEA O&C; The National Science Foundation (NSF), through RSMAS; NIOZ
Duration: 2015–2019

Scope
The Agulhas System Climate Array is designed to provide long-term observations of Agulhas Current volume, heat and salt transport and its variability from mesoscale (eddies), through seasonal to inter-annual timescales, and critically, its contribution in terms of heat and salt to the large-scale Atlantic Meridional Overturning Circulation (AMOC) and thus its impacts on global climate variability and climate change.

Overview and Aims
The ASCA array consists of a suite of tall moorings and Current- and Pressure-recording Inverted Echo Sounders (CPIES) across the Agulhas Current along Jason altimeter 'reference track' 096. Two shelf and seven full-depth tall moorings are interspersed with five CPIES, measuring pressure, current velocities, temperatures and salinities. The ASCA shelf and tall moorings extend 200 km offshore along the descending Jason satellite altimeter groundtrack 096, through the core of the Agulhas Current, with CPIES measurements extending the array to 300 km offshore.

Key Objectives:
The developing east African countries which border the Greater Agulhas system are vulnerable to degradation of their marine resources and fisheries, and to severe weather systems. They would benefit from sustained observations of some of the key oceanic processes which ultimately impact their coastal zones. Such data will improve both regional ocean and weather forecasting and preparedness.
The Agulhas System is linked upstream to tropical Indian Ocean Dipole (IOD) events which are largely coupled with Pacific winds and the El Nino Southern Oscillation (ENSO), and downstream with the strength of the Atlantic Meridional Overturning Circulation (AMOC), making it an effective link between the Pacific, Indian, and Atlantic tropical arrays, as well as with conditions in the Southern Ocean.
Monitoring of the Gulf Stream and Kuroshio is already underway. No such monitoring exists in the Southern Hemisphere where the Agulhas is the strongest and the most significant of the western boundary currents. Sustained observations of the Agulhas System can be likened to having a 'finger on the pulse' of climate variability over the Indian Basin because the Agulhas is a natural integrator of water mass and dynamical signals throughout the basin.
Climate change projections predict substantial changes in the Agulhas region, including warming and strengthening of the Current, increased leakage of Agulhas waters into the South Atlantic and increased heat input into the Southern Ocean. A warmer Agulhas Current could lead to increased storminess over the African continent and a collapse of local fisheries. Increased leakage into the Atlantic Ocean could have feedbacks on the climate system through changes in the AMOC, whereas increased heat input into the Southern Ocean could make the effect of climate change in this ocean more pronounced. As yet, Intergovernmental Panel of Climate Change (IPCC) models are unable to sufficiently resolve the Agulhas Current, in particular the heat fluxes, and this could have a significant impact on global climate predictions.
Ocean and climate models need *in situ* observations for verification. In a highly variable and eddying regime like the Greater Agulhas system, robust, long-term data are crucial for verifying models and climate predictions. Continuous coverage in time is essential to constrain models to allow the evaluation of key quantities like Agulhas leakage, which are extremely difficult to observe. Unlike the Gulf Stream or Kuroshio, the large moisture source of the warm Agulhas Current region contributes significantly to continental precipitation, where it feeds societal water resources (Gimeno et al., 2010).
Observations of the Agulhas System need to be targeted. As a dynamic and divergent system, observations at the western boundary are not achieved effectively with floats and drifters because they have a short residence time. Sea surface height data are contaminated at the land-ocean boundary by small-scale tropospheric moisture changes and aliased tides. Sea surface temperature data are often obscured by clouds as a result of the expansion of the marine boundary layer and enhanced convection over the warm waters of the Agulhas. High density XBT sections can provide upper ocean heat content in the Agulhas Current off Durban (IX21, ~ quarterly) and in the Agulhas leakage off Cape Town (AX25, ~ semi-annually), but lack the temporal resolution and density information to provide decadal variability of heat and mass transports.

Key Researchers:
Dr Juliet Hermes – SAEON
Prof. Lisa Beal – RSMAS
Dr Shane Elipot – RSMAS
Dierdre Byrne
Dr Femke de Jong – NIOZ
Tammy Morris – SAEON

DEA EAF-Nansen Programme

Imlementing Agency: Food and Agriculture Organisation of the United Nations (FAO) in cooperation with the Institute for Marine Research (IMR), Norway
Funding Agency: Norwegian Agency for Development Cooperation (Norad)
Duration: 2017–2021

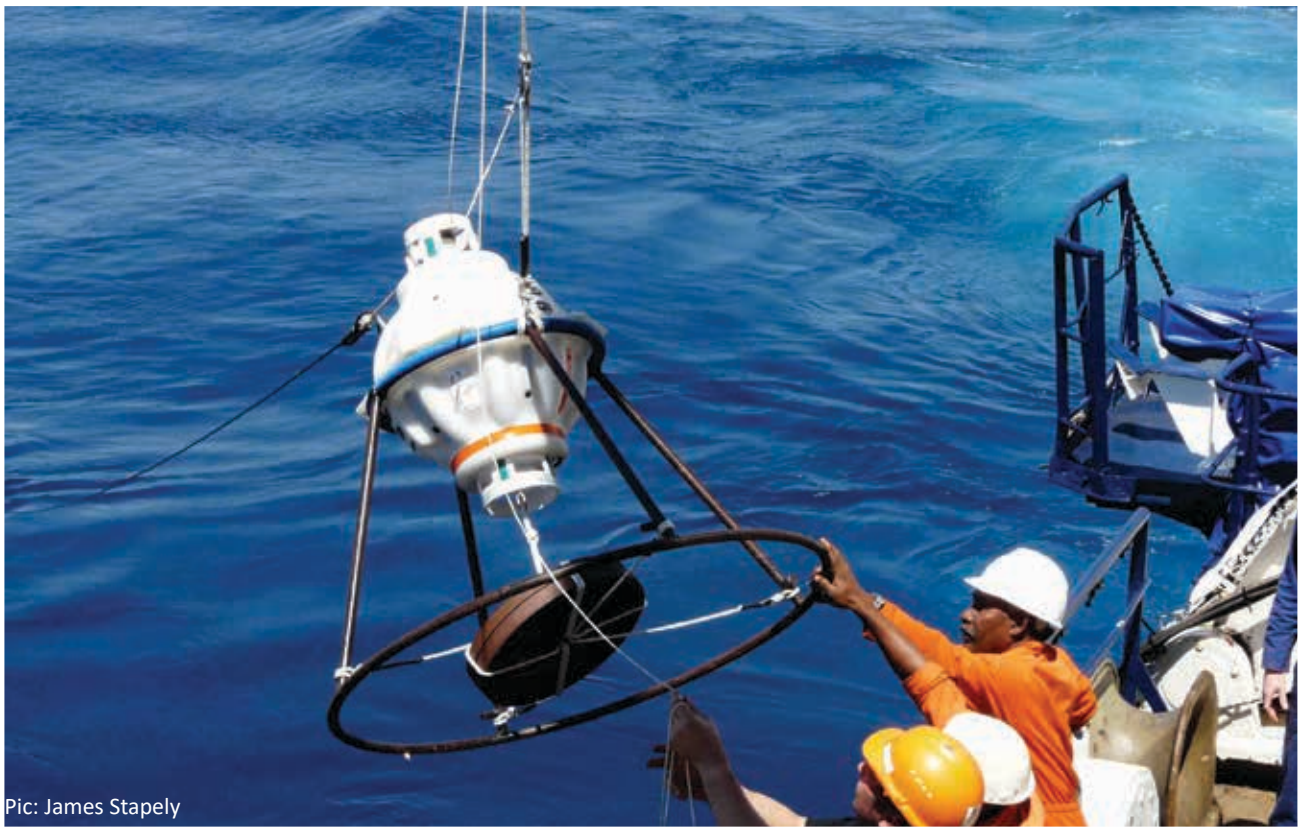
Scope
The area to be surveyed in 2018 by the *RV Dr Fridtjof Nansen* includes the continental shelf and upper slope of East Africa (continental) (Leg 1, Jan–May 2018), the Mascarene Bank (Leg 2, May–Aug 2018) and parts of the Bay of Bengal region (Leg 3). The science activities proposed in the new phase of the EAF-Nansen Programme can be classified into the following main categories:

- Fishery resources, associated/impacted species and fisheries (mapping the distribution of and assessing the abundance, structure and dynamics of main fishery resources, including understanding key biological parameters and the impacts of fisheries);
- Understanding the impacts of oil/gas activities, land-based pollution, including marine debris and microplastics;
- Understanding the impacts of climate change on fish stocks and ecosystems, including setting up monitoring systems.

Overview and Aims
The EAF-Nansen Programme (supporting the application of the Ecosystem Approach to Fisheries management considering climate and pollution impacts) is designed around the following three main areas of work:

1. Strengthening the knowledge base for sustainable management of fisheries in the face of increasing fishing pressure, climate variability and change, pollution and other anthropogenic stressors.
2. Supporting improved fisheries policy and management in line with EAF, taking into consideration the risks and opportunities related to climate and other environmental variability and change.
3. Developing capacity at the institutional and human resources levels, including the promotion of gender equality and effective participation of women in all programme activities.

Key Researchers
Department of Environmental Affairs (DEA) personnel involved in the first planning meeting held in Mauritius (August 2017) were: Mr Mthuthuzeli Gulekana and Dr Jenny Huggett. South African participation in the first cruise in 2018 is being facilitated by Dr Sean Fennessy (ORI).



Pic: James Stapely

Second International Indian Ocean Expedition (SA-IIOE-2)

Implementing Agency: Department of Environmental Affairs (Branch: Oceans and Coasts) (DEA: O&C)
Funding Agency: National Treasury; Department of Environmental Affairs
Duration: 2016–2020

Scope
The geographical scope of the programme is the South West Indian Ocean (SWIO). The research scope includes the following disciplines: physical oceanography, chemical oceanography, biological oceanography, benthic biodiversity and top predators (seabird and cetacean observations).

Overview and Aims
The Second International Indian Ocean Expedition (IIOE-2) was launched in Goa, India, in December 2015. The IIOE-2 seeks to revisit and advance on the highly successful International Indian Ocean Expedition in the 50th year after its commencement. The Department of Environmental Affairs has identified the undertaking of research cruises on *SA Agulhas II* in the SWIO in 2017 and 2018 as a national contribution to the IIOE-2. Each cruise will be about 30 days, to undertake research of regional significance around South Africa and neighbouring countries.

The themes around which the IIOE-2 is envisaged are

- Theme 1: Human impacts
- Theme 2: Boundary current dynamics, upwelling variability and ecosystem impacts
- Theme 3: Monsoon variability and ecosystem response
- Theme 4: Circulation, climate variability and change
- Theme 5: Extreme events and their impacts on ecosystems and human populations
- Theme 6: Unique geological, physical, biogeochemical and ecological features of the Indian Ocean

The current draft the Department of Environmental Affairs (DEA) plan is to address Themes 2 and 4 by deploying moorings in the northern part of the Agulhas Current in Replications of the Agulhas System Climate Array Line (RASCAL), along the shelf edge between Port Edward (the ASCA line), and north of Durban to measure volume transport variability along the length of the current and interaction with the coast and inshore shelf. There is expected to be time available to carry out associated surveys south of Madagascar and in the Mozambique Channel and to make diplomatic visits in neighbouring ports. During the first cruise from 15 Oct–15 Nov 2017, the focus will be on regional capacity building and multi-disciplinary sampling off the Mozambican and Tanzanian shelves, with a port call in Dar es Salaam during the Western Indian Ocean Marine Science Association (WIOMSA) symposium. Closely associated in time and space are the ACEP-IV cruises, investigating upwelling and other shelf processes on the Agulhas Bank shelf edge between Cape Agulhas and Port Alfred. Other on-going programmes and projects in the Branch may address one or more of the six science themes of the IIOE-2.

Key Researchers
Physical Oceanography:Dr Tarron Lamont
Chemical Oceanography: Dr Stephanie de Villiers and Mr Mutshutshu Tsanwani
Biological Oceanography: Dr Jenny Huggett
Benthic Biodiversity: Dr Toufiek Samaai
Seabirds: Dr Newi Makhado
Marine Mammals: Mr Mdu Seakamela
Data Management: Dr Chris Duncombe-Rae

South African Chapter of the Indian Ocean Rim Association Academic Group (SA IORAG)

Implementing Agency: SAEON
Funding Agency: DST-NRF
Duration: 2017–2019

Scope
This programme focuses on research of importance to countries surrounding the Indian Ocean Basin with particular focus on the areas of:

- Maritime safety and security
- Disaster risk management
- Fisheries management
- Academic cooperation, science and technology
- Trade and investment facilitation
- Tourism and cultural exchanges
- Blue economy (cross-cutting priority)
- Gender empowerment and transformation (cross-cutting priority)

Overview and Aims
The Indian Ocean Rim Association (IORA) was formally launched by a ministerial meeting in Mauritius in March 1997. The Association's stated broad objective is 'to promote the sustained growth and balanced development of the Region and of the Member States (South Africa, India, Australia, Mauritius, Indonesia, Comoros, Iran, Madagascar, Oman, Tanzania, United Arab Emirates, Kenya, Bangladesh, Seychelles, Malaysia, Mozambique, Singapore, Sri Lanka, Thailand, Yemen, Somalia), and to create common ground for Regional Economic Cooperation'. The main focus groups within IORA are: the Academic Group, the Trade and Investment Working Group, and the Business Forum. These groups report to the Meeting of Senior Officials who then advises the highest decision-making authority of the Association, the Council of (Foreign) Ministers.

South Africa will chair IORA from mid-October 2017 until October 2019.

The role set out for the Academic Group is both advisory and catalytic, with the principal objectives of servicing the needs of government and business; promoting intellectual dialogue amongst the participating Member States; serving as a vehicle for the development and dissemination of the Indian Ocean Rim concept, and serving the region through coordinated and rigorous research.

South Africa has established the South African Chapter of the Indian Ocean Rim Association Academic Group consisting of academics with expertise in each of the above-listed focus areas to provide input to South Africa's chairship of IORA and to use this opportunity to foster greater collaboration between researchers in the region.

Key researchers
IORAG Chair – Prof. Narnia Bohler-Muller (HSRC)
SA IORAG Chair – Dr Juliet Hermes (SAEON)

FOCUS AREA: Blue Economy
Co-leader: Prof. Ken Findlay (CPUT)
Co-leader: Prof. Narnia Bohler-Muller

FOCUS AREA: Academic Cooperation, Science and Technology
Co-leader: Dr Gilbert Siko (DST)
Co-leader: Dr Mandla Msibi (WRC)

FOCUS AREA: Disaster Risk Management
Co-leader: Prof. Henri Fouche (SU)
Co-leader: Ms Ernesta Swanepoel

FOCUS AREA: Fisheries Management (Fisheries and Aquaculture)
Co-leader: Dr Andy Cockroft (DAFF)
Co-leader: Dr Niall Vine (UFH)

FOCUS AREA: Gender Transformation
Co-leader: Prof. Joleen Steyn Kotze (HSRC)
Co-leader: Prof. Narnia Bohler-Muller

FOCUS AREA: Maritime Safety and Security
Co-leader: Prof. Henri Fouche
Co-leader: Ms Busi Khaba (Monash)

FOCUS AREA: Tourism and Cultural Exchanges
Co-leader: Prof. Haretsebe Manwa (NWU)
Institution: North West University
Co-leader: Prof. Jo-Ansie Van Wyk (UNISA)

FOCUS AREA: Trade and Investment
Co-leader: Dr Jaya Josie (HSRC)
Co-leader: Mr Kgame Molope (NWU)

South African National Antarctic Programme (SANAP)

Implementing Agency: The National Research Foundation: Research and Innovation Support and Advancement (RISA)
Funding Agency: Department of Science and Technology
Duration: Programme support is ongoing. A competitive call for research proposals happens every three years. The current funding cycle is 2018–2020. A new call will open in 2020 for funding from 2021–2023.

Scope
SANAP is a region-specific, theme-driven funding instrument which supports research in the Southern Ocean, including the Prince Edward Islands, and in Antarctica.

As a competitive funding instrument, the chief eligibility criteria are:

- Research in the geographic region of the Southern Ocean, including the Prince Edward Islands, and/or in Antarctica
- Alignment with the research themes as detailed in the South African Antarctic and Southern Ocean Research Plan (2014–2024)
- Scientific merit and quality of the research proposal
- Evidence of associated human capacity development

SANAP research addresses the research themes detailed in the South African Antarctic and Southern Ocean Research Plan (2014-2024), and is underpinned by the overarching South African Marine and Antarctic Research Strategy (MARS) of 2015. The Antarctic and Southern Ocean Research Plan (the Research Plan) is focused on an integrative systems approach to understanding the evolution of the earth systems and ecosystems in the 21st Century. The Research Plan provides the overarching framework of operations for SANAP research activities, and follows the integrated progression from Earth Systems to Ecosystems to Human Systems in the research themes. Human activities and socio-political complexities in this international arena are of equal importance (South African Antarctic and Southern Ocean Research Plan (2014–2024).

Specific research themes detailed in the Research Plan are:

- Earth systems
- Living systems
- Human enterprise
- Innovation: Southern Ocean and Antarctic technology and engineering

Social Sciences, Law and Humanities applications are especially encouraged, as are applications addressing innovation. Each research theme has a number of sub-themes, and applicants are encouraged to familiarise themselves with the thematic focus of the Research Plan, as well as with the overall strategic context provided in the MARS to ensure that their applications meet the very specific scientific and strategic objectives of this funding instrument.

Overview and Aims
The Research Plan serves to link South Africa's comparative geographic and research advantage, regional stewardship and national interest considerations to research themes so as to stimulate systems scale integration of knowledge and understanding. This will not only strengthen South Africa's profile and develop advanced skills, but, in so doing, will also support the country's geo-political and citizenship goals in both regional and global dialogues. The importance of South Africa's geographical proximity to Antarctica and its position as a Southern Ocean littoral state cannot be overstressed, (this area includes the Prince Edward Islands over which South Africa exercises undisputed sovereignty. The Southern Ocean is defined as the region south of Africa comprising the ocean and the sub-Antarctic Islands up to, and including, the Antarctic Continental Shelf Zone).

South Africa also maintains bases at Marion and Gough Islands, administered by the Department of Environmental Affairs (DEA). Marion Island and Prince Edward Island together form the Prince Edward Islands Group, annexed by South Africa in 1947. Gough Island, a British protectorate, which hosts the South African meteorological station, which operates as part of an agreement between South Africa and the United Kingdom.

The country runs the risk of not fully utilising or maximising the benefits of this geographic advantage, owing to a lack of adequate human capacity. This includes the risk that that the country may own research platforms and facilities, but could be subject to a form of 'knowledge colonization' from international quarters, many of whom already possess a critical mass of requisite skills. The SANAP is a long-term funding instrument designed to ensure the creation of a demographically balanced Antarctic research programme that strives for internationally competitive research, promotes inter-disciplinarity and creates links with other African countries.

SANAP Grantholders and their Projects for 2018–2020

- Dr Katye Altieri (UCT) Biogeochemical controls on the sources and chemical composition of Southern Ocean

marine aerosols

- Prof. Isabelle Ansorge (UCT) SAMOC-SA and SEAmester - South Africa's Class Afloat
- Dr Anriëtte Bekker (SU) Decision aiding for the SA Agulhas II through modelling, monitoring and data capture
- Dr Maelle Connan (NMU) Small Procellariiformes as indicators of ecosystem changes and plastic pollution
- Prof. Don Cowan (UP) Microbial diversity, functionality and resilience in Antarctic terrestrial niche communities
- Prof. Nico de Bruyn (UP) Marion Island Marine Mammals: Individual Variation and Population Processes in Changing Environments
- Dr Sarah Fawcett (UCT) A nitrogen cycle view of atmospheric CO^2 sequestration in the Antarctic Ocean
- Dr Susanne Fietz (SU) Shifts in phytoplankton and microbial community composition and functional diversity related to trace metal cycling in the Southern Ocean
- Dr Geoffry Grantham (UJ) Gondwana Amalgamation and Correlation Research Project
- Dr Michelle Greve (UP) Invasions in the changing sub-Antarctic
- Prof. Bettine Jansen van Vuuren (UJ) Biocomplexity: Understanding biological patterns in space and time
- Prof. Michael Kosch (SANSA) SANAE HF radar
- Dr Peter le Roux (UP) Modelling wind patterns and their ecological impacts
- Dr Stefan Lotz (SANSA) Polar Space Weather Studies (PSWS)
- Dr Azwianewi Benedict Makhado (DEA) Bottom-up and top-down control of seabirds of the Southern Ocean: implications for conservation
- Dr Thulani Makhalanyane (UP) Disentangling the role of chemolithoautotrophs in the sequestration of atmospheric CO^2
- Dr Pedro Monteiro (CSIR) How storm characteristics in the Southern Ocean influence inter annual variability of CO^2 fluxes
- Dr Thato Nicholas Mtshali (CSIR) Seasonal evolution of biogeochemical *Fe* cycle in the Southern Ocean
- Prof. Werner Nel (UFH) Landscape and climate interactions in the sub-Antarctic
- Dr Sarah-Anne Nicholson (CSIR) The role of storms in shaping upper ocean physics and primary production in the Southern Ocean
- Dr Pierre Pistorius (NMU) Southern Indian Ocean Top Predators: linking ecology, oceanography and marine spatial planning needs
- Prof. Chris Reason (UCT) Southern Ocean influences on Western Cape Drought and Flood Events
- Prof. Alakendra Roychoudhury (SU) Distribution and Speciation of Bioactive Trace Elements in Southern Ocean
- Prof. Peter Ryan (UCT) Managing mice on Marion Island
- Prof. Jonathan Sievers (UKZN) Observing Dawn in the Cosmos
- Dr Du Toit Strauss (NWU) Living with cosmic radiation
- Dr Sandy Thomalla (CSIR) An improved understanding of the climate sensitivity of the Southern Ocean's biological carbon pump

South African Research Chairs Initiative (SARChI)

SARChI has been successful in retaining leading South African researchers in the country as well as attracting leading international researchers to South African universities. It has also strengthened research collaboration between industry and universities and contributed to the training of the next generation of researchers for the NSI. Of the 198 filled Research Chairs, 49 are filled by incumbents who were either recruited from outside the country or from industry, thus making an addition to the research capacity within the Higher Education System.

Professor Rosemary Dorrington (RU)
Research Chair: Marine Natural Products Research
Professor Dorrington's research forms part of a multi-disciplinary programme to study the role of the microbiota (focusing on bacteria and viruses) in ecosystem functioning. The research programme is built around the application of metagenomics technologies to characterise microbial diversity and metabolic activity in aquatic and terrestrial ecosystems and their response to global change. In particular, the interest is in studying specialised microbial symbionts associated with indigenous marine sponges and other invertebrates that produce bioactive compounds with pharmaceutical potential. The research aims to exploit the potential of these natural biosynthetic pathways as a platform for drug discovery.

Globally, marine organisms are recognised as an important source of new bioactive compounds with potential pharmaceutical and other economically important applications. Over the past 30 years, marine organisms, and in particular, invertebrates (sponges and ascidians), have been a rich source for the isolation and characterisation of novel marine natural products. A significant number of these compounds have potential applications either directly or as lead compounds in the pharmaceutical industry. South Africa is surrounded by diverse marine environments, rich in unique indigenous organisms with incredible potential to provide novel natural products. The aim of this research programme is to develop a multi-disciplinary research platform in marine biodiscovery and fundamental studies on the functioning of our marine ecosystems.

Professor Amanda Lombard (NMU)
Research Chair: Marine Spatial Planning (MSP)
Marine Spatial Planning (MSP) has emerged internationally as the recommended approach to implementing integrated management of coastal and ocean areas, and is linked to ecosystem-based management and the ecosystem approach to fisheries. However, there is no MSP capacity in research, teaching, or policy development is South Africa. Professor Lombard's research aims to address these gaps. Her research focuses on:

- Strategic strengthening and analysis of knowledge of the spatial and seasonal distribution of marine biodiversity features in coastal, benthic and pelagic environments;
- Evaluation of ecosystem services (ecological infrastructure) and development of accounting techniques for the marine environment;
- Sourcing and collating available baseline biodiversity information to evaluate marine management strategies;
- Developing predictive spatial models of the outcomes of environmental and anthropogenic drivers of change in the marine environment, and
- Using outputs from themes 1 to 4 in an MSP framework to inform policy and management.

Working closely with South African colleagues and international collaborators, her research is highly collaborative. Operation Phakisa was launched to 'unlock the economic potential of South Africa's Oceans' in 2014. Phakisa identified MSP as a key initiative to support marine protection, and to provide a legislative framework to promote the rational use of the ocean, while not compromising its ecosystem-based services. Professor Lombard's work is directly relevant because it focuses on marine conservation assessments and plans. She conducts applied research that can be implemented for effective conservation outcomes.

'The Algoa Bay Project'
This SARChI Community of Practice brings together a trans-disciplinary, multi-institutional research team actively engaged in research within the broad field of Marine Science with the aim of developing a regional marine spatial plan for Algoa Bay. Marine spatial planning depends on understanding and managing the complexity of legal and socio-economic requirements with environmental considerations providing a framework for the sustainable development of the South African Oceans Economy. The first phase of the Algoa Bay Project aims to produce a bio-regional plan including a detailed biophysical map of the region, together with data on biodiversity patterns and processes of the system and a governance framework that integrates the complex legal regimes that govern activities in the region; the second phase will develop a socio-economic plan that addresses stakeholder needs, human use, impacts on ocean and human health, the economic value of ocean resources and activities, the valuation of ecosystem services, and mapping ecological infrastructure.

Key Researchers in the Algoa Bay Project

Prof. Rosemary Dorrington (PI)	Prof. Janine Adams	Dr Hayley Cawthra
Prof. Amanda Lombard (Co-PI)	Dr Tommy Bornman	Dr Shaun Deyzel

Dr Wayne Goschen
Prof. Ken Liu
Mr Jacques Mahler-Coetzee
Dr Gwynneth Matcher
SARChI Prof. Christopher McQuaid
Dr Shirley Parker-Nance
SARChI Prof. Renzo Perissinotto
Dr Francesca Porri
SARChI Prof. Mike Roberts
Ms Bernadette Snow
Prof. Hennie van As
SARChI Prof. Patrick Vrancken

Associate Professor M Tuffin (UWC)
Research Chair: Microbial Genomics

Micro-organisms are a significant resource for novel enzymes, biocatalysts and biologically active compounds. The traditional route of enzyme or product discovery depends on cultivating a micro-organism containing the activity of interest. However, only a minority of micro-organisms living in any given habitat is cultivable. This has stimulated the development of metagenomics and high throughput technologies. Metagenomics, the major research focus of this Research Chair, facilitates the direct access of all microbial genomes in any given environment, presenting infinite bioprospecting possibilities. Innovative and sophisticated approaches are being developed in this programme to overcome the current limitations associated with metagenomics, so as to accelerate the discovery of novel microbial-derived products. Microbial biotechnology, simply put, is a technology that uses micro-organisms to make innovative products that improve our lives. The research activities are focused on developing a service or a product for the healthcare, agriculture, renewable energies, dairy and chemical industries. Some of the examples include:

- discovering and developing novel drugs from marine environments to treat a variety of diseases, including HIV, TB, malaria, cancer, central nervous diseases, inflammation and bacterial infections;
- identifying sorghum-associated endophytes for crop improvement;
- converting lignocellulosic biomass into different value-added products, including biofuels and fine chemicals;
- identifying microbial bio-indicators to assess the effects of climate change and environmental impacts; and

- developing phage-resistant organisms to improve fermentation-based industries (dairy and biofuels).

Professor AC Jarre (UCT)
Research Chair: Marine Ecology and Fisheries
Research is currently focussed on:

- improved knowledge of the functioning and dynamics of marine social-ecological systems under global change;
- stronger capability for proactive and effective management of human impacts on marine ecosystems at national and regional levels, and
- active research into a multi-criteria decision support for fisheries management, including mediated systems modelling, development of indicators and management strategy evaluation.

The marine environment around South Africa is unique, ranging from the upwelling Benguela ecosystem of the Atlantic Ocean to the Indian Ocean coral reef systems in the north-east of the country, and supports high biodiversity. These oceans also provide important goods and services to the people of South and southern Africa, including contributions to food security, employment, economic returns, and a range of human cultural practices. Benefits are obtained through different activities, such as fisheries, tourism, coastal and offshore mining, oil and gas extraction, and others, all of which impact on the structure and functioning of the ecosystems, and are, in turn, impacted by these. These activities need to be managed responsibly to ensure that the health and productivity of the ecosystems are sustained for present and future human use. Research into understanding the complexity of the marine social-ecological systems under global change will improve the knowledge base for management, as well as develop tools to improve management advice. The research is carried out increasingly in a transdisciplinary setting across Natural and Social Sciences and involving non-academic stakeholders, an approach still in its infancy in South Africa.

Professor CD McQuaid (RU)
Research Chair: Marine Ecosystems Research
Current research focus:

- the physiological and genetic basis for patterns of biodiversity and biogeography, including the spread of biological invasives; and
- how physical conditions drive fundamental differences in ecosystem functioning in both coastal benthic and offshore pelagic ecosystems.

The focus is on the distribution, genetic structure and habitat segregation across multiple scales of species, including interactions between invasive and indigenous species. The coastal work also focuses strongly on recruitment into marine populations, including the consequences for exploited species that are partially protected by marine reserves. The team is interested in how these communities are affected by upwelling and have approached this by comparing systems in South Africa and South America and most recently, North Africa.

The deep-sea research uses the opportunities offered by the African Coelacanth Ecosystem Project to study communities along the Agulhas Current and how the distribution of larvae is affected. The Southern Ocean work has been extended to include both ends of the food chain, involving collaboration with many institutes within South Africa and abroad. Many marine ecosystems are profoundly influenced by their physical environment because they do not allow the accumulation of biomass that modifies conditions on land. The environment is changing at unprecedented rates and understanding how marine ecosystems are influenced by the physical environment is the key question of our time.

Professor P Vrancken (NMU)
Research Chair: Law of the Sea and Development in Africa
Professor Vrancken's research interests include the legal developments affecting the African coasts and maritime environment, the incorporation of the international law of the sea into the domestic legal system of African states, and the legal aspects of coastal and marine tourism. During the present funding cycle (2013-2017), Professor Vrancken will focus on the legal regime of ports in the SADC region.

Research on the legal frameworks of port assets and activities in the SADC states will substantially advance the knowledge required to ensure that SADC states have in place, implement, monitor compliance with and enforce legal regimes which promote the rule of law at sea, avoid distorting competition between ports and are best suited to the states' present developmental needs, while being in a position in the years ahead to keep up with, and proactively influence relevant developments at global level.

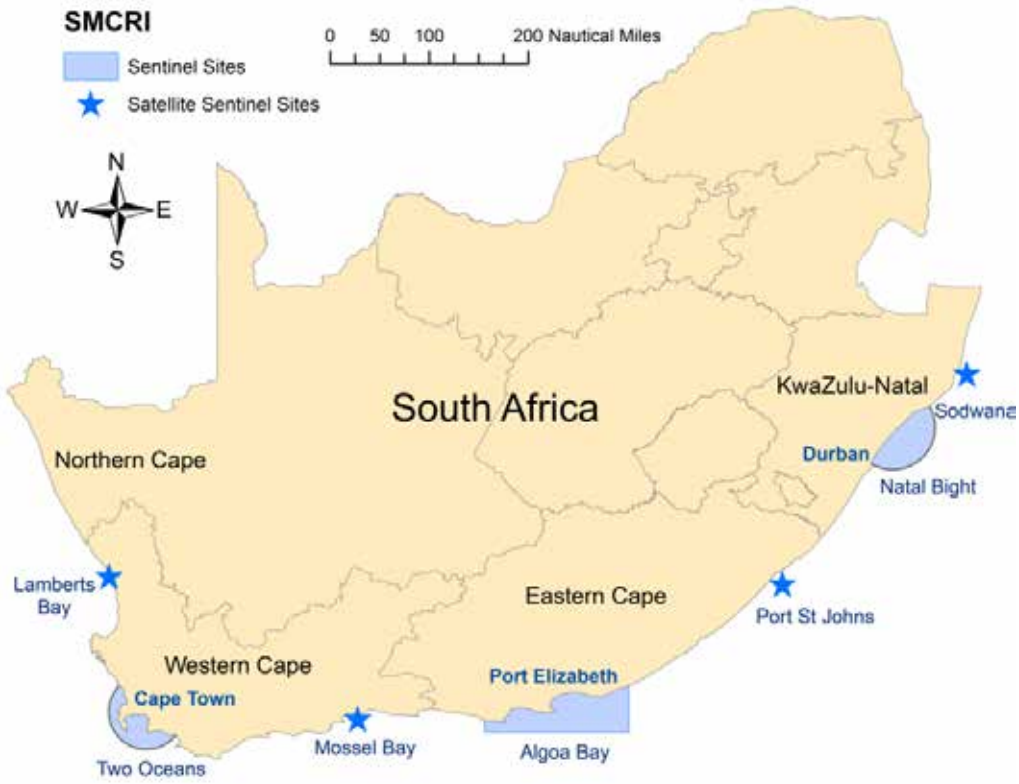
Sentinel Sites for Long-Term Ecological Research (SSLTER)

Imlementing Agency: SAEON
Funding Agency: Department of Science and Technology
Duration: 2008 – ongoing

Scope
The Sentinel Sites for Long-Term Ecological Research programme includes three Sentinel Sites: Algoa Bay SS in the Eastern Cape (established in 2008), Natal-Bight SS in KwaZulu-Natal (rolling out in 2018), and the Two-Oceans SS in the Western Cape (rolling out in 2018). In addition, Satellite Sentinel Sites (SSS) will be established along the West Coast, Mossel Bay, Wild Coast, Sodwana Bay, and the Prince Edward Islands (sub-Antarctic). Each Sentinel Site will consist of continuous *in situ* observatories (thermistor strings, shallow underwater temperature recorders, current and wave sensors) at selected sites as well as a pelagic ecosystem programme to collect physical, chemical and lower trophic biological data on a monthly basis from selected stations in the Sentinel Site. Satellite Sentinel Sites will consist of a single coastal observation mooring collecting a suite of variables (including pCO^2, pH, telemetry, currents, waves, temperature, etc.) near real-time. Sentinel Sites will be restricted to South Africa.

Overview and Aims
The aim of the Sentinel Sites is: 1) to carry out an intensive study of a small section of the coast and then apply the results to the larger ecoregion; 2) to tap into South Africa's geographical advantage by providing access to cutting-edge research platforms and data in all the coastal biogeographic regions from the three oceans and so to stimulate innovative research and IP generation that is of global relevance; 3) to create dynamic natural laboratories for carrying out multi-disciplinary, multi-institutional field-based research, and 4) provide comparable datasets from sites around the entire coastline.

Key Researchers
Key researchers include all coastal and shallow marine researchers in South Africa.



Shallow Marine & Coastal Research Infrastructure (SMCRI)

Implementing Agencies: South African Earth Observation Network (SAEON)
South African Institute of Aquatic Biodiversity (SAIAB)
Funding Agency: Department of Science and Technology
Duration: 2016–2031

Scope
The Shallow Marine and Coastal Research Infrastructure will contribute significantly to the knowledge economy and benefit all South Africans by delivering long-term, reliable data for scientific research to help decision makers formulate appropriate environmental policies, with a view to reducing the risk and vulnerability of the coastal zone to climate and global change, at the same time, acknowledging the need for economic development, job creation and reduced inequality. Long-term datasets are vital to develop robust climate-resilient strategies and policies to ensure continued economic growth, despite the changes to our environment. Rising sea levels, increases in the frequency and magnitude of storm surges, ocean acidification, harmful algal blooms, and changing water temperatures will have the greatest impact on the economy, displacing coastal communities, damaging coastal infrastructure, and potentially collapsing commercial and aquaculture stocks.

Overview and Aims
The SMCRI will provide coastal research platforms and data to the scientific community. In particular, the SMCRI will improve on and expand the Sentinel Site concept originally developed by SAEON Elwandle Coastal Node in Algoa Bay, and the coastal craft fleet and telemetry network developed by SAIAB. New platforms will include

- an aerial surveillance platform to collect remotely sensed and geo-referenced still and video imagery with the intention of expanding this platform in the future to include Light Detection and Ranging (LiDAR), and/or hyperspectral imagery capability;
- a new coastal craft to be based in Port Elizabeth;
- a decompression chamber facility in the Eastern Cape for diving emergencies and training;
- a marine chemistry laboratory, primarily for the analyses of seawater nutrients;
- marine remote imagery platform.

The SMCRI proposes to establish one of the largest arrays of coastal observatories in the world and the long-term datasets will be of global significance. The SMCRI will increase the capacity of researchers to conduct coastal marine science by providing the platforms not available at Higher Education Institutions and will build the capacity of future marine scientists by providing platforms and data for post-graduate studies. Most of these platforms will be restricted to South Africa and its sub-Antarctic territories, although the data will be made freely available to scientists and students from the entire Western Indian Ocean (WIO) region. The only exception is the coastal temperature network platform that will be rolled out to the broader southern African region.

Research Infrastructure Platforms
Sentinel Sites
Coastal Aerial Surveillance Platform
Research Dive and Decompression Facility
Coastal Information Management System
Marine Chemistry Laboratory
Acoustic Telemetry Array Platform (ATAP)
Coastal Craft Fleet
Marine Remote Imagery Platform

Key Researchers
Key researchers include all coastal and shallow marine researchers in southern Africa. The SMCRI, through its distributed network of Sentinel Sites and Satellite Sentinel Sites, will provide direct access to research infrastructure, e.g. the Coastal Craft Fleet, to all HEIs, especially coastal institutions and historically disadvantaged universities that do not currently have access to marine research infrastructure.

Western Indian Ocean Upwelling Research Initiative (WIOURI)

Part of the IIOE-2 (International Indian Ocean Expedition 2: UNESCO-IOC programme)

Implementing Agencies:
Nelson Mandela University (NMU), Port Elizabeth, South Africa
Rhodes University, Grahamstown, South Africa
In partnership with:
National Oceanography Centre (NOC), Natural Environment Research Council (NERC), Southampton, United Kingdom
Institut de recherche pour le développement (IRD), Sete, France
Funding Agencies:
Department of Science & Technology (DST) + Newton Fund, UK-SA Bilateral SARCHI
Global Challenge Research Fund (GCRF), UK (funding SOLSTICE-WIO-Sustainable Oceans, Livelihoods and Food Security through Increased Capacity in Ecosystem research in the Western Indian Ocean)
Interactive Research Development (IRD), Sete, France (in-kind: scientists, ship time)
Duration: 2016–2021

Scope
Because of the strongly related socio-economic impacts, upwelling has been selected as a major focus in the newly formulated IIOE2 Science Plan. In particular, the WIO contains a rich diversity of geophysical mechanisms that induce upwelling and make this region so different from the Eastern Indian Ocean (EIO); in fact, unique, worldwide. This unique difference is largely due to the interaction of wind (especially the monsoon), currents, eddies, and Coriolis force with unique coastlines and topographic features, such as the landmass of Madagascar, the Mascarene Plateau, seamounts and ridges – all of which produce great contrasts in the size, intensity and seasonality of upwelling between the eastern and western parts of the basin, as well as between the north, southern and central WIO. Two complementary, regionally unifying projects have therefore been set up to study upwelling and its influence on the dependant ecosystems. The projects are referred to as the Western and Eastern Indian Ocean Upwelling Research Initiatives, respectively (WIOURI and EIOURI). The varying forms of upwelling in the WIO have been distinguished into nine systems, referred to as regional 'upwelling' projects (RUPs) in WIOURI. These include:

Agulhas Current-driven upwelling,
Upwelling in the Mozambique Channel,
Madagascar Ridge and seamounts upwelling,
South-East Madagascar shelf and the South Indian Ocean Counter Current (SICC) chlorophyll bloom,
Upwelling in the East African Coastal Current (EACC) and influence of major islands (Mafia, Zanzibar, Pemba),
Upwelling Somalia Current system,
Oman/Arabian Sea upwelling system, (8) Chagos-Seychelles upwelling dome, and Chagos Ridge, and
Mascarene Plateau-induced upwelling.

WIOURI is designed to have at least two cruises per RUP and the data collection phase is scheduled to run between 2016 and 2021. Over and above the socio-economic implications, such as strengthening food security, WIOURI also will leave several legacies in the form of research centres (NMU, IMS), equipment build, schools, and scientific outputs, including human research capacity in the region.

Overview and Aims
The focus of WIOURI is upwelling ecosystems and their importance to (marine) food security and livelihoods in the WIO. A set of Generic Key questions are applied to each RUP which form the central frame around which the RUP research is undertaken:

- Where does upwelling occur?
- How extensive is it, and frequently does it occur?
- What are the mechanisms responsible for this upwelling?
- How do these mechanisms vary over spatial and temporal scales?
- What are the associated nutrient (and bio-geochemical) fluxes?
- Are there other sources of nutrients, apart from upwelling?
- What is the biological response to upwelling in terms of productivity?
- Are there limiting factors (mechanisms) to productivity?
- Does ocean mesoscale activity impact production (i.e. advection by eddies and currents)?
- What is the food web/trophic structure of the upwelling system?
- What food resources are harvested from the upwelling system?
- How does the ecosystem adjust to short dynamical and long-term perturbations?
- In view of climate change and a changing global ocean, what are the long-term scenarios for ecosystem performance (health) and food security?
- What are the societal implications of ecosystem variability — especially food security and livelihoods?

WIOURI uses a multi-disciplinary approach to address these. Physical oceanography concentrates on the mechanisms and drivers that induce upwelling, and hence transport of bio-geochemical tracers (including nutrients). These are revealed using scientific platforms and techniques such as *in situ* ships, gliders, moorings; satellite remote-sensing observations, and hydrodynamic modelling. *In situ* instrumentation such as Acoustic Doppler Current Profilers (ADCPs), Conductivity, Temperature and Depth (CTD) devices, Argo Floats, and satellite-tracked surface drifters (SVP) are used to collect these data. Remote-sensing studies are based around sea surface temperature (SST), altimetry (SSH) and ocean colour data, and complement the ocean modelling and *in situ* observations.

The bio-geochemistry of upwelling systems is complicated, involving the interaction of the nitrogen, phosphorus, silicate, carbon, and oxygen cycles with the intervention of micro-nutrients. Geochemistry in WIOURI concentrates on nutrient and trace element (Fe) availability and limitations for phytoplankton uptake. Related processes and cycles investigated include natural variations in carbon dioxide concentrations and pH on seasonal and inter-annual timescales.

Phytoplankton studies aim to determine community structure and spatial-temporal variability. These are coupled with bio-optical and physiological characteristics, and address how communities adapt to changing environmental conditions of temperature, nutrient supply and irradiance. Sampling is ship-based with CTD hydrography, bio-optical profiling and seawater sampling at stations for irradiance, absorption, scattering, fluorescence, chlorophyll-a, nutrients, HPLC pigments and primary production estimates. These are linked to remotely-sensed ocean colour and temperature data to provide greater spatial and temporal assessments of variability in phytoplankton and bio-optical characteristics. The zooplankton component of WIOURI aims to determine the spatial and temporal variability of the microplankton, mesozooplankton and ichthyoplankton assemblages on shelf, slope and oceanic waters – and how the various planktonic assemblages vary in relation to the physical and biotic environment, and importantly, whether planktonic biota are retained within these upwelling systems, or exported. Although conventional techniques are employed (i.e. water sample collection, vertical/oblique bongo net hauls), more advanced apparatus such as Laser-Optical Plankton Counters (LOPCs), Digital Video Plankton Recorders (DVPRs) and Continuous Plankton Recorders (CPRs) are used.

The biological oceanography is complemented by food web structure studies including fish, predators and marine mammals, using a combination of stable isotope profiles, stomach content and fatty acid composition (Fatty Acid Trophic Markers (FATMs)). Fisheries are a major service from marine ecosystems, a key aspect of food security, and are embedded in ecosystem models. Fisheries-socio-economic modelling is undertaken at NOC (in partnership with Plymouth Marine Laboratory), while the fisheries data collection and application is done in collaboration with Rhodes University and regional institutions of the neighbouring RUP countries. In the case of South Africa, this is done with strong input from the Department of Agriculture and Fisheries.

Key Researchers

Prof. Michael Roberts (NMU)
Dr Margaux Noyon (NMU)
Dr Jean-Francois Ternon (IRD)
Dr Katya Popova (NOC)

NON-GOVERNMENTAL ORGANISATIONS

Oceans Research

Location: Mossel Bay, Western Cape

Overview of Marine Research
Oceans Research provides and facilitates innovative and dynamic research relevant to the management and conservation of southern Africa's wildlife. Its research is interdisciplinary, ranging from biological to socio-economic studies of marine and terrestrial resource utilisation in southern Africa's coastal society.

Oceans Research specialises in investigating the biology and ecology of mega-fauna, including sharks and marine mammals; we advise governmental and non-governmental bodies on relevant conservation issues.

Oceans Research offers multi-disciplinary practical and theoretical training for aspiring researchers from internship to post-graduate levels in conjunction with partner schools, technical colleges and universities. In addition to the in-house research projects, the institute provides facilities for visiting marine scientists conducting a variety of projects throughout southern Africa.

Oceans Research strives to publicise its research findings not only to the scientific community, but also, and even more importantly, to the general public through its website, media releases, scientific and popular articles, and documentaries.

Pic: Oceans Research

Key Programmes
Collaborative white shark population assessment
Deployment partner of the National Acoustic Tracking Array Platform
Collaborative movement ecology studies on sharks and rays
Post-graduate development in collaboration with Rhodes University, Nelson Mandela University, University of Western Cape, University of Pretoria

Key Researchers
Dr Enrico Gennari

Key Collaborators
Dr Paul Cowley (SAIAB)
Prof. Marthan Bester (UP)
Prof. Mark Gibbons (UWC)
Dr Simon Elwen (UP)
Dr Malcolm Smale (Bayworld)
Dr Alison Kock (SANParks)
Prof. Nathan Hart (Macquarie University)
Prof. Shaun Collins (University of Western Australia)
Prof. Charlie Huveneers (Flinders Uni)
Prof. Les Noble (Aberdeen University, UK)
Prof. William Hughes (Sussex University, UK)

Oceanographic Research Institute (ORI)

A Division of the South African Association for Marine Biological Research (SAAMBR)

Location: Durban, KwaZulu-Natal

Overview of Marine Research

The Oceanographic Research Institute (ORI) was established in 1958 as the research arm of the South African Association for Marine Biological Research (SAAMBR). A specific area of focus was to develop collaborative research networks with other institutes around the WIO and thereby to promote biological research of the animals and plants of the region in order to assist governments in taking measures to ensure sustainable food security and the protection of biodiversity. As a non-governmental research institute, ORI was able to collaborate freely beyond South Africa's borders. Over the years this has seen ORI leading or participating in a series of regional programmes on biodiversity and vulnerable resources. Notable are the seminal studies on sea turtles, sharks and rays, corals, and lobsters, which today still serve as benchmark studies.

Contributions by ORI to regional governance and scientific development in the WIO were achieved through a number of programmes. The multinational study, TRANSMAP, explored the scientific, biological, policy and administrative opportunities and requirements for the establishment of transnational marine conservation zones in East Africa. The Nairobi Convention has provided an important platform for ORI to collaborate in WIO scientific development, for example by input to the Convention's Articles – especially the most recent dealing with integrated coastal zone management. The role played by ORI in the diagnostic analysis of land-based activities and sources of pollution in the WIO was an important milestone in regional scientific collaboration, hosted by UNEP. In several specific cases, the environmental and fisheries policies of WIO countries were strengthened with ORI support, as in the case of Mozambique linefish, and notably, Somali fisheries policy. To a considerable extent this was achieved in partnership with FAO and the Ecosystem Approach to Fisheries. The multinational World Bank-funded South West Indian Ocean Fisheries Project (SWIOFP), was largely driven by ORI and played a significant role in forging scientific collaboration between the nine main countries of the WIO region.

The successful regional scientific network known as the Western Indian Ocean Marine Science Association (WIOMSA), has provided ORI with opportunities to contribute to WIO scientific development, notably through implementing a number of scientific studies, serving in various administrative capacities and also in providing editorial support for the WIO Journal of Marine Science. A number of students from East African countries have been trained by ORI staff, either as students via UKZN or for a decade as part of a master's degree module on artisanal fisheries assessment, through the University of Brussels.

Over the past few years, ORI has built on its established scientific networks in the WIO region with a focus on reducing bycatch in commercial trawl fisheries; continued development and implementation of a large regional artisanal fisheries database, WIOFISH, and the multi-sector socio-economic study of large WIO estuaries, Estuarize. The connectivity between ecosystems of the WIO and their resources as well as transboundary fish migrations through tagging are also current priority programmes.

Key Selected Recent (< 3 years) Publications

1. Everett BI, Groeneveld JC, Fennessy ST, Dias N, Filipe O, Zacarias L, Igulu M, Kuguru B, Kimani E, Munga CN, Rabarison GA, Razafindrakoto H and Yemane D. 2015. Composition and abundance of deep-water crustaceans in the Southwest Indian Ocean: Enough to support trawl fisheries? *Ocean & Coastal Management* 111: 50–61.
2. Everett BI, Groeneveld JC, Fennessy ST, Porter SN, Munga CN, Dias N, Filipe O, Zacarias L, Igulu M, Kuguru B, Kimani E, Rabarison G and Razafindrakoto H. 2015. Demersal trawl surveys show ecological gradients in Southwest Indian Ocean slope fauna. *Western Indian Ocean Journal of Marine Science* 14(1&2): 73–92.
3. Fennessy ST. 2016. Subtropical demersal fish communities on soft sediments in the KwaZulu-Natal Bight, South Africa. *African Journal of Marine Science* 38(sup1): S169–80.
4. Fennessy ST, Roberts MJ, Barlow RG. 2016. An editorial synthesis of the ACEP project: Ecosystem Processes in the KwaZulu-Natal Bight. *African Journal of Marine Science* 38(sup1): S217–23.
5. Floros C, Schleyer MH. 2016. The functional importance of *Acropora austera* as nursery areas for juvenile reef fish on South African coral reefs. *Coral Reefs* 36(1): 139–149.
6. Goble BJ, Hill TR, Phillips MR. 2017. An assessment of integrated coastal management governance and implementation using the DPSIR framework: KwaZulu-Natal, South Africa. *Coastal Management* 45(2): 107–124.
7. Green AN, MacKay CF. 2016. Unconsolidated sediment distribution patterns in the KwaZulu-Natal Bight, South Africa: the role of wave ravinement in separating relict versus active sediment populations. *African Journal of Marine Science* 38(sup1): S65–74.
8. Groeneveld JC, Cliff G, Dudley SFJ, Foulis AJ, Santos J and Wintner SP. 2014. Population structure and biology of shortfin mako, *Isurus oxyrinchus*, in the Southwest Indian Ocean. *Marine and Freshwater Research* 65(12): 1045–1058.
9. Maggs JQ, Cowley PD. 2016. Nine decades of fish movement research in southern Africa: a synthesis of research and findings from 1928 to 2014. *Reviews in Fish Biology and Fisheries* 26(3): 287—02.
10. Maggs JQ, Mann BQ, Potts WM and Dunlop SW. 2016. Traditional management strategies fail to arrest a decline in the catch-per-unit-effort of an iconic marine recreational fishery species with evidence of hyperstability. *Fisheries Management*

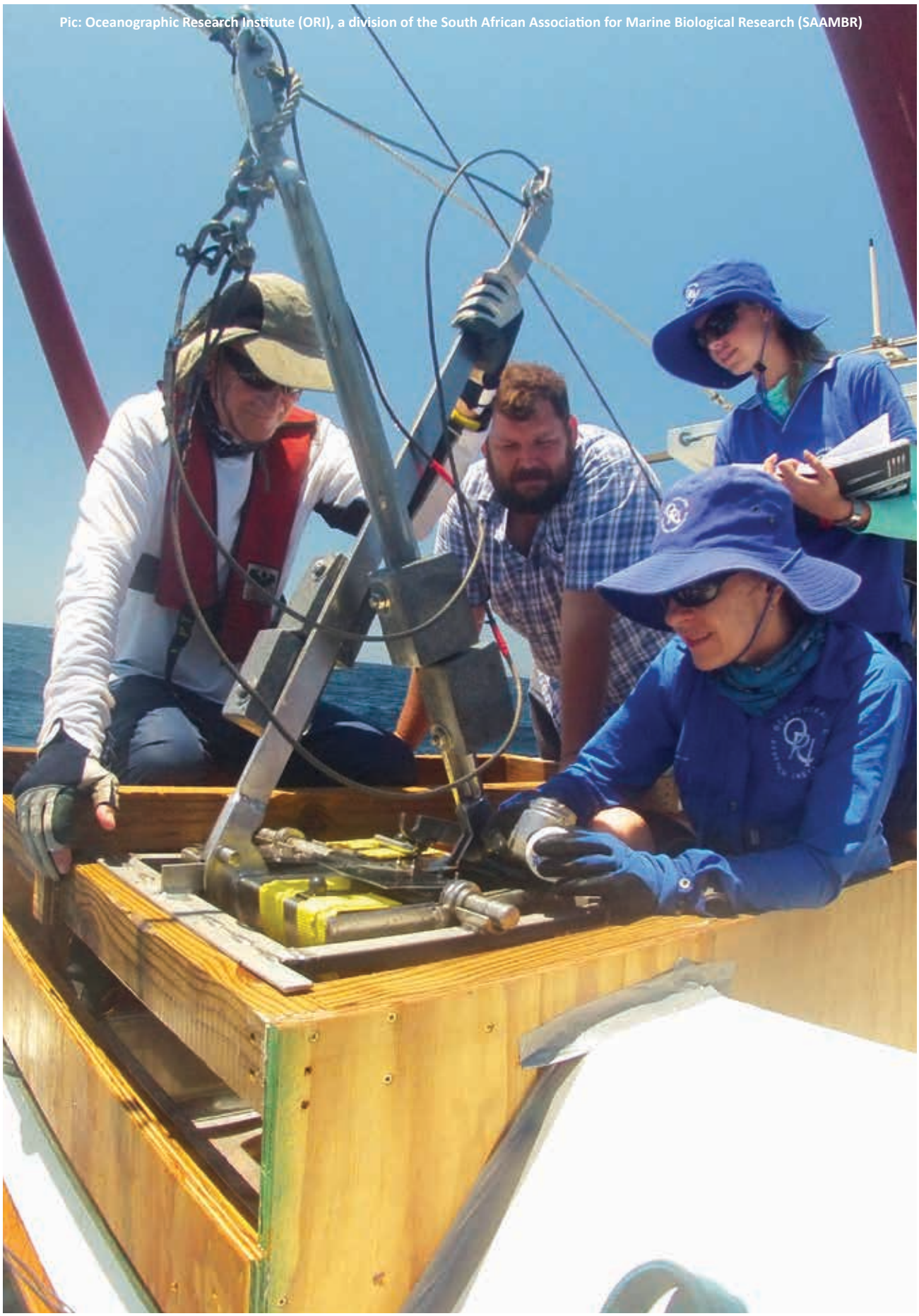
and Ecology 23(3–4): 187–199.
11. Mann BQ, Lee B and Cowley PD. 2016. Growth rate of speckled snapper *Lutjanus rivulatus* (Teleostei: Lutjanidae) based on tag-recapture data from the iSimangaliso Wetland Park, South Africa. *African Journal of Marine Science* 38(1): 111–118.
12. Mann BQ, Cowley PD and Kyle R. 2016. Estimating the optimum size for inshore no-take areas based on movement patterns of surf-zone fishes and recommendations for rezoning of a World Heritage Site in South Africa. *Ocean & Coastal Management* 125: 8–19.
13. Mkare TK, von der Heyden S, Groeneveld JC and Matthee CA. 2014. Genetic population structure and recruitment patterns of three sympatric shallow-water penaeid prawns in Ungwana Bay, Kenya, with implication for fisheries management. *Marine and Freshwater Research* 65:255–266.
14. Montoya-Maya PH, Schleyer MH and Macdonald AHH. 2014. Cross-amplification and characterization of microsatellite loci in *Acropora austera* from the south-western Indian Ocean. *Genetics and Molecular Research* 13: 1244–1250.
15. Munga CN, Mwangi S, Ong'anda H, Ruwa R, Manyala J, Groeneveld JC, Kimani E and Vanreusel A. 2014. Fish catch composition of artisanal and bottom trawl fisheries in Malindi-Ungwana Bay, Kenya: a cause for conflict? *Western Indian Ocean Journal of Marine Science* 13: 31–46.
16. Paula J (ed). 2015. *The Regional State of the Coast Report: Western Indian Ocean*. UNEP-Nairobi Convention and WIOMSA, Nairobi, Kenya, 546 pp. a. Chapter 8: Shelf sediments and biodiversity. Fennessy ST, Green A.
    b. Chapter 12: Summary on marine biological diversity. Schleyer MH.
    c. Chapter 20: The Western Indian Ocean as a source of food. Groeneveld JC.
    d. Chapter 21: Capture fisheries. Groeneveld JC.
17. Porter SN, Schleyer MH. 2017. Long-term dynamics of a high-latitude coral reef community at Sodwana Bay, South Africa. *Coral Reefs* 36(2): 369–382
18. Reddy MM, Macdonald AHH, Groeneveld JC and Schleyer MH. 2014. Phylogeography of the scalloped spiny lobster *Panulirus homarus rubellus* in the Southwest Indian Ocean. *Journal of Crustacean Biology* 34(6): 773–781
19. Schleyer MH, Pereira MAM. 2014. Coral Reefs in Maputo Bay. In: Bandeira S and Paula JP (eds). *The Maputo Bay Ecosystem.* Pp 187–205.
22. Schleyer MH, Benayahu Y, Parker-Nance S, van Soest RWM and Quod JP. 2016. Benthos on submerged lava beds of varying age off the coast of Reunion, Western Indian Ocean: sponges, octocorals and ascidians. *Biodiversity* 17(3): 93–100.
23. Schleyer MH, Pereira MAM, Fernandes RS. 2016. The benthos and ichthyofaunal of Baixo São João, Ponta do Ouro Partial Marine Reserve, southern Mozambique. *Western Indian Ocean Journal of Marine Science* 15: 1–8.
24. Séré MG, Chabanet P, Turquet J, Quod JP and Schleyer MH. 2015. Identification and prevalence of coral diseases on three Western Indian Ocean coral reefs. *Diseases of Aquatic Organisms* 114(3): 249–261.
25. Séré, MG, Tortosa P, Chabanet P, Quod J-P, Sweet MJ and Schleyer MH. 2015. Identification of a bacterial pathogen associated with Porites white patch syndrome in the Western Indian Ocean. *Molecular Ecology* 24: 4570–4581.
26. Singh SP, Groeneveld JC, Al-Marzouqi A and Willows-Munro S. 2017. A molecular phylogeny of the spiny lobster *Panulirus homarus* highlights a separately evolving lineage from the Southwest Indian Ocean. *Peer J* 5(e3356): 1–21.
27. Temple AJ, Kiszka JJ, Stead SN, Wambiji N, Brito A, Poonian CNS, Amir OZ, Jiddawi N, Fennessy ST, Pérez-Jorge S, and Berggren P. 2017. Marine megafauna interactions with small-scale fisheries in the south-western Indian Ocean: a review of status and challenges for research and management. *Reviews in Fish Biology and Fisheries*.
28. van der Elst RP, Everett BI. 2015 (eds). *Offshore fisheries of the Southwest Indian Ocean: their status and the impact on vulnerable species*. Oceanographic Research Institute: Special Publication 10, 448 pp.

Key Programmes

Connectivity in the WIO (including the ACEP Suitcase project).
East Coast coral reefs - ecology, genetics, recruitment, connectivity, economics.
Ecosystem functioning in the KwaZulu-Natal Bight (including ACEP KZN Bight project).
Biodiversity and ecosystem processes on the East Coast (including ACEP Surrogacy project).
KZN fisheries – invertebrates, linefish, crustacean trawl.
East Coast Marine Protected Areas.
Marine linefish tagging.
KZN coastal zone research.
Estuarine and soft sediment ecology.
WIO fish database of fisheries of the WIO.
WIO coral reef biodiversity and taxonomy.
BYCAM megafaunal bycatch assessment in the WIO.
ESTUARIZE A socio-ecological assessment of estuarine fisheries of the WIO.
SWIO fish technical support.
WIO prawn fisheries research programme.

Key Researchers

Ms Bernadine Everett
Dr Sean Fennessy
Dr Camilla Floros
Prof. Johan Groeneveld
Ms Fiona MacKay
Dr Bruce Mann
Dr Larry Oellermann
Dr Sean Porter
Prof. Michael Schleyer
Dr Rudy van der Elst



Pic: Oceanographic Research Institute (ORI), a division of the South African Association for Marine Biological Research (SAAMBR)

South African Shark Conservancy (SASC)

Location: Hermanus, Western Cape

Overview of Marine Research
SASC research in the WIO Region is focussed on understanding the role of elasmobranchs in coastal marine ecosystems. Specifically, research investigates transboundary movement ecology of sharks, human-shark interactions, mitigation of human-shark interactions, and outreach projects training recreational fishers in responsible catch and release fishing of elasmobranchs.

Key Programmes
1. Acoustic telemetry on bull sharks, spotted grunter and dusky kob.
2. Baited remote underwater video (BRUV) as a monitoring tool across marine management zones.
3. RecFishSA: working with recreational fishers to understand the role, value and impact of recreational shark fishing.
4. Population genetics and ecology of endemic catsharks.
5. Population genetics of bull sharks.
6. Advising Reunion government on human-shark conflict mitigation measures.

Key Researchers
Mrs Meaghen McCord
Ms Natalia Drobniewska

Sustainable Seas Trust (SST)

Location: Kenton-on-Sea, Eastern Cape;
Port Elizabeth, Eastern Cape;
Cape Town, Western Cape

Overview of Marine Research
The Sustainable Seas Trust runs the African Marine Waste Network (AMWN). Accordingly, its principal programme is related to studies of marine debris, mainly plastics (including microplastics) entering the sea. The aim of the trust is to find solutions to reduce and then stop leakage from land and vessels at sea. The responsibilities of the AMWN in the Western Indian Ocean Region are for all continental and island states. The Sustainable Seas Trust is also involved in projects that promote sustainability and alleviate poverty through the education of coastal communities.

Key Programmes
Catchments, rivers and estuaries as conduits for waste to the coast: cutting off the source, microplastics, plastics and marine life

Key Researchers
Dr Anthony (Tony) Ribbink
Dr Holly Nel
Ms Tatjana Baleta
Ms Nozibusiso Mbongwa
Mr Wade Lane
Ms Kirsty Venter

Two Oceans Aquarium (TOA)

Location: Cape Town, Western Cape

Overview of Marine Research

The Two Oceans Aquarium is a privately owned public aquarium in Cape Town, South Africa, and has for many years collaborated on various resarch programmes and projects. As a marine conservation organisation with a very active marine science programme, the aquarium supports many external research projects by offering resources (funding) and capacity (time, staff and experience). The aquarium has various internal research projects aimed at improving animal husbandry and display effectiveness and has presented its research and operational findings at various local and international conferences. The aquarium works alongside Higher Education institutions and hopes to be recognised as an aquatic research centre contributing to the growth of marine biological and conservation sciences and understanding.

Key Programmes

Turtle research

Data analysis of loggerhead turtle hatchling recoveries at the TOA between 2014 and 2017. Melissa Nel. Cape Peninsula University of Technology (CPUT). Supervisors: Prof. Ken Findlay, Maryke Musson.

Tracking the movement of an adult female hawksbill turtle after successful rehabilitation at the TOA and subsequent release. TOA. Department of Environmental Affairs. CPUT.

Amounts and impacts of ingested plastics in loggerhead turtle hatchlings. UCT, NMU, TOA. Principal scientist: Prof Peter Ryan.

Characterisation of fusarium isolates associated with juvenile loggerhead turtles**.** DAFF, University of the Western Cape (UWC), TOA. Principal scientist: Dr Mariska Laubscher.

Biosecurity and treatment of fungal pathogens infecting stranded loggerhead sea turtles (*Caretta caretta*) in South Africa. TOA, DAFF. Principal scientist: Dr Mariska Laubscher.

Parasitology

Hexabothrid Monogenaean parasites in a group of short-tail stingrays (*Dasyatis brevicaudata*) and successful use of a blood transfusion to treat anaemia. DAFF, TOA, RZSS. Principal scientists: Dr Kevin Christison and Dr Georgina Cole.

Anoplodiscus sonsino, 1890: a new Australian species and the first record from South African hosts. DAFF, UWC, TOA, JCU. Principal scientists: Dr Kevin Christison, David Vaughan.

Epizootiology of *Ichthyophonus hoferi* in South Africa and the assessment of potential risks to captive fish populations. UWC, DAFF, TOA. Brett Wurdeman. Supervisor: Dr K. Christison.

Managing *Ichthyophonous* in multi-species exhibits at the Two Oceans Aquarium. DAFF, TOA, UWC. Nicholas Nicolle. Principal scientists: Dr K. Christison.

Biodiversity

The effect of submergent macrophytes on the abundance and behaviour of fish assemblages between salt marsh and mangrove habitats of the Nahoon Estuary, South Africa. UWC, SAIAB. Intern funding support from TOA. Razaan Keur.

Behavioural study on feeding and reproduction in *Semicassis labiata zeylanica*. UCT. Intern funding support from TOA. Thando Mazomba.

Using environmental DNA metabarcoding to reveal genetic fish diversity in multiple marine systems of South Africa. US. Molly Czachur.

Sharks

The demography and spatial ecology of the broadnose sevengill shark (*Notorynchus cepedianus*) in South Africa. UCT. TOA funding and capacity support. Principal scientist: Dr Alison Kock.

The movement analysis of ragged-tooth sharks (*Carcharias taurus*) released from a captive environment on the south east coast of South Africa. CPUT, TOA. Paul Cronje. Supervisors: Prof. Ken Findlay, Maryke Musson.

Penguins

Effect of wear and colour on the carbon and nitrogen stable isotopes of feathers. UCT. Capacity and samples from TOA. Laurie Johnson. Supervisor: Prof. Peter Ryan.

Do stable isotope values of feathers change with age? UCT. Capacity and samples from TOA. Principal scientist: Prof. Peter Ryan.

Sperm biology and cryopreservation of the African Penguin. UWC. Siya Mafunda.

Key Researchers

Mr Nicholas Nicolle
Ms Maryke Musson
Prof. Ken Findlay
Prof. Peter Ryan
Dr Mariska Laubscher
Dr Kevin Christison
Dr Georgina Cole
David Vaughan
Dr Alison Kock
Molly Czachur Czachur

WILDOCEANS

Location: Durban, KwaZulu-Natal

Overview of Marine Research

WILDOCEANS is the marine programme of the Wildlands Conservation Trust, a South African non-profit NGO. Wildlands' vision is a 'Sustainable Future for All'. By working at the critical interface between environmental conservation and socio-economic advancement, Wildlands aims to support resilient ecosystems through the development and facilitation of innovative solutions which promote social inclusiveness and sustainable development. Research-related activities are focussed on improving biodiversity knowledge, building science capacity, creating awareness of threats to the oceans, encouraging citizen science participation, increasing protection of the marine environment, and promoting sustainable resource use and resilience of coastal communities.

Key Programmes

The Ocean Stewards Programme is a capacity-building initiative launched in 2015 that provides young marine science students with an experiential journey and gives them unique insights into marine conservation. It aims to inspire them to continue in the marine science field, and supports them to do so. Ocean Stewards participate in annual offshore research cruises, where they use equipment provided by ACEP's research platforms and work closely alongside scientists. The goals of this program are:

1) emergence of a strong cohort of passionate marine conservation scientists;
2) strategic placement of informed and committed individuals in key decision-making, communication and policy development positions in government, non-profit, academic and environmental management organisations, and
3) a supportive network of connected individuals focussed on supporting a sustainable blue economy. A fellowship of over 50 students from five Universities have participated to date.

The *RV Angra Pequena* provides a unique platform for offshore marine science and capacity-building. This classic 72 ft vessel was built as a Fisheries Patrol boat and served as a South African Fisheries Research vessel. Recently she has been used for research and training on the east coast of South Africa and in Mozambique, deploying equipment such as ROVs, CTD equipment, plankton nets, multibeam, BRUVs, and grab samplers. She offers a good platform for diver and deck observation studies. She has a fuel range of 3000 NM, and can stay at sea for over 30 days. She is equipped with a crane, winches, dive compressor and a semi-rigid inflatable boat.

Marine Protected Areas (MPAs): The Ocean Stewards Programme has been implemented in direct partnership with two ACEP open call projects (Spatial Solutions and Biodiversity Surrogacy projects), which aim to map offshore biodiversity for conservation planning and to survey poorly understood deeper habitats, in support of the proposed expanded Phakisa MPA network in South Africa. The WILDOCEANS team also engages in assessing the value and effectiveness of MPAs, and has presented on this at regional international meetings.

The Whale Time project was launched in 2016 to highlight the humpback whale migration along the coast of KwaZulu-Natal between their summer Antarctic feeding grounds and the coastal waters of Mozambique, Tanzania and Kenya, Madagascar, the Mascarenes and the Western Indian Ocean islands where they give birth to their calves. This project's goal is to bring science, conservation, responsible tourism, and community together around this species. It aims to contribute to updating scientific knowledge of humpback whale populations and to engage the public in whale sightings and associated monitoring of the distribution, behaviour patterns, and habitat use of the whales. The project includes establishing an online platform, www.whaletime.co.za, that will allow 'citizen scientists' to upload photos of whales, to be identified by marine science experts. It provides a platform to develop a coastal community-based 'citizen science' movement that will bring benefits not only to conserve the whales and their ocean environment, but also for coastal communities through training and economic opportunities (including community tour-guide training).

Key Researchers

Dr Jean Harris
Dr Andrew Venter
Ms Rachel Kramer

HIGHER EDUCATION INSTITUTIONS

Cape Peninsula University of Technology (CPUT)

Location: Cape Town, Western Cape

Overview of Marine Research

Over the years oceanographic research in the Western Indian Ocean has been focussed mainly on understanding the circulation of currents and their potential impact on marine ecosystems by means of dynamic processes taking place across the interface between Large-scale and Meso-scale phenomena. This has been achieved largely through the application of numerical ocean circulation models.

The main ongoing activities are the following geographical domains:

Greater Agulhas Current System

Through a University Research Funding programme, in 2016 CPUT funded a small departmental project to investigate the role of small-scale oceanic turbulence on general circulation and ecosystems along the east coast of South Africa. The numerical model configuration used in this study is also being used to assess the role of seafloor ocean bathymetry on the general circulation in the greater Agulhas Current system.

East African Coastal Current system

In 2016, the Western Indian Ocean Marine Science Association (WIOMSA), through a Marine and Coastal Science for Management (MASMA) call funded a multi-disciplinary and multi-institutional project: 'Responses of biological productivity and fisheries to changes in atmospheric and oceanographic conditions in the upwelling region associated with the East African Coastal Current'. The project is led by the Tanzanian Fisheries Research Institute. At CPUT we are currently working on the numerical ocean model configuration for this study, focussing mainly on trends in upwelling and productivity.

Marine Mammal Research

Two areas of population demographic and conservation management research carried out by Ken Findlay in the Western Indian Ocean pertain to:

- Dugong (*Dugong dugong*) distribution, abundance and population structure across the Western Indian Ocean through projects funded by the WIOMSA in Kenya, Tanzania, Mozambique, Comoros and Seychelles, and the Global Environmental Facility (GEF) in Mozambique. Prof. Findlay is a member of the International Union for Conservation of Nature (IUCN) Sirenian Specialist Group, and has based his research in this region.
- Cetaceans, particularly the humpback whale (*Megaptera novaeangliae*) population is recovering in the Mozambique breeding grounds, and elsewhere in the region. In this regard, Ken Findlay has been integrally involved in the global Southern Hemisphere Comprehensive Assessment of humpback whales carried out by the International Whaling Commission Scientific Committee. He also sits on the Steering Committee of the Indian Ocean Cetacean Research Group (IndoCet) and acts as a research adviser to the Arabian Sea Whale Network in the North Western Indian Ocean. He is a member of the IUCN Cetacean Specialist Group with his research based in the Western Indian Ocean.

Oceans Economy and Governance Research

This is a new area of research. Prof Findlay co-chairs the South African Blue Economy chapter of the Indian Ocean Rim – Academic Group and is currently formulating research proposals in marine spatial planning and associated decision support in the region. In the Western Indian Ocean, for the past two years we have worked towards an assessment of the contribution of the *R/V Dr Fridtjof Nansen* to research capacity development, management, and conservation of marine resources and ecosystems in the Western Indian Ocean. This work has led to the publication of a book launched during the WIOMSA conference at the end of October 2017. The Cape Peninsula University of Technology worked on Chapter 4 of the book, focussing especially on the physical oceanography. The project was funded by the Food and Agriculture Organisation (FAO), and administered by WIOMSA, the Oceanographic Research Institute (ORI), Durban, South Africa, and the Institute of Marine Research, Bergen, Norway.

Key Researchers

Dr Issufo Halo, Physical Oceanographer Greater Agulhas Current System and East African Coastal Current System
Prof. Ken Findlay, Research Chair: Oceans Economy

Nelson Mandela University (NMU)

Institute for Coastal and Marine Research (CMR)

Location: Port Elizabeth, Eastern Cape

Overview of Marine Research

Eastern Cape

Research by the Marine Apex Predator Research Unit (MAPRU) is focussed on the St Croix and Bird Islands in Algoa Bay. Aspects, such as behavioural demographics, indicators of environmental change, taxonomic status, phenotypic plasticity during global changes, marine top predator distribution and diet, foraging ecology, genetic structures of various cetaceans, pinnipeds and seabirds are investigated. Furthermore, habitat characterisation and epibenthic biodiversity in Algoa Bay is studied and much effort is put into abalone and algal aquaculture. Estuaries, mangroves, sandy beaches and rocky shores are studied extensively in terms of their vulnerabilities, ecosystem services, responses to climate change, etc. The characterisation of micro-estuary systems along the Eastern Cape coast also takes place, and the biogeochemistry of living stromatolites along the Eastern Cape coastline is being researched. Research into the early life history strategies and nursery areas of fish, studying the larval stages of fish and plankton ecology is being carried out.

KwaZulu-Natal

KwaZulu-Natal has many estuaries and wetlands that have been studied over the long term. One such project is research into the biodiversity, ecological functioning and rehabilitation of Lake St Lucia. Additional research projects are: sediment conditions and population structure of the largest mangrove forests in South Africa (forests of northern KwaZulu-Natal); the variability in the distribution and abundance of sub tidal benthos of the temporarily open/closed Mngazi Estuary; investigations into the composition and biomass of zooplankton in estuaries at Kosi Bay; the macrozoobenthos of the Mngazana estuary flood-tidal delta, and using baited remote underwater video systems to assess deep water benthic fish communities of the KwaZulu-Natal shelf to inform Marine Spatial Planning.

Mozambique

Research in Mozambique through the Western Indian Ocean Marine Science Association (WIOMSA), includes the assessment of various invertebrates, mangroves, seagrasses and estuaries as socio-ecological assets in the Western Indian Ocean (WIO). Specific projects include zooplankton and ichthyoplankton spatial distributions associated with a dipole eddy system in the western Mozambique Channel; composition and distribution of larval fishes associated with an oceanic eddy in the Mozambique Channel; classification, identification and reassessment of mysids; defining the biology of sandy beaches; ensuring conservation of mangrove forests through conservation; researching estuarine flow requirements.

Kenya

A WIOMSA project exists on understanding and predicting responses of mangrove trees and formations to climate change in the WIO (Kenya Wildlife Services). Investigations related to the commonly occurring larval stages of fishes in Kenyan coastal waters have been conducted, as has an investigation into the phenology of *Avicennia marina* in a distinctly zoned mangrove stand.

General

Research covers the following fields: the status and management of mangroves in the WIO; the development of a botanical importance rating system and database for South African estuaries; researching mysid shrimps of the WIO; the impact of freshwater attenuation on the dynamics of estuarine tidal inlets, and the implications for biotic exchange; WIO Marine Turtle Task Force and International Union for Conservation of Nature (IUCN) Marine Turtle Specialist Group; the status and future of WIO leatherback turtles and sea turtle bycatch; zoning the WIO to reduce conflict between ocean-based hydrocarbon exploration and production, and marine focal species in East Africa; marine apex predator research on Marion Island; assessment of ecosystem conditions of consolidated and unconsolidated benthic habitats on the east coast. Nine upwelling regions have been identified in the WIO that sustain ecosystems and resources. Regional research and training capacity are being developed, with the aim of using this capacity to undertake marine research in support of food security in the WIO.

Key Researchers

Prof. Janine Adams. Botany. Eastern Cape and KwaZulu-Natal estuaries
Prof. Renzo Perissinotto. SARChI: Shallow Water Ecosystems. St Lucia and Eastern Cape shallow water ecosystems.
Prof. Nadine Strydom. Zoology. Estuarine and plankton ecology and inshore marine biology, mainly in the Eastern Cape.
Prof. Tris Wooldridge. Zoology. Eastern Cape, KwaZulu-Natal.
Prof. Ronel Nel. Zoology. KwaZulu-Natal, Mozambique, Eastern Cape.
Dr Paul-Pierre Steyn. Botany. Eastern Cape.
Dr Phumelele Gama. Botany. Eastern Cape Wetlands.
Dr Pierre Pistorius. Zoology. Marion Island, Bird Island, St Croix Island.
Prof. Amanda Lombard. SARChI: Marine Spatial Planning. Algoa Bay, KwaZulu-Natal.
Prof. Mike Roberts. SARChI: Oceanography and Food Security. Various sites (nine upwelling stations) in the WIO.

Rhodes University (RU)

Location: Grahamstown, Eastern Cape

Overview of Marine Research

Marine Pollution

This research programme focuses on the microplastic loads in the nearshore marine waters and sediment along the southern African coastline. The research assesses the incorporation of microplastics into the marine food web mainly through ingestion by filter feeders (acidians, mussels and barnacles) and early-stage life history fish. The project is funded through incentive funding provided to the principal investigator, Professor PW Froneman by the National Research Foundation (NRF) and Rhodes University.

Shallow Water Marine Ecosystem Studies

This research programme seeks to better understand the role of predation, mainly early life history fish and mysids, in structuring plankton communities within shallow water ecosystems employing mesocosm experiments. In particular these studies investigate the impact of predator diversity in mediating predator/prey interactions. The project is funded through incentive funding provided to the principal investigator, Professor PW Froneman by the NRF and Rhodes University.

Coastal Oceanography

Studies of the influence of large-scale variability in oceanography on coastal systems include two main themes. First, the consequences of long-term changes to upwelling regimes. This work, based on study regions on different continents, includes characterising variability in the physical environment using remote sensing, the role of upwelling centres as refugia from global warming, and examining generality in the effects of upwelling on the diets of filter feeders. Second, large-scale effects on recruitment, including the effects of changes to the phytoplankton community and the influence of nearshore topography and hydrodynamics on larval supply.

Thermal Biology

This includes large-scale effects linked to climate warming, small-scale thermodynamics, the evolution of the thermal environment during biological succession and the moderation of thermal stress through biological interactions**.**

SOLSTICE-WIO (Sustainable Oceans, Livelihoods and Food Security through Increased Capacity in Ecosystem Research in the Western Indian Ocean)

The overall aim of SOLSTICE-WIO is to strengthen capacity in the WIO to address challenges of food security and the sustainability of the livelihoods of 60 million people dependent on the region's marine ecosystems. This is reflected in the main objectives of the project:

- to grow marine environmental research capability to address challenges facing the WIO region in a cost-effective way via state-of-the-art technology transfer, collaborative environmental and socio-economic research and hands-on training;
- to strengthen the capacity of UK marine scientists to apply leading-edge technologies in developing countries, and work with regional and local experts to ensure that their research addresses local and regional needs;
- to strengthen the ability of WIO scientists to effectively deliver evidence-based environmental and socio-economic information to support policy development and implementation at national and regional levels;
- to ensure future sustainability of marine research capability in the region by training and mentoring early career scientists and post-graduate students from the WIO, and by developing on-line resources to use in distance learning and hands-on training of marine scientists outside the partner organisations and beyond the duration of the project;
- to ensure on-going support for an Ecosystem Approach to Fisheries in the WIO by building lasting strategic research partnerships between UK marine science and regional centres of excellence, between these centres and other WIO research organisations, and between marine scientists and government agencies and NGOs mandated to deliver sustainable development and exploitation of marine living resources in the WIO**.** This project provides a significant opportunity for funding.

Development of a Tuna Research Agenda (2017–2027) and Grant Mechanism for Tuna and Tuna-like Fisheries Research in Tanzania

The Tuna Fisheries Research Agenda was developed to ensure the sustainable exploitation of tuna and tuna-like species (including sharks) in Tanzanian national waters. Research priority areas identified in the National Fisheries Research Agenda (2015–2020) and the goals of the Tuna Fisheries Management Strategy were also taken into consideration. Priority actions and research areas identified were:

- establishment and set up of relevant working group, trust fund, and research committee;
- biological research of tuna, tuna-like and shark species;
- environmental research;

- fishery-related research;
- stock structure research;
- business planning and social and economic research;
- monitoring, control and surveillance.

Within each category, a number of priority sub-categories were highlighted. The research plan provided a framework that identified the key strategic research needs for the ten-year period 2017–2027 for Tanzania, taking into account Tanzania's' membership of the Indian Ocean Tuna Commission (IOTC). The grant mechanism component included developing official programme documentation such as general guidelines for submitting a proposal, and technical and financial forms for Applications for Support. The future research activities funded by this programme will focus on attaining the primary objective of ensuring sustainable exploitation of tuna and tuna-like species (including sharks) in Tanzanian national waters, with identified research priorities guiding the assessment of research proposals submitted to the programme for funding.

Determining and Promoting Resilience in Artisanal Fishery Social-ecological Systems in Pemba Bay, Mozambique
Understanding the interactions between humans and ecosystems is increasingly urgent as human use and over-exploitation causes deterioration of ecosystems which, in turn, causes deterioration in human wellbeing. This pattern is often seen in artisanal fisheries where many small-scale fishers become trapped in poverty as ecosystems deteriorate and human desperation creates deleterious feedback loops. In these systems, human decision making has not been adequately studied. Human fishing decisions create a strong link between social and ecological systems, and most management depends on changing human behaviour. Unfortunately, we do not understand the factors that influence human decisions well, nor do we have much data on how the effects of specific fishing decisions feed back into future fisher decisions. The goals of this study are to understand:

1. the factors that influence fishing decisions and how their effects feed back into future decisions;
2. how important fishing behaviours are in determining the interactions between the social and ecological aspects of the fishery;
3. how or whether human behaviours affect the resilience of the fishery's social-ecological system and to find ways to increase that resilience.

Assessing the connectivity of estuarine and marine nursery habitats along the south-east coast of South Africa
Although it is well understood that estuaries serve as important nurseries for fish and invertebrates, with many species in South Africa thought to be estuarine dependent, comparative data on the degree of estuarine and marine nursery habitat use by marine species is lacking. A mixed-method approach assessing habitat quality and settlement stage larval and juvenile fish and invertebrates concurrently in estuaries and nearshore coastal habitats is being conducted in the warm-temperate coastal region from St Francis to Kenton. Results from this study will help fill knowledge gaps critical to the understanding of nursery habitat use by several economically and ecologically important fish and invertebrate species.

The Marine Natural Products (MNP) research platform
The Marine Natural Products (MNP) research platform covers the broad field of marine biodiscovery focusing on the potential of bioactive secondary metabolites produced by marine organisms endemic to the Agulhas Bioregion as lead compounds for drug discovery. More than half of new pharmaceutical drugs on the market or in clinical trials are natural products and their derivatives and the majority of these are now coming from marine sources. This programme seeks to expand the search for new bioactive compounds to the unexplored coastal shelf of the Agulhas bioregion focussing on marine invertebrates, tunicates and their associated microorganisms. The research aims: (1) to assemble MNP chemical extract and pure compound libraries (2) to screen these libraries for biological activity and (3) to elucidate the biosynthetic organ of lead compounds.

Key Researchers in the MNP
SARChI Prof Rosemary Dorrington (r.dorrington@ru.ac.za)
Dr Gwynneth Matcher (gfmatcher@gmail.com)
Dr Meesbah Jiwaji (mezjiwaji@gmail.com)
Dr Shirley Parker-Nance (shirley@saeon.ac.za)

Key Rhodes University Researchers
Professor William Froneman. Marine pollution, south coast and south-eastern Cape coastline and shallow water marine ecosystem studies, Eastern Cape coastline, South Africa.
Prof. Christopher McQuaid. Coastal Oceanography and Thermal Biology.
Prof. Warwick Sauer. Department of Ichthyology and Fisheries Science, Rhodes University.
Nicola Downey-Breedt. Department of Ichthyology and Fisheries Science, Rhodes University.
Prof. Shankar Aswani. Department of Anthropology, Rhodes University.
Dr Amber Childs. Coastal and estuarine fish, South African south-east coast.
Prof. Warren Potts. Coastal fish and global change, South African south-east coast.

Stellenbosch University (SU)

UNIVERSITEIT STELLENBOSCH UNIVERSITY

Location: Stellenbosch, Western Cape

Overview of Marine Research

Research Group 1 – Genomics, Evolution, and Conservation

The Evolutionary Genomics Group, led by Prof. Conrad Matthee, has a strong history of working on Western Indian Ocean (WIO) crustaceans and applying molecular tools for elucidating evolutionary patterns and processes. Current work includes genomic signatures of adaptabilty and resilience of the seagrass *Zostera capensis* throughout its south and east African range. A combined approach of genomics and environmental and habitat modelling will provide better insight into the potential impacts of climate change on this keystone species. We are also working on the biodiversity patterns of sponges with a particular focus on Rodrigues and Mauritius Islands. Phylogenetic methods are being used to place the evolutionary history of sponges into a broader Indo-Pacific context. Work in the von der Heyden lab has a strong foundation in the applicability of genetics and genomics for management, developing tools that enable the integration of molecular data into systematic spatial planning.

Research Group 2: Shark and Ray Management

This research is aimed at improving management, enforcement, and reporting on sharks and rays across the South Atlantic and WIO regions, and includes assessment of genetic diversity and population connectivity, development of molecular species identification assays, and morphological identification guides for elasmobranch species in the region.

Research Group 3: TraceEX

The TraceEx team based at Stellenbosch University, Earth Sciences, concentrates on trace elements and bio-geochemical cycles in the ocean, with a focus on the Southern Ocean, recently extended into the Western Indian Ocean. The rationale behind investigating the trace elements is that many trace elements are essential for the growth and functioning of marine organisms, e.g. photosynthetic phytoplankton, and therefore influence the functioning of ocean ecosystems and the global carbon cycle. This leads to an impact on the carbon dioxide concentration in the atmosphere and thus, an essential impact on the global climate. One of the TraceEx team's major aims is to identify processes and quantify fluxes that control the distributions of key trace elements and establish the sensitivity of these distributions to changing environmental conditions. In addition, we interrogate the other driving factors such as dust deposition, and changes in the microbial communities.

Key Researchers

Research Group 1:

Prof. Sophie von der Heyden, Marine Genomics and Conservation, Mascarene Archipelago, South Africa, Kenya, Mozambique

Research Group 2:

Dr Aletta Bester-van der Merwe, Molecular Ecology and Genetics, South Africa and Mozambique (east African WIO region)

Research Group 3:

Prof. Alakendra Roychoudhury, Environmental Geochemistry, Southern Ocean/southern Africa
Dr Susanne Fietz, Environmental Geochemistry, Southern Ocean/southern Africa
Dr Bjorn von der Heyden, Geology, Southern Ocean/southern Africa

University of Cape Town (UCT)

UNIVERSITY OF CAPE TOWN
IYUNIVESITHI YASEKAPA • UNIVERSITEIT VAN KAAPSTAD

Location: Cape Town, Western Cape

Overview of Marine Research

Oceanography

The Meridional Overturning Circulation (MOC) is a system of surface, intermediate and deep ocean currents encompassing all ocean basins. It is the primary mechanism for transporting and storing heat, freshwater, and carbon between ocean basins, and connects the upper layers of the ocean and the atmosphere with the huge reservoir of the deep sea. The physical structure of this circulation and its efficiency in regulating climate are substantially influenced by the nature of water mass exchange between ocean basins. Climate models have shown that past changes in the strength of the MOC were linked to climate variations, with further predictions hinting that the MOC will continue to modulate future climate change scenarios on time scales from decades to centuries. Schiermeier identified the South Atlantic near 34.5°S as a crucial location for examining how the ocean currents and inter-ocean exchange influence the MOC. Recognition of the critical importance of the MOC in this region led to the creation of an international initiative on the south Atlantic MOC (SAMOC), and subsequent testing in numerical models has led to a robust design for a trans-basin MOC array that will form the backbone of the SAMOC observing system, and overlap with current arrays through the Agulhas System Climate Array (ASCA) programme.

The overarching goal of SAMOC is to observe and understand the mechanisms that control the mean and time-varying MOC as well as the meridional heat and freshwater (or salt) transport in the South Atlantic, and the inter-ocean exchanges of heat and salt. The SAMOC initiative consists of a large number of on-going and proposed observational platforms aimed at monitoring long-term physico-chemical changes within the Agulhas, Brazil, Antarctic Circumpolar and deep-ocean current systems, as well as trans-basin and inter-ocean exchanges of heat and salt. A subset of SAMOC includes a trans-basin mooring line along 34.5°S to monitor the South Atlantic MOC, which is referred to as the South Atlantic MOC Basin-wide Array (SAMBA); the monitor of the Agulhas Current is referred to as Crossroads and ASCA, while the connection to the neighbouring Southern Ocean is known as Good Hope. With the establishment of the various lines achieved under SAMOC during the 2015–2017 Department of Science and Technology (DST)-led South African National Antarctic Programme (SANAP) call, many of the goals of SAMOC can now be realised. The large meridional gap between the African and Antarctic continents provides a significant crossroad for water mass exchange between the eastward-flowing Agulhas Counter Current (ACC) as well between water masses of the subtropical Indian and South Atlantic gyres. Most of the Indian to Atlantic Ocean transfer takes place near the Agulhas Current Retroflection through the generation of large warm rings known as the Agulhas Leakage. Recent modelling studies suggest that the Agulhas Leakage is a critical influence; not only is the region a gateway for the upper limb of the MOC northward flow, but the shedding of Agulhas rings provides one of the major sources of salinity to the South Atlantic. Other modelling investigations suggest that variability in this leakage may correlate to changes in strength of the North Atlantic MOC. Thus, in order to understand the nature of global climate change, the quantification, physical understanding, and long-term monitoring of the inflow of Indian waters into the Atlantic Ocean is essential. The local community has now responded through the 2015–2017 SAMOC-SA DST-led SANAP-funded programme to the need for such measurements and the necessity of developing full basin-wide arrays. This is a crucial step if the many uncertainties in model projections of global warming are to be reduced. It is critical that this monitoring system continues to be supported into its third phase in order to realise a better understanding of the variability of the Agulhas Leakage and its impact further afield.

Marine Biodiscovery

The bio-prospecting of southern Africa's terrestrial environment for pharmaceutical drugs is well recognised, while the natural product diversity and bio-medicinal potential of the plethora of marine invertebrate populations endemic to the extensive Western Indian Ocean (WIO) is still relatively unexplored, despite the global interest in this research field. Nevertheless, some useful marine natural-product compounds have been discovered from southern African waters, in particular *Dolastatin 10* which was identified in a sea hare collected off the coast of Mauritius in the WIO. *Dolastatin 10* has demonstrated outstanding *in vitro* cytotoxic activity against various human cancer cell lines, which warranted its further research and development into this marine natural product. A synthetic analogue of *Dolastatin 10*, Adcetris® was successfully awarded Food and Drug Administration (FDA) approval in 2011 for the treatment of Hodgkin's lymphoma and anaplastic large cell lymphoma in humans. The Mauritius Oceaography Institute (MOI) initiated a project entitled "Bioprospecting of Mauritius Waters" in 2004 with the aim of screening, isolating and characterising bioactive compounds from marine sponges collected from the Mauritian waters. To date, the MOI has isolated a number of compounds from the marine sponge extracts but has not been able to characterise and identify them because they lack adequate and appropriate instrumentation, and have limited collaboration with other research institutions.

After two years of discussions with the MOI, a formal collaborative agreement was concluded with the Natural Products Research Group (NPRG) led by Dr Sunassee in the Chemistry Department at the UCT. To the best of our knowledge, this is the first marine research of its kind linking a South African University with the island of Mauritius. Through this

research collaboration, a comprehensive collection of marine sponge extracts from the south WIO region of Mauritius will be made available by the MOI for screening against tuberculosis, malaria, trypanosoma, HIV, and different cancer cell lines. The collaboration between the MOI and UCT aims to strengthen the links and build capacity between two WIO countries that are also part of the South African Development Community (SADC). The NPRG, led by Dr Sunassee in the Chemistry Department at the UCT, has ready access to state-of-the-art equipment, not available in Mauritius, that we plan to use during the course of this project. However, this project is not yet funded, with both the MOI and the NPRG seeking project funding to start working on this collaboration.

Seaweed Biodiversity
Biodiversity studies on seaweeds of the southwestern Indian Ocean include taxonomy, molecular systematics, biogeography, resource use and aquaculture. The prospects for aquaculture of WIO sea urchins (*Tripneustes gratilla*) are being studied as is the integrated aquaculture of seaweeds with abalone and urchins. Collaboration with chemists at the University of the Western Cape (UWC) and UCT on marine natural products from seaweeds are also underway, and a website for identifying South African south coast seaweeds (http://southafrseaweeds.uct.ac.za/index.php) has recently been produced.

Modelling
Regional ocean modelling applies to the following areas: Agulhas Current, circulation in the Mozambique Channel (eddies, Zambezi River plume, tidal range on the Mozambican coast), East African Coastal Current, Somali Current and associated mesoscale variability, North East Madagascar Current, South East Madagascar Current, Madagascan bloom, Seychelles Chagos thermocline ridge, intra-thermocline eddies in the WIO, coral connectivity and larval dispersal in the tropical WIO, and changes in upper ocean characteristics important for tropical cyclone generation and intensification. Regional atmospheric modelling applies to ocean-atmosphere interaction, evolution of tropical storms in the region, moisture fluxes and rainfall impacts of the WIO on east and southern Africa.

Other Projects
Work has started on the socio-economics of squid in the WIO, a project being run by Mike Roberts in conjunction with researchers from University of Southampton under the aegis of SOLSTICE.

Bi-lateral/Multi-lateral Funded Work:
United Kingdom Natural Environment Research Council (UK NERC) / Department for International Development (DfID)
European Union – Justice Policy Institute (EU JPI) Waterworks
Carnegie Regional Initiative in Science and Education (RISE)

Key UCT Researchers
Dr Suthananda Sunassee. Marine biodiscovery and natural products chemistry in Southern Africa.
Prof. Anthony Leiman. Economics and socio-economics of squid, in WIO.
Prof. John J Bolton. Seaweed biodiversity, biology, biogeography, resource use, systematics, and integrated aquaculture of seaweed with marine animals (abalone, sea urchins). Collaborations with natural product chemists on seaweed chemistry research, around the entire coast of South Africa; has also published on the seaweeds of Kenya, Madagascar, Mauritius and Reunion in the WIO.
Prof. Chris Reason. Physical oceanography, meteorology, climate science.
Prof. Isabelle Ansorge. Oceanography, Southern Ocean, Indian sub-Antarctic Sector as well as Agulhas Retroflection Region.
Prof. Mathieu Rouault (SARCHI chair).

Nansen-Tutu Centre for Marine Environmental Research
The Nansen-Tutu Centre for Marine Environmental Research is a joint venture between the University of Cape Town, the Nansen Environmental and Remote Sensing Centre, University of Bergen and IMR, Norway and their partners to gather information about the three oceans around southern Africa and their impact on climate and weather, to better understand and deal with global change and to train Masters' and PhD students. The Nansen-Tutu Centre is hosted at the Department of Oceanography, Marine Research Institute, UCT. The Nansen-Tutu Centre's activities are enabled from contributions from its Norwegian and South African partners and from projects funding. In-kind contributions are received from the other partners. A web site containing most information is hosted at www.nansen-tutu.org. The Centre's research activities are grouped into five overarching themes:

- ocean modelling and prediction;
- ocean-atmosphere interaction;
- climate variability and change;
- high resolution ocean satellite remote sensing and
- regional sea level variability and change.

Indian Ocean activities include modelling and observing the Agulhas Current and its sources in the South West Indian Ocean, Mozambique Channel oceanography, impact of the Agulhas Current and the Indian Ocean on weather and climate and coastal climate change in the South West Indian Ocean. A cooperative project exists with IHSM, Tulear, Madagascar

to study the climate and weather of south Madagascar and the south Madagascar coastal upwelling system. Cooperation in training PhD students from Madagascar is implemented through the RAMI project coordinated by University of La Reunion.

The Percy Fitzpatrick Institute of African Ornithology

The Percy Fitzpatrick Institute of African Ornithology DST-NRF Centre of Excellence and is funded by the Department of Science and Technology (DST) through the National Research Foundation (NRF). It is is located at the University of Cape Town, South Africa, where it is housed within the Department of Biological Sciences.

Conserving Benguela endemic seabirds

This is a large, multi-faceted programme, which focusses on the endemic seabirds of the Benguela upwelling ecosystem. Understanding the drivers behind these population changes is the crucial first step necessary to mitigating population declines. Co-sponsors include: BirdLife International; BirdLife South Africa; Charl van der Merwe Foundation; DST-NRF CoE grant; Raggycharters Whale Watching.

Researchers on this project:

Prof. Peter Ryan (FIAO, UCT)
Prof. Res Altwegg (SEEC, UCT)
Dr Maëlle Connan (NMU)
Dr Timotheé Cook (FIAO, UCT)
Dr Rob Crawford (DEA: O&C)
Dr Jon Green (U. Liverpool)
Dr David Grémillet (FIAO, UCT and CNRS)
Dr Azwianewi Makhado (DEA: O&C)
Dr Lorien Pichegru (NMU)
Dr Pierre Pistorius (NMU)
Dr Richard Sherley (U. Bristol)
Dr Ross Wanless (FIAO, UCT and BLSA

Impacts of disturbance and development on coastal and water birds

Human population densities are greatest in coastal areas and around wetlands. As a result, many coastal and water birds face significant threats from direct human disturbance. Some species appear to be able to tolerate disturbance, whereas others are decreasing in numbers. A key question is how tolerance develops among populations; is it learned, or is it the result of selection for more tolerant individuals? This programme considers the impacts of disturbance and development on coastal and water birds.

Key co-sponsors: BirdLife Plettenberg Bay; Cape Nature; DST-NRF CoE grant; Keurboomstrand Property Owners' Association; Knysna Toyota; Table Mountain Fund; Wader Quest.

Researchers on this project

Prof. Peter Ryan (FIAO, UCT)
Dr Mark Brown (Nature's Valley Trust)
Dr Robert Thomson (FIAO, UCT)

Plastics in the ocean

Plastic litter persists for many years, is readily dispersed by water and wind, and has been accumulating in the sea for decades. It entangles and is eaten by a wide diversity of marine fauna, killing them directly, or reducing their appetite. Concerns about 'microplastics' introducing persistent organic pollutants (POPs) into marine foodwebs, combined with the discovery of 'garbage patches' in all the main ocean gyres, has sparked renewed interest in the subject in the last decade. The most significant impacts of plastics on marine organisms arise from plastic ingestion, so it is important to understand why organisms ingest plastic. Tracking trends in plastic ingestion provides perhaps the best indication of the efficacy of mitigation measures introduced to reduce the amount of plastic in the oceans. However, it is not always feasible to sample plastic ingested by organisms, so we also monitor plastic in the environment, both at sea and washed up on beaches. Much of the recent research in this project has focused on understanding how plastics move through marine systems, and how this affects estimates of plastic abundance.

Key co-sponsors: Plastics SA, ACE Foundation.

Researchers on this project

Prof. Peter Ryan (FIAO, UCT)
Assoc. Prof. Coleen Moloney (MaRe, UCT)
Prof. Hideshige Takada (Tokyo)
Dr Stefano Aliani (CNR-ISMAR)

University of Fort Hare (UFH)

University of Fort Hare
Together in Excellence

Location: Alice, Eastern Cape

Overview of Marine Research

Although landlocked, the University of Fort Hare has a number of active marine research interests in the WIO. The main contributors are from the Departments of Zoology and Entomology, Biochemistry and Microbiology, Geographic Information Systems (GIS) and Remote Sensing, Geology, and Geography and Environmental Science. Most of the marine research at UFH is funded through the ACEP *Phuhlisa* Programme (through SAIAB). The success of the programme has been achieved through providing project funding and student bursaries as well as access to the various marine research platforms managed by the NRF/SAIAB.

Prof. Werner Nel investigates rainfall characteristics, erosivity and soil erosion on Round Island, Mauritius. This research is a collaboration between researchers from the Mauritian Wildlife Foundation, UNISA, and UP. The purpose of this research is to understand the drivers of soil erosion on Round Island with the aim of developing strategies for erosion control. This research project is ongoing with plans to extend it to other offshore islands, like Gunners Quoin. Investigations into the potential impacts of burrowing bird species as geomorphic agents will also be conducted, especially with regard to sediment displacement and nutrient cycling within the ecosystem. An investigation into the spatial extent of burrowing by bird species, the volume of displaced soil by burrowing, and nutrient cycling around the burrows could provide insights into the impacts of burrowing bird species as geomorphic agents and ecosystem engineers on the offshore islands of Mauritius.

Prof. Graeme Bradley is studying the red algae biodiversity along the South African coast, with a current focus on Algoa Bay and the surrounding coastal region. His research involves developing barcoding primers to identify the different classes and species of red algae; the sequencing of selected Red Algae genomes; annotating and mining the genomes to identify novel enzymes for the medical and food industries; recombinant expression and kinetic characterisation of the novel proteins identified, and the evaluation of climate change on the biodiversity of the red algae found along the South African coastline. He is also carrying out a metagenomics study to identify the microbial populations found in various marine sediments and selected shell fish with the aim of identifying novel microbial species which may be of industrial or medicinal interest.

Mariculture research conducted by Dr Niall Vine currently includes investigations into the use of the calanoid copepod, *Psuedodiaptomus hessei,* as a candidate livefood organism for early-stage larval rearing of marine species. The copepod possesses a suitable fatty acid profile which can be manipulated by changing the dietary microalgae. Recent studies indicate that it feeds both in the water column and on the benthos, which has implications for large-scale culture of the species. Ongoing and future studies are investigating the culture requirements of the species with the aim of optimising production.

Working with the marine finfish farming sector and colleagues from DAFF, research into the development of an egg disinfection protocol for farmed dusky kob (*Argyrosomus japonicus*) is underway. The outcome of this project will help reduce the potential transfer of disease between farms that have hatcheries and those which function as grow-out facilities only.

Investigations into the farming potential of the collector urchin, *Tripneustes gratilla,* are currently underway, in collaboration with colleagues from the DAFF and UCT. These urchins are highly prized for their gonad (called *uni*) in the Japanese sushi market and the research focuses on the effect of various diets (various fresh macroalgae and formulated diet combinations) on the gonad quality. The experiments are being conducted on the Wild Coast Abalone (WCA) farm, just outside East London. Other research currently being undertaken in collaboration with WCA, Rhodes, and NMU includes assessing the baseline habitat for potential abalone reseeding in the Hamburg, Eastern Cape area.

A collaborative project with SAIAB, Rhodes, and DAFF is investigating the genetic stock structure of the blue bream (*Pachymetopon auneum*), an important linefish species in South Africa. Tagging studies have suggested that the species is highly resident. Considering its life history, this residency may make the species sensitive to over-exploitation, being a significant species in the line-fishery sector. A comprehensive assessment of genetic stock structure is therefore needed, such that appropriate management measures can be put in place.

Prof. Anthony Okoh is the leader of the Water Research Niche Area of UFH and has been actively involved in the quality indices of key marine environments in the Eastern Cape Province, including Algoa Bay and several recreational beaches, and in exploring their microbial diversities for new bio-active compounds relevant to health and biotechnology, including antimicrobials, neuro-degenerative disease suppressants, and bio-flocculants, among others. His current studies emphasise pollutant fingerprinting (chemical and biological) of these marine environments. Key targets include emerging chemical and microbial pollutants and their fates in the environment, as well as reservoirs of anti-microbial resistance determinants. Prof. Okoh leads a research group titled Applied and Environmental Microbiology Research

Group (AEMREG) consisting of nine members of staff (four of whom are professors) and the group has published an average of over 25 articles per year in the last five years.

Prof. Hamisai Hamandawana is currently supervising an ACEP *Phuhlisa* PhD student who is working on the validation of in situ chlorophyll a and hourly temperature data in the Southern Sentinel from Cape St Francis to Port Alfred using multi-temporal remotely sensed imagery. He also supervises an ACEP *Phuhlisa* Masters student who has been working on a project designed to map the provenance, spread and geographic extent of the 2014 *Lingulodinium polyedrum* harmful algal bloom in Algoa Bay.

Ms Kudzanai Rosebu Marembo is involved in the application of geospatial technologies to monitor and model marine environments. GIS and Remote Sensing (RS) offer a unique ability to remotely monitor environmental ecosystems spatially with high prediction accuracy of future challenges and their solutions. The project is focused on Gamtoos, Swartkops, and Nahoon Estuaries in the Eastern Cape, South Africa. At present these sensitive environments experience severe degradation, erosion and pollution as a result of human activities and the project aims to assess and possibly quantify the overall damage the estuaries are exposed to and suggest sustainable uses of their resources in the long run.

Key researchers

Dept of Biochemistry and Microbiology
Prof. Graeme Bradley
Prof. Anna Clarke
Prof. Anthony I Okoh
Prof. LV Mabinya
Prof. UU Nwodo
Prof. N Mkwetshana
Miss O Gcilitshana
Miss N Ntsangani

Dept of Geology
Prof. Ken Lui

Dept of GIS and Remote Sensing
Prof. Hamisai Hamandawana

Dept of Geography
Prof. Werner Nel

Dept of Zoology and Entomology
Dr Niall Vine
Mr Lukhay Vumazonke

Dept of GIS and Remote Sensing
Ms Kudzanai Marembo

Dept of Chemistry
Prof. Omobola O Okoh,

SAMRC Microbial Water Quality Monitoring Centre
Miss Nolonwabo Nontongana

Pic: Niall Vine

University of Johannesburg (UJ)

Location: Johannesburg, Gauteng

Overview of Marine Research

UJ is an inland university where aquatic research focuses primarily on freshwater systems and pollution. Not surprisingly, research on the Western Indian Ocean (WIO) is thus very limited. At present, a single research group is involved in such research, namely the Aquatic Division of the Centre for Ecological Genomics and Wildlife Conservation headed by Prof. Peter Teske in the Department of Zoology. Most of the work of Prof. Teske's group is conducted through collaboration with researchers based at coastal institutions, and many studies compare WIO fauna with that of the South African Atlantic coast. The group uses genetic and genomic tools to address questions relating to biogeography, speciation and coastal connectivity. Below is a list of ongoing projects.

Highway or bypass: the role of the Agulhas Current in facilitating coastal connectivity

This project investigates whether the Agulhas Current is primarily responsible for explaining recruitment patterns along the coast, or whether weaker inshore currents are more important. The latter have been poorly studied, but it is possible that they are more important because most of the propagules that reach the Agulhas Current do not return to the coast to settle. The project has so far focused on fish and invertebrate species with various types of dispersal (active dispersers, planktonic dispersers and direct developers). Ongoing sub-projects include a study on *Pyura* spp. (red bait) in the WIO, and one on estuarine crabs (*Hymenosoma* spp.).

Collaborators: Dr Marc Rius, Ocean and Earth Science, University of Southampton, National Oceanography Centre, Southampton, United Kingdom; Prof. Christopher McQuaid, Department of Zoology and Entomology, Rhodes University.

A genomic appraisal of the stock structure of South African sardines

The South African population of the southern hemisphere sardine *Sardinops sagax* is presently managed as a single stock. Although non-genetic methods have indicated that there may be at least two stocks, and the present management approach risks over-exploiting one of these, genetic data have so far failed to confirm this. The aim of the present project is to use next-generation sequencing approaches (including ddRAD-seq and RNA-seq) to identify subtle differences between sardines collected from the west, south and east coasts. The data so far indicate that there is a clear pattern of isolation-by-distance from west to east, suggesting that even though there are no clear stock boundaries, the South African sardines do not comprise a panmictic population.

Collaborators: Dr Carl van der Lingen, Department of Agriculture, Forestry and Fisheries, Cape Town; Prof. Luciano Beheregaray, Molecular Ecology Lab, Flinders University, Australia.

Identification of incipient ecological speciation using genomics

Many South African marine species that occur in more than one marine biogeographic province are subdivided into regional genetic lineages that, on closer inspection, may be morphologically and physiologically distinct from each other. This suggests that they are young, cryptic species that do not readily establish themselves in the habitat of their sister taxa because of competitive exclusion. However, there are also many examples of species that are not genetically subdivided across biogeographic boundaries that define deep phylogenetic lineages in co-distributed species. This project uses genomic approaches to determine whether genetic subdivisions exist, but have evolved too recently to be detectable with traditional genetic methods (e.g. DNA barcoding). The first data confirm that this is indeed the case, and indicate that loci that are under thermal selection are the first to display links with biogeography.

Collaborators: Prof. Luciano Beheregaray, Molecular Ecology Lab, Flinders University, Australia; Prof. Sophie von der Heyden, Department of Botany and Zoology, Stellenbosch University; Prof. Christopher McQuaid, Department of Zoology and Entomology, Rhodes University.

African Sponge Ecology Programme (ASEP)

The aim of this project is to use a multi-disciplinary approach to comprehensively document the sponge fauna in benthic habitats along the South African Exclusive Economic Zone (EEZ) and associated Large Marine Ecosystems (LMEs). One of the components of this project is DNA barcoding, which is conducted at UJ. Several previously overlooked species have been discovered, of which, two have been described so far.

Collaborators: Dr Toufiek Samaai, Department of Environmental Affairs, Cape Town; Prof. Marc Gibbons, Department of Biodiversity and Conservation Biology, University of the Western Cape, Cape Town; Prof. Denzil Beukes, School of Pharmacy, University of the Western Cape, Cape Town.

Conservation of threatened coastal fish species

The aim of this project is to use field surveys, tagging, and genetic analyses to improve the management of threatened syngnathids along the South African south coast. The work has focused so far on the endangered Knysna seahorse, *Hippocampus capensis*, and the critically endangered pipefish, *Syngnathus watermeyeri*. Genetic analyses of the seahorse (using microsatellites) have revealed that the three populations of this species have diverged so recently that there is no reason to discourage the translocation of individuals between estuaries to maximise the genetic diversity of each.

Collaborators: Dr Paul Cowley, Dr Nikki James and Prof. Alan Whitfield, South African Institute of Aquatic Biodiversity (SAIAB), Grahamstown; Dr Louw Claassens and Prof. Alan Hodgson, Knysna Basin Project, Knysna.

A genetic investigation of female philopatry in the raggedtooth shark, Carcharias taurus
Female raggedtooth sharks undertake well-documented reproductive migration, which includes mating in central and southern KwaZulu-Natal (KZN), gestation in northern KZN or Mozambique, and pupping in the Eastern Cape. Five nursery areas have been identified, and it is possible that the return of females to the same areas has resulted in genetically distinguishable sub-populations. The present projects uses microsatellite data to investigate how reproductive philopatry has shaped genetic structure of raggedtooth sharks in the WIO.
Collaborators: Dr Kolobe Mmonwa and Dr Matt Dicken, KwaZulu-Natal Sharks Board, Umhlanga; Dr Aletta Bester-van der Merwe, Department of Genetics, Stellenbosch University.

An investigation of edge-centre population dynamics in marine mussels
This study investigates the idea that genetic diversity is lower at a species' range edge than in the centre of the range. The study species are the native mussel *Perna perna* (of which two evolutionary lineages exist whose ranges overlap on the south east coast), and the invasive mussel, *Mytilus galloprovincialis*.
Collaborators: Dr Katy Nicastro, Centro de Ciências do Mar, Faro, Portugal; Dr Gerardo Zardi and Prof. Christopher McQuaid, Department of Zoology and Entomology, Rhodes University, Grahamstown.

Pathways of larval dispersal: the roles of alongshore and cross-shore transport
This project is part of the intensive research on the 'Sentinel Site' that is presently being conducted in the Algoa Bay area (Port Elizabeth). It uses high-resolution microsatellite data to investigate connectivity of mussel larvae throughout the site, with the aim of determining the relative roles of the currents that play a role at this relatively small geographic scale.
Collaborators: Dr Francesca Porri, SAIAB, Grahamstown; Prof. Christopher McQuaid, Department of Zoology and Entomology, Rhodes University.

Key Researchers
Prof. Peter Teske, Phylogeography, Seascape genetics, DNA barcoding in the South African portion of the WIO.


Pic: ACEP Imida

University of KwaZulu-Natal (UKZN)

Location: Durban/Pietermaritzburg, KwaZulu-Natal

Overview of Marine Research

Aquaculture Stress Physiology

Stress biomarkers in South African marine aquaculture (DAFF funded). Feed optimisation for stress mitigation in South African marine aquaculture (TIA funded). Non-destructive markers associated with parasitic infection of farmed and wild fish (DAFF funded).

Estuarine Ecology

Research areas have included estuarine ecology and zooplankton ecophysiology, specifically species diversity, trophic interactions and the response of zooplankton communities to variable biotic and abiotic conditions/stressors in temporarily open closed estuaries (TOCEs). While some of this work was conducted in smaller TOCEs in KwaZulu-Natal, South Africa, the majority has focussed on Lake St Lucia, the largest estuarine lake in Africa, and a region of significant conservation importance. Estuarine and nearshore ecology, ecosystem modelling, ecosystem connectivity. Theoretical Ecology. Funders: various NRF programmes (SeaChange, ACEP, SASAC).

Coastal and Marine Geology

High resolution seismic and multibeam bathymetric mapping of the inner shelf to upper slope East London to northern KwaZulu-Natal (ACEP-NRF-UKZN funded, co-funding with BGR); petroleum systems and seismic basin analysis Algoa Basin to Zululand Basin (funded by SACCCS); palaeo-climate studies Mossel Bay to southern Mozambique (funded by the BGR-SPACES); evolution of large coastal waterbodies and embayments (Durban to Maputo Bay) (WRC-NRF and Grindrod), short-term morphometric changes to shallow marine systems (NRF-EU); sea-level changes along the southern and eastern coasts of southern Africa (UKZN-Liverpool University).

NEARCONTROL Project

This is funded via the EU H2020 Marie Skłodowska-Curie Actions, and involves the Universities of Ulster, KwaZulu-Natal, Algarve and Bordeaux. NEARCONTROL is a research project that aims to provide an improved, quantitative understanding of the fundamental role of nearshore geological control on coastal morphodynamics and to evaluate its implications for coastal hazards and storm impacts. The project also explores the societal implications and coastal management solutions of these hazards and impacts, with Isipingo embayment as a case study. This projects combines multi-disciplinary expertise from all partner institutions, making use of state-of-the-art geophysical techniques and exploratory numerical modelling. www.nearcontrol.eu.

Coral Reefs

Coral population dynamics and recruitment. Funding Agencies: NRF, Oppenheimer Memorial Trust

Microplastics

A major focus of the laboratory is to determine the impacts of microplastics on marine biota. The work in the lab is funded by the NRF and a bi-lateral Kenyan-South African grant, in conjunction with Dr Robertson-Andersson.

Other Research

Aquaculture
Aquaponics
Conservation education
Microplastics
Shark and dolphin numbers
Citizen science
Phycology
Marine ecotoxicology and ecophysiology

Key Researchers

Dr Andre Vosloo, Aquaculture Stress Physiology, South Africa (KwaZulu-Natal, Eastern Cape, Western Cape, Limpopo).
Dr Nicola Carrasco, Estuarine Ecology, KwaZulu-Natal.
Prof. Andrew Green, Coastal and Marine Geology, Eastern Cape to KwaZulu-Natal shelf, southern Mozambique shelf.
Dr Carlos Loureiro, Honorary Research Fellow, Geological Sciences, beach and nearshore areas in Durban and Isipingo.
Dr David Glassom, Coral reefs, benthic ecology, plastic pollution in KwaZulu-Natal.
Dr Deborah Robertson-Andersson, Marine biology, Aquaculture. KZN East Coast and South Africa, respectively.
Gan K Moodley, Life Sciences (Marine Biology).
Prof. Ursula Scharler, Estuarine Ecology.

Other Researchers

Fernando Albericio
Angus MacDonald
Michael Gebreslasie
Ahmed Thandar
Ramlall Biseswar
Gonasageran Naidoo
Dianne Scott
Tshoanelo Miya
Nonkululeko Dladla
Fatima Ahmed

University of Pretoria (UP)

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Location: Pretoria, Gauteng

Overview of Marine Research

Marine research in the Western Indian Ocean (WIO) conducted at UP currently involves two main research entities in the Faculty of Natural and Agricultural Sciences: the Mammal Research Institute (MRI), Department of Zoology & Entomology; and the Molecular Ecology and Evolution Programme (MEEP), Department of Genetics.

Research in the MRI Whale Unit (established in 1985) focuses on the ecology, population dynamics and behaviour of a diverse range of cetaceans from the southern African sub-region, with the aim of advancing knowledge about these species and their conservation. The three research themes are:

- recovering whales – the role of large whales in southern hemisphere ocean systems;
- building a conservation inventory of South Africa's whale and dolphin fauna and African Links;
- building African marine mammal research capacity.

Additional information on work initiated through the Whale Unit can be found in the submission by Prof. Ken Findlay.

One of the flagship projects of the Whale Unit is the long-term monitoring of the South African population of Southern Right Whales. Annual Southern Right Whale photo-identification aerial surveys have been conducted in October since 1979, making it now a 38-year-long database, one of the longest-standing databases of any marine mammal in the world. The survey is flown from Nature's Valley to Muizenberg, and focuses on photo-identifying all females with calves, and all individuals with distinctive brindle colouration or markings. These images are subsequently analysed to investigate individual movement and distribution patterns, as well as the reproductive/calving histories of females, together with calf survival rates, in order to assess vital population parameters and model population dynamics.

In collaboration with the Department of Environmental Affairs (DEA), the unit has been involved in studying migrating humpback whales along the east coast of South Africa. Main activities have been deploying satellite tags and collecting biological data from migrating humpback whales along the Durban coast, which will result in collecting long-term data for monitoring this annual pattern.

Another project, conducted by current PhD student Jean Purdon, models the spatial and temporal distribution of cetaceans and assesses the acoustic propagation of sound produced by seismic surveys and commercial shipping. The aim of this project is to contribute a scientific basis to the spatial and temporal management of the maritime industry in the South African marine environment. Specifically, it looks at two main outputs:

1. assessing the spatial and temporal distribution of cetaceans to produce viable models using data science and biostatistics in order to help marine spatial planning of conservation areas within the South African Exclusive Economic Zone (EEZ), and determining seasonal distribution of cetaceans in relation to marine protected areas (MPAs) and ecological or biological significant areas (EBSAs) in the South African EEZ; and
2. acoustic propagation of seismic surveys and commercial shipping to produce models of acoustic propagation using data science and biostatistics to help in planning industry-related activities such as seismic surveys and commercial shipping routes.

A number of other, more localised MRI studies have focused on the coastal cetacean species around South Africa. The environmental and biological factors underlying the distribution and timing of cetaceans on the Cape south coast has been studied in Mossel Bay (five years, in collaboration with Oceans Research), and Kleinbaai (three years, plus opportunistic data over 12 years, in collaboration with Dyer Island Conservation Trust).

The conservation status of Indo-Pacific bottlenose dolphins has been the focus of study in Durban, where they are caught in bather protection (shark) nets, and the Indian Ocean humpback dolphins in Mossel Bay. Research on the humpback dolphin, South Africa's most endangered cetacean, produced the first abundance estimate of the species in Mossel Bay (the most westerly in the species range), and a first assessment of long-shore movements on the south coast of the Cape. This project has developed into a nation-wide collaborative study of the species, largely motivated by MRI researchers. The 'SouSA Consortium' provides a comparison of all photographic databases of humpback dolphins in South Africa and production of a publication on movements and population structure of the species in South Africa. This work has highlighted the animals of the Cape south coast as an apparently isolated population at the western extreme of the species' range.

Numerous collaborative studies on the great white shark in Mossel Bay (Oceans Research) and Gansbaai (Marine Dynamics and Dyer Island Conservation Trust) centred on its behavioural and foraging ecology (1999–2012), including interaction with Cape fur seals (at Seal Island and Dyer Island). More recently the focus has been on the possible deterrent effects of killer whale decoy patterns on hunting great white sharks, and the influence of environmental factors on the occurrence of great white sharks in Mossel Bay (2012–2017).

The Molecular Ecology and Evolution Programme (MEEP) marine team members, from the Departments of Genetics, and Zoology and Entomology, are evolutionary biologists who, together with collaborators, employ both molecular phylogenetics and molecular ecology to investigate the origin and evolution of marine biodiversity, with a special emphasis in the Western Indian Ocean (WIO). The team has focused on endemic and/or exploited marine organisms that mainly include fish, but also tropical echinoderms and hydroids. In addition to describing evolutionary processes driving speciation and influencing populations, the team is interested in identifying the biological and environmental factors influencing marine biodiversity, such as dispersal ability, oceanographic features, and past and current climatic events, to name a few.

The different projects have been developed in collaboration with researchers from South African organisations: the African Coelacanth Ecosystem Programme (ACEP), Department of Agriculture, Forestry and Fisheries (DAFF: Fisheries Management), Ezemvelo KwaZulu-Natal (KZN) Wildlife, Oceanographic Research Institute (ORI), South African Institute for Aquatic Biodiversity (SAIAB), University of Cape Town, University of Stellenbosch), or other organisations from the WIO region: South West Indian Ocean Fisheries Project (SWIOFP), Institut de Recherche pour le Développement and Université de La Réunion, Instituto Nacional de lnvestiqacao Pesqueira de Moçambique, JEAI ACOM and the NGO Reef Doctor, from Madagascar, Kenya Marine and Fisheries Research Institute. These projects have involved a number of postgraduates who worked on multiple fish families with the core focus on the Sparidae, Sciaenidae, Dasytidae, Serranidae, Siganidae and Zanclidae.

Based on analyses of variation at multiple genetic markers, the research has shown that, in many species, the strong Agulhas Current facilitates connectivity and gene flow between populations across the southern parts of the region. However, unique biological features and habitat preferences in some species lead to restriction on adult movements and thus various levels of isolation between separate populations or stocks. As an example, SWIOFP-funded research by MSc graduate Ilkser Kiper on the demersal snapper kob, *Otolithes ruber,* found historical isolation and contemporary restriction on gene flow between the northern and southern parts of the South West Indian Ocean (SWIO), with populations off Madagascar representing a potential third stock. In addition to an understanding of population structure, the amount of genetic variation can also be investigated in a demographic context, which in some species, indicates the impact of fisheries pressure, for example, silver kob *Argyrosomus inodorus* and seventyfour *Polysteganus undulosus*). Understanding these patterns of variation and the underlying processes, inform sustainable utilisation and management of these resources.

Interpretation of genetic variation is enriched through simultaneous investigation of oceanography and adult or larval movement patterns. Recent work on riverbream, *Acanthopagrus berda,* (by former PhD student, Carel Oosthuizen, at UP) and white steenbras, *Lithognathus lithognathus* (by former PhD student, Rhett Bennett, at Rhodes) combined genetic variation and telemetry and showed high levels of connectivity along the South African coast. Genetic analyses done by former PhD student, Kerry Reid, and hydrodynamic connectivity modelling by collaborator Estelle Crochelet (ENTROPIE, Réunion) suggested long-distance colonisation of Réunion Island by dusky grouper, *Epinephelus marginatus,* from a South African-related stock, probably off a yet-to-be identified Madagascan location, and facilitated by cyclone Bingiza. Using reef brittle-stars as a model, the group and collaborators showed that the WIO is an evolutionary hotspot, an area characterised by high species richness and diversity within species, i.e. a globally important region for maintaining evolutionary potential.

Key Researchers

Prof. Marthán Bester. Marine mammal ecology, pinnipeds, great white sharks; Southern and Western Indian Ocean, Southern Ocean

Prof. Paulette Bloomer. Vertebrate phylogenetics and phylogeography, conservation genetics; South Africa, (through collaborators: Mozambique, Kenya, Tanzania, Madagascar)

Dr Simon Elwen. Marine mammal ecology; southern Africa

Dr Thierry Hoareau. Evolutionary biology, marine biodiversity, coalescent modelling; South Africa and extensive collaboration network in WIO and Indo-Pacific

Mr Arrie Klopper. Linefish phylogeography and conservation genetics; southern Africa (and broader WIO)

Dr Carel Oosthuizen. Linefish phylogeography and conservation genetics; southern Africa

Dr Els Vermeulen. Animal behaviour, ecology, population biology, conservation biology; southern Africa

Mr Christopher Wilkinson. Marine conservation and management, conservation biology; southern Africa

University of the Western Cape (UWC)

Location: Bellville, Western Cape

Overview of Marine Research

Research section 1

Studies on the distribution, abundance and diversity of zooplankton communities in the Western Indian Ocean in collaboration with Dr J Huggett (DEA: O&C), Dr D Thibault (IRD, France) and Dr C Bourmaud (Univ. of Reunion, France).

Studies on the diversity and composition of macrobenthic communities (especially sponge communities) of the Western Indian Ocean; in collaboration with Dr T Samaai (DEA).

Studies on the distribution, abundance and diversity of neuston communities in the Western Indian Ocean; in collaboration with the Institute of Marine Research (IMR), Norway.

Collaborator on a large-scale study of the marine macrophytes of scattered islands in the Western Indian Ocean (Zanzibar to Madagascar, and surrounding islands); in collaboration with Dr PW Gabrielson (Unive.of North Carolina, USA), Dr C Payri and Dr A Caragnano (IRD, New Caledonia), Dr L Mattio (Univ. of Western Australia) and Dr J Kangwe (Tanzania Fisheries Research Institute).

Research section 2

Studies on the tropicalisation of the Eastern Cape estuaries through the spread of mangrove forests into salt marsh habitats in Eastern Cape estuaries (collaboration with NMU). Studies on the role of mangroves, salt marsh and seagrass as nursery grounds for fish species and the quantification of habitat complexity in these ecosystems (collaboration with SAIAB).

Research Section 3

Research into the changing patterns in mesoscale activity of the Agulhas Current and its associated heat budget as driver of coastal/nearshore 'marine heat waves' around the South African coast, and the ecological implications of these extreme thermal events. This research is in collaboration with Prof. E Oliver (Dalhousie Univ., Canada) and Prof. T Wernberg (Univ. of Western Australia).

Key Researchers

Prof. Gavin W Maneveldt. (Research section 1) Taxonomy and Systematics of coralline algae
Prof. Mark J Gibbons. Marine Community Ecology: plankton, neuston, benthos
Dr Anusha Rajkaran. (Research Section 2) Estuarine Ecology: mangrove, salt marsh and seagrass ecology.
Associate Prof. Albertus J Smit. (Research Section 3) The Link between the Physical Dynamics of the Nearshore and Coastal Ecological Processes

Pic: Jackie Raw

University of Zululand (UNIZUL)

Location: Richards Bay, KwaZulu-Natal

Overview of Marine Research

There are three research projects in the Richards Bay Harbour. The first is a PhD project on the fish stocks in the harbour. The second is a PhD project on the accumulation of metals in media and *P. blephariskio*s in the harbour and the Mhlathuze estuary. The third is a Masters project on the responses of an amphipod *M. zeylanica* to sediment from the Bhizolo Canal.

In the coastal rocky shores, a Masters student is working on mussels and oysters from the Sheffield Beach and the Richards Bay Harbour. There is also a joint supervision with Dr Dlaza from WSU of a Masters student from WSU who is looking at differences in metal accumulation between barnacles with algae and those without algae from Sheffield Beach and the Richards Bay Harbour.

On the sandy shore, a Masters student is working on the population dynamics and the stock assessment of a sand prawn, *C. kraussi.*

Key Researchers

Prof. Hendrick Jerling
Prof. Leon Vivier
Mr Mduduzi Mzimela
Dr Thembinkosi Dlaza
Mrs Ann De Fortier

Walter Sisulu University (WSU)

Location: Mthatha, Eastern Cape Province

Overview of Marine Research

Research theme 1: Patterns and processes

This section of research deals with the diversity and taxonomy of limpets, sea cucumber and seaweed species along the Wild Coast. Systematic studies of endemic limpet, sea cucumber, and seaweed species are studied, together with the population dynamics, interactions, and ecology of the three groups. Geospatial distribution patterns of intertidal rocky shore species are modelled in relation to habitat heterogeneity and climate change. The trophic ecology of the intertidal rocky shores is also studied. Nutritional studies are conducted on edible seaweeds and limpets along the Wild Coast and on estuarine fish and shrimp diversity.

Research theme 2: Marine pollution monitoring

Physico-chemical analysis of marine and estuarine water, together with sediments, are conducted from selected sites. Tissue samples are collected from estuarine fish and benthic invertebrate for ecotoxicology studies. Tissue is also collected from sessile filter-feeding molluscs on rocky shores and snails are collected from the sandy shores.

Research theme 3: Socio-economic research

Research is conducted on species targeted by fishers from different localities along the Wild Coast. Indigenous knowledge of the various tools used by coastal communities to fish intertidal rocky shore species is documented. This knowledge is collected on how rural communities process, store, and use the harvested intertidal resources. Research is also conducted on the potential species to promote the blue economy drive in coastal areas within O.R. Tambo District Municipality. The vulnerability of rural coastal communities to climate change is continuously assessed and the potential for aquaculture is researched for food security.

Theme 4: Protected area research

The impact of overexploitation of edible intertidal species is studied in unprotected sites and compared to the protected areas. The pros and cons of strictly no-take marine protected areas are compared to those of protected areas that allow restricted harvesting. The impact of partial opening of a previously strictly no-take Marine Protected Area (MPA) on the density and size structure of harvested organisms is monitored. Mussel rehabilitation projects are conducted on a small scale in over-exploited sites for stock enhancement.

Key Researchers

Dr Motebang Vincent Dominic Nakin (Marine zoologist)
Dr Thembinkosi Steven Dlaza (Marine botanist)
Mr Dumisani Horaius Kali (Museum curator and taxonomist)
Mr Sifiso Mjobo (Molecular taxonomist)
Mr Emile Plumstead (Estuarine ecologist)

University of the Witwatersrand (Wits)

Location: Johannesburg, Gauteng

Overview of Marine Research

Current and past research related to the Western Indian Ocean being conducted at Wits is largely focused on estuaries, which includes those within the sub-tropical and warm temperate east coast of South Africa.

Dr Marc Humphries, an environmental geochemist, has a particular interest in the geochemistry and geomorphological evolution of wetlands, lakes and estuaries. His research has focused on understanding processes related to chemical cycling, nutrient accumulation, and sedimentation in freshwater lakes and wetland systems. More recently, he has developed an interest in using sedimentary deposits to investigate sea-level fluctuations and environmental variability associated with global climate change, and the application of stable and radioactive isotopes in understanding aspects of hydrology and sedimentology. Collaborating with Dr Andrew Green and Dr Jemma Finch (University of KwaZulu-Natal, Pietermaritzburg), he has investigated processes driving ecosystem change across a range of temporal scales, from long-term geomorphological evolution influenced by climate and sea-level fluctuations, to short-term environmental responses caused by human-induced stresses. Submarine groundwater discharge (SGD) has become increasingly recognised as a major pathway for the flow of nutrients, organic carbon, metals, and even contaminants from land into the coastal ocean. In collaboration with Dr Claudia Benitez-Nelson and Dr Willard Moore (University of South Carolina), radium isotope methods were used to investigate groundwater flow and nutrient fluxes between systems on the east coast of South Africa and the ocean. Understanding the mechanisms of nutrient delivery and the composition of those nutrients is essential for elucidating how these estuarine and coastal ecosystems develop in response to regional and large-scale climate change. Such information is critical for understanding not only regional SGD and its influence on the local environment, but in understanding how SGD impacts global ocean bio-geochemistry.

Also collaborating with the University of KwaZulu-Natal, Dr Kate Strachan (palaeo-environmental post-doctoral researcher) has developed and refined methods used to extract precise records of past relative sea levels from intertidal sediments. Study sites include: Kariega, Keiskamma and Knysna estuaries. Statistical models (transfer functions) have been used to analyse foraminifera from saltmarsh sediments in order to quantify their vertical relationships with former sea levels. These data are then combined with detailed radiocarbon dating to construct high-resolution records of relative sea-level change from sediment cores covering the last few thousand years. Current research involves investigating processes driving ecosystem change across a range of temporal scales: from long-term geomorphological evolution influenced by climate and sea-level fluctuations, to short-term environmental responses caused by human-induced stresses using foraminifera as a proxy at Lake St Lucia.

Much research has been conducted on estuaries to determine estuarine freshwater requirements; the amount of river water required for estuaries to maintain their ecological function. Dr Gavin Snow, an aquatic ecologist specialising in bio-geochemistry and microalgae, has been involved in 25 estuary freshwater studies from the Thukela River mouth in KwaZulu-Natal to the permanently open Duiwenhoks Estuary in the Western Cape Province. Other studies have included impact assessments of the construction of a large shipping jetty in the Port of Nacala (Mozambique), development of desalination plants on local estuarine and coastal environments (Knysna and Sedgefield), and a proposed bridge across the upper Knysna Estuary. In addition, research has included a mass balance study of the temporarily open/closed Great Brak Estuary (Western Cape Province), an assessment of the ecological health of the heavily urbanised Swartkops Estuary (Eastern Cape Province), as well as the usefulness of benthic algae (diatoms, in particular) as an index of estuarine health related to sediment type and organic content. Future research is likely to include biomass and community structure analyses of marine phytoplankton in the south-western Indian Ocean, collected from the *SA Agulhas II* research ship during the SeaMester floating university voyages.

Key Researchers

Dr Marc Humphries, Environmental Geochemistry (South African coast)
Dr Gavin Snow, Aquatic Ecology (southern African coast)

CONTACT DETAILS

SCIENTIST	EMAIL	AFFILIATION
Dr Babatunde Abiodun	Babatunde.Abiodun@uct.ac.za	UCT/WRC
Prof. Janine Adams	Janine.Adams@nmmu.ac.za	NMU/WRC
Fatima Ahmed	fahmed@ukzn.ac.za	UKZN
Dr Katye Altieri	katye.altieri@uct.ac.za	UCT
Dr Lee Annamalai	lannamalai@csir.co.za	CSIR
Prof. Isabelle Ansorge	isabella.ansorge@uct.ac.za	UCT
Prof. Shankar Aswani	s.aswani@ru.ac.za	RU
Dr Lara Atkinson	Lara@saeon.ac.za	SAEON
Dr Björn Backeberg	bbackeberg@csir.co.za	CSIR
Ms Tatjana Baleta	Tatjana@africanwastenetwork.org.za	SST
Bukeka Bandezi	bbandezi@environment.gov.za	DEA O&C
Prof. Lisa Beal	lbeal@rsmas.miami.edu	ASCA/RSMAS
Dr Anriëtte Bekker	annieb@sun.ac.za	SU
Dr Stewart Bernard	sbernard@csir.co.za	CSIR
Dr Anthony Bernard	a.bernard@saiab.ac.za	SAIAB
Prof. Marthán Bester	marthan.bester@up.ac.za	UP
Dr Aletta Bester-van der Merwe	aeb@sun.ac.za	SU
Prof. Paulette Bloomer	paulette.bloomer@up.ac.za	UP
Prof. Narnia Bohler-Muller	nbohlermuller@hsrc.ac.za	HSRC/SA IORAG
Prof. John Bolton	john.bolton@uct.ac.za	UCT
Dr Tommy Bornman	Tommy@saeon.ac.za	SAEON
Dr Alan Boyd	aboyd@environment.gov.za	DEA O&C
Prof. Graeme Bradley	gbradley@ufh.ac.za	UFH
Dr Nicola Carrasco	carrasco@ukzn.ac.za	UKZN
Dr Hayley Cawthra	hcawthra@geoscience.org.za	CGS
Dr Amber Childs	a.childs@ru.ac.za	RU
Dr Kevin Christison	KevinCH@daff.gov.za	Two Oceans Aquarium
Prof. Anna Clarke	aclarke@ufh.ac.za	UFH
Geremy Cliff	cliff@shark.co.za	KZNSB
Dr Andy Cockroft	AndrewC@daff.gov.za	DAFF/SA IORAG
Dr Georgina Cole	Georgina.cole@outlook.com	Two Oceans Aquarium
Dr Charine Collins	charinecollins@gmail.com	SAEON
Dr Maelle Connan	maelle.connan@gmail.com	NMU
Prof. Don Cowan	don.cowan@up.ac.za	UP
Prof. Paul Cowley	p.cowley@saiab.ac.za	SAIAB
Molly Czachur Czachur	mollyczachur@sun.ac.za	Two Oceans Aquarium
Prof. Nico de Bruyn	jndebruyn@zoology.up.ac.za	UP
Mrs Ann De Fortier	DefortierA@unizulu.ac.za	UNIZUL
Dr Femke de Jong	femke.de.jong@nioz.nl	ASCA/NIOZ

SCIENTIST	EMAIL	AFFILIATION
Dr Stephanie de Villiers	Sdevilliers@environment.gov.za	DEA O&C
Mr Marc de Vos	marc.devos@weathersa.co.za	SAWS
Mr N. Devanunthan	nDevanunthan@environment.gov.za	DEA O&C
Dr Shaun Deyzel	Shaun@saeon.ac.za	SAEON
Dr Matt Dicken	matt@shark.co.za	KZNSB
Dr Thembinkosi Dlaza	tdlaza@wsu.ac.za	WSU
Prof. Rosemary Dorrington	r.dorrington@ru.ac.za	RU/SARCHI
Ms Natalia Drobniewska	natalia@sharkconservancy.org	SASC
Mr Russell Egypt	russelle@imt.co.za	IMT
Dr Shane Elipot	selipot@rsmas.miami.edu	ASCA/RSMAS
Dr Simon Elwen	simon.elwen@gmail.com	UP
Ms Bernadine Everett	bernadine@ori.org.za	ORI
Dr Sarah Fawcett	sarah.fawcett@uct.ac.za	UCT
Dr Sean Fennessy	seanf@ori.org.za	ORI
Dr Susanne Fietz	sfietz@sun.ac.za	SU
Prof. Ken Findlay	findayk@cput.ac.za	CPUT/SA IORAG
Dr Camilla Floros	cfloros@ori.org.za	ORI
Prof. Henri Fouche	dochenri@sun.ac.za	SU/SA IORAG
Prof. William Froneman	w.froneman@ru.ac.za	RU
Dr Phumelele Gama	Phumelele.Gama@mandela.ac.za	NMU
Miss O Gcilitshana	ngcilitshana@ufh.ac.za	UFH
Dr Enrico Gennari	e.gennari@oceans-research.com	Oceans Research
Prof. Mark J Gibbons	mgibbons@uwc.ac.za	UWC
Dr David Glassom	glassom@ukzn.ac.za	UKZN
Dr Wayne Goschen	Wayne@saeon.ac.za	SAEON
Dr Albrecht Götz	albrecht@saeon.ac.za	SEAON
Dr Gavin Gouws	g.gouws@saiab.ac.za	SAIAB
Dr Geoffry Grantham	ghgrantham@uj.ac.za	UJ
Prof. Andrew Green	greena1@ukzn.ac.za	UKZN
Dr Michelle Greve	michelle.greve@up.ac.za	UP
Prof. Johan Groeneveld	johan@ori.org.za	ORI
Mr Mthuthuzeli Guleka	Mgulekana@environment.gov.za	DEA O&C
Dr Issufo Halo	haloi@cput.ac.za	CPUT
Prof. Hamisai Hamandawana	HHamandawana@ufh.ac.za	UFH
Dr Jean Harris	jeanh@wildlands.co.za	Wildoceans
Dr Juliet Hermes	juliet@saeon.ac.za	SAEON/ASCA/IORAG
Dr Thierry Hoareau	thoareau@gmail.com	UP
Prof. Isabelle Hofmeyer	Isabel.Hofmeyr@wits.ac.za	Wits
Dr Jenny Huggett	Jhuggett@environment.gov.za	DEA O&C
Dr Lucienne Human	lucienne.human@saeon.ac.za	SEAON
Dr Marc Humphries	marc.humphries@wits.ac.za	Wits

SCIENTIST	EMAIL	AFFILIATION
Dr Jennifer Jackson-Veitch	veitch.jennifer@gmail.com	SAEON
Dr Nikki James	n.james@saiab.ac.za	SAIAB
Prof. Astrid Jarre	Astrid.Jarre@uct.ac.za	UCT
Prof. Hendrick Jerling	JerlingH@unizulu.ac.za	UNIZUL
Dr Meesbah Jiwaji	mezjiwaji@gmail.com	RU
Mr Ashley Johnson	Ajohnson@environment.gov.za	DEA O&C
Dr Jaya Josie	jjosie@hsrc.ac.za	HSRC/SA IORAG
Mr Dumisani Horaius Kali	hkali@wsu.ac.za	WSU
Prof. Bruce Kelbe	bekelbe@gmail.com	UNIZUL/WRC
Dr Dipuo Kgotleng	dipuo.kgotleng@dst.gov.za	DST
Ms Busi Khaba	busikhaba@gmail.com	Monash/SA IORAG
Tracy Klarenbeek	tracy@nrf.ac.za	NRF
Mr Arrie Klopper	arrie.klopper@up.ac.za	UP
Dr Alison Kock	alison.kock@gmail.com	Two Oceans Aquarium
Prof. Michael Kosch	mkosch@sansa.org.za	SANSA
Ms Rachel Kramer	rachelk@wildlands.co.za	Wildoceans
Mr Nico Kroese	nico.kroese@weathersa.co.za	SAWS
Dr Marjolaine Krug	mkrug@csir.co.za	CSIR
Dr Tarron Lamont	Tlamont@environment.gov.za	DEA O&C
Mr Wade Lane	Wade@sst.org.za	SST
Dr.Mariska Laubscher	Mariska.Laubscher@aquarium.co.za	Two Oceans Aquarium
Dr Peter le Roux	peter.leroux@up.ac.za	UP
Prof. Anthony Leiman	tony.leiman@uct.ac.za	UCT
Prof. Ken Liu	kliu@ufh.ac.za	UFH
Prof. Amanda Lombard	Mandy.Lombard@mandela.ac.za	NMU/SARCHI
Dr Stefan Lotz	slotz@sansa.org.za	SANSA
Dr Carlos Loureiro	loureiroc@ukzn.ac.za	UKZN
Prof. LV Mabinya	lmabinya@ufh.ac.za	UFH
Mr Michael MacHutchon	michael@geoscience.org.za	CGS
Ms Fiona MacKay	fiona@ori.org.za	ORI
Ms Prideel Majiedt	p.majiedt@sanbi.org.za	SANBI
Mr Jacques Mahler-Coetzee	mvagabond@gmail.com	NMU
Dr Newi Makhado	Amakhado@environment.gov.za	DEA O&C
Dr Thulani Makhalanyane	Thulani.makhalanyane@up.ac.za	UP
Neil Malan	neilcmalan@gmail.com	SAEON
Prof. Gavin W Maneveldt	gmaneveldt@uwc.ac.za	UWC
Dr Bruce Mann	bruce@ori.org.za	ORI
Prof. Haretsebe Manwa	23815310@nwu.ac.za	NWU/SA IORAG
Ms Kudzanai Rosebud Marembo	KMarembo@ufh.ac.za	UFH
Mrs Benita Maritz	bm@imt.co.za	IMT
Dr Gwynneth Matcher	gfmatcher@gmail.com	RU

SCIENTIST	EMAIL	AFFILIATION
Ms Nozibusiso Mbongwa	Nozi@sst.org.za	SST
Mrs Meaghen McCord	meag@sharkconservancy.org	SASC
Prof. Christopher McQuaid	c.McQuaid@ru.ac.za	RU/SARCHI
Ms Siyasanga Miza	s.miza@sanbi.org.za	SANBI
Mr Sifiso Mjobo	smjobo@wsu.ac.za	WSU
Prof. N Mkwetshana	nmkwetshana@ufh.ac.za	UFH
Dr Lucas Mmonwa	lucas@shark.co.za	KZNSB
Mr Kgame Molope	e.Molope@nwu.ac.za	NWU/SA IORAG
Dr Pedro Monteiro	pmontiero@csir.co.za	CSIR
Gan K Moodley	moodleygk@ukzn.ac.za	UKZN
Ms Tammy Morris	tammy@saeon.ac.za	SAEON
Dr Thato Nicholas Mtshali	tmtshali@csir.co.za	CSIR
Dr Mandla Msibi	mandlam@wrc.org.za	WRC/SA IORAG
Ms Maryke Musson	maryke.musson@aquarium.co.za	Two Oceans Aquarium
Mr Mduduzi Mzimela	MzimelaH@unizulu.ac.za	UNIZUL
Gonasageran Naidoo	gnaidoo@ukan.ac.za	UKZN
Dr Motebang Vincent Nakin	mnakin@wsu.ac.za	WSU
Prof. Ronel Nel	Ronel.Nel@mandela.ac.za	NMU
Dr Holly Nel	Holly@africanwastenetwork.org.za	SST
Prof. Werner Nel	wnel@ufh.ac.za	UFH
Mr Nicholas Nicolle	Nicholas.Nicolle@aquarium.co.za	Two Oceans Aquarium
Dr Sarah-Anne Nicholson	snicholson@csir.co.za	CSIR
Nomfundo Nkabi	nomfundo@shark.co.za	KZNSB
Miss Nolonwabo Nontongana	200705831@ufh.ac.za	UFH
Dr Margaux Noyon	margauxnoyon@gmail.com	NMU/WIOURI
Miss N Ntsangani	nntsanagi@ufh.ac.za	UFH
Prof. UU Nwodo	unwodo@ufh.ac.za	UFH
Dr Larry Oellermann	loellermann@ori.org.za	ORI
Prof. Anthony I Okoh	aokoh@ufh.ac.za	UFH
Prof. Omobola O Okoh	ookoh@ufh.ac.za	UFH
Dr Carel Oosthuizen	carel.oosthuizen@up.ac.za	UP
Ryan Palmer	r.palmer@saiab.ac.za	ACEP
Dr Shirley Parker-Nance	shirley@saeon.ac.za	SAEON
Mr Tim Parker-Nance	timpn@saeon.ac.za	SEAON
Prof. Renzo Perissinotto	Renzo.Perissinotto@nmmu.ac.za	NMU/SARCHI
Dr Brilliant Petja	brilliantp@wrc.org.za	WRC
Ms Z. Philander	zphilander@environment.gov.za	DEA O&C
Dr Pierre Pistorius	Pierre.Pistorius@mandela.ac.za	NMU
Nicole du Plessis	samref@saeon.ac.za	SAEON
Mr Emile Plumstead	eplumstead@wsu.ac.za	WSU
Dr Katya Popova	e.popova@noc.ac.uk	NOCC/WIOURI

SCIENTIST	EMAIL	AFFILIATION
Dr Francesca Porri	F.Porri@saiab.ac.za	SAIAB
Dr Sean Porter	sporter@ori.org.za	ORI
Prof. Warren Potts	w.potts@ru.ac.za	RU
Dr Anusha Rajkaran	arajkaran@uwc.ac.za	UWC
Mr Claude Ramasami	cr@imt.co.za	IMT
Prof. Chris Reason	chris.reason@uct.ac.za	UCT
Dr Anthony Ribbink	a.ribbink@sst.org.za	SST
Prof. Michael Roberts	mike.roberts@nmmu.ac.za	NMU/WIOURI/SARCHI
Dr Deborah Robertson-Andersson	robertsond@ukzn.ac.za	UKZN
Prof. Mathieu Rouault	mathieu.rouault@uct.ac.za	UCT/WRC
Prof. Alakendra Roychoudhury	roy@sun.ac.za	SU
Prof. Peter Ryan	peter.ryan@uct.ac.za	Two Oceans Aquarium
Dr Toufiek Samaai	Tsamaai@environment.gov.za	DEA O&C
Prof. Warwick Sauer	w.sauer@ru.ac.za	RU
Prof. Ursula Scharler	scharler@ukzn.ac.za	UKZN
Prof. Michael Schleyer	schleyer@ori.org.za	ORI
Mr Mdu Seakamela	Smseakamela@environment.gov.za	DEA O&C
Prof. Jonathan Sievers	sieversj@ukzn.ac.za	UKZN
Dr Gilbert Siko	Gilbert.Siko@dst.gov.za	DST/SA IORAG
Dr Kerry Sink	k.sink@sanbi.org.za	SANBI
Dr Kobie Smit	ksmit@csir.co.za	CSIR
Prof. Albertus J Smit	ajsmit@uwc.ac.za	UWC
Ms Bernadette Snow	Bernadette.Snow@nmmu.ac.za	NMU
Dr Gavin Snow	gavin.snow@wits.ac.za	Wits
Mr Johan Stander	johan.stander@weathersa.co.za	SAWS
Dr Paul-Pierre Steyn	Paul.Steyn@mandela.ac.za	NMU
Prof. Joleen Steyn Kotze	jkotze@hsrc.ac.za	HSRC/SA IORAG
Dr Du Toit Strauss	dutoit.strauss@nwu.ac.za	NWU
Prof. Nadine Strydom	Nadine.Strydom@mandela.ac.za	NMU
Dr Suthananda Sunassee	sunny.sunassee@uct.ac.za	UCT
Ms Ernesta Swanepoel	contact@ernestaswanepoel.com	SA IORAG
Dr Neville Sweijd	nsweijd@access.ac.za	ACCESS
Dr Jean-Francois Ternon	jean-francois.ternon@ird.fr	IRD/WIOURI
Prof. Peter Teske	prteske@uj.ac.za	UJ
Dr Sandy Thomalla	sthomalla@csir.co.za	CSIR
Dr Mamohloding Tlhagale	mamohlodingt@wrc.org.za	WRC
Mr Mutshutshu Tsanwani	Mtsanwani@environment.gov.za	DEA O&C
Prof. Marla Tuffin	ituffin@uwc.ac.za	UWC
Prof. Hennie van As	hennie.vanas@vodamail.co.za	NMU
Paul von Blerk	vonblerk@shark.co.za	KZNSB
Dr Rudy van der Elst	rudyvanderelst@gmail.com	ORI

SCIENTIST	EMAIL	AFFILIATION
Prof. Bettine Jansen van Vuuren	bettinevv@uj.ac.za	UJ
Prof. Jo-Ansie Van Wyk	vwykjak@unisa.ac.za	UNISA/SA IORAG
Mr Wilhelm van Zyl	wvanzyl@geoscience.org.za	CGS
David Vaughan	david.vaughan@my.jcu.edu.au	Two Oceans Aquarium
Ms Kirsty Venter	Kirsty@sst.org.za	SST
Dr Andrew Venter	andrewv@wildlands.co.za	Wildoceans
Dr H. Verheye	hverheye@environment.co.za	DEA O&C
Dr Els Vermeulen	elsvermeulen5@gmail.com	UP
Dr Niall Vine	nvine@ufh.ac.za	UFH/SA IORAG
Prof. Leon Vivier	VivierL@unizulu.ac.za	UNIZUL
Mr Grant van der Heever	grant@saeon.ac.za	SAEON
Garth van der Heerden	g.vanderheerden@saiab.ac.za	ACEP
Prof. Sophie von der Heydem	svdh@sun.ac.za	SU
Dr Bjorn von der Heyden	bvon@sun.ac.za	SU
Dr Charles von der Meden	Charlie@saeon.ac.za	SAEON
Dr Andre Vosloo	vosloo@ukzn.ac.za	UKZN
Prof. Patrick Vrancken	Patrick.Vrancken@nmmu.ac.za	NMU/SARCHI
Mr Lukhay Vumazonke	lvumazonke@ufh.ac.za	UFH
Prof. Alan Whitfield	a.whitfield@saiab.ac.za	SAIAB
Mr Christopher Wilkinson	christopher.wilkinson@up.ac.za	UP
Sabine Wintner	wintner@shark.co.za	KZNSB
Prof. Tris Wooldridge	Tris.Wooldridge@mandela.ac.za	NMU

ACRONYMS & ABBREVIATIONS

ACCECSS	Alliance for Collaboration on Climate & Earth Systems Science
ACEP	African Coelacanth Ecosystem Programme
AMOC	Atlantic Meridional Overturning Circulation
AMWN	African Marine Waste Network
ASAP	Automated Shipboard Aerological Programmes
ASCA	Agulhas System Climate Array
ASU	Arizona State University
CGS	Council for Geoscience
CMR	Coastal and Marine Research
CPIES	Current- and Pressure-recording Inverted Echo Sounders
CPRR	Competitive Programme for Rated Researchers
CPUT	Cape Peninsula University of Technology
CSIR	Council for Scientific and Industrial Research
CSUR	Competitive Support for Unrated Researchers
DACST	Department of Arts, Culture, Science and Technology
DAFF	Department of Agriculture, Forestry & Fisheries
DEA	Department of Environmental Affairs
DNA	Deoxyribonucleic acid
DST	Department of Science and Technology
EACC	East African Coastal Current
EDTEA	Economic Development, Tourism and Environmental Affairs
EEZ	Exclusive Economic Zone
EMEL	Elasmobranch Molecular Ecology Laboratory
ENSO	El Niño Southern Oscillation
ESM	Earth System Model
ESASTAP	Strengthening of Technology Research and Innovation between Europe and South Africa
FAO	Food and Agricultural Organisation
FATMs	Fatty Acid Trophic Markers
FBIP	Foundational Biodiversity Information Programme
GDPFS	Global Data-processing and Forecasting System
GOS	Global Observing System
GTS	Global Telecommunications System
ICAO	International Civil Aviation Organization
IIOE-2	Second International Indian Ocean Expedition
IMT	Institute for Maritime Technology
IOC	Intergovernmental Oceanographic Commission
IORA	Indian Ocean Rim Association
IRD	Interactive Research and Development
IUCN	International Union for Conservation of Nature
KZNSB	KwaZulu-Natal Sharks Board
LTER	Long-Term Ecological Research
MAPRU	Marine Apex Predator Research Unit
MARS	Marine and Antarctic Research Strategy
MEEP	Molecular Ecology and Evolution Programme
MJO	Madden-Julian Oscillation
MOC	Meridional Overturning Circulation
MoU	Memorandum of Understanding
MPA	Marine Protected Areas
NIOZ	Royal Netherlands Institute for Sea Research
NMU	Nelson Mandela University
NNSF	National Natural Science Foundation
NWU	North West University
OCIMS	Oceans and Coastal Information Management System
ORI	Oceanographic Research Institute
RASCAL	Replications of the Agulhas System Climate Array Line
RSMAS	Rosenstiel School of Marine and Atmospheric Sciences
RU	Rhodes University
RTF	Research and Technology Fund
SA IORAG	South African Chapter of the Indian Ocean Rim Academic Group
SAAMBR	South African Association for Marine Biological Research
SAEON	South African Earth Observation Network
SAIAB	South African Institute for Aquatic Biodiversity
SA-IIOE-2	South Africa's contribution to the Second International Indian Ocean Expedition
SANAP	South African National Antarctic Programme
SANBI	South African National Biodiversity Institute
SANMAP	South African Nearshore Mapping Programme
SARChI	South African Research Chairs Initiative
SAWS	South African Weather Service
SGD	Submarine groundwater discharge
SICC	South Indian Ocean Counter Current
SLP	Sea level pressure
SOT	Ship Observation Team
SRC	Shark Repellent Cable
SSLTER	Sentinel Sites for Long-Term Ecological Research
SST	Sustainable Seas Trust
SST	Sea Surface Temperature
SU	University of Stellenbosch
SWIOFP	South West Indian Ocean Fisheries Project
TOA	Two Oceans Aquarium
UCT	University of Cape Town
UFH	University of Fort Hare
UJ	University of Johannesburg
UKZN	University of KwaZulu-Natal
UNEP	United Nations Environment Programme
UNESCO	United Nations Organization for Education, Science and Culture
UNISA	University of South Africa
UniZul	University of Zululand
UP	University of Pretoria
UWC	University of the Western Cape
VOS	Voluntary Observing Ship
WIO	Western Indian Ocean
WIOMSA	Western Indian Ocean Marine Science Association
WIOURI	Western Indian Ocean Upwelling Research Initiative
Wits	University of the Witwatersrand
WMO	World Meteorological Organization
WRC	Water Research Commission
WSU	Walter Sisulu University


science
& technology
Department:
Science and Technology
REPUBLIC OF SOUTH AFRICA
NRF
National Research Foundation
RISA
Research and Innovation Support and Advancement
NRF
National Research Foundation
SAIAB
South African Institute for Aquatic Biodiversity
NRF
National Research Foundation
SAEON
South African Environmental Observation Network