NELSON MANDELA
UNIVERSITY

ONE OCEAN

what are we doing about it?

One Ocean – what are we doing about it?

This publication features the discussions, research, and solutions emanating from two major international ocean sciences conferences held at Nelson Mandela University, Port Elizabeth, in March this year, namely the Second International Indian Ocean Expedition (IIO-E2) and the South Africa–Norway Research Co-operation on Blue Economy, Climate Change, the Environment and Sustainable Energy (SANOCEAN).

Collective Ocean Action

Introduction by the Vice-Chancellor of Nelson Mandela University, Professor Sibongile Muthwa

We have reached the hour when we need to know what is being done to conserve our oceans and to ensure that the so-called blue economy is sustainably developed. To achieve this we need new modes of thought and novel solutions that engage all our communities, locally and globally, and address poverty and inequality.

As we know, the oceans cover 70% of our planet and are a critical source of oxygen, food, marine resources, employment, and subsistence. We have lost more than 40% of the biodiversity in the ocean in the past 40 years, and the latest International Panel on Climate Change report shows that since the 1970s about 93% of the excess heat from greenhouse gas emissions has been absorbed by the oceans. At the same time the oceans are under pressure from unsustainable resource extraction. This is a crisis call for collective action.

What is encouraging is that a growing network of outstanding research and innovation initiatives in South Africa, the continent and internationally are collaborating to better understand this vast body of water and to implement solutions for its conservation and sustainable development.

Contributing to this, two pivotal international ocean sciences conferences were held at Nelson Mandela University in Port Elizabeth in March this year.

The first of these was the Second International Indian Ocean Expedition (IIO-E2). Hosted for the first time in Africa, the conference brought together partners from throughout the world, including the major ocean sciences nations. IIO-E2 is the single largest effort to study the Indian Ocean in a transdisciplinary manner, in order to advance our understanding and enable informed decision-making.

The second conference was SANOCEAN, the South Africa–Norway Research Co-operation on Blue Economy, Climate Change, the Environment and Sustainable Energy. The long-term programmes in this partnership enhance the knowledge base for policies and decisions for sustainable development in the areas of oceans and ocean space (the blue economy), environment (with emphasis on oceans and pollution), climate change and sustainable energy in South Africa and Norway.

British High Commissioner, Nigel Casey and Norwegian Ambassador, Astrid Helle are good friends of Nelson Mandela University and attended the respective conferences. Our countries partner on several of the key programmes and research chairs

Professor Sibongile Muthwa

that are discussed in this publication. For example, the Faculty of Law's FishFORCE programme works closely with Norway in combatting the major problem of organised fisheries crime: fishforce.mandela.ac.za. The university also collaborates with several Norwegian universities and institutions on ocean research, innovation and sustainable industry for the blue economy, including offshore oil and gas, fisheries, aquaculture, shipping, and marine plastic pollution clean-ups. These programmes are funded by government agencies, industry and European Union projects.

Nelson Mandela University is positioning itself as the hub for ocean sciences in Africa and the Western Indian Ocean: oceansciences.mandela.ac.za. As a coastal university we partner with the national and international marine and maritime research community, and have strong collaborations with other coastal countries in Africa and globally. We also have strong partnerships with other South African universities, the Nelson Mandela Bay Metro, government and key industry players to propel a collective drive and collective solutions.

Our faculties and dedicated Ocean Sciences Campus (the first of its kind in South Africa) offer a range of qualifications and programmes to support ocean sciences development, conservation and a sustainable, well managed blue economy.

We are also positioning ourselves as a maritime hub. Last year the Faculty of Engineering, Built Environment and Information Technology (EBEIT) launched a Marine Engineering degree, and this year we launched our Marine Robotics Unit.
ebeit.mandela.ac.za

We welcome the United Nations declaration of the *Decade of Ocean Science for Sustainable Development* from 2021 to 2030. It will hopefully be the largest driver ever to protect the oceans, address ocean warming, use the space sustainably, and bridge science, policy and practice.

With South Africa's coastline spanning approximately 3000 kilometres, bordered by three oceans – the Atlantic, Southern and Indian Ocean – we are perfectly placed to contribute to and benefit from the much anticipated blue decade.

Professor Sibongile Muthwa
Vice-Chancellor Nelson Mandela University

Mouth of the Sundays River Estuary, Eastern Cape. Photo: Dr Tor F. Næsje.

"Nelson Mandela University is positioning itself as the hub for ocean sciences in Africa and the Western Indian Ocean ..."

Why the Indian Ocean?

By Heather Dugmore and Professor Peter Burkill, Co-Chair of the Second International Indian Ocean Expedition (IIOE-2) Steering Committee and Past President of the Scientific Committee on Oceanic Research (SCOR), Emeritus Professor, University of Plymouth, UK.

The Indian Ocean remains the least known of all the global oceans, and the least scientifically studied. From the 1990s, economic recession made the West turn its back on the Indian Ocean due to the cost of operating in far waters, and the resurgence of piracy in the region.

In the last few years this has changed, as the Western world begins to realise the impact that this ocean has on both the marine and the terrestrial environment.

The monsoons

The Indian Ocean is bounded to the north by countries that include Somalia, Oman, Pakistan, Bangladesh, India and Indonesia, a region of monsoonal weather systems. As part of this there is huge upwelling of deep nutrient-rich water in the ocean during the monsoon months of June, July and August, only subsiding when the winds die down in September. This seasonal upwelling enhances the productivity of the surface waters of the ocean: migratory tuna are attracted to the area, while residents such as squid grow profusely due to the abundance of food.

One of the questions that scientists are grappling with is whether the pattern of monsoons is changing. To monitor this, data are collected over the northern Indian Ocean basins using satellites and oceanographic moorings. The data from these are fed into climate models to establish changes. While some patterns are already becoming evident, longer term predictions on seasonal rainfall patterns and its spatial distributions are still to emerge.

Indian Ocean is warming faster

One of the recent research findings is that the surface waters of the Indian Ocean south of the equator seem to be warming faster than in any other ocean region.

Prof Peter Burkill scuba diving on the Lakshadweep Islands in the eastern Arabian Sea. Photo: peterburkillphotography

While the reasons for this are not yet clear, it must in some way be associated to the conveyance of water that we call the Thermohaline Circulation that links the Indian Ocean with the Atlantic and the Pacific Oceans. There is some evidence that part of this circulation in the Atlantic is slowing down and, if true, this will have knock-on effects elsewhere in the transfer of heat between our oceans.

The regional warming pattern in the Indian Ocean is globally significant as it amounts to a large proportion of the heat assimilated by the ocean as a whole.

This effect may be a crucial aspect of the ocean's role in global climate regulation; however, it will also have more local effects. These include a rise in sea levels, flooding or even submerging coastal land, while the warming waters severely damage coral reefs within the region; the effects may even extend to widespread changes in rainfall patterns.

Tipping point

The best scientific research, data and prediction models are needed if countries are to manage the impact of climate change and to avoid reaching an environmental 'tipping point' beyond which it may be impossible to recover.

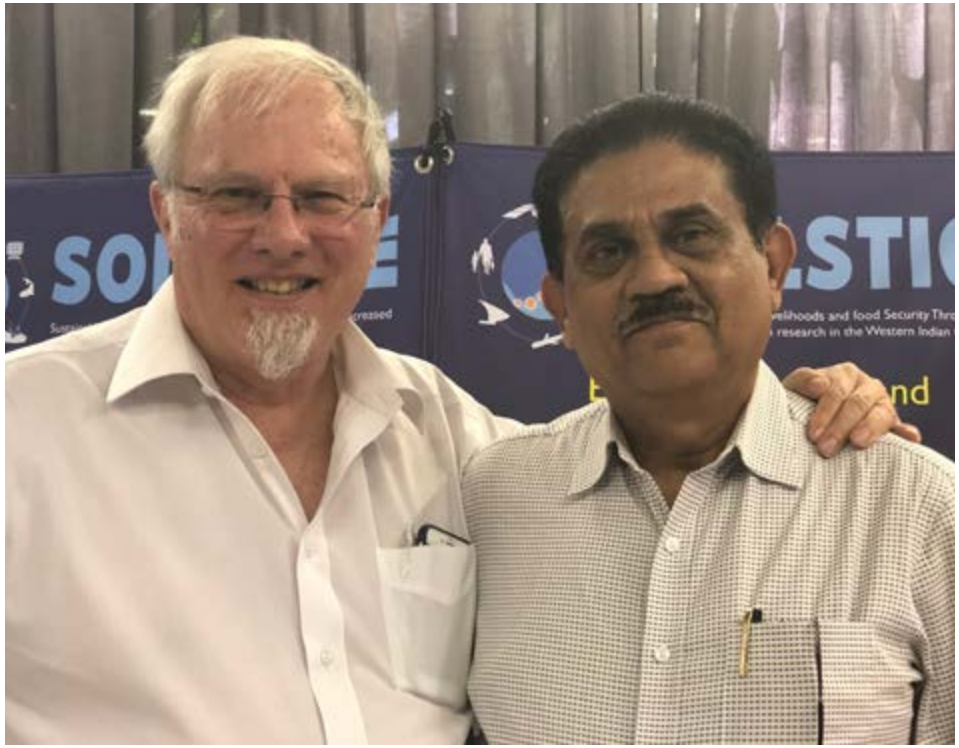
Sea levels are already rising at a rate of 30 to 40 cm per century, with predictions that this will increase significantly in the future. Some 500 million people live on land that will be submerged or exposed to chronic flooding by 2100. This will affect all low-lying countries bordering the Indian Ocean, with the Maldives, Seychelles and Bangladesh most at risk: the Maldives could be submerged within the next two decades.

The Indian Ocean is surrounded by countries in which artisanal fisheries are of significant importance for income and food, yet we know little about the impact of ocean warming and marine pollution on this critical coastal community resource. Tourism is another resource of great importance to the Indian Ocean countries. And coral reefs, a vital asset to both fishing and tourism, are bleaching and dying as a result of ocean warming

Blue economy rapid development

In the face of these environmental concerns, responsible stewardship of ocean resources – the blue economy – is rapidly being prioritised by many nations. The Southern African Development Community (SADC), for example, has proposed a strategy for the sustainable development of sea-based activities, and member states Mauritius, Seychelles and South Africa have developed their own national strategies and institutions.

The blue economy depends critically on knowing what resources are where and what governs their sustainability and since 1957, SCOR – the Scientific Committee on Ocean Research – has been bringing together ocean scientists from all parts of the world to advance ocean science and overcome barriers to understanding the ocean.



Prof Peter Burkill and Dr Satheesh Shenoi at the IIOE-2 Conference at Nelson Mandela University in March this year.

Advancing our understanding of the Indian Ocean

SCOR sponsors the Second International Indian Ocean Expedition (IIOE-2) programme together with UNESCO's Intergovernmental Oceanographic Commission (IOC) and the Indian Ocean Global Ocean Observing System (IOGOOS),.

The IIOE-2's mission statement is "to advance our understanding of the Indian Ocean and its role in the Earth System in order to enable informed decisions in support of sustainable development and the well-being of humankind".

In 2019, ocean scientists from around the world met at Nelson Mandela University for IIOE-2's conference on Indian Ocean science.

The conference brought together the 'Big 5' committees that play a significant role in steering ocean science endeavours:

- IIOE-2 Steering Committee
- Indian Ocean Global Ocean Observing System (IOGOOS)
- Indian Ocean Observing System (IndOOS) physical and biogeochemical monitoring network and resources forum
- Indian Ocean Research Programme (IORP)
- Sustained Indian Ocean Biogeochemistry and Ecosystem Research (SIBER)

Such collaborations are essential to working out what can be done for the environment and who should be doing it. Despite what President Trump may think, human-driven climate change is a reality. The role of the Indian Ocean in affecting the global climate is currently being investigated. Those who live in the region and suffer the immediate effects of the changing climate will certainly have an important part to play in ensuring global action to return the planet to a sustainable footing.

One of the recent research findings is that the surface waters of the Indian Ocean south of the equator seem to be warming faster than in any other ocean region.

FishFORCE – Combatting Fisheries Organised Crime

Organised crime linked to the illegal harvesting, processing and trading of fish and seafood is so huge globally that it is effectively a parallel economic system, undermining sustainable economic growth.

"Countries are being deprived of taxes; citizens of jobs, food and income; and fisheries and environments are being destroyed. Africa is particularly vulnerable and loses more than $20 billion per year," says Professor Hennie van As, who presented at the SANOCEAN conference. An admitted advocate, van As is Director of the Centre for Law in Action, professor of Public Law at Nelson Mandela University and head of South Africa's first Fisheries Law Enforcement Academy, FishFORCE.

Established in 2016 by Nelson Mandela University in partnership with the Norwegian Ministry of Foreign Affairs and South Africa's Department of Agriculture, Forestry and Fisheries, FishFORCE works to equip enforcement agencies to handle the increasingly complex investigations and prosecutions of fisheries crime throughout Africa and the world.

Buy-in from INTERPOL

FishFORCE has buy-in from the world's largest international police organisation, Interpol, the African Union and the United Nations Office on Drugs and Crime.

Fisheries crime, or "multi-crimes" affecting the fisheries sector, range from illegal fishing to human trafficking and forced labour,

Checking fishing nets with a smaller than permissable size.

ABOVE: FishFORCE training on Fisheries Crime Law Enforcement in South and East Africa, led by Professor Hennie van As and attended by Kenyan and South African officials and universities. The Kenyan delegation included representatives from the University of Nairobi School of Law & School of Biological Sciences; Office of the Director of Public Prosecutions, Kenya; Kenyan State Department for Fisheries & the Blue Economy, Kenya Marine & Fisheries Research Institute; Kenya Coast Guard Service. The South African officials were from the Department of Agriculture, Forestry & Fisheries (DAFF).

Below: FishFORCE training in Tanzania
The FishFORCE Academy is helping to build fisheries law enforcement capacity along the east coast of Africa.

Trans-shipment of illegally caught fish taking place from one vessel to the other.

fraud, forgery, corruption, money laundering and tax and customs evasion. These crimes pose a significant challenge to fisheries law enforcement agencies across the world.

"Fisheries law enforcement requires traditional policing methods and tools, and expertise in law, criminology, police science, as well as fisheries management and conservation," says FishFORCE COO Michael de Lange. "The aim is to achieve intelligence-led investigations and prosecutions of criminals engaged in fisheries crime."

25 years to Life

Cases prosecuted as Illegal, Unreported, Unregulated (IIU) fishing have had very limited success, with penalties amounting to a rap on the knuckles and being seen as "the cost of doing business" by culprits. Instead, as van As argues, "they should be addressed under the Prevention of Organised Crime Act, with severe penalties of 25 years to life. "It is encouraging to see that three recent major abalone racketeering cases have done this, with sentences of 18 to 20 years."

Closing the law enforcement loopholes

"Together with the National Prosecuting Authority (NPA), we are getting to the bottom of why prosecutions for fisheries-related crimes often fail," continues van As. "The regulating, and policing of fisheries vessels in the past has been too compartmentalised and full of loopholes because of the many different players involved.

"Illegal fisheries vessels take advantage of this. They fraudulently under-report catches, they fish illegally, transfer illegally caught fish from one boat to another or change their flags (because countries only have jurisdiction on the high seas over vessels that fly their flags)."

"We are now collaborating with the South African Police Service (SAPS), Defence Force, NPA and Home Affairs to develop a combined offensive."

FishFORCE research

A cornerstone of FishFORCE is to facilitate research and innovation so that fisheries law enforcement officers have the most updated information, techniques and tools available.

De Lange explains that FishFORCE research associates and postgraduate students will carry out multidisciplinary research that includes analysis and evaluation of law enforcement gaps, as well as focusing on the development of national and international law and policies.

Training

"FishFORCE is training fisheries control officers, police officers and prosecutors in South Africa and Kenya, where there is already a FishFORCE academy. Others are being opened in Angola, Namibia, Mozambique, Tanzania, Madagascar, Mauritius and Seychelles," says de Lange. "We are also assisting with training along the Indian Ocean Rim, including countries like Indonesia. Organised fisheries crime knows know borders, and neither do marine living resources."

The training developed and delivered by FishFORCE provides formal qualifications, such as a Higher Certificate in Criminal Justice and a Diploma in Law Enforcement. These were specifically developed in order to professionalise the sector, promoting fisheries law enforcement as a career choice.

"In 2018 FishFORCE trained 276 delegates through its Law Enforcement by Peace Officers short learning programme, at a success rate of 90%," says de Lange.

Electronic support

FishFORCE has an electronic helpdesk to provide post-training support to SAPS, fisheries control officers (FCOs) and the NPA.

In addition, WhatsApp groups have been set up to respond to requests for assistance with regard to suspicious activities. This has proved successful, especially on South Africa's west coast where a number of arrests have resulted.

Scientists are also linked to the WhatsApp groups, to help enforcement agents identify marine species and products, including shark fins, and notify them about the occurrence of natural phenomena, such as shoals of young fish moving up rivers. FCOs can then be on site to prevent illegal large-scale harvesting of these fish.

FishFORCE is currently investigating the use of drones to assist agencies with monitoring and surveillance operations.

FishFORCE and StopGAP

Although ports are a key point for fisheries crimes, port security officers are not trained in critical skills to prevent them, such as differentiating between marine species or identifying whether fisheries products that are leaving the country are illegal or not. They are also not trained to detect smuggling or tampering with containers or to identify illicit substances such as drugs that are often associated with the poaching of marine living resources.

In a joint project with the Norwegian government, the FishFORCE Academy has embarked on the "StopGAP" project, to remedy this skills deficit.

"It is a way of stopping a gap in the way we fight fisheries crime. That is why we call the project 'StopGAP'," says Prof Van As.

For more information:
FishFORCE
fishforce.mandela.ac.za
PescaDOLUS
www.pescadolus.org
Oxpecker environmental investigative website:
oxpeckers.org/2019/03/abalone-rhino-poaching-links

Institute for Coastal & Marine Research (CMR)

Over 40 years of coastal and marine research at Nelson Mandela University led to the 2016 launch of the transdisciplinary Institute for Coastal and Marine Research (CMR). It is situated at the Ocean Sciences Campus with membership from all seven faculties and including 50 staff members and over 100 postgraduate students, doctoral candidates and postdoctoral researchers.

The CMR and Ocean Sciences Campus have been driven from the top by the Vice-Chancellor, Professor Sibongile Muthwa, and Deputy Vice-Chancellor of Research and Engagement, Professor Andrew Leitch.

The Director of the CMR, Dr Bernadette Snow, was integral to the organisation of the IIOE-2 and SANOCEAN conferences at Nelson Mandela University.

Two research units in the CMR are:

Marine Apex Predator Research Unit (MAPRU)

MAPRU conducts research on marine top predators, including seabirds, seals, sharks and cetaceans, particularly in relation to global change, conservation and sustainable resource management. Learning opportunities are provided for postgraduate students in various aspects where marine top predators are involved. MAPRU members are also involved in various forms of engagement, using charismatic predator species to stimulate public interest in marine biodiversity and conservation. This group's research focuses on marine top predators as a group, addressing questions of fundamental and applied interest by drawing on a range of disciplines. Geographically, most of the projects are focused on the South African coastline, in the sub-Antarctic region, and they also extend into Mozambique and Namibia.

Research Diving Unit (RDU)

The RDU provides diving support to projects registered with Nelson Mandela University. It provides scientific diver training, and ensures that all health and safety

Cape gannets on Bird Island, Algoa Bay. Photo: Dr Gavin Rishworth.

requirements for diving-related activities are met by maintaining a SHEQ programme in accordance with national legislation and international best practice. During 2018, the RDU facilitated diving activities on 90 days, equating to 623 incident-free man-hours.

Research Chairs in the CMR include:

Shallow Water Ecosystems (Chair holder: Prof Janine Adams): The research focuses on integrated ecosystem functioning of estuarine and coastal systems. Water is a scarce commodity in southern Africa and many ecosystems are currently on a trajectory of rapid deterioration. The sustainable use of our water resources and their rehabilitation requires adaptive management structures and continuous scientific knowledge on the processes that govern ecosystems and their health.

Marine Spatial Planning (Chair holder: Prof Mandy Lombard): This Chair looks at the strategic strengthening and analysis of knowledge on the spatial and seasonal distribution of marine biodiversity features in coastal, benthic and pelagic environments.

Law of the Sea and Development in Africa (Chair holder: Prof Patrick Vrancken): This Chair's research focuses on South Africa and the law of the sea (including the legal regime governing the South African continental shelf and the exploitation of its resources), development in Africa, and the law of the sea.

Ocean Science and Marine Food Security (Chair holder: Prof Mike Roberts): Current research investigates the underpinning processes that sustain food security, with a strong focus on climate change, particularly in the Western Indian Ocean.

For more information:
cmr.mandela.ac.za

Have South Africa's leatherback and loggerhead sea turtles been displaced from their optimal habitats by human activities or by changing climatic conditions? This is the question that Nelson Mandela University Professor Ronel Nel is investigating for her Pew Fellowship, awarded for unique research that informs better management and conservation of the world's marine life and oceans. Prof Nel is one of eight scientists and conservationists selected from seven countries for 2018.
Photo: Linda Harris

Over 40 years of coastal and marine research at Nelson Mandela University led to the 2016 launch of the transdisciplinary Institute for Coastal and Marine Research (CMR).

Estuarine Fish – Overexploited or Collapsed

By Dr Tor F. Næsje (Norwegian Institute for Nature Research) and Professor Paul D. Cowley (South African Institute for Aquatic Biodiversity)

For more than 100 000 years South Africa's fish have been an important food source. Yet today, we find ourselves in a position where the populations of prominent species such as dusky kob, spotted grunter, white steenbras and leervis (garrick) are considered to be either collapsed or over-exploited.

Estuaries provide nursery areas for these species and they continue to use them to a certain extent as adults. Dusky kob, for example, spend most of the nine years they take to mature in the estuary, before they head out to sea, returning occasionally in adulthood. All being well, dusky kob live to about 50 years.

250 estuaries along SA's coastline

There are more than 250 sheltered estuaries along South Africa's coastline, which serve both as critical nursery areas and provide fishing opportunities for subsistence and recreational fishing. Based on the over-exploitation and collapse of many of the fish stocks, in addition to degradation of the estuaries, fishery is becoming unsustainable, threatening the livelihoods of vulnerable coastal communities and the recreational fishing industry.

Urgent need of management attention

Insufficient knowledge of fish behaviour, area use and distribution patterns contributes to the failure of measures to manage and protect these over-exploited estuarine species. The upshot is that these imperilled fishery resources are in need of urgent management attention.

Dr Amber Childs from Rhodes University's Department of Ichthyology inserts a transmitter into a spotted grunter. Transmitters are surgically implanted into the fish, which is then stitched up and returned to the water. Photo: Dr Tor F. Næsje

In 2002 researchers from the South African Institute for Aquatic Biodiversity (SAIAB) and the Norwegian Institute for Nature Research (NINA), led by Professor Paul Cowley and Dr Tor Næsje, met and discussed the situation of valuable coastal fisheries resources

Dr Amber Childs and Professor Paul Cowley surgically implanting a transmitter in a juvenile dusky kob in the Sundays Estuary. Photo: Dr Tor F. Næsje

in South Africa, and the worrying consequences for fishing communities.

The important management questions are: where do the fish like to be in the estuary, and for how long; when do they leave the estuaries and go to sea; and, do they utilise multiple estuaries? It is also important to gain insights on the coastal migrations of adults, to identify spawning areas, and to know how and where the fish are exploited and by whom.

At the same time as the SAIAB and NINA scientists discussed the future for South Africa's coastal fisheries, officials from South Africa and Norway met to plan the funding of a joint-financed research programme. This created the opportunity for a long-lasting collaboration, which has led to outstanding new knowledge about the estuary-dependent fishery species and their exploitation. Fisheries management is, after all, a question of managing people's exploitation of the resources.

75% women researchers

In addition to world class research, this international collaboration has developed human capacity, with an emphasis on postgraduate students and postdoctoral fellows from historically disadvantaged universities. And, as one of the criteria of the South African–Norwegian partnership is increasing the presence of women in science, approximately 75% of the researchers are female.

Following fish

But how can we study the behaviour of animals that we cannot see? The answer: acoustic telemetry, a powerful tool to study fish behaviour, area use and migrations. By attaching a sound transmitter with unique signals to the fish, we detect its whereabouts and behaviour with acoustic receivers.

Smaller fish are usually followed for up to a year, while larger fish can be followed for five to six years and longer. In the South African–Norwegian study, stationary receivers for monitoring fish movement have been deployed in estuaries and coastal waters from False Bay to the Mozambican border. This nationwide array of receivers forms the Acoustic Tracking Array Platform, which is managed by SAIAB.

Results from the first decade of fish telemetry studies have confirmed that the four species – dusky kob, spotted grunter, white steenbras and leervis (garrick) – are threatened, both from fishing exploitation, human caused degradation of estuaries, and reduced rainfall resulting from climate change. Recapture rates of tagged fishes in estuaries over a period of one to two years varied from 5% for juvenile white steenbras to 56% for juvenile dusky kob. This highlights the fish stocks vulnerability to exploitation in estuaries and the need for immediate management action to protect them.

Species-dependent differences in habitat use ranged from localised site fidelity (they stick to particular sites) in juvenile white steenbras and spotted grunter to wide-ranging movements in dusky kob and leervis. Furthermore, the period fish remained in estuaries or moved among them also varied. Important drivers for fish behaviour were environmental conditions like light, tide and season, causing ever changing conditions in the open estuary.

No-take zones

Marine Protected Areas (MPAs) have been shown to be highly beneficial for the rehabilitation and management of fish stocks, but few studies have evaluated the benefits of Estuarine Protected Areas (EPAs). To remedy this, Godfrey Padare, a master's student from the Department of Zoology and Entomology at the University of Fort Hare is researching whether partial estuarine area protection in the form of no-take zones can reduce the vulnerability of the spotted grunter.

In this study, 14 spotted grunter were tagged with acoustic transmitters and monitored for an average of 310 days in the Goukou Estuary, in order to evaluate the efficacy of the existing partial no-take EPA. The results confirmed high site fidelity by spotted grunter in estuaries, and the positive value of no-take area closures as a potential management option.

Fishery policy lagging

However, these important findings have had little direct impact on fishery policy formulation. For the next four years, funding obtained through the SANOCEAN programme will be used for a follow-up project that aims to produce guidelines on how to communicate important fish and fisheries information to managers. Nelson Mandela University is part of the SAIAB-NINA partnership, conducting case study research on the social, economic and governance dynamics of estuarine fisheries.

An essential component of this project is to make managers and policy makers aware of the major environmental and economic consequences of their decisions. The South African and Norwegian project leaders hope that in future these leaders will listen and take into consideration the new and important knowledge on South Africa's coastal fisheries resources. Our marine biodiversity depends on the protection and sustainable development of all our fish species.

Nelson Mandela University is part of the SAIAB-NINA partnership, conducting case study research on the social, economic and governance dynamics of estuarine fisheries.

No Single Nation Has The Capacity

"The reality is that no single nation has the resources, capacity or mandate to undertake all of the research and effort needed to resolve the questions and issues facing our oceans, particularly the least researched, the Indian Ocean," said Dr Nick D'Adamo at the IIOE-2 conference at Nelson Mandela University in March this year.

D'Adamo is head of the Perth Programme Office of UNESCO's Intergovernmental Oceanographic Commission (IOC) and Director of the Australian Node of the IIOE-2 Joint Project Office. Dr D'Adamo.

"Countries worldwide urgently need to join forces to resolve the global warming and sustainability issues affecting the entire Indian Ocean – a region with a population of over 3 billion. This includes researching the ocean's structure and currents and addressing its warming, changing anatomy, increasing acidification, the stress on its fisheries, changes in its oxygen levels, rapid increases in industrial usage, including marine mining, prospecting and much more."

UNESCO's Intergovernmental Oceanographic Commission (IOC) Perth Office

A gateway ocean

D'Adamo explains the Indian Ocean's role in global earth: "It's a pathway ocean for global flows, and a gateway ocean that plays a pivotal role in the great ocean 'conveyor belt'. For example, the Agulhas current that runs down the east African coastline, takes a turn towards south-western Australia and some of it branches off into the Atlantic.

"The Indian Ocean's surface temperature idiosyncrasies have a profound effect on weather patterns, which then affect countries far and wide, including China, Japan, the whole of Africa, northern and western Asia, and even influence the Pacific." D'Adamo emphasises that the world needs to start thinking about all the oceans as one ocean, and of the world as one world.

He adds that the Indian Ocean has become an increasingly important transport route for trade and geopolitical reasons, and many more countries are bringing their scientific interest to bear in the Indian Ocean because of these geopolitically strategic imperatives.

Ocean's GDP is at least US$24trillion

A 2015 Worldwide Fund for Nature (WWF) report states: "Goods and services from coastal and marine environments amount to about $2.5 trillion each year – that would put the ocean as the seventh largest economy in the world if put into terms of Gross Domestic Product." But the report adds that these goods and services are dwindling fast:

"More than two-thirds of the annual value of the global ocean relies on healthy conditions to maintain its current output. However, habitat destruction, overfishing, pollution, and climate change are endangering this economic engine and the security and livelihoods it supports. Marine resources are in a rapid decline and our oceans are changing faster than we have ever seen before." www.worldwildlife.org/stories/ocean-assets-valued-at-24-trillion-but-dwindling-fast

"The oceans are our 'natural capital' – a global savings account from which we keep making only withdrawals," says Brad Ack, Senior Vice President for Oceans at WWF. "To continue this pattern leads to one place: bankruptcy. It is time for significant reinvestment and protection of this global commons."

Big stakes in the Indian Ocean

Expanding on these observations, D'Adamo elaborates on the underplayed dependence on the Indian Ocean and blue economy of so many countries, including South Africa which has large stakes in the Indian Ocean, and how countries need to increase the emphasis in developing a comprehensive conservation, marine spatial planning and economic strategy.

UN Decade of Ocean Science for Sustainable Development

Collective understanding of ocean observations and research is essential to predict the consequences of climate change, and to design mitigation strategies for the oceans, which play an overarching role in what happens to the planet.

This collective action is a key goal of the United Nations Decade of Ocean Science for Sustainable Development (2021–2030), coordinated by UNESCO's Intergovernmental Oceanographic Commission.

One of the largest ocean science focuses in history, it will enhance and even transform elements of oceanography as a driver to bring together nations to understand and protect the oceans, and to use their space sustainably, bridging science and policy. For the first time, the global ocean community will collaborate in planning the next ten years in ocean science and technology in order to deliver ***"the ocean we need for the future we want"***.

For more information: ioc.unesco.org.
en.unesco.org/ocean-decade

Boats in the Mediterranean sea in Oludeniz,Turkey. Photo: © Shutterstock.com/Denis Belitsky via IOC-UNESCO

World's Most Advanced Ocean Research Vessel

REV Ocean is a new international marine research initiative targeting climate change, acidification, marine pollution and the over-exploitation of marine resources with innovative ocean research and solutions. Its goal is to raise awareness that all the oceans in the world form one connected ocean, and to focus global efforts on achieving "One Healthy Ocean".

The initiative comprises three interconnected platforms: the Research Expedition Vessel (REV), the World Ocean Headquarters (WOH), and the Ocean Data Platform (ODP).

Norwegian businessman Kjell Inge Røkke, founder of American Seafoods, one of the largest fisheries in the world, is financing this initiative with a vision "to advance from understanding to solution". He is working with REV Ocean's CEO Nina Jensen (former WWF Norway General Secretary) in finding the way forward for a healthy ocean and sustainable fish resources.

"I am a fisherman and curious by nature," Røkke says. "Resources in the oceans and on the seabed have provided significant value for society – and also for my family and myself. For this, I am very grateful." REV Ocean is his commitment to giving back.

Research Expedition Vessel (REV)

When completed in 2021, the $350 million REV I will be the largest and most advanced marine research platform in the world. The first research missions, in the latter part of 2021, plan to visit Arctic Norway and Greenland.

Rendering of REV I, the largest, most advanced marine research platform in the world, currently being built. Photo: REV Ocean.

International scientists, research institutes, and innovative thinkers will submit proposals: if successful, they will have free access to the vessel and its state of the art technology for at least three years.

The 183 metre long vessel will accommodate 60 scientists and 30 crew. It will be equipped with scientific trawls, sonar systems, a moonpool, underwater vehicles, advanced communication equipment, live streaming facilities, laboratories, classrooms and an auditorium.

Government leaders will be invited to take part in dialogues and events on REV I so that the outcomes of these expert discussions will enable them to implement effective marine conservation policies in their home countries.

World Ocean Headquarters

The World Ocean Headquarters will be an incubator for the ocean research community, with conference facilities, education centres, and live streaming to REV I. The headquarters will enable stakeholders from a diversity of backgrounds and countries to meet and work together to find solutions to issues of ocean health.

The Ocean Data Platform

The Ocean Data Platform (ODP) will integrate public sector, business and academic ocean data into an open source platform. The aim is to foster better decision-making and more successful conservation and utilisation of ocean resources by improving availability, access and analysis of global ocean data for all.

Triton: a three-person ocean research vessel with a diving depth of 2300m that will be used by researchers on REV I. Photo: REV Ocean

South Africa On Board

Professor Asgeir J. Sørensen, Director of the Centre for Autonomous Marine Operations and Systems, in the Department of Marine Technology at the Norwegian University of Science and Technology www.ntnu.edu/amos gave a presentation on REV Ocean at the SANOCEAN Conference at Nelson Mandela University in April 2019. He said:

"Ocean sciences research universities like Nelson Mandela University and other relevant stakeholders and organisations in South Africa will be welcome to submit proposals and participate in the scientific campaigns organised by REV Ocean.

"There will be calls for participation on selected science topics, and an international group of independent experts headed by Dr Alex Rogers, REV Ocean's Science Director, will evaluate the proposals and allocate ship time."

Rogers, formerly a professor of conservation biology at the University of Oxford, has spent over 25 years studying deep sea and coral reefs. His focus has been on marine biodiversity and its drivers, and how to mitigate human impact on the oceans.

Links to REV Ocean information and videos
Facebook: @RevOcean
revocean.org

New Marine Robotics Unit

Boaty McBoatface – one of the National Oceanography Centre's autosubs – a long range autonomous vehicle that can travel for many kilometres and to great depths underwater, gathering scientific data.
Photo: National Oceanography Centre (NOC)

Nelson Mandela University has been chosen by the IIOE-2 to be the hub for marine robotics in a Western Indian Ocean (WIO)-wide research network.

The IIOE-2 or the Second International Indian Ocean Expedition (IIOE-2) is a global scientific programme that is currently engaging the international scientific community in collaborative, wide-ranging Indian Ocean research.

In March 2019 Nelson Mandela University's Faculty of Engineering, the Built Environment and Information Technology (EBEIT) launched its transdisciplinary Marine Robotics Unit (MRU). The MRU's engineering team is headed by Akshay Lakhani, Group Specialist: Systems and Control at eNtsa, a research and innovation hub within the faculty.

"Our oceanographic researchers need robotic technologies to collect *in situ* ocean data both in the coastal and offshore regions, and we need to develop innovative ways to assist robotic platforms to navigate in unknown and difficult regional ocean environments," Lakhani explains.

"Current methods of collecting ocean sciences data using conventional ships, amongst other methods, are very expensive and few developing countries have the resources to own and operate research vessels. Marine robotics offer a much needed

solution as they are relatively inexpensive and easy to deploy, allowing our ocean scientists and research units to operate at a world-class level."

Marine robots for our oceans

"The MRU will support WIO-wide research through the design and development of new marine robotics and deployment systems, specifically designed for our oceans,

This includes aerial platforms (i.e. drones), specialised sensor development, and optimised data-capturing, storage and sharing in support of ocean sciences."

The MRU will also manage the deployment and operation of off-the-shelf, existing robotics such as autonomous underwater vehicles (AUVs), subsurface ocean gliders, surface wave gliders and ARGO floats. These devices are commercially available and relatively inexpensive (R2 to 3million) when compared to the use of research ships. These platforms can be deployed from small boats and remain at sea for anything from days to months. The MRU will host and maintain this equipment with dedicated Nelson Mandela University engineers, technologists and technicians.

Marine robotics partnership with Norway

The Norwegian University of Science and Technology (NTNU) in Trondheim, Norway is collaborating with Nelson Mandela University on marine robotics for ocean research including in coastal waters, deep oceans such as the Atlantic Ocean, Indian Ocean and Southern Ocean. "Norway and South Africa are on each end of the Atlantic Ocean entering into Antarctica and the Arctic regions. We share the same interest in ocean governance and value creation from pole to pole," says Professor Asgeir J. Sørensen, Director of the Centre for Autonomous Marine Operations and Systems (AMOS) in the Department of Marine Technology at NTNU. folk.ntnu.no/assor

"By using small-satellites customised with sensors and communication payloads, unmanned aerial vehicles, ships, unmanned surface vehicles and underwater vehicles we will jointly work on common education, research and innovation programmes," he explains.

"The new technology increases the ocean mapping spatial and temporal coverage and resolution tenfold and in considerably less time compared to previous methods. This does also pose challenges that we are addressing in terms of data management and analysis. Again, we look forward to addressing this with our partners and in cooperation with the pioneering Research Expedition Vessel (REV) Ocean initiative launched in Norway in 2018, with whom we are working on an open data platform for ocean research."

Akshay Lakhani

"Marine robotics offer a much-needed solution as they are relatively inexpensive and easy to deploy, allowing our ocean scientists and research units to operate at a world-class level."

ecoSUB's Terry Sloane describing this nifty marine research robot at the IIOE-2 conference.
Photo: Michael Sheehan

"As battery and sensor technology and electronic equipment got smaller, we saw an opening for smaller, far more affordable versions of this technology."

Democratising Marine Research

ecoSUBm25 and ecoSUBμ5.

Autonomous underwater vehicles (AUVs) are essentially small unmanned robot submarines used for monitoring and research. AUVs are equipped with powerful electronics and artificial intelligence to independently collect data using their on-board sensors.

There are a wide range of AUVs used for marine research, and in the oil and gas industry, but they are expensive, ranging from £100 000 to £2 million.

"As battery and sensor technology, and electronic equipment got smaller, we saw an opening for smaller, far more affordable versions of this technology," says Terry Sloane, the co-owner and managing director of Planet Ocean Ltd which developed ecoSUB. "Our mission is to democratise the use of AUV technology because at the moment it is only available to wealthy institutions and we want to change this.

"We applied for and won UK government funding and developed the ecoSUB, which enables the use of AUV technology from a beach or jetty or from small boats. You can do excellent science and the benefit is they are very easy to use and one-tenth of the price. The half-a-metre long ecoSUBu is around £10 000 and the 1metre version is about £20 000."

Larger AUVs can carry several sensors, whereas the ecoSUBs carry one or two sensors but scientists can use a 'shoal' of them, each with different sensors, to monitor anything from the salinity and dissolved oxygen in the water to the chemistry, pH, zooplankton and phytoplankton and sound. "In January we put a shoal of six in the water at Loch Ness and we will be going for a shoal of 10 in July off the UK coast," says Sloane.

He explains "the ecoSUBs can stay in the water from a few hours to two days, and they can 'talk to each other', which is a relatively new development. Basically one of the ecoSUBs in the shoal will occasionally come to the surface and get the GPS position and communicate this acoustically to the others that have stayed submerged, which reduces the mission error to 5m regardless of how far they have travelled. How far they travel depends on what sensors and batteries they carry, but we are aiming for 100 and 200 km for smaller and larger ecoSUBs respectively. The smaller ecoSUBμ currently goes down to 500m – the depth of most continental shelves – and larger one, ecoSUBm, can go down to 2500m."

For more information:
www.ecosub.uk
www.planet-ocean.co.uk

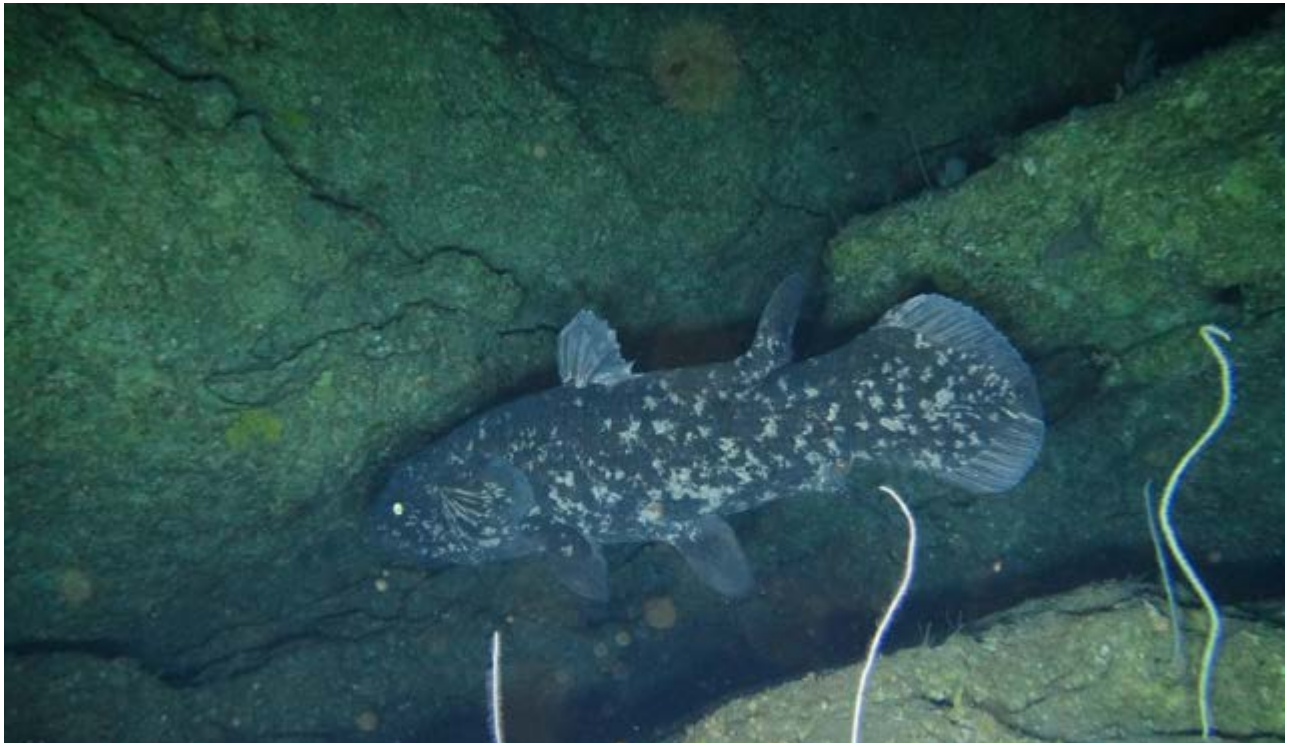
Transforming South African Marine Research

Ryan Palmer of the Grahamstown-based South African Institute for Aquatic Biodiversity (SAIAB) is the Technical and Scientific Manager of the African Coelacanth Ecosystem Programme (ACEP).

The African Coelacanth Ecosystem Programme (ACEP) is an inter-departmental flagship programme of the South African Department of Science and Technology, with close ties to the Department of Environmental Affairs.

Implemented by the South African Institute for Aquatic Biodiversity, ACEP works on multiple fronts:

- It supports multidisciplinary marine research projects, through funding, infrastructure and technical and logistical support;
- It promotes the importance of marine science and encourages the younger generation to pursue careers in marine disciplines;
- It trains students as the next generation of researchers, resource managers and policy makers; and
- It is transforming the South African marine research landscape to better represent the South African community, including a dedicated intervention to build capacity at historically black universities.



Coelacanth photographed at 114m in Jesser Canyon, Sodwana Bay. (ACEP Canyon Connections Project)

ACEP Phuhlisa

The ACEP Phuhlisa (development) programme aims to build the reputation of historically black universities within the marine research community. Four universities are currently receiving capacity-building training: Walter Sisulu, Fort Hare, Zululand, and the University of the Western Cape.

ACEP then offers prioritised access to its Marine Platforms, and provides running costs and student bursaries. Four projects are currently researching questions relating to Marine Protected Areas (MPAs), to assist in deciding where – and how much – protection is needed, for which species, and from what pressures.

ACEP Marine Platforms

The ACEP Marine Platforms consist of technologically advanced, specialist equipment that is typically not available to universities and research institutions. The platforms are managed by skilled instrument scientists, who not only assist with data collection, but train researchers and students on the use of the equipment, data analysis and interpretation and also supervise postgraduate student research projects.

These platforms include:

- Coastal Craft: a fleet of small vessels, which provide marine researchers with access to their study sites, one of the biggest hurdles they usually face. The vessels are equipped with oceanographic equipment such as Conductivity Temperature Depth (CTD) profilers, water samplers, Acoustic Doppler Current Profilers (ADCP) and plankton sampling equipment.
- A Marine Remote Imagery Platform (Mar-RIP) consisting of a range of stereo baited remote underwater video systems used to study fish communities between 10m and 1100m deep, as well as a Remotely Operated Vehicle (ROV). This technology is allowing researchers to visually explore the South African deep sea environment for the first time.
- An Acoustic Tracking Array Platform (ATAP) consisting of a network of over 100 listening stations strategically positioned around the coast and in estuaries to monitor the movement of animals tagged with acoustic transmitters. Over 1000 animals are being tracked and the network is revealing astounding movement patterns for many species.
- GEOMAP, ACEP's geophysics platform, which allows researchers to map the seafloor in high resolution using multi-beam sonar, providing useful data to marine geologists, ecologists, and marine spatial planners.

For more information:
www.saiab.ac.za/acep.htm

The ACEP Phuhlisa (development) programme aims to build the reputation of historically black universities within the marine research community.

Maritime Engineering & Naval Architecture

Nelson Mandela University's New Engineering Building, Phase I.

In January 2018 Nelson Mandela University's Faculty of Engineering, the Built Environment and Information Technology (EBEIT) launched its bachelor's degree in Engineering Technology in Marine Engineering .

"There is such enthusiasm about our marine engineering degree and we plan to register 75 first year students each year," says Howard Theunissen, EBEIT's Marine Engineering and Nautical Science Project Manager, and programme leader for this unique qualification in South Africa.

"The degree is accredited by the South African Maritime Safety Authority and the Engineering Council of SA, which is a signatory to the body of engineering councils around the world."

Since 2018, EBEIT's degree programme – along with those at selected European universities – has been funded by the European Union's Erasmus+ programme. Nelson Mandela University is the lead South African university in the consortium.

EBEIT plans to offer a Naval Architecture honours degree from 2022 and a master's thereafter. The faculty is engaging with the Royal Institute of Naval Architects (RINA) and Philip Wilson, a world-renowned professor of naval architecture from

the University of Southampton, to ensure that its postgraduate curriculum meets international marine engineering education standards.

Growing the maritime industry in SA

"It's essential that we meet international standards," says Theunissen. "The maritime industry in South Africa growing, and forms part of the Operation Phakisa Ocean Economy growth drive, but at the moment there are limited posts available here, which means that currently most our marine engineering graduates will need to work overseas. Hopefully South Africa will provide future opportunities for employment in the sector, including ship's officers, engineers and technologists for the shipping, and leisure craft construction sector.

"As a faculty we intend to play a significant role in developing Port Elizabeth as a manufacturing hub for all marine vessels, including ships in the 80m to 130m range. This includes our biggest navy vessels – our 130m corvettes – and modernisation of our fishing fleet."

Naval Architecture PhD

The Faculty of EBEIT's first Naval Architecture PhD candidate, Boswell Douse, is focusing on the hulls of fishing vessels in the southern hemisphere. He explains that all fishing vessel hulls are designed for northern hemisphere ocean conditions, and our southern oceans are very different, which calls for a different design of hull.

In lay person's terms, most of the continental land mass is in the northern hemisphere and therefore there are relatively smaller ocean expanses between the landmasses, with relatively smaller more frequent waves. In the southern hemisphere there are vast oceans between the landmasses, which results in longer, higher waves being generated from the south pole and Antarctic. The frequency of the waves is also less in our oceans, which results in the build-up of bigger, more powerful swells.

University of Southampton towing tank carriage and work station.

The result is that the vessels roll a lot more in the southern hemisphere oceans, which is not comfortable for the seafarers on the boats. Another factor that needs to be built into the design is the high temperature variability in the southern hemisphere oceans – from the cold temperatures when they go down south to the hot, tropical conditions up the east coast of Africa.

Key training partnerships: merSETA and Wärtsilä

The faculty has received considerable support locally and internationally for its marine and maritime focus. Credit is due to Dr Raymond Patel, the CEO of the manufacturing, engineering and related services SETA (merSETA). His foresight as to what the growth of EBEIT's offerings can contribute to the blue economy, led to the SETA awarding the faculty an annual R10m grant over the past three years.

One of EBEIT's key industry partners is the Finnish marine manufacturing and engineering corporation, Wärtsilä. The company routinely trains engineers and technicians from all over the world, with English as the medium of instruction.

Wärtsilä sales are represented in South African by USG Advisory Services, a division of the Urban Soul Group whose CEO, Greg Davids, is a prominent figure in the marine manufacturing sector. He has extensive experience and long-standing partnerships in the international and South African shipbuilding and repair industries, and among vessel owners and fleet managers, as well as the fishing sector.

In 2016, EBEIT appointed Davids as an Adjunct Professor, bringing his industry knowledge to the University and his foresight in developing EBEIT's marine and maritime strategies.

Wärtsilä is contracted to supply the engines and power train for the South African Navy's new

Marine Engineering PhD Boswell Douse (left) and John Fernandes lecturer in Marine Engineering, from Nelson Mandela University, at the University of Southampton.

hydrographic vessel – a scientific research and investigation vessel being built by the Southern African Shipyards in Durban. As part of the development activities required in their contract, Wärtsilä is establishing a Wärtsilä/Nelson Mandela University Land and Sea Academy.

The company has donated engines, a gearbox, thruster and propeller, and a range of leading-edge simulation and software packages for the training of technicians and marine engineers who work on ship power systems. Marine Engineering students at Nelson Mandela University will also attend live video link training classes from Wärtsilä's headquarters in Finland.

Short Learning Programmes

From 2019 EBEIT is offering a range of accredited short learning marine programmes, including sea safety courses, first aid and personal survival techniques, and Wärtsilä-accredited short courses for their equipment.

These courses are all Standards of Training Certification and Watchkeeping (STCW) short courses, and they are for anyone going to sea – from a ship's captain to a yacht crew member, to a hair stylist on a cruise ship or a yacht.

Marine Engineering Lab

EBEIT is working on concept proposal for a new Nelson Mandela University/ Wärtsilä/merSETA Marine Engineering Lab to be constructed in the New Engineering Building at Nelson Mandela University. The proposal includes a construction of a mezzanine floor with marine offices above the Engine Lab.

virtualmedia.co.za/CLIENTS
afriplantour/1001/1001/virtualtour.html

Coastal Link in the Origins of Human Awareness

Vast deposits of discarded shells were found in the middens along the southern Cape coastline.
Photo: Jan De Vynck

The cognitive revolution of humans took place when we evolved not only anatomically but also cognitively. For signs of human development into sentient, conscious beings, we look to the first indications of planning, invention, art and adornment, which, in turn reflect an awareness of self, others and the world.

Outstanding scientists from Nelson Mandela University's African Centre for Coastal Palaeoscience (ACCP) are collaborating on research into this phase of human evolution. The team includes Professor Richard Cowling and Dr Alastair Potts from Nelson Mandela University, and, from the United States, Professor Curtis Marean, Associate Director of the Institute of Human Origins and professor at the School of Human Evolution and Social Change at Arizona State University.

At Pinnacle Point Cave in Mossel Bay on the southern Cape coast, they have found sandblasted shells collected by humans some 164 000 years ago. Dr Potts explains that they know the shells weren't collected fresh for food because they were sandblasted, so had already been lying on the beach. These shells would have been used for adornment, such as necklaces.



Left to right: Khoe-San descendants participating in the ACCP's ethnographic study of marine intertidal foraging. They built a fire to cook the Turbo sarmaticus, or giant turban snails. Photo: Jan De Vynck. **Painting by Maggie Newman reflecting the lives of humans on the southern Cape coast dating back 164 000 years.** Photo: Maggie Newman. **ACCP member Dr Jan De Vynck who recently graduated with his PhD in Ocean Science from Nelson Mandela University, taking notes during an ethnographic study of marine intertidal foraging.** Photo: ACCP.

"There were also signs of art during this period, including abalone shells with five different types of ochre in them – an artist's palette. And although we do not know whether this was used for adornment or paintings, it is a clear sign of the progression in cognitive development."

During the same period, the team found vast deposits of discarded shells in the middens in the cave – evidence that humans had been harvesting shellfish in the intertidal zone. Shellfish and other aquatic resources are extremely rich in the specific nutrients that the brain requires to grow, such as iodine and omega3 polyunsaturated fatty acids.

"These humans also had a rich source of terrestrial plant foods, including bulbs and berries, and the region at the time was full of animals: giant zebras, wildebeest, buffalo, even giraffe," says Potts who, with his colleagues, has reconstructed what this extinct ecosystem might have looked like.

Also in Pinnacle Point Cave and dating from 164 000 years ago to about 72 000 years ago, the scientists found many heat-treated pieces of a shiny red rock called silcrete, small chips of which were used to make implements and light projectiles for hunting.

It is much easier to strike off small, sharp flakes of heat-treated silcrete than raw silcrete from a chunk of the rock. To demonstrate this, the scientists built underground ovens and slowly heated the silcrete to 350°C, maintaining it at that temperature for a few hours. The rock was then gradually cooled down to 40°C, usually overnight, at which point it could be chipped into sharp pieces. This example of how pyrotechnology was used to form some of humanity's oldest tools, is further evidence of the cognitive development of these early hunter-gatherers.

Big Thinking. Big Science.
What is Africa doing about its oceans?

The Western Indian Ocean (WIO) region, extending up the eastern coast of Africa, has the most serious food security problem on the planet.

It is estimated that 60 million people in the WIO directly depend on the ocean for their livelihoods at a time when the indications are that the WIO is warming faster than the world's other oceans, which impacts all levels of the marine food web. Overfishing, destructive fishing practices and high levels of pollution are causing the WIO marine environment to deteriorate further.

What is Africa doing to address this?

"We are pursuing intensive research to understand and address the key questions of what sustains marine food security, what are the underpinning ecosystems and how do they function in this era of climate change and changing global oceans," says marine specialist scientist Professor Mike Roberts, who heads the South African Research Chairs Initiative (SARChI) in Ocean Science and Marine Food Security.

"At the same time we are upscaling the number of South African, African and international scientists, PhDs and postdoctoral fellows pursuing pioneering ocean sciences research in South Africa and the WIO region"

Fisherman with the day's octopus catch, Zanzibar. Photo: rahimsaggaf_photography

Maroantsetra market in Madagascar.
Photo: © Josh Cinner

Launched in May 2016, the Chair is jointly hosted by Nelson Mandela University in Port Elizabeth, the University of Southampton (UoS) and the Southampton-based National Oceanography Centre (NOC) – the United Kingdom's leading marine science research and technology institutions.

All the way up the food chain

Roberts and his team's Western Indian Ocean Upwelling Research Initiative is a flagship project of the International Indian Ocean Expedition phase 2 (IIOE2), a major UNESCO supported research initiative. Upwelling, he explains, is the upward movement of deep, cold, nutrient-rich water to the ocean surface, encouraging the growth of phytoplankton (microplants which form the base of the marine food web), which ultimately provides energy all the way up to the top marine predators. As the planet's climate changes, so does the ocean's upwelling system, affecting marine food security in the Western Indian Ocean (WIO).

Transdisciplinary research approach

"Researching this requires a transdisciplinary approach, investigating physical oceanography, biogeochemistry, plankton, trophic ecology, fisheries and food resources, and quantified by end-to-end ecosystem and socioeconomic modelling," says Roberts. "It further requires the development and use of advanced – and costly – ocean-atmospheric computer models and big data facilities. Africa does not currently have these resources."

Innovation Bridge – Regional Hubs

The encouraging news is that Roberts' Chair is developing what he has termed the *Innovation Bridge – Regional Hub* (IB-RH). Essentially this will build strong, formal partnerships between top institutions in Africa and top, well-resourced institutions in the Global North. "Through this alliance, we can build southern hemisphere research capacity and critical mass to tackle developmental and ocean science challenges that are equally challenging for Northern institutions, as the Indian Ocean is the least researched and understood in the world."

Prof Mike Roberts and ecoSUB – a new generation marine research robot.

Time is not on our side

"Time is not on our side, so we managed to put the IB-RH in place in a record time of 1.5 years," says Roberts. "Salaries and research costs, ships and robotics are secured for field campaigns, and access

to the large NEMO/MEDUSA-2 biogeochemical ocean model and satellite data acquired."

The innovation bridge will have a continuous flow of people and research between the Global North and Africa, with regional projects extending from South Africa all the way up Africa's eastern coastline. The Ocean Science Campus at Nelson Mandela University, in partnership with Rhodes University – which brings fisheries science into the mix – forms the principal southern footprint of the bridge.

Growing Master's and PhD students

"Nelson Mandela University, with its African partner institutions, is focusing on growing the postgraduate ocean sciences pipeline to over 100 students, and we already have 50 master's and PhD students registered. Combined with the additional exposure to researchers and facilities at the University of Southampton (UoS) and the National Oceanography Centre (NOC), we are creating a Centre of Excellence in Ocean Sciences.

A number of these postgraduate students have already spent time at the UoS and the NOC to acquire specialist technology skills.

One of these technologies, already being used by the programme's researchers, is coastal altimetry, a form of satellite measurement.

"Altimetry measures the height of the ocean surface, and from this we can determine much about the ocean currents that play a very important role in the functioning of the ecosystems," Roberts explains.

"Only time will tell whether this ambitious initiative can overcome the hurdles of accessing big science to address the impending WIO food security crisis. In the meantime we will put massive effort into producing the next generation marine scientists in Africa to help fix the future."

A young man plays his role in getting the daily catch home to his family, Matemwe, Zanzibar. Photo: © rahimsaggaf_photography

"Nelson Mandela University, with its African partner institutions, is focusing on growing the postgraduate ocean sciences pipeline ... "

The Ellen Kuzwayo – research ship of South Africa's Department of Agriculture, Forestry and Fisheries.

Fishermen, Matemwe, Zanzibar.
Photo: © rahimsaggaf_photography

Two Major Ocean Sciences Case Studies

Through the SARChI Chair in Ocean Science and Marine Food Security, Prof Roberts has secured R160 million from the United Kingdom's Global Challenges Research Fund SOLSTICE-WIO programme (Sustainable Oceans, Livelihoods and food Security Through Increased Capacity in Ecosystem research in the Western Indian Ocean.) www.solstice-wio.org

These funds are being used for case studies in South Africa, Kenya and Tanzania.

Case Study 1

South African Squid Fishery Collapse 2013

Nelson Mandela University researchers are investigating the causes of the squid fishery collapse in the Eastern Cape between 2013 and 2016, during which time some 2 500 squid fishermen lost their livelihoods, affecting an estimated 35 000 family dependants.

Both the fishing industry and the Department of Agriculture, Forestry and Fisheries (DAFF) need to understand what caused the collapse of the squid fishery, and if it will happen again.

In April this year a research team from Nelson Mandela University's Ocean Sciences Campus completed a two-week field study aboard the DAFF research ship Ellen Kuzwayo. The team comprised postdoctoral fellows, Dr Sarah Asdar and Dr Patrick Vianello, specialising in ocean modelling and satellite observations, and eight PhD and MSc candidates, seven of whom are

women. Their focus? One of the world's toughest questions – how will climate change impact our fisheries and food security?

Three hypotheses have been put forward to explain what happened:

1. There was an unusual high occurrence of the Benthic Nepheloid Layer (BNL) – a thick layer of suspended particles that cloud the water – on the squid's spawning grounds. The ability to detect body patterning is important to the squids' sexual behaviour; lack of visibility caused by the BNL may have prevented them from mating successfully.
2. Ocean productivity (zooplankton) on the Agulhas Bank at the time was particularly poor, starving the squid paralarvae of nutrition.
3. Unusual meanders in the trajectory of the Agulhas Current washed the squid larvae off their hatching grounds into the southern ocean, leading to their mass demise.

"To explore these hypotheses requires a formidable research effort involving ocean models, satellite observations, marine robotics, ship-based surveys and laboratory experiments. This is putting Nelson Mandela University at the very forefront of ocean science," says Roberts, adding that it would not be possible without the help of the Innovation Bridge.

The researchers are looking at the bigger Indian Ocean picture, where the landmass of Madagascar is responsible for the unique ocean dynamics of the south. "Here, the South Equatorial Current

Mama samaki (fisherwomen) East Africa © Oskar Henriksson

that flows across the Indian Ocean from east to west strikes the unique configuration of the Mascarene Plateau and Madagascar Island," Prof. Roberts explains. This induces mesoscale eddies – large, swirling masses of water – in the Mozambique Channel and the Agulhas Current. In the Mozambique Channel this mesoscale turbulence is responsible for significant ocean production, but further south on the edge of the Agulhas Bank, it can cause substantial loss of shelf waters. It is not known whether the turbulence is increasing and therefore whether this kind of fishery crash could be more regular, and what this means for livelihoods and food security.

The data from the research trip still needs to be analysed. However, interestingly, the satellite observations and ocean models suggest that an oceanographic feature of the Agulhas Bank, believed to be responsible for much of the ocean productivity here, was absent in 2012. This would explain the fishery crash in 2013. "Ultimately, we believe there has been a regime shift in the Agulhas Bank ecosystem, probably as result of climate change. If this is the case, we need big models to help us anticipate future shifts and to predict if or when this will happen again."

Case Study 2

East African Marine Ecosystems

The Chair's partner institutes in Kenya and Tanzania are carrying out case studies on the northern Western Indian Ocean (WIO), where there has been limited scientific research. Their research will increase understanding of how the marine ecosystems function in this region, how they are changing and how this is impacting the ocean food resources.

Roberts explains:

"Our partners from the Tanzanian Institute of Marine Studies and the UK National Oceanography Centre deployed a series of satellite-tracked ocean drifters in the Pemba Channel as a precursor to further experiments, using underwater ocean gliders, in July this year.

"The focus here is small artisanal pelagic fisheries, which sustain coastal communities. Tens of small, locally built boats venture out into the Channel to fish at night using nets and lamps.

"Zanzibar and mainland Tanzania coastal communities are dependent on the monsoon-related small pelagic fish (anchovies, sardines, mackerel, threadfin and herring) for food and income. The abundance of these fish varies from year-to-year depending on the strength of the monsoon. Fluctuations in the supply depend on the degree of coastal upwelling caused by the monsoons – which brings nutrients into the surface waters.

"As resources are scant, the drifter experiment used nine simple surface drifters, constructed from inexpensive, off-the-shelf electronics and locally available materials, to identify the complexity of flow in the lee of Pemba Island, north of Zanzibar, during the South-East monsoon season, the most energetic period for this part of the Western Indian Ocean (WIO). In July scientists from Nelson Mandela University, the UK and locally will augment this information with a ten-day ship survey to collect data under the sea surface.

"In Kenya, together with the Kenya Marine and Fisheries Research Institute, we are looking coastal upwelling around the North Kenyan Banks. Here there is an emerging line fishery, with small boats venturing some 80 km offshore to fish the waters. Early results from a two-week field study aboard the Kenyan research ship Mtafiti suggest major changes in upwelling occur during El Niño climate cycles.

"In synopsis, we know ocean productivity is decreasing in the tropical WIO as a result of warming seas. The research aims to determine if this coastal region of the WIO is changing too, how this is affecting the food web, and most importantly, to use the computer models to forecast the future. We suspect the answers point towards a decrease in food production in the future. The trick then is to engage with the respective governments and to initiate policies to mitigate this challenge."

The French Connection

In addition to the Africa-UK Innovation Bridge-Research Hub, an equally important innovation link is being built with leading French marine research institutions, most notably the Institut de Recherche pour le Développement (IRD) in Marseille and the Université de Bretagne Occidentale (UBO) in Brest.

The first large ecosystem functioning research project with the French was on the Mozambique Channel. It looked at the impacts of mesoscale eddies on the Mozambican prawn fishery. Another research project is focused on a seamount 200 km south of Madagascar. Seamounts play a special role in the global ocean, their special shape and depth providing biodiversity hotspots. They attract top predators such as tuna, billfish and sharks near their summits, and fish like the orange roughy much deeper on the flanks.

Roberts says: "To date, we have had three cruises using French ships with scientists and students from NMU, France and Madagascar. The NMU-France research team plans to publish an 18-paper special issue for December 2019's volume of the journal *Deep-Sea Research II*. Their recommendations may play an important role in helping Madagascar formulate conservation measures."

Era of Marine Spatial Planning

South Africa has more ocean territory than land and more than 40% of South Africans live on or near a coastline. In 2014, the government launched *Operation Phakisa: Oceans Economy*, to unlock the economic potential of the oceans, based on the principles of sustainable development. One of the key tools available to promote sustainable practices in the ocean is marine spatial planning.

Professor Mandy Lombard, who holds the DST/NRF SARChI Chair in Marine Spatial Planning at Nelson Mandela University, explains, "Marine spatial planning is all about using marine resources sustainably. We bring together the research, data and everyone with an interest in the oceans—government, fisheries, shipping, energy, tourism, conservation and recreation—to make coordinated, evidence-based decisions about how to sustainably use resources and manage our oceans. Optimising economic opportunities has to be done without compromising the environment. This is non-negotiable because the ecosystem services the oceans deliver are essential for our survival."

These services include provisioning (such as food and water production), regulating (such as climate regulating through CO_2 and heat absorption), supporting (such as oxygen production), and cultural (such as recreational or spiritual activities).

Technology for mapping and monitoring of the oceans, including marine robotic platforms. Illustration: NTNU AMOS/Stenberg

Maritime tourism, shipping and fishing, Stone Town, Zanzibar. Credit: Prof Rose Boswell.

Despite a clear understanding of this dependency, humans continue to impact marine systems in potentially irreversible ways. An estimated 70% of fish populations are either fully or over exploited and altered food webs together with ocean warming are reducing food security and increasing the frequency of toxic algal blooms. Habitat destruction, pollution, ocean acidification, ocean warming … the list goes on.

The big move required

"We need to act and regulate now," says Lombard, "and the big move required is towards integrated ocean management – this has been globally recognised in policies and strategies such as the United Nations Sustainable Development Goal 14 (to conserve and sustainably use the oceans, seas and marine resources for sustainable development). However, these goals need to be implemented at local and regional levels, based on matching policy and management strategies at a national level in our Exclusive Economic Zone (EEZ), as well as in the high seas (areas beyond national jurisdiction).

"Unfortunately, South Africa's national policies tend to be fragmented and sector-specific and include decision-support tools that address only components of marine systems. For example, fisheries management tools focus on living resource extraction; integrated coastal management tools are implemented mainly along coasts; and marine protected areas and marine spatial planning are both area-based management tools. These tools are all represented in South Africa's legislative toolbox, the most recent addition being the draft Marine Spatial Planning Bill, and our 20 new marine protected areas."

Gains for all South Africans?

The enabling policy environment for these recent developments is Operation Phakisa, but is Phakisa's agenda, based on economic growth, in line with sustainable development goals? Will it really address poverty, or is it just the "business-as-usual" model of short-term gains for the few (catch all the real and predictable fish now), rather than long-term gains for all South Africans ("infinity" fish)?

Hopefully the latter, but what is required to move South Africa's ocean policies into a safe operating space? Do we need more research, and if so, which questions should we be asking, and which relationships should we be building, and with whom? The SARChI Chair in Marine Spatial planning addresses these questions through its transdisciplinary research approach, built on key

research projects and research gaps identified over 15 years of marine spatial planning initiatives in South Africa's continental and Southern Ocean Exclusive Economic Zone.

Working across marine habitats

Lombard explains that the research projects range from purely ecological, to social-ecological, and include researchers from the physical, social and economic sciences, and law. "We work with academics, government scientists, managers and civil society (particularly key NGOs). We work across habitats (from deep water corals, through marine canyons, to shallower reefs and estuaries), oceans (Indian, Atlantic, Southern) and countries (from Angola to Western Indian Ocean Islands).

"Using a Systems Thinking approach, we build spatial and temporal models, and are working out how best to couple them with policy and decision-making that can be implemented for effective sustainable-use outcomes. This critically requires addressing the current disconnect between socioeconomic and environmental policy objectives; the general lack of meaningful engagement with local communities, the lack of clarity around the philosophies, values and power dynamics that underlie concepts such as 'blue growth'; the lack of enforcement of environmental legislation (e.g., laws on illegal, unreported and unregulated (IUU) fishing); and the distinct challenges posed by global problems such as climate change and plastic pollution."

Juvenile fish. Photo: Larize Nel

One Ocean Hub

Nelson Mandela University is part of an ambitious new £20 million (R358 million) UK Government Research and Innovation Global Challenges Research Fund (GCRF) programme aimed at tackling threats to the world's oceans and addressing the challenges faced by developing countries. From plastic pollution to rising sea levels and acidification to over-fishing, the threats facing our oceans are well documented.

Called the *One Ocean Hub* it is led by the University of Strathclyde and it brings together the competing interests and agendas of the individuals, groups and organisations that rely on our oceans to realise a vision of an integrated, transdisciplinary and sustainable approach.

Nelson Mandela University is one of the 50 partners in this global research initiative that will see a number of its researchers and postgraduate students working together with the other partners in the hub.

Nelson Mandela's hub members include: Professors Patrick Vrancken (SARChI Chair in Law of the Sea and Development in Africa) Professor Mandy Lombard (SARChI Chair in Marine Spatial Planning), Professor Rose Boswell (Executive Dean of the Faculty of Arts), Professor Janine Adams (SARChI Chair in Shallow Water Ecosystems), Professor Hennie van As (Director: FishFORCE and Centre for Law in Action), Dr Bernadette Snow (Director: Institute for Coastal and Marine Research (CMR)), Dr Kerry Sink (CMR Research Associate and Marine Programme Manager at the South African National Biodiversity Institute (SANBI)).

Bridge the disconnects

One Ocean Hub programme leader, Professor Elisa Morgera, Director of the Strathclyde Centre for Environmental Law & Governance with the Law School, says: "The One Ocean Hub will bridge the current disconnects across law, science and policy to empower local communities, woman and youth – who are particularly impacted by decision-making – to co-develop research and solutions.

"The aim is to predict, harness and share equitably environmental, socioeconomic and cultural benefits from ocean conservation and sustainable use. The hub will also identify hidden trade-offs between more easily monetised fishing or mining activities and less-understood values of the ocean's deep cultural role, function in the carbon cycle, and potential in medical innovation."

Nelson Mandela University's Deputy Vice-Chancellor for Research and Engagement, Professor Andrew Leitch, says:

"The One Ocean Hub represents an innovative and dynamic plan to integrate research across disciplines in different sectors and at different scales (global-local) to address the multiple challenges to ocean health and sustainability, and hopefully advance our knowledge and actions to address the global issues challenging our planet. It speaks directly to Sustainable Development Goal 14 – the conservation and sustainable use of the oceans – but also to other goals, including blue economies and vulnerable communities."

EEZ and the high seas

Prof Lombard's focus in the One Ocean Hub is her area of speciality: marine spatial planning. "We're doing marine spatial planning in the Exclusive Economic Zone, which extends 200 nautical miles out to the sea (just under 400km)," she explains. "Through the One Ocean Hub we have research time on one of the British research vessels to do deep seabed research.

"We also want to extend marine spatial planning to the high seas which fall under the UN Law of the Sea, so that we can create 'off limit areas', such as where, for example, the tuna and migratory fish use a particular high seas corridor or juveniles grow there or when the humpback whales are migrating north from Antarctica."

An inclusive blue society

Another of the five focus areas in the One Ocean Hub is *Transformative governance for an inclusive, innovative and responsible blue society* which is looking at socioeconomic decision-making for ocean management. The project team includes lawyers, economists, social scientists, biophysical scientists and postgraduate students who are using Port Elizabeth and Algoa Bay as the project area and looking at everything from the dynamics and ocean economy of this coastal city and community, to marine genetics, to international law, to estuaries and the deep sea.

The team is working with the Nelson Mandela Bay municipality, ports and tourism authority, based on the premise that the socioeconomic engine of Port Elizabeth is driven by the ocean and you need a healthy environment to achieve increased growth, tourism and socioeconomic sustainability. The city has two ports, and a number of fisheries operate out of Port Elizabeth's harbour, including the squid and small pelagic fisheries. It has a significant number of marine mammals, including several species of whales and dolphins, as well as significant seabird populations, attracting increasing numbers of tourists to the city.

In so many ways, this is a transorganisational, transdisciplinary, trans-society mega-project, where artists are working with scientists and lawyers with city managers. It's difficult to do this as we all see things differently," says Lombard.

"As a marine scientist I find it both challenging and energising as it is not only about good science and good law, it is equally about culturally and economically connecting with the ocean, about

sustainable, better governed fisheries and about looking to the near future when the technology is available to achieve the deepest sea mining, which comes with threats and impacts that we do not yet understand in the very deep benthic environment."

The Oceans and Africa's Maritime Domain

"The vast, diverse and rich expanses of the African maritime domain need to become as much part of the African worldview as the continent's savannahs, mountains and cities. Africans must not only explore and exploit, but also protect their marine resources and their environment themselves. African ocean governance has to be based on cooperation, transformative justice, transparency, accountability and the rule of law."

This is an excerpt from the preface of a seminal 800-page book published in 2017 titled *The Law of the Sea – The African Union and its Member States*. The co-editor is Professor Patrick Vrancken who heads the South African Research Chair in the Law of the Sea and Development in Africa at Nelson Mandela University. The other co-editor is Emeritus Professor Martin Tsamenyi, who is a former director of the Australian National Centre for Ocean Resources and Security (ANCORS) and an adviser to Ghana on maritime boundaries issues and fisheries governance.

It is the first work to attempt to systematically collate the legal aspects of ocean governance in African countries. The book is therefore an indispensable reference for all the role players in the African maritime domain, including governments, business, civil society, lawyers, scientists and students. "Before this book, you had to rely to a much greater extent on what was written outside of Africa, which was often unreliable, biased and incomplete," Prof Vrancken explains.

"This book, by contrast, is produced on the continent, focusing exclusively on the continent and written by people who are based in Africa or are part of the diaspora."

Prof Vrancken spent most of 2015 to 2017 working on this opus, including encouraging several young African scholars to produce chapters for the book.

He explains, "As Africans we are making renewed efforts to explore, exploit and protect the maritime zones that surround the content so that they play their rightful role in the global ocean economy, which is essential for us to be ablt to contribute to the realisation of a just and equitable international economic order."

Law of the Sea and Development in Africa

The SARChI Chair in the Law of the Sea and Development in Africa was established in 2013 and has been renewed for a second five-year cycle until 2023.

The Chair and its numerous master's and doctoral students are focusing on the following three areas:

1. South Africa and the law of the sea, including the legal regime governing the South African continental shelf and the exploitation of its resources;
2. Development in Africa and the law of the sea, including relevant indigenous law – research at international and comparative level on:
   i. the East coast of Africa and the Indian Ocean;
   ii. the West coast of Africa and the Atlantic Ocean; and
   iii. the Southern Ocean and Antarctica;

3. The legal aspects of marine tourism.

IUCN Marine Mammal Task Force includes SA

In March 2019, the International Union for the Conservation of Nature's (IUCN) Marine Mammal Protected Areas Task Force (the "Task Force") completed the fifth Important Marine Mammal Area workshop in Salalah, Oman.

The week-long workshop hosted 38 marine mammal scientists and observers from 15 countries to map the important habitats for 130 species of marine mammals in the Western Indian Ocean and Arabian Seas.

The delegates from South Africa were Dr Stephanie Plön (who heads the Ocean Health Unit at the Earth Stewardship Science Research Institute, Nelson Mandela University), Dr Vic Cockcroft (Nelson Mandela University) and Professor Ken Findlay (Cape Peninsula University of Technology (CPUT), Cape Town).

"A record 55 candidate important marine mammal areas, or IMMAs, were identified," says Dr Plön. This includes five for South African waters, which encompass all of South African coastal and shelf waters, including:

- The inshore waters along the southern Cape

Humpback whale breaching. Photo: Dr Stephanie Plön

coast – False Bay to Algoa Bay - where southern right whales are found to mate and give birth between June and November every year;
- East coast waters within 15km from shore that are known for migrating humpback whales. They migrate from their feeding grounds in the Antarctic to the Indian Ocean/Mozambique/Madagascar to give birth between June and November each year, and back to the Antarctic from about September or October to November;
- Southern coast inshore and shelf waters where the inshore Bryde's whale is found. It has been declared as 'vulnerable' in the last South African Red List assessment;
- The south coast inshore Indian Ocean humpback dolphin habitat where South Africa's only 'endangered' marine mammal is found; and
- The south-east coast seasonal sardine run area, where marine apex predators, such as common dolphins, Indo-Pacific bottlenose dolphins, Bryde's whales, Cape fur seals and killer whales can be seen following the annual migration of sardines in May/June every year.

The candidate IMMAs are currently being assessed through a rigorous scientific process. Once approved (towards the end of 2019), they will be placed on the IMMA e-Atlas and can be used for conservation planning.

"South Africa's marine environment is a global biodiversity hotspot," says Plön. "Hopefully our five candidate IMMAs will be approved because far more needs to be done to raise awareness about our incredible marine heritage, and the need to experience it and conserve it."

For more information:
marinemammalhabitat.org

Algoa Bay – The Dolphin Capital
"You are out there in the middle of hundreds of dolphins and it is amazing and overwhelming to experience them in a feeding frenzy. The water is literally boiling with dolphins and gannets, and amongst all this you're observing and trying to photograph the dolphins, because we identify individuals for our research from notches or marks on their dorsal fins," says Dr Stephanie Plön, who specialises in dolphin and whale (cetacean) research.

"These species are not only important in their own right, they are key indicator species for overall ocean health, because they are at the top of the marine food chain. Research on them informs the decisions and actions required to sustainably conserve our oceans and marine species."

Dolphin and whale (cetacean) specialist, Dr Stephanie Plön.

Algoa Bay in Port Elizabeth is the ideal place to do this research for a number of reasons, including the abundance of dolphins and whales in these waters and the marine mammal collection at the Port Elizabeth Museum, which is the largest in the Southern Hemisphere and third largest in the world.

"Algoa Bay is fascinating for marine scientists, with its unusually large group sizes of common and bottlenose dolphins – we see groups ranging from 10 to 15 bottlenose dolphins to several hundred common dolphins, often associated with bait balls or large schools of sardines or red eyes (part of the herring family). Sometimes these bait balls are a kilometre in diameter," Plön explains.

Indian Ocean Humpback Dolphin in trouble
While Algoa Bay's bottlenose and common dolphin populations appear to have healthy population sizes, the Indian Ocean Humpback Dolphin is in serious trouble. It is now classified as 'Endangered' according to the 2016 Red Data Book of Mammals of South Africa. The estimate is that the population has dropped to under 1000 individuals for South African waters and is most likely close to only 500 animals.

Common dolphins. Photo: Dr Stephanie Plön

The population decrease could be related to a decrease in food availability and/or a range of human impacts – from shipping and fishing to pollution and paddle skis. Plön explains that the Indian Ocean humpback dolphin is an extremely shy animal that is easily disturbed:

"These animals live in the coastal zone within 500 metres from the shore where there is a lot of human activity, and this might have a negative impact on their reproductive rate or food abundance. Even paddle skiers surprise them when they get within a few metres of them, which is why I always advise paddle skiers to be on the lookout and to keep their distance," explains Plön.

Dolphin strandings

Over the past decade Plön has been researching the pathology and health aspects of stranded Indian Ocean dolphins, comparing them to the dolphins incidentally caught in the KwaZulu-Natal shark nets.

"We know that strandings are in most instances a result of the animal being sick, whereas the by-catch animals should be reflective of the normal, wild population. The pathology investigation therefore significantly assists us in assessing the general health of South Africa's oceans," Plön explains.

Since 2009 parasite lesions have been detected in all the dolphin species, and in both stranded animals as well as those caught in the shark nets. The specific parasite is yet to be identified, but marine parasites are increasingly being linked with ocean pollution.

In an international study published in April this year, Plön and her co-authors from Spain and Northwest University, Potchefstroom, found polybrominated diphenyl ethers (PBDEs) and dechloranes in dolphins from the eastern coast of South Africa at levels 10 times higher than those from more industrialised areas, such as the Alborán Sea in the Mediterranean. PBDEs are the most used flame retardants (FRs) and are incorporated in a great variety of indoor and outdoor products, and applied to all kinds of materials, such as household appliances, office electronics, textiles and furniture.

Reports about FRs in biota and environmental samples from South Africa and the Indian Ocean are scarce. This region should be further studied to see if these levels are the consequence of a high local contamination, and if these compounds contribute towards population decline and deteriorating health in local whales and dolphins.

India Rapidly Gearing Up

"India is rapidly gearing up its blue economy and its ocean sciences research," says Hyderabad-based Dr Satheesh Shenoi, director of the Indian National Centre for Ocean Information Services (INCOIS), and co-chairperson of the IIOE-2 steering committee.

"We are building more ports and harbours so that many more goods can be transported by ship, which is far more cost effective, with fewer carbon emissions. India is also looking at the resources in the oceans, including oil and gas and potential medicines. We recognise the critical role of our oceans in climate change, and are investing substantially in ocean research and ocean observation.

Monsoon winds

Sailors in the Indian Ocean have always known that the monsoon wind pattern changes twice a year, but investment in research into these winds and the many complex dynamics of the Indian Ocean is only fairly recent. With the Indian Ocean warming faster than any of the world's other oceans, the IIOE-2 is very much part of the shift towards conducting scientific research in the region.

"The International Panel on Climate Change (IPCC) report published a few years back, showed that in two decades, ±93% of the excess heat that has gone into earth systems has gone into the ocean; the remainder has gone into the atmosphere and into melting the glaciers," says Shenoi.

Recovery of a Lagrangian Float that is used to study the top uniform layer of the ocean

Why the Indian Ocean is warming

Shenoi suggests two possible explanations for Indian Ocean warming that require further research:

1. The Indonesian throughflow from the Pacific has increased, bringing more of its warm water into the Indian Ocean.
2. The westerly winds over the equatorial Indian Ocean are becoming stronger, strengthening the downwelling conditions, and leading to the warming of the upper ocean.

Over 40% of the world's population lives in countries prone to cyclones, flooding and droughts along the Indian Ocean, so it is important to understand how the climate affects the people and their livelihoods.

A key question is how Indian Ocean warming influences the monsoons. "We don't know the answer to this yet," Shenoi replies. "Some of the published research indicates that warming is happening more at the subsurface layers, in which case it won't immediately affect the atmosphere; but is it a matter of time before the ocean transfers the heat to the surface? Increased surface temperature is certain to affect the African and Asian monsoons; the entire

regional pattern could change, with either increased or decreased rains. All this will directly impact the Indian Ocean populations and their livelihoods."

Macroeconomic level – looking to the ocean

At a macroeconomic level, India is a major importer of oil and it is looking to the ocean for an alternative, with the discovery of solidified methane gas deposits on the ocean floor.

"India is one of the pioneer investors in future ocean technology, but it might take another decade to develop the technology to extract these deposits without losing the methane," Shenoi explains. "Another example is the technology required to mine the deposits of manganese, zinc, cobalt and several other metals at a depth of about 500 metres in the central Indian Ocean.

"India has completed the mapping of this region and made a quantity assessment but it is a question of how sustainably, safely and economically you can mine it. These metals are used to make alloys for many purposes – from engineering to technology. Assessments predict that these will run out on land in about 30 years, so these ocean deposits will become a critical resource. In all forms of ocean management – from conservation to mining – we need to think several decades ahead. It's a very short period of time in the greater scheme of things."

www.incois.gov.in

Indian fishermen from the Lakshadweep Islands who are successfully using the information from INCOIS advisories regarding catches, which is saving them time and fuel.

Interconnected Ocean Power and its Influence on the Earth's rotation

Massive exchanges of water between the Pacific and Indian Oceans emphasise the interconnectivity of the world's oceans, with significant climate-related implications.

Dr Satheesh Shenoi was part of a group of scientists from France and INCOIS working on this research. Their findings were published in April 2019 in the journal *Nature Communications*, **in a paper titled: "Basin-wide sea level coherency in the tropical Indian Ocean driven by Madden–Julian Oscillation"**

(Rohith et al. www.nature.com/articles/s41467-019-09243-5**)**

Sea level rise or fall of ~4cm

Excerpts from this read as follows: During the months of December to April, the Indian Ocean routinely gains or loses ~3 trillion tons of water from the Pacific Ocean every ~30–80 days accompanied by a sea level rise or fall of ~4cm which is ~30% of the total sea-level change during the period. This process is driven by intense winds hovering over a very small area in the eastern Indian Ocean. This intense wind is associated with a little-known tropical weather phenomenon known as Madden-Julian Oscillation (MJO).

INCOIS headquarters in Hyderabad, India

The MJO, an eastward moving disturbance of clouds, rainfall, winds, and pressure, circles the planet along the tropical belt in 30–80 days. During its global ride, it intensifies over three distinct regions – the eastern Indian Ocean, south of the maritime continent and the western Pacific Ocean – and transfers a part of its energy to the underlying ocean. When the MJO winds reach the eastern Indian Ocean, particularly over the North West Australian Basin (NWAB), MJO energy is transferred deep down to the ocean bottom leading to an oscillation of the entire water column.

Exploding hundreds of atomic bombs

This oscillation is subsequently radiated out from the NWAB through fast-moving ocean waves that eventually invade the entire tropical Indian Ocean within some hours. These waves carry a lot of energy and momentum. The kinetic energy contained within the North Indian Ocean due to these waves is ~20 peta Joules. This energy is similar to exploding hundreds of atomic bombs like the one over Hiroshima in 1945. It will be interesting to explore the various manifestations of this energy and how this energy is eventually dissipated.

Impact on GPS

The rise and fall of sea level in the Indian Ocean leads to mass exchanges between the Indian Ocean and the Pacific Ocean. Such large mass exchanges are known to influence the polar motion of the Earth and the length of the day of the Earth, whose variability is of utmost importance to the accuracy of the Global Positioning System (GPS).

The MJO, being a low pressure system, is further known to facilitate cyclone formation over the Indian Ocean. Some of these cyclones, under favourable conditions, intensify and inundate the coasts of the Indian subcontinent.

In summary, the implications of the water exchange between the Pacific and Indian Oceans are as follows:

1. It involves the entire water column (barotropic process), the energy is very high and it has to be dissipated throughout the continents. This energy can affect the rotational speed of the earth by micro- or nanoseconds, which could impact on the accuracy of GPS systems.

2. Climate change is referred to in millimetres of ocean rise and this research is talking about a ~4 cm rise and fall. We don't know if this is increasing with climate change – to determine this, we would need records over few decades or more.

3. We use the data from satellite altimeters, which measure sea levels up to 2mm accuracy. What we are saying is there is appreciable barotropic variability and so the sea level altimeters need to be recalibrated.

The Indian Ocean Observing System

The Indian Ocean Observing System (IndOOS), an intrinsically important component of IIOE-2, is an example of strong international collaboration in the Indian Ocean. www.clivar.org/clivar-panels/indian/IndOOS

Professor Lis Beal of the Ocean Sciences Department at the University of Miami's Rosenstiel School of Marine and Atmospheric Science, is a leading member of IndOOS and presented at the IIOE-2 conference at Nelson Mandela University. She is an expert on the Indian Ocean, including specific expertise in the Agulhas System of currents off South Africa and has focused international attention on the key role this system plays in a warming climate.

Also presenting was Dr Roxy Koll, another leading IndOOS member. A climate scientist, Koll is from the Indian Institute of Tropical Meteorology and is currently working at the National Oceanic and Atmospheric Administration in the USA. He is leading research on climate change and its impact on the rapid warming in Indian Ocean, the monsoon and the marine ecosystem. He is a lead author of the IPCC *Special Report on Oceans and Cryosphere in a Changing Climate.*

They explain the key functions of IndOOS:

"IndOOS is the sustained observing system for the Indian Ocean, a network operated and supported by various national agencies and coordinated internationally. With about one third of the global population living around the Indian Ocean, many in small island developing states and least developed countries that are especially vulnerable to climate impacts, there is growing societal demand for monitoring, understanding, and predicting the state of the Indian Ocean and its climatic influences in a time of accelerating changes.

"Despite its small size, the Indian Ocean has accounted for 60% of the global oceanic heat content increase over the last decade, is home to 30% of the world's coral reefs, and accounts for 13% of global wild-catch fisheries. Cyclones, floods, and heatwaves are becoming more extreme around the Indian Ocean and anthropogenic and decadal change is impacting weather patterns and marine and terrestrial resources.

"Moreover, climate phenomena with global impacts, such as the Madden-Julian Oscillation and the Indian Ocean Dipole, originate in the Indian Ocean. The goal of IndOOS is to provide sustained high-quality oceanographic and marine meteorological measurements that can support knowledge-based decision-making and policy development through improved scientific understanding, and ultimately, improved regional weather, ocean, and climate forecasts."

Life Below Water From Zanzibar

An experienced Kenya Wildlife Service ranger helps a non-swimmer experience coral reefs for the first time for the Strategic Adaptive Management (SAM) Project in Mombasa Marine Park. Photo: Jennifer O'leary

The Zanzibar-based Western Indian Ocean Marine Science Association (WIOMSA) is supporting scientists in the region to advance ocean science and conservation, with associated legislation, throughout the Western Indian Ocean (WIO) countries, including Somalia, Kenya, Tanzania, Mozambique, South Africa, Comoros, Madagascar, Seychelles, Mauritius and Réunion.

WIOMSA's Executive Secretary, Dr Julius Francis, who lives in Zanzibar and presented at the IIOE-2 conference, says their aim is to establish a science-to-policy platform by addressing the research gaps in the WIO, including research on ocean acidification, marine litter and mining activities. They also closely engage with coastal cities and communities who depend on the ocean for their livelihoods.

"Through the Nairobi Convention (a regional Convention for the Protection, Management and Development of the Marine and Coastal Environment) the 10 countries agreed to develop a coordinated approach to the implementation of the Sustainable Development Goal (SDGs), with a focus on SDG 14: Life Below Water," Francis explains.

"We are setting up baselines for at least four SDG 14 targets, providing management and policy recommendations, and tracking the progress of these targets over time. These include: Marine Pollution, with a focus on marine litter, Healthy Oceans, Ocean Acidification, and Marine Protected Areas (MPAs)."

To date, WIOMSA has provided support to set up monitoring programmes for ocean acidification and marine litter as the first steps in establishing baselines against which to measure change and the degree of success of mitigation strategies.

Partnering in WIOMSA's regional marine litter monitoring programme is Port Elizabeth-based Africa Marine Waste Network (AMWN), which uses similar sampling methodologies.

Work on targets related to Healthy Oceans and MPAs, now in its final stages, requires a regional assessment of the status and baseline of MPAs and critical habitats in the WIO, resulting in policy recommendations to the region's governments.

"Focusing on SDG 14 also provides the opportunity to work on other linked SDGs, such as Sustainable Cities (SDG 11) and Climate Action (SDG 13)" says Francis.

Coastal cities sit at the nexus of climate change and the ocean

Climate change impacts – particularly rising sea levels, increased storm events, and tidal surges – have significant adverse effects on concentrations of vulnerable populations living in coastal cities in the WIO region. Large areas of many coastal cities in the region are situated below 10 metres above sea level, making them particularly vulnerable."

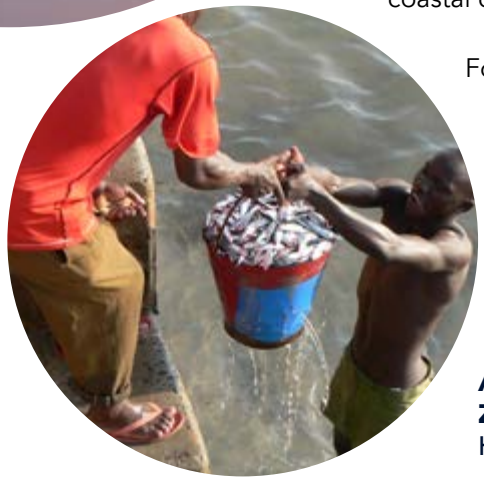
Francis explains that the coastal zone of the WIO region hosts major cities, harbours, industries and other development infrastructure that, while vulnerable to climate change themselves, also pose increasing threats to the integrity of coastal and marine ecosystems.

To address this, services using climate research and modelling can provide tools for city planning, with science, technology, architecture, socioeconomic information and planning all contributing to sustainable decision making.

In support of action on this front, in 2018 WIOMSA launched a four-year programme titled *Cities and Coasts*. One of the research projects supported by the programme is *Cities and Climate Change in Coastal Western Indian Ocean: A Grand Challenge (CICLICO)*, led by Dr Bernadette Snow, Director of the Institute for Coastal and Marine Research at the Ocean Sciences Campus of Nelson Mandela University cmr.mandela.ac.za, in collaboration with the German Climate Service Centre.

Together with decision makers and society, this three-year project is exploring and planning how coastal and marine planning can be implemented to enable better adaptation to climate change in vulnerable coastal cities of the WIO.

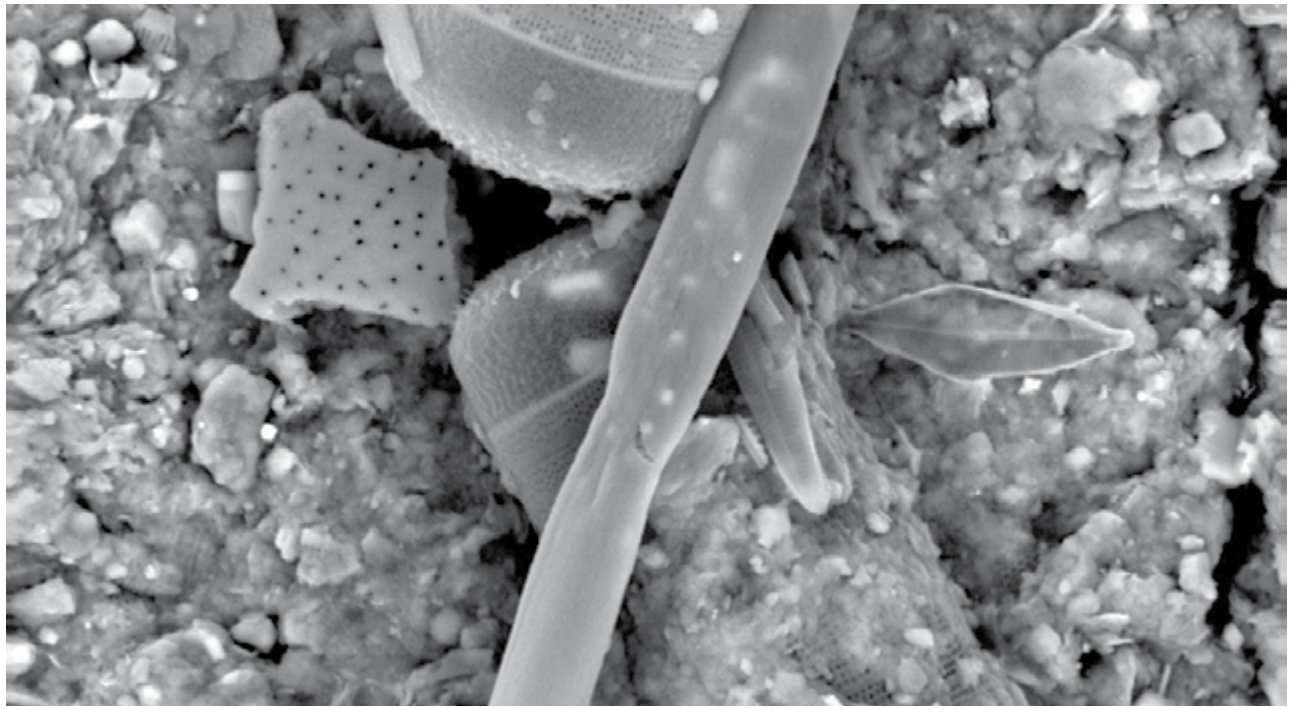
For more information www.wiomsa.org



Above: Sunset over Stone Town, Zanzibar, Tanzania. Photo: © Oskar Henriksson

Tackling the Ocean Plastics Problem Now

By Professor Andy Cundy, School of Ocean and Earth Science, University of Southampton.



Electron microscope image of a microplastic fibre (long piece) with marine plankton. These microplastic fibres originate from synthetic fabrics such as polyester, nylon and acrylics, and are released into wastewater every time we wash our clothes, from where they can enter estuaries and the marine environment through wastewater treatment works and storm water outflows.
Photo: Prof Andy Cundy

Over 100 million tonnes of plastic may now be present in the oceans and the amount is increasing year on year. Estimates suggest that by 2050 there may be more plastics (by weight) than fish in the sea.

Multiple types of plastic are now found well beyond our coastal seas, from remote mid-ocean surface waters to the deepest ocean trenches. Once plastics enter the ocean they are difficult and costly to remove.

Extensive research is being done on the lifetime of marine plastics and their breakdown into microplastics and nanoplastics – smaller and more easily ingested particles – their toxic effects, and their full impact on the marine environment.

Tackling the source of the plastics problem is critical. Interventions include reuse, recycling and replacement with alternative materials, restricting the flow of plastics through areas such as rivers, beaches and estuaries, enhanced management of wastewater treatment works, banning of microbead plastics in, for example, cosmetics, and communities worldwide coming together to collaborate in a

proposed Integrated Marine Debris Observing System (IMDOS).

There is real value and huge potential in scientists, policymakers, industry and the public working together:

a. To better understand the amount of plastics entering the sea, and their pathways and distribution between land, the coastal ocean and the deep sea to assess the risks to people and fisheries; and

b. To tackle the plastics problem at source by developing local, regional and national policies to reduce the amount of plastic debris entering the sea and impacting marine ecosystems.

Several nations have already put in place measures to limit the amount of plastics pollution entering the environment and our seas, ranging from bans on certain plastic products to reducing the use of single-use "throwaway" plastics and plastic packaging. There are so many opportunities to build on this, collaborate, and learn from each other's experiences.

At the international meeting of oceanographers, fisheries experts and coastal scientists at Nelson Mandela University in Port Elizabeth in March this year, South African and international experts presented and discussed a range of local and regional strategies, monitoring networks and technologies that can be used to identify and reduce the impact and potential harms from plastics. An international dimension is key, both to draw on local knowledge and best practices, and because marine plastics by their nature do not follow national boundaries.

To tackle the marine plastics problem, we need an approach that encourages societal, academic and industrial innovation, action and co-working. For example, the International Union for Conservation of Nature's MARPLASTICCs programme is promoting local integrated solutions to the marine plastic pollution problem, in Kenya, Mozambique, and South Africa. The Nairobi Convention also provides a regional mechanism for cooperation, coordination and collaborative actions.

While we continue to engage industry, government and the public, we also need to build on existing monitoring programmes and international ocean collaborations. By improving our knowledge of marine plastics sources and pathways, using ship-based research, river and estuary monitoring, and novel marine technology, we can ensure that action to overcome the plastic pollution of our oceans is effectively implemented.

To tackle the marine plastics problem, we need an approach that encourages societal, academic and industrial innovation, action and co-working.

The Marine Plastic Pollution Crisis

Peter Manyara is the South Africa-based regional project coordinator for the International Union for Conservation of Nature's (IUCN) Marine Plastics and Coastal Communities (MARPLASTICCs) programme for southern and East Africa.

Plastic is cheap, lightweight, strong and malleable so is a useful, affordable material for a wide variety of applications. The problem is the quantity in which it is produced and the buildup of it on land, in our water sources and oceans.

Scientists estimate that since the 1950s, 8 300 million tons of plastic have been produced globally, half of this since 2005, and only 9 percent has been recycled. The rest has been discarded in landfills or has accumulated in the environment. Currently, global plastic production is projected to rise from the current 335 million tons per year to 1000 million tons per year.

This means the way we design, produce, transform, use and dispose of plastic needs re-thinking, and innovative circular economy approaches must be developed to stem the plastics flood.

Plastic Pollution: The Facts

- Globally, over 300 million tons of plastic is produced every year.
- Between 8–10 million tons of this plastic flows into our oceans every year.
- Plastic kills an estimated one million seabirds and 100 000 marine mammals each year.
- Plastic pollution costs a minimum of $13 billion annually in damage to marine ecosystems.

Marine Plastics and Coastal Communities Project (MARPLASTICCs)

In 2017 the IUCN launched the Marine Plastics and Coastal Communities initiative (MARPLASTICCs) with the support of the Swedish International Development Cooperation Agency. This is a three-year initiative working with five countries: South Africa, Mozambique, Kenya, Thailand and Vietnam.

MARPLASTICCs assists the governments, municipalities, industry, research institutions and organisations in these countries to strengthen and effect legislative and practical measures to reduce plastic pollution from source to sea.

This requires co-generating detailed data and analysis to understand each country's current plastic leakage status, then putting in place agreements, implementation targets and progress monitoring mechanisms.

Working with the private sector

The IUCN is also working with the private sector to measure how much plastic is used, wasted and leaking into the environment. By consolidating data, and quantifying scales of plastic flows, the programme helps businesses to develop solutions to the excessive use of plastics.

Plastic packaging is currently largely single use in business-to-consumer applications. It is paramount that extended producer responsibility schemes should be designed and implemented to stimulate design change within the consumer goods industry.

MARPLASTICCs engagement with the private sector includes supporting platforms for leadership and corporate stewardship to address the plastic problem and come up with innovative solutions and actions, as well a better understanding and assessment of the plastic footprint.

Closing the plastic tap

In an article titled *Closing the Western Indian Ocean's plastic tap*, Luther Bois Anukur, Regional Director, IUCN Eastern and Southern Africa writes:

"Solutions need to shift beyond the traditional focus on waste management to product eco-design and lifecycle thinking. The conventional plastic use and disposal model is unsustainable and presents challenges that are only likely to escalate in magnitude, considering a projected three-fold increase in annual production by 2050.

"Research and technological advances present an alternative model – the circular economy – which is restorative by design and not as reliant on virgin fossil-fuel derived feedstocks in plastic manufacture. This model promotes sustained maintenance that ensures plastic materials are of high value, free of harmful toxins, have extended use and reuse cycles, and have value creation potential for businesses, society, and the environment."

Plastic litter action

"The Western Indian Ocean region recognises the threat posed by plastic litter in its coasts and oceans and has catalysed some action. For example, South Africa, Kenya, and Rwanda have instituted measures to deter the use of short life plastic bags. Kenya deferred a ban on polyethylene terephthalate (PET) bottles in order to explore with industry and other stakeholders, the concept of extended producer responsibility through container deposit schemes as applied in Asia, Europe, the US, Canada and Australia.

"South Australia implemented container deposit legislation in 1975 that led to a return rate of more than 80% of plastic containers. South Africa has conducted a study to assess the status of production and management of plastics as a whole, to guide improvements in recycling.

"However, the challenge of the plastic pollution requires holistic approaches, multi-stakeholder involvement as well as regional cooperation. The Continental Free Trade Area, for example, creates new opportunities beyond national borders. It will enable companies and manufacturers to expand their operations into neighbouring countries. However, without a regional approach [to plastics regulation], manufacturers facing stringent plastic bans may be tempted to explore options to shift base to countries where such regulatory restrictions are not yet developed. The illegal entry of banned plastic commodities will potentially undermine progress in countries trying to tackle the plastics pollution problem."

For more information
www.iucn.org/theme/marine-and-polar/our-work/close-plastic-tap-programme

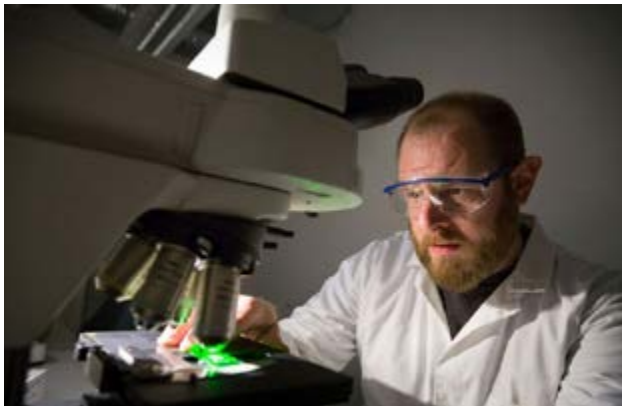
Peter Manyara in Algoa Bay

Vehicle Tyre Particles a Major Marine Polluter

"Globally, we are increasingly concerned about microplastic and nanoplastic pollution in the ocean because if a particle of this size is ingested by fish, it might be small enough to transfer across the walls of the digestive system and into the organism, possibly accumulating in organs such as the brain, liver and kidneys," says Dr Andy Booth, Senior Research Scientist in the Environmental Technology department at one of Europe's largest independent research institutes, SINTEF Ocean, in Norway.

Speaking at the SANOCEAN conference at Nelson Mandela University in March 2019, he explained that microplastic particles are less than 5mm and nanoplastic particles are less than 100 nanometres – they are so small you wouldn't be able to see them. "Estimates are that what we see is only about 10% of the total marine plastic pollution. What this means is that about 90% of plastic litter is already on the sea floor."

Booth explains that while we know that most plastics break down slowly, there is little data on the rates at which different polymers degrade under varying ocean conditions – such as from tropical seas to open ocean to polar to shallow seas to beach to deep ocean. "We need to understand this, and we need to better understand the process of



Dr Andy Booth using fluorescence microscopy to identify microplastic particles in environmental samples.

microorganisms attaching themselves to particles of plastic and changing their density, so that floating particles sink to the sea floor where sediment-living organisms are exposed to them. A lot of organisms that live on or near the sea floor, including shrimp, crabs and flatfish, are crucial to the functioning of a healthy marine ecosystem and are very much part of the food chain."

Research into these processes is being conducted by the FORTRAN project (Factors influencing the formation, fate and transport of microplastic in marine coastal ecosystems). It's a partnership between SINTEF Ocean, Stellenbosch University, the University of the Western Cape and WILDOCEANS – a programme of the WILDTRUST in KwaZulu-Natal.

"Very importantly, different plastics and polymers contain a broad range of chemicals some of which are added specifically to make the polymers more resistant to degradation. Some chemicals are very toxic, and this is a big unknown at the moment. What we need to identify, as part of coming up with solutions for plastic pollution, is which are the benign and which are the toxic materials.

"We know, for example, that vehicle tyres are not benign. Not only are they one of the highest volume emitters of microplastic particles, which are continuously released when the tyre comes into contact with the road surface, they have some of the most toxic chemical additives in their composition."

Booth explains that the average car tyre loses 1.5 kg in its lifetime in the form of micro- and nanoplastic tyre wear particles that are released directly into the environment. Therefore, every car with four wheels releases 6 kg of micro- and nanoplastic into the environment – into the land, freshwater sources and oceans. Scale up to the number of cars in the world

and this may be one the main sources of micro- and nanoplastic particles polluting the ocean.

To determine their toxicity, microplastic tyre particles were added to fresh and sea water and the FORTRAN research team analysed the metals and chemicals that came out. "We found that they are really toxic," says Booth. "We are now looking at the transport route and toxicity effect of tyre wear particles on test organisms in the ocean, including microalgae, zooplankton and small sediment crustaceans.

"We also need to expose them to tyre wear particles in controlled test environments representing multiple environmental stresses, such as in a climate change environment where we increase the water temperature by two degrees, and in an ocean acidification test environment.

"Obviously you can't ban car tyres, but what can be done is to assist, guide and regulate tyre manufacturers and other producers of plastic to better manage their plastic footprint, to develop products with reduced plastic particle pollution and to replace the toxic chemicals in plastics with non-toxic counterparts.

"What we can also do is to look at the points of origin of high flows of macro and microplastic into the environment. A good example is wastewater treatment plants – these are ideal points for targeted management."

For more information:
www.sintef.no/en
wildtrust.co.za/wildoceans

Dr Andy Booth studying man-made microplastic additives in consumer products.

Clean and healthy oceans: towards zero plastics to the seas

By Dr Tony Ribbink, CEO of Sustainable Seas Trust (SST) www.sst.org.za from his presentation at the SANOCEAN conference.

No matter where you are on the planet, every breath you take, every drop you drink, every morsel of food you eat, even the weather that you experience, is all derived from the oceans. Two hundred years ago the oceans of the world were pristine, healthy and productive. Only four decades ago, many people still believed that the sea was an endless provider and would not be affected by what we took out or put in to it. We now recognise that the oceans are sensitive to change and that some changes are developing a momentum that we may struggle to stop. The oceans are not able to withstand what we do to them. In short, we are turning off our life-support systems.

What we take out of the seas

Fisheries

For over 120 years fisheries scientists have been telling decision makers around the world that the fisheries are unsustainable. They were largely ignored until several major global fisheries collapsed and predictions emerged that if current trends continued the fisheries of large marine ecosystems would collapse by 2045. Almost all top predators are now less than 10% of the numbers they should be; our West Coast rock lobster is down to 3%, our African penguin is at about 2%. Many marine animals are extinct due to human activities.

Fishing peaked in 1996, with over 350 000 tonnes being taken out every 24 hours. Since 1996 catches have declined, but fisheries have increased globally. That is unsustainable. The good news is we know about this, we know what to do and with the right leaders we can win the political will to act.

SST and a team from Isuzu Motors standing with the waste collected from the World Oceans Day beach clean-up.

Elukholweni Farm School, one of the schools that is a part of our African Youth Waste Network.

Oil, gas, mining and ocean floor

We mine the sea for oil, gas and minerals. We suck up the ocean floor for diamonds, manganese and phosphate nodules. All of these activities negatively impact ocean health.

What we put into the seas

Deadzones

In South Africa and other countries there are still sewage and other outflows into the sea, such as plastics, fertilisers, toxins, nutrients, hormones and heavy metals. The sea is unable to deal with the increasing pollution. A consequence is that 405 permanent deadzones exist and are growing; deadzones are unproductive, toxic areas covering hundreds of kilometres of ocean.

CO2

The plant life of the ocean absorbs large amounts of CO^2 and produces much of the planet's oxygen. However, anthropogenic CO^2 production is currently adding 34% of carbon to the seas, and leaving them unable to take much more. This leaves more CO^2 in the atmosphere and in turn exacerbates global warming.

Acidification

CO^2 entering the water produces carbonic acid which attacks calcium carbonate, the substance from which the shells of many species are made, and decalcifies them, weakening and breaking down the shells. This has a potentially major disruptive impact on our food chains.

Heat

Huge amounts of heat enter, are stored and moved around in the oceans. The greatest impacts on climate change, including major storms, are driven by temperature changes in the oceans. Warming leads to the melting of ice and to sea level rise. Hurricane intensity and rainfall are projected to increase as the climate continues to warm.

Plastics

Current estimates are that 21 tonnes of plastics enter the seas every minute. Plastics do not break down (they break up and form microplastics) so they are accumulating in the sea, adding 350kg per second to the 160 million tonnes of plastics already in the seas. Should practices not change within 10 years, experts project that the ocean will contain an estimated 1kg of plastic for every 3kg of fish.

Towards Zero Plastics to the Seas of Africa

Stopping at source

About 80% of plastics enter the seas from land, the other 20% are from sources at sea; ships, oil rigs, and fishing vessels. About 95% of the plastics coming from land are via waterways, rivers and estuaries. To stop the flow of plastics we need to do so at source, where people live, work and play, before it enters the sea.

Scientific studies in Nelson Mandela Bay Municipality

Nelson Mandela Bay municipal area is ideal for proof of concept: it is big enough to represent large coastal cities of Africa, but small enough to be manageable. The bay has several rivers and estuaries that carry plastics to the sea.

During a Norwegian-supported feasibility study, the SST, through its African Marine Waste Network (AMWN project), has been developing and testing techniques to measure and establish baselines, monitor change, develop and implement strategies and plot progress in Nelson Mandela Bay. We are also

training people in six other Western Indian Ocean countries in data collection techniques.

Our data collection includes measurements of waste on land, on beaches and in the sea, measurements in the plastic waste conduits (rivers, estuaries, deltas), and movements of waste in the seas around Africa.

Our surveys include macro- (greater than 25mm), meso- (between 5 and 25mm) and microplastics (less than 5mm diameter). In addition, our work in Nelson Mandela Bay has indicated that animals at the bottom of the food chain (e.g. oysters) are accumulating large amounts of microplastic-associated pollutants.

Value chain

The role of different players in the plastics value chain is pivotal in the battle against polluting plastics. This includes the producers and retailers, consumers and sustainability organisations. Partnership between the plastics industry, government, the public and other institutions is thus vital to solving the plastics problem.

Defining Zero Plastics

Zero plastics to the sea is unattainable but hopefully there can be a considerable drive against macro-plastics entering the sea. An alternative is zero growth in the plastics in the sea, indicating that we are not adding to the existing load.

Community engagement

Community engagement is essential for creating awareness, getting people involved and enthusiastic about taking action against plastic pollution. The SST works with schools, teachers and learners through its Schools Programme which provides interactive learning activities in the schools and extramurally in the environment.

The African Youth Waste Network (AYWN) was specifically established as an active youth-driven platform for collaboration, resource and knowledge sharing within countries and across borders for and with the youth of Africa, to find relevant solutions to Africa's plastic pollution problems. The SST also organises coastal walks and clean-ups, such as the World Oceans Day beach clean-up that attracted incredible community support and enthusiasm.

An SST volunteer for the research project.

Titanic Task

Green sea turtle with a plastic bag, which can be confused with jellyfish. The bag was removed by the photographer before the turtle had a chance to eat it. Photo: © Troy Mayne / WWF

From 3 to 7 December 2018, experts from all over the world met in Geneva to develop a globally binding agreement on marine plastic pollution.

The Worldwide Fund for Nature (WWF) is one of the key actors driving the initiative to convince governments to endorse a global agreement to stop the flow of plastics into natural environments.

In South Africa, the WWF Nedbank Green Trust launched a three-year Marine Plastic Pollution Programme in July 2018, to address the marine and environmental plastic problem throughout its life cycle – from production and consumption to waste management. The programme involves consumers, industries, retailers and the government working collectively towards implementing practical approaches to overcoming plastic pollution.

"No organisation can achieve this on its own. Because the plastic challenge is so huge and multi-faceted, it has to be addressed at multiple levels and sectors," says Tatjana von Bormann, programmes and innovation lead at WWF-SA.

Von Bormann describes plastic as "an extraordinary material", which has revolutionised many aspects of our lives over the past 80 years. The problem, as she explains, "is that it is cheap and therefore widely

used and easy to throw away. It doesn't break down for a couple of hundred years, creating a serious source of pollution in our oceans, watercourses, wetlands and environments."

The Manager of WWF's Marine Plastic Pollution programme, industrial engineer Lorren de Kock, says the overarching objective of the programme is to eliminate the flow of plastics into the environment, using a phased approach. This includes:

- Promoting a client action campaign, similar to the WWF's consumer-championed Southern African Sustainable Seafood Initiative (http://wwfsassi.co.za/). This highly successful initiative demonstrates that consumers have the power to drive change by supporting responsible suppliers and sellers.
- Shifting market practices to reduce waste and move towards a circular plastics economy by rallying producers, brands, retailers and all businesses to respond to the environmental and social risks associated with plastic pollution, and to demonstrate how they are reducing plastic use, recycling, reusing, and addressing the problem.
- Supporting effective national plastic waste management policies and regulations, including a first step of sorting municipal waste, and engaging informal waste collectors in the process.

Marine plastic pollution, Cape Town. Photo credit: WWF-SA

Evaluating the Origins and Pathways of Microplastics

By Divya Latcheman, MSc student in the Environmental Analytical Group, School of Chemistry, Wits University

South Africa has been ranked as one of the top 20 countries with the highest mass of mismanaged plastic waste. It is vital, therefore to understand the extent of microplastic pollution on the country's beaches and in its oceans.

Microplastics can pass through wastewater treatment plants and emanate from a vast range of products; they can even be released during the washing of clothes. Once microplastics enter the aquatic system, animals and plant life are exposed to them and the toxic chemicals they often contain.

This research investigates South African wastewater treatment plants (WWTPs) as potential release pathways for microplastics entering the aquatic environment. Microplastics will be extracted from water and sediment samples collected from inland freshwater river systems in Johannesburg, and beaches in Durban and Cape Town. Assessing the influent and effluent of WWTPs in this manner will aid in understanding how well-equipped they are to remove microplastics, and will give an indication of the rate at which microplastics are entering the aquatic systems.

The research results will aid in decision-making for the improvement of sewage treatment infrastructure, and in developing methods to prevent sewage outfalls from releasing microplastics into the environment. Evaluation of microplastics from water and sediment samples will give an indication of the main sources of microplastic pollution, providing a baseline for pollution mitigation strategies that are of fundamental importance to South Africa's water supplies.

Divya Latcheman, MSc student

Sewage and Contaminants in the City of Cape Town Sea

By Professor Leslie Petrik, Department of Chemistry, University of the Western Cape

The City of Cape Town discharges a large volume of untreated or partially treated sewage effluent into the ocean via outlets located around the Cape Peninsula. This sewage contains a high degree of contaminants, including chemicals, pesticides, perfumes and disinfectants, which up until recently could not be accurately measured.

Many contaminants are able to pass through wastewater treatment systems without adequate removal, as well as through systems used in desalination plants, or through treatment systems for wastewater reuse. To make matters worse, 80% of wastewater treatment plants are only marginally functioning – a situation that deteriorated further with the concentrations of effluent caused by water use restrictions during the Cape's recent period of drought.

Risks to humans

Uncertainty over the magnitude of risk of human exposure to these contaminants means it is necessary to measure their levels in the ocean, as well as in potential sources of potable 'reclaimed' water – such as desalinated sea water.

Senior scientists from the University of the Western Cape, the University of Cape Town and Stellenbosch University, in partnership with others from the University of Stavanger and the International Research Institute of Stavanger, in Norway, are conducting a substantial study of the seasonal behaviour of the effluent outfall plumes around Cape Town and the current outfall flow rate impacts, neither of which have previously been studied.

Ocean health directly impacts human health

The areas being studied are Table Bay, the Atlantic seaboard and False Bay. Although the three areas are in close proximity to each other, they present a variety of physical, atmospheric and oceanographic phenomena.

Risks to marine organisms

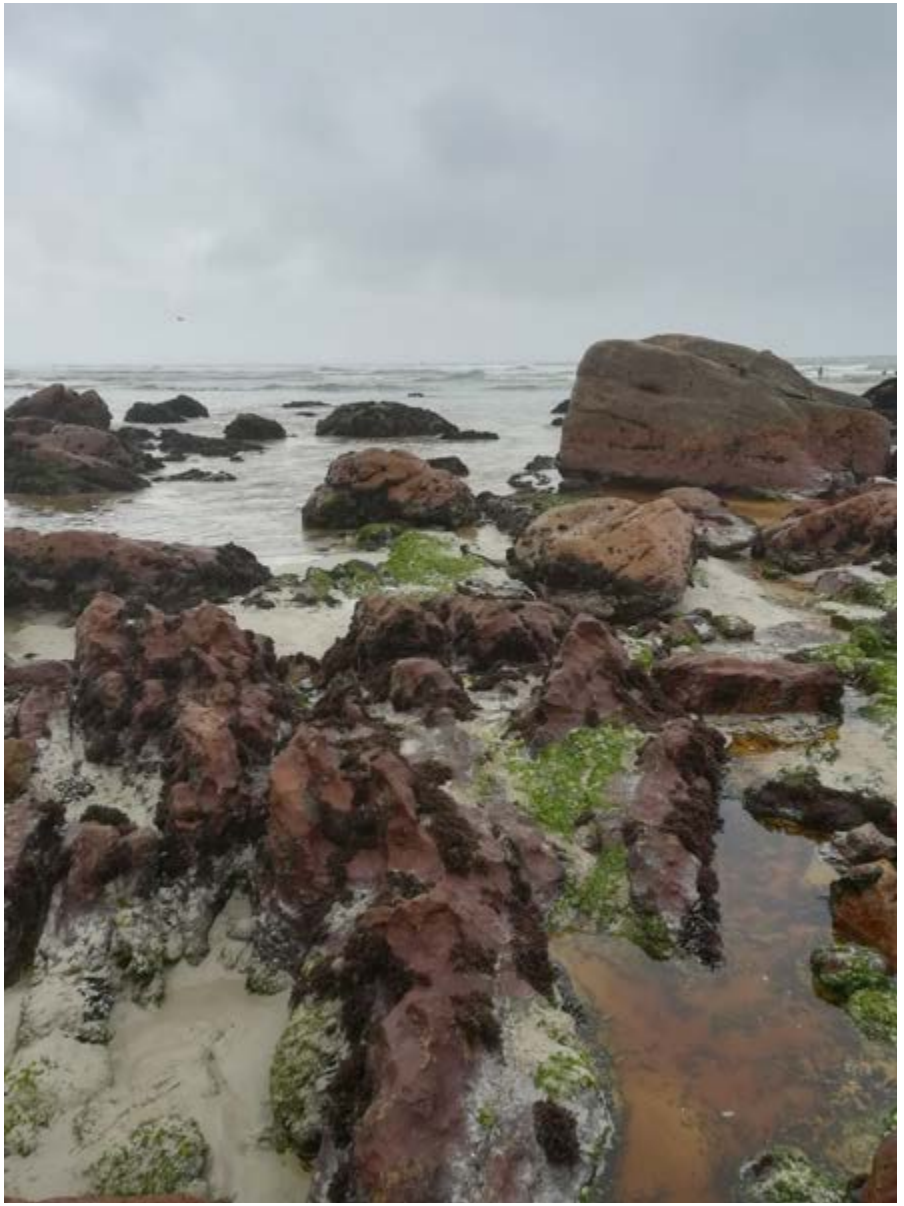
The impact of sewage and desalination brine discharges on the near-shore marine environment may be causing an ecological shift, due to the bioaccumulation of persistent organic pollutants in marine organisms. The team's research started with a survey in 2016, and the current project tracks the harmful chemicals and microbes and how they flow and impact on the terrestrial and marine food chain. Limpets, mussels, starfish, snails and seaweeds have been sampled and compounds extracted from them.

The research group published a paper in the *South African Journal of Science* showing the concentration of contaminant compounds which are bioaccumulating in the organisms surveyed. The study began in Green Point, and was repeated in Camps Bay, a Blue Flag beach. The sampling campaign is continuing, as well as an underwater camera survey. Currently, it is being conducted in False Bay, where fish are collected from commercial catches – snoek, panga, hottentot and bonito – in areas where effluent discharges into the ocean.

City management side

City managers need to work with marine researchers to improve the situation and collaborate on addressing the problems in populated coastal cities, including those that attract a high percentage of tourists. Urban planning and strategy must incorporate responses to the risks exposed by the research and data to date, which demonstrates that the disposal of sewage into the sea has effects that are currently poorly understood and that are impacting on the ocean and coastal ecologies.

There is also a clear need for democratic participation in decision-making on the issue, and for the public to become more aware of the consumer choices they make in respect of the purchasing and disposing of harmful chemicals and pharmaceuticals, which have direct effects on the long-term well-being of humans and marine species.



Near-shore marine environment, Cape Town.

ARVs in the Ocean

By Nomchenge Yamkelani Mlunguza, Durban University of Technology

Antiretroviral drugs (ARVs), used in combatting HIV, belong to a group of pharmaceuticals causing growing concern, as they are increasingly detected in the aquatic environment around the world. South Africa's high rate of HIV infection highlights the need to monitor the occurrence of ARVs in the country's water.

Three ARVs, namely emtricitabine, tenofovir disoproxil and efavirenz were all found present in wastewater and river water samples. This indicates that the drugs are excreted from the human body unmetabolised and enter the water supply. South African wastewater treatment plants were never designed to eliminate them during the purification process. As a result, the drugs remain in the water and enter surface water bodies, such as rivers, through which they are transported to the ocean, endangering the marine environment.

The study was further extended to monitor the uptake of the same drugs by aquatic plants, some of which were found to be effective in reducing the water pollution caused by ARVs.

The next stage of research is focusing on isolation, identification and quantification of pharmaceuticals in various water bodies. This is a continuation from the earlier work but employs different sample preparation and preconcentration techniques, as most of the work will deal with sea water. The study is focused mainly in coastal areas of KwaZulu-Natal, the Eastern Cape and Western Cape, where it will be the first to report on the concentrations of the ARVs in sea water.

Nomchenge Yamkelani Mlunguza

Pharmaceuticals and Brine in the Ocean

By Sisonke Sigonya, Durban University of Technology

This research also considers the presence of pharmaceuticals in the water supply, and involves developing a method for their preconcentration and extraction. The pharmaceuticals being studied include non-steroidal anti-inflammatory drugs, antiretroviral drugs and trihalomethanes.

Further research will also focus on brine discharge, a highly concentrated waste by-product of the desalination process. Desalination has attracted great interest as a means of solving South Africa's water shortage. However, it is estimated that for every cubic meter of desalinated water, an equivalent amount is generated as reject brine.

The common practice in dealing with brine is to discharge it back into the sea, where it could result in long-term detrimental effects on marine life as well as the quality of sea water available for desalination. The lack of economically and ecologically feasible concentration management options is a major barrier to widespread implementation of desalination.

In this study we aim to assess the levels of brine content pre-desalination and after the brine has been discharged into the sea, and to determine the effects of the brine on aquatic life.

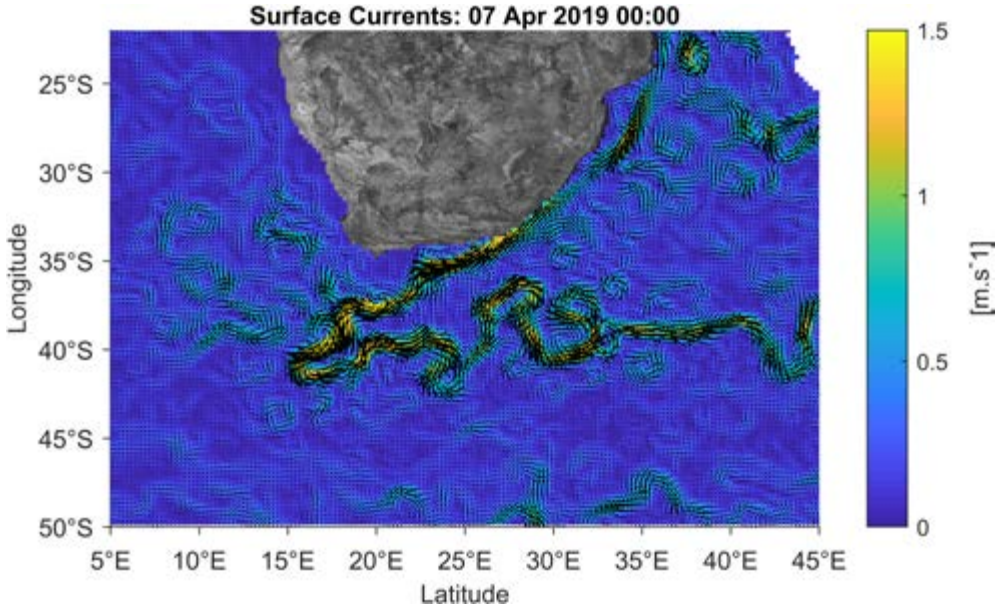
Sisonke Sigonya

A New Era for Marine Forecasting in South Africa

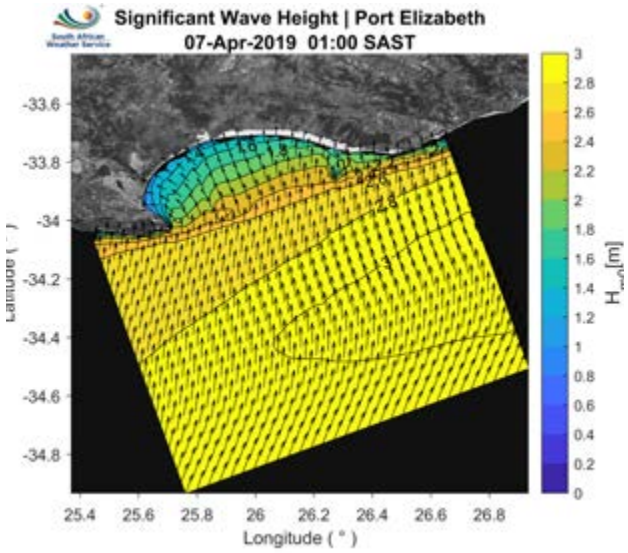
By Tamaryn Morris, Dr Christo Rautenbach, Johan Stander
Marine Unit, South African Weather Service (SAWS), Cape Town Weather Office, Cape Town International Airport.

The South African Weather Service (SAWS) is responsible for providing marine meteorological information and warnings across a huge ocean area from the Antarctic to the coastal waters and island nations of southern Africa. Known as METAREA VII, it is the second largest of the ocean geographical areas that were established by the World Meteorological Organization (WMO) in 1950. The information ranges from daily forecasts of passing weather systems that might impact on safe shipping, to more extreme and potentially life-threatening events. The latter might include storm surge and destructive wave activity along the coast, hazardous seas in the METAREA, or Marginal Ice Zone navigation and warnings in the Antarctic region.

The oceans are extensively used for commerce and recreation. Shipping is by far the dominant method for global commerce, with trillions of US dollars' worth of trade passing through the world's harbours annually. The oceans also contain resources such as gas and oil, while precious minerals, such as diamonds, are mined on the sea floor. Recreational activities and tourism bring millions of visitors every year to the coastal areas of many countries,



Surface Currents for 7 April 2019 for the South African region from data made available by Copernicus (www.copernicus.eu).
Similar to sea surface temperature, the surface current image produced is an interpolated daily product of ¼ of degree resolution. Currents are shown in m/s and the Agulhas Current is usually a prominent feature in these images. Again, such images are useful mainly to mariners for navigation, but also to physical oceanographers looking to study the in situ dynamics of current systems or spin-of features and can use daily images to track their progress.



Significant wave height (2 km) forecast product for Algoa Bay for 7 April 2019. Significant wave height is the mean wave height from trough to crest of one third of the waves passing within a system. It was a developed as a way for observers to measure waves for forecasting purposes, but became a common measure over time.

supporting local communities and economies. And, it should be noted, in most countries that have a coastline, much of the population typically lives in those locations.

Marine services not only contribute to shipping information and safety, but also provide information to coastal engineers and environmental managers about best practices for ensuring coastal longevity. Population trends and changing climate conditions have increased the vulnerability of coastal populations and infrastructure, and these are amplified by the effects of weather and conditions in the ocean.

Technology has also changed rapidly in the last decade, vastly improving the services provided. In addition, effective access, dissemination, and alerting systems are critically important for a national meteorological service. For no matter how accurate products are, they must be used wisely in decision-making processes. The ability to facilitate reliable, timely access to information is critical to ensuring that products and services are relevant.

Marine meteorological and climate observations and research must precede the rollout of any new or improved operational products. Rigorous testing of predictive models must occur prior to the use of the product in an operational setting. Ongoing research is therefore integral to the service delivery process.

The Marine Unit of the SAWS is a young and energetic team, comprising an applied mathematician, physical oceanographers and marine meteorologists, with technical support. Its work is underpinned by strong operational and academic collaborations, which range from academic institutions and research councils, to environmental consultancy groups, local and national government departments, and coastal engineering companies.

The Unit has developed a dynamic marine forecasting website for all coastal and marine users. The website is primarily used to disseminate operational high-resolution wave, storm surge and tidal forecasts (72 hours), and additional products are planned as the Unit and its website develop.

This allows coastal and offshore ocean users, disaster management structures, and municipal authorities to prepare for potentially damaging situations in real-time. The forecasts also assist small-scale commercial fishermen and recreational ocean users, such as surfers, kayakers and long-distance swimmers, to plan their marine activities in the short term. In addition, the website showcases the research that underpins the Marine Unit's products and services. Projects range from those related to infrastructure and observations (such as from ocean surface drifters, Argo floats and sea-ice drifters) to the high resolution numerical prediction of water levels and waves.

As part of its aim to service as large a met-ocean community as possible, the Unit is keen for all users of met-ocean information to visit their website at www.weathersa.co.za/marine. They propose to survey different user communities to determine the usability and general perception of the portal. The feedback they obtain will help to make improvements as needed.

Informally, marine users have already commented favourably on having 'old-school' synoptic charts and SOLAS (Safety of Life at Sea) communications available under the "Observations" tab, because many seafarers still rely on these systems for their work, particularly further out from the coastline. Other users have been pleased with the coastal automatic weather station map available under the

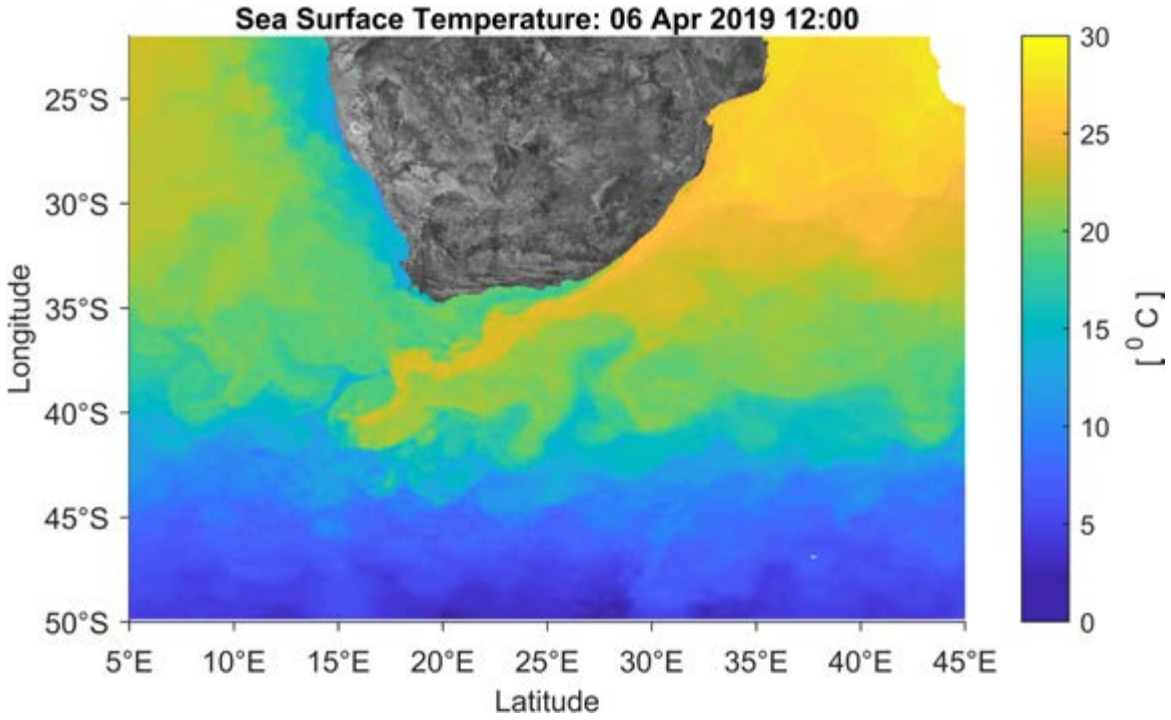
"Products and Services" tab (observational data), which assists students, engineering teams, and coastal users.

Through the development of a map and with relevant feedback from stakeholders, the Marine Unit will be able to motivate for additional automatic weather stations in key areas, such as False Bay, where currently only one station, at Strand, is available.

The Unit has also begun work on sea-ice observations and, in July, will be deploying sea-ice drifters to understand how sea-ice drifts in the Antarctic region directly south of South Africa, which may help us to forecast sea-ice movement in the future. Finally, the Unit aims to make a daily Forecaster's Synopsis available on its web portal, which will summarise the wave, storm surge and tidal forecasts, coupled with information from coastal observations and meteorological forecasts.

During extreme events such as storm surges, where flooding of terrestrial regions, potential loss of life and damage to infrastructure may become a possibility, these forecasts will be updated more regularly to assist in informing disaster management and similar organisations.

To take part in our surveys, or to provide feedback, please contact the Marine Coordinator on tamaryn.morris@weathersa.co.za.



Sea Surface Temperatures for 6 April 2019 for the South African region from data made available by Copernicus (www.copernicus.eu). Sea surface temperature is measured from passing satellites interpolated as daily products on a resolutions of ¼ of a degree. The values represent only the 'skin' temperature of the upper few millimetres of the ocean, and do not give any further indication of the temperature dynamics subsurface. However, the skin temperature gives a very good indication of anomalies and fronts occurring in the ocean at the surface and provide guidance to marine scientists, marine biologists and mariners looking to target fronts for fishing, ocean studies or to make the best use of passing currents for navigation.

Indian Ocean Africa – Perfume, Politics and a Rich World of Expression

These photos were part of an exhibition in Port Elizabeth in 2018 titled *Indian Ocean Africa* by Nelson Mandela University's Executive Dean of Arts, Professor Rose (Rosabelle) Boswell, who has a PhD in Anthropology.

"It was my first photographic exhibition and it consisted of images from my anthropological field research in the south-west Indian Ocean islands of Zanzibar, Madagascar and to a lesser extent, Mauritius," says Boswell who was born in Mauritius and grew up in Malawi. "To understand the earth's oceans, one must also understand the people who inhabit coastal areas and islands. This includes human use of lagoons, beaches and sea."

Boswell's work in the region offers deep insight into the lives of those who are part of the Indian Ocean world.

Excerpts from her introduction to the exhibition read as follows:

"The historian, Edward Alpers described the Ocean off the east coast of Africa as 'Indian Ocean Africa'. For him, this part of the world was deeply influenced by Africa and Africans and yet, for a very long time (and to a large extent, one might argue, still), the story of the socially diverse Indian Ocean region is not well known.

Maasai woman and man on the beach in Zanzibar. Photo: Prof Rose Boswell

"We know more today about the upwelling currents of the Indian Ocean, its geological history and its unique endemic species than we do about the people living there. My sense is that, in our increasingly post-humanist world, we forget that there are many still not considered human enough to deserve to have their story told.

"My journey into the region began in Mauritius in 1999. I wanted to follow the story of African descendants in Mauritius to understand why so many are still socially and politically marginalised in the society. I also wanted to know why their story

had been silenced for so long, what riches their communities held and how I, also an islander, was connected to other islanders in the region.

"The fieldwork, as anthropologists call it, was conducted over a period of 20 years in the three islands featured in the exhibition, as well as Seychelles. The output was mostly written, published in four books, seven book chapters, 20 accredited articles and six other articles.

"The photographs presented here do not showcase the particularly skilled eye of the photographer. I use photographs to help me remember sites, issues, people and feelings engendered by particular locales. In other words, the photographs are mnemonic devices – glimpses of the recent past, useful to the rekindling of memory.

"Since 1999, my work has focused on the identity, the political situation and the rich intangible cultural heritage of the islanders. Heritage being the cultural 'gifts' passed from one generation to the next – songs, poetry, ritual practices, languages and so on. In this regard, I have studied and written on the manifestation of culture and identity in dress and proverbs, indigenous scent and perfume practice, ritual practices, music and dance, sexualities and storytelling.

"What I found was an incredibly rich world of aroma, sound, emotional expression and oratory. A world of alternative 'starting points' for identity formation. The work also revealed the extraordinary creativity and resilience of Africans and their descendants."

Seaweed cultivation, east coast, Zanzibar. Photo: Prof Rose Boswell

In an evocative paper Boswell authored titled *Scents of Identity: Fragrance as Heritage in Zanzibar',* published in the *Journal of Contemporary African Studies* in July 2008, she wrote:

References to fragrance abound in the Koran. The fragrance of paradise, the sweet breath of believers and the aroma of good company all indicate the centrality of fragrance to sanctity, identity and sociality. Zanzibar, which is 90% Muslim, is located close to the east coast of Africa, where scent is an important organising principle. Its people have (and had) numerous encounters with the complex olfactory discourses of the Middle East. The islands were also historically selected for spice cultivation, making Zanzibari fragrance a multicultural product that has its roots in many histories. Fragrance is therefore a significant factor in identity and heritage in Islamic Zanzibar.

A Woman Seaweed Farmer Named Padima

Extract on Padima from Scents of Identity: Fragrance as Heritage in Zanzibar

Padima, an inhabitant of Kandwi is a *mwani* (seaweed) woman farmer. When I met her in 2007 she was living in Kandwi with her six children, the eldest one being ten and the youngest two years old. She told me that cultivating *mwani* is a difficult, smelly job. The seaweed has to be checked regularly, which involves many hours of labour, wading in the low tide under the hot sun.

Women carry up to ten kilograms of *mwani* on their shoulders from the 'plantation' to the beach. The distance varies, as some women cultivate right up to the reef. The seaweed can only be sold once it is dry and this can take between 24 hours and a week, depending on the weather.

The income from *mwani* is not great: one kilogram of seaweed (and there are different varieties) equates to about one US dollar. Women working hard can make up to 50 dollars a week, which is significant for Zanzibaris, as this is about 50,000 Tanzanian shillings. The seaweed is bought by Zanzibari middlemen, who sell it to Chinese merchants at the docks.

"*Mwani* makes us smelly," Padima said, "but it makes others beautiful." Beauty creams with a seaweed base form part of the arsenal of anti-ageing products in the West. Seaweed is also used in health foods (vitamin supplements and organic food preparations) and contributes to Westerners' ongoing fight against free radicals which they have unleashed with their own poor nutritional habits and toxic living environments. In the East, it contributes significantly to a wide array of dishes and as a complementary medicine in the quest to establish physical and spiritual balance.

SA's first boat-based whale-watching study

Bottlenose and common dolphins, the endangered Indian Ocean humpback dolphin, southern right, humpback and Bryde's whales, South Africa has them all, and people come from all over the world to experience them up close in the oceans off our south-east coastline, where boat-based whale-watching operators offer up close encounters with our dolphins and whales.

Over the past two decades this has developed into an important, growing tourist industry, with new and established operators in marine tourism hotspots such as False Bay, Hermanus, Gansbaai, Knysna, Plettenberg Bay and Port Elizabeth.

In partnership with the Nature's Valley Trust, this WWF Nedbank Green Trust project, funded by Nedbank, will be the first to assess the impact of South Africa's boat-based whale-watching industry on the dolphins and whales, as well as the socioeconomic impact of the industry on the towns where the operators are based. Research started in September 2018 and they will be able to talk about the findings and trends early in 2020.

Bottlenose dolphin with calf in Algoa Bay. Photo: Lloyd Edwards, Raggy Charters

Where the whale-watching boats operate

"Using Plettenberg Bay for our case study, we are looking at the key areas the dolphins and whales use in the bay; where they rest, feed and socialise and where the whale-watching boats operate in these areas," explains the project leader Dr Gwenith Penry, who is also a postdoctoral researcher at Nelson Mandela University's Institute for Coastal and Marine Research, focusing on the 'data deficient' Bryde's whale.

"If there are too many operators in one area, the animals could leave. We need to safeguard the animals, develop a spatial plan, and offer feedback to the Department of Environmental Affairs on which parts of the existing regulations need updating and the rate of transgressions in the industry, as there are ethical and less ethical operators."

To observe how the dolphins and whales use the bay when undisturbed Penry's team is doing land-based observations using a theodolite – a land surveyoing tool with a powerful zoom, providing vertical and horizontal angles that are converted into GPS coordinates to track animals through time and space.

Chinese tour guides with Bottlenose dolphins at St Croix Island in Algoa Bay. Photo: Lloyd Edwards

High season versus undisturbed behaviour

PhD student Minke Witteveen, also registered with Nelson Mandela University, is looking at animal and boat interactions. "During the whale-watching high season, from about June to December, operators conduct more trips daily than at other times of the year; this will be our primary season for data collection," Witteveen explains. "By observing the animals' undisturbed behaviour, we can assess how this changes when they are approached by boats."

This includes conducting manipulated boat-based disturbance trials on their research vessel *Fluke* – a 7,5 m rigid-hulled inflatable boat. Following experimental protocol, they will approach the animals adhering to the legal distance restriction of 50 m for whales and humpback dolphins, and 25 m for common and bottlenose dolphins.

They plan to test the difference in the animals' behaviour under different scenarios, for example when they approach at full speed or at no-wake

speed; from different angles and staying for different lengths of time (current regulation is 20 minutes). They will also get closer than 50 m and 25 m to monitor the behavioural changes this may cause.

Whales and dolphins are curious creatures

Cetaceans (whales and dolphins) are curious creatures and may initiate closer contact with vessels, which is always a special and exhilarating experience for vessel passengers. In these instances, operators are still within regulation restrictions, but it is important to ensure that the animals control these interactions and not the operator.

Ultimately, Penry's team wants to determine what type of approach and encounter leaves the animal undisturbed and implement these as permit restrictions.

"We're often asked whether these restrictions are applied when swimming with whales and dolphins, but in South Africa this practice is illegal, both for the safety of the humans and the animals," Penry explains. "People think dolphins are smiley, friendly animals because this is how they are portrayed in captivity, but they are powerful, wild, top marine predators. If dolphins or whales bump you, they can do a lot of damage."

In addition to this research, Witteveen will conduct surveys with tourists about their boat-based whale-watching experience in our waters: "I'll be asking about their views of the industry, and whether the experience matched their expectation, because people are so used to seeing National Geographic-type shots that can take years to capture that some think they are going to see the same thing live," she explains. "We want to determine whether unrealistic marketing is placing unnecessary pressure on the skippers to get too close to the animals to satisfy tourist expectations."

Direct benefits of marine tourism

On the socioeconomic side the team is looking at the direct and indirect benefits of marine tourism activities for the communities and towns that offer these. They will also assess the contribution of marine tourism to employment and hospitality, such as how many accommodation establishments, restaurants and shops depend on it.

"Our research is truly transdisciplinary, as we collaborate with sociologists, economists and development specialists," Penry explains. "Our research includes assessing how it would affect the economy of these towns if there were no whale-watching operators. Some of these towns don't have other industries and it's important to understand the contribution of marine tourism and to encourage local government to value and support it and play its part in ensuring the industry is ethical and well regulated."

It's all part of the greater marine conservation effort, as dolphins and whales are not only important in their own right as key players in marine tourism, but also as key indicator species for overall ocean health because they are at the top of the marine food chain. Research on them informs the decisions and actions required to sustainably conserve our oceans and the communities who rely on them.

"Our research is truly transdisciplinary, as we collaborate with sociologists, economists and development specialists."

St Croix Island, Algoa Bay, has the largest breeding colony of African Penguins on the continent. Photo: Michael Sheehan

Raggy Charters Whale-Watching Cruise

One of the most established whale-watching cruises is Raggy Charters in Algoa Bay, national winner of the 2018 Lilizela Tourism Award for Best Marine Adventures in South Africa.

Guests depart from the Nelson Mandela Bay Yacht Club in Port Elizabeth Harbour for a 3.5 to 4 hour cruise. St. Croix Island is home to 22 000 breeding pairs of African penguins, the largest breeding colony in Africa. During the cruise, guests have a good chance of spotting bottlenose dolphins, common dolphins, humpback dolphins, bryde's whales, minke whales, humpback whales (June to December), southern right whales (July to September), Cape fur seals, various species of sharks, Cape gannets and various species of pelagic birds including terns, petrels, skuas, shearwaters and albatrosses.

The founder and owner of Raggy Charters, Lloyd Edwards, says: "Putting South Africa into perspective with other whale-watching operations around the world, we are up there with the best in terms of diversity of species, and we have higher numbers of most of our species than most other global hotspots I have visited."

In 2016 Edwards was a driving force in launching Algoa Bay as "The Bottlenose Dolphin Capital of the World". "According to the research, 28 500 bottlenose dolphins make use of Algoa Bay," he explains. "Visitors can also experience the phenomenon of the sardine run here from around March until the end of June, and Algoa Bay is the furthest east that southern right whales give birth in large numbers. They nurse their calves in the sheltered waters of the bay. Common dolphins are found further offshore here in schools of between 1000 and 3000 individuals throughout the year.

Raggy Charters also runs the Baywatch Marine Conservation Project, based in Port Elizabeth. The team engages with the greater Nelson Mandela Bay community, especially the youth, to talk about the marine environment and the need for its conservation and protection. They also assist with marine law enforcement and marine research.

Marine Guide Purity Khosa

Purity Khosa, a Marine Guide with Raggy Charters who also assists with the Baywatch Marine Conservation Project, had never seen the sea until 2014 when she started her Diploma in Tourism Management at Nelson Mandela University in Port Elizabeth.

"I'm from Bushbuckridge, Mpumalanga, and if you wanted to go to the beach you had to go to Mozambique or Durban, but we just didn't have the finance to do this," she explains. "When I first saw the sea I could not believe there could be such an expanse of water. And when I first stood in the ocean it felt weird, I had never had that feeling, it felt like it was pulling me.

"I initially joined Raggy Charters from February to June 2017 during my final year for the experiential learning component I needed to complete my degree. That was when I fell in love with the sea and in January 2019 I joined as a full-time staff member," says Khosa, who is currently pursuing a marine guiding qualification with the Field Guides Association of Southern Africa (FGASA).

"I have so much to learn about the marine life and I have also had to learn to swim So many people – especially from inland – don't know about the ocean or their impact on the ocean. We do educational talks at a wide range of schools and when I go home for a visit I'll do the same at the schools there, to let my people know about the ocean and that if they litter it will land up in the ocean through all the rivers.

"It doesn't make sense but growing up we were never taught about not littering and it is something that needs to be taught; times are changing and we need to make sure there is so much more awareness.

"As for myself, I have seen myself growing and in the future I would love to do something in marine biology; I have the perfect platform from which to do this."

www.raggycharters.co.za
www.thebaywatchproject.com
www.facebook.com/raggycharters

International Indian Ocean Expedition

In the 1960s, Australia made a significant contribution to the first International Indian Ocean Expedition by repeated voyages along the 110°East meridian in the south-east Indian Ocean. Now, nearly six decades later, a major voyage is under way to repeat this trip as part of the second International Indian Ocean Expedition (IIOE-2).

From 13 May to 14 June 2019 a multi-institutional team of 30 oceanographers from around the world will head offshore from Fremantle on board the 93m Australian Research Vessel Investigator. "We will be studying the oceanography of the south-east Indian Ocean," says Lynnath Beckley, Professor of Marine Science at Murdoch University, Perth, Western Australia who is originally from Port Elizabeth and an alumna of the University of Port Elizabeth, now Nelson Mandela University.

Beckley is leading the multinational study. "We will be going down to about 40° south and then we'll head north to about 12° south, before returning to Fremantle, conducting various tasks along the way. We'll travel about 6 500km from temperate areas through to the subtropics and tropics sampling a whole range of water masses, some 550 km away from the West Australian coast."

Prof Lynnath Beckley and the RV Investigator.

"On the month-long voyage we will repeat the 110°East line to examine multi-decadal change in the physics, chemistry and biology of the water column, investigate microbes, biogeochemistry and nitrogen sources, and study the pelagic food web from plankton through to the little understood mesopelagic lantern fish.

"They are the 'sardines' of the open ocean – about 10cm in length – and occur in the deep, dark, waters, where sunlight does not penetrate, but they rise towards the surface waters at night to feed. They are highly abundant and there are about 250 different species of them with an estimated global biomass of 10000 million tonnes. They are an extremely important component of the marine food web but we know very little about their ecology.

"The voyage will also enable ground truthing of bio-optical quantities like sea surface colour recorded by satellites as well as conducting acoustic surveys of whales. For comparison, some of our work will use the original techniques employed during the first International Indian Ocean Expedition but these will be supplemented with a host of modern techniques and electronic technology that will assist us in better understanding the pelagic ecosystem at the western edge of Australia's Exclusive Economic Zone."

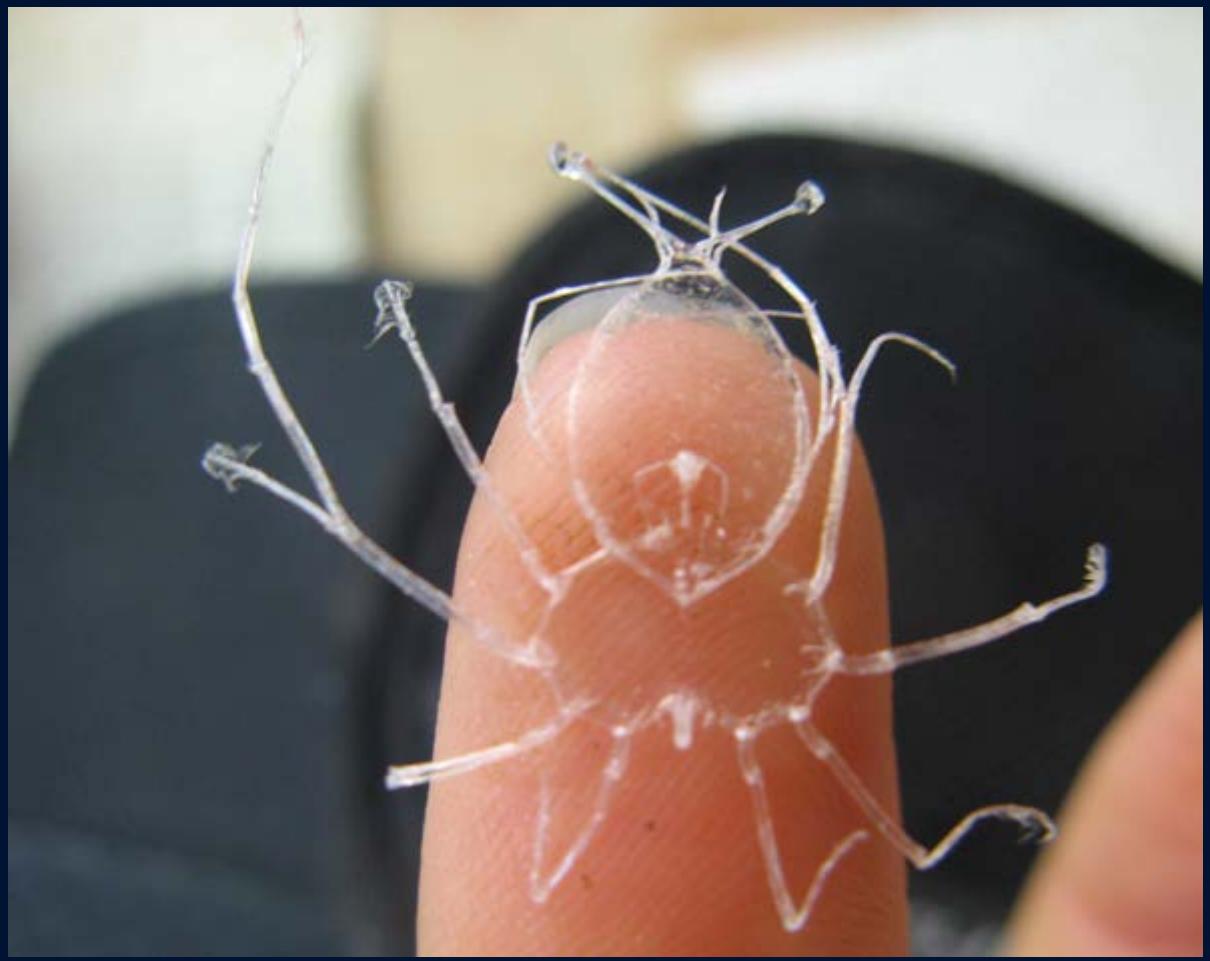
The May/June 2019 RV *Investigator* voyage can be tracked on iioe-2.incois.gov.in website where there will be updated news every day.

The voyage will also enable ground truthing of bio-optical quantities like sea surface colour recorded by satellites as well as conducting acoustic surveys of whales.

Australia's most valuable wild-caught fishery

The western rock lobster provides Australia's most valuable wild-caught fishery and is dominant in Western Australia, where it is valued at 500 million Australian dollars per year. "About a decade ago there was a dramatic decline in settlement of the post-larval phase to their natal coastal reefs," Beckley explains.

"We conducted in-depth research on the 9 to 11-month larval phyllosoma phase while they were out drifting in the south-east Indian Ocean, examining what they eat, the oceanographic conditions they favour and how eddies and currents affect them. During this phase they are transparent and are distributed widely where we assume they are eaten by pelagic fish like tuna. After this phase they metamorphose into puerulus larvae which look like mini-lobsters which then swim back to the coast and settle into the inshore seagrasses and reefs, reaching adulthood after three to four years when they become available to the tightly managed rock-lobster fishery."



Rock lobster phyllosoma larvae (planktonic stage)

Science as Darwin did it

By Dr Deborah Robertson-Andersson, Integrated Aquaculturist and Senior Lecturer Marine Biology, School of life Sciences, University of KwaZulu-Natal

"Haul away," yells the bosun. "Take up slack on the guide rope!"

My hands burn with the hemp sliding through them, "Lower away." Five people walk forward and sigh with relief.

You may be wondering what on earth … well it's science at sea, the only difference is that it is on a tall ship, the *Bark Europa*, and although modernised (she has an engine and power generation) all heavy lifting is done via sheets and lines and blocks and tackle and lots of manual labour.

A three-masted tall ship, the *Bark Europa* was built in 1911 in Hamburg, Germany to serve as a light ship on the German river Elbe. In 1986 she was brought to the Netherlands and over eight years she was completely renovated and re-rigged into a three-masted barque. Since 2000 she has been sailing the seven seas.

20 people for a plankton net

To put a single plankton net into the water requires 20 people on deck each one with their own function: the helmsman and lookouts; riggers who run up the mast and stow sails so that

Bark Europa. Photo: © Brett Yates

Cape Town and *Bark Europa*. Photo: Brett Yates

the ship can move slowly enough for the trawl to be placed in the water; three people to move the yardarm out perpendicular to the boat so that the net is as far away from the boat as possible; and seven people on lines to lift and control the net.

This is science as Darwin did it on the *Beagle* in 1831 and I am one of the lucky few scientists who have sailed with the *Bark Europa* and been given an opportunity to experience just how tough it was in the days of the tall ships and how astonishing it is that he managed to contribute so much to science.

Our plankton net's gaping mouth catches anything that's been disturbed as the ship sails through the waves, including a smack of jellyfish that turns the net purple. I turn to the bosun and say we need to raise it quickly or they won't be able to lift it. People groan they've just finished coiling all the lines and now have to lay them out again on deck. "Heave away," yells the bosun and the net slowly rises from the ocean, bursting with sea creatures.

Marine treasures

I open the cod end of the net and life pours into the bucket that another crew mate is holding. It's always one hand for yourself and one for the ship as it is being rolled by both wind and waves. Tasks that seem simple require team work to accomplish. The smiles and excitement are amazing, what treasures and new things will we see today: jellyfish, salps, larval fish, crabs, bluebottles and much more … we spend hours poring over the bucket.

Each discovery we make offers a sense of what those early scientists felt like when they brought up their nets. The thrill of learning something new is infectious and I can't wait for tomorrow.

Voyage of discovery

From the 8th April to the 29th May the *Bark Europa* is voyaging from Cape Town to Horta, in the Azores, with stops at St Helena and the Ascension Islands. On the 30th of May she will depart Horta, Azores, and arrive 16 days later in Rouen, France, followed by a seven day hop to Scheveningen, Netherlands.

From Cape town to the Netherlands, she will have three scientists on board, Marcus Fortune, a BSc student in applied marine biology from Bangor University, Marloes Schravesande, an MSc from Utrecht University, and myself.

It all starts with plankton

Fortune is looking at how plankton numbers and species change with latitude from the South Atlantic to the North Atlantic, collecting data on variables such as ocean temperature and salinity in order to develop a better understanding of plankton communities within this area. There is considerable interest in phytoplankton – which are single-celled, mostly microscopic organisms: the plants of the oceans – which use sunlight to photosynthesise and grow in a process called net primary production.

They can only do this in the sunlit surface layer of the ocean, down to about 100 metres, and they also need nutrients to grow, particularly nitrogen and

phosphorus, which can be scarce in surface waters. Climate change is predicted to warm many parts of the ocean and warming on this scale would alter key factors that drive marine ecosystems, including nutrient transfer from the deep ocean depths to the surface, ultimately leaving fewer nutrients for the plankton to live on. The domino effect on the entire marine ecosystem is that it becomes increasingly nutrient-starved over time, with a reduction in global fish catches, thus reducing a key food source for millions of people.

The great nurdle hunt

Schravesande is focusing on the global plastic pollution problem, specifically the distribution of microplastics over the voyage. And I am on the great nurdle hunt, following the nurdle spill that happened in Durban harbour in 2017. Scientists have predicted where they might end up and I am trying to find them and see how they have deteriorated over time as well as what is growing on them. We have reports and samples from St Helena and I will be looking in all the plankton trawls to see if we find any nurdles.

About three tonnes of waste lands up in our oceans every minute and with the sun, wind, and waves the plastics become broken up into smaller and smaller pieces, which are called microplastics. The wind and waves will then move them into different areas where they can have different effects, for example on Midway Island the 250 000 albatross chicks die after being fed plastic by their parents. Its estimated that the albatrosses remove four tons of plastic each year from the oceans.

My second subject of interest is jellyfish; any samples we get in the nets will be counted, photographed and genetic samples taken.

Future kings of the sea

Why jellyfish? Well the next time you see one wash up on the beach you could be looking at the future kings of the sea. All around the world gelatinous animal numbers are increasing and they are being found in areas where they've never been seen before and they have huge impact.

Jellyfish have halted seafloor diamond mining off the coast of Namibia by gumming up sediment-removal systems. Comb jellies eat so much food in the Caspian Sea they're contributing to the commercial extinction of beluga sturgeon – the source of fine caviar. In 2007, mauve stinger jellyfish stung and asphyxiated more than 100 000 farmed salmon off the coast of Ireland as aquaculturists watched in horror. South Africa's own nuclear power station has been shut down by the compass jellyfish. In fact they are better environmental activists than Greenpeace and have shut down more powerplants.

The news media have published all sorts of headlines to describe this, including "the jellyfish typhoon," "the rise of slime" and "jellyfish are taking over the world". As scientists we have several reasons as to why their numbers are increasing, including warming seas and perhaps even increased pollution; unlike many other marine creatures, jellyfish can cope with reduced oxygen levels. They're a phenomenon to research and a part of me marvels at nature's warning signals.

On an aesthetic level, seeing jellyfish at night out at sea, especially *Pelagia noctiluca,* is my favourite thing to witness. The name means 'open ocean night light' and as the ship sails past them in the dark they get irritated, causing a mass bioluminescence, as if someone has turned on hundreds on lights. On a moonless night, it's like the stars are mirrored in the sea.

Change the World

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