ACEP

AFRICAN COELACANTH ECOSYSTEM PROGRAMME

PROJECT OVERVIEWS 2021/22

The African Coelacanth Ecosystem Programme (ACEP) is a Flagship Programme of the Department of Science and Innovation (DSI) and is hosted by the South African Institute for Aquatic Biodiversity (SAIAB).

Key contributing partners include:
National Research Foundation - Human and Infrastructure Capacity Development Programme (NRF-HICD)
South African Environmental Observation Network (SAEON)
Department of Forestry, Fisheries & Environment (DFFE)
National Research Foundation - Knowledge Fields Development (NRF-KFD)
Shallow Marine & Coastal Research Infrastructure (SMCRI)

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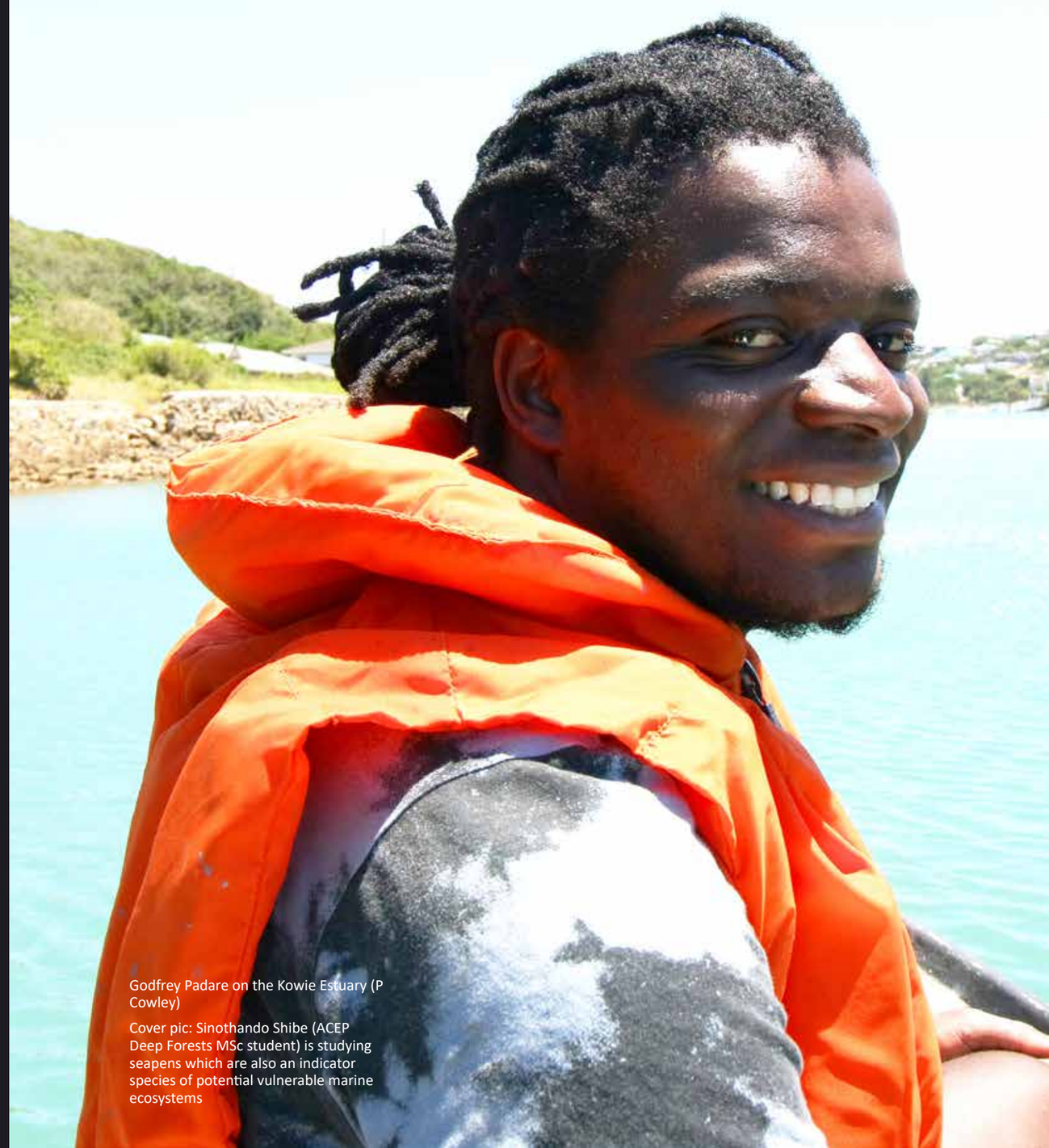

Godfrey Padare on the Kowie Estuary (P Cowley)

Cover pic: Sinothando Shibe (ACEP Deep Forests MSc student) is studying seapens which are also an indicator species of potential vulnerable marine ecosystems

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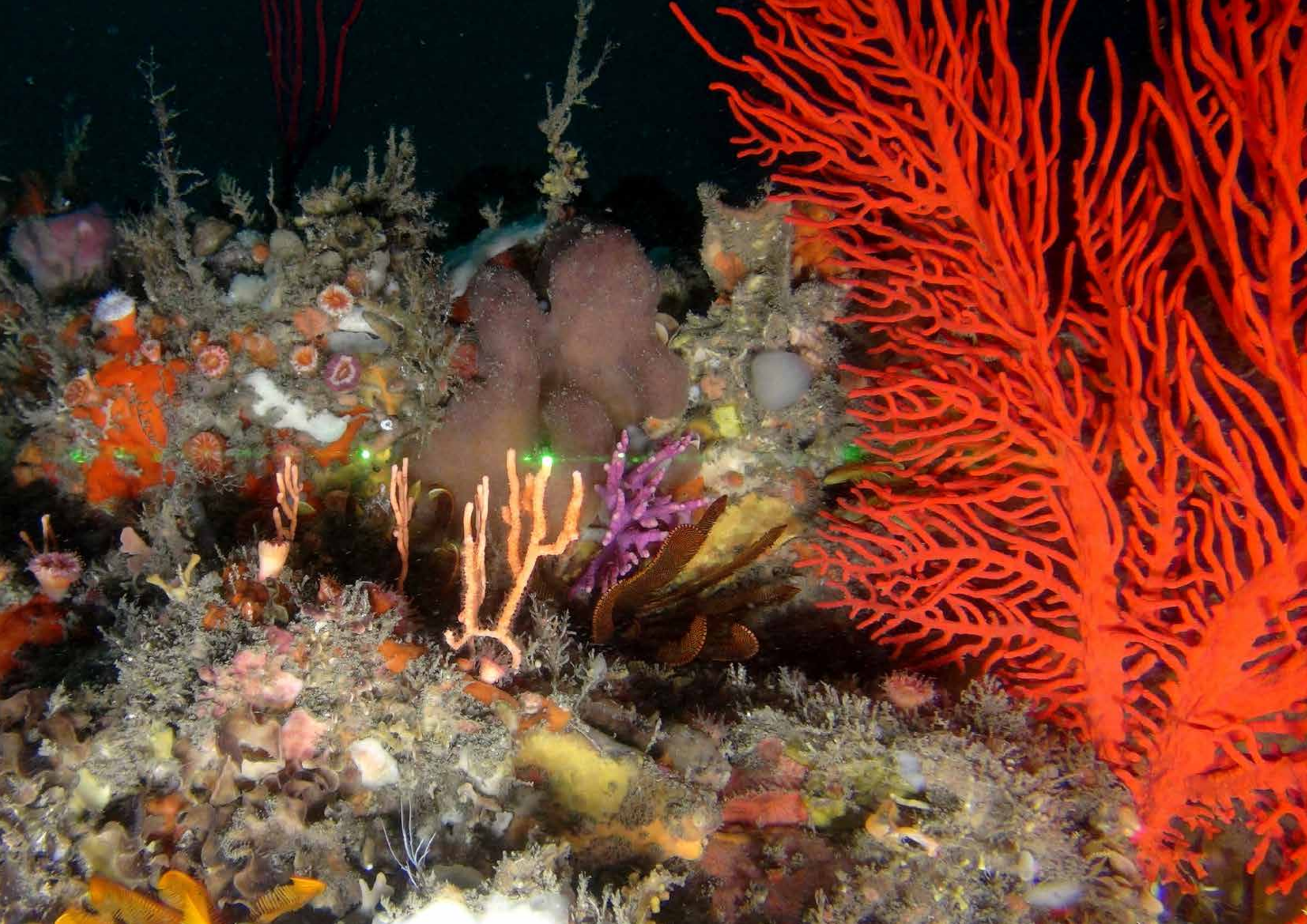
Kaylee Smit and Siseko Benya getting ready to use the drop camera to collect benthic photoquadrats, on board the SAIABDSTNRF *RV Phakisa*



ACEP OVERVIEW

The Department of Science and Innovation (DSI) and the National Research Foundation (NRF) African Coelacanth Ecosystem Programme (ACEP) promote competitive, multi-disciplinary and multi-institutional east coast marine research with an emphasis on building capacity in the marine sciences. The key to ACEP's success has been ongoing collaboration between the South African Institute for Aquatic Biodiversity (SAIAB), the South African Environmental Observation Network (SAEON), the Department of Forestry, Fisheries and Environment (DFFE), and the NRF's Research and Innovation Support Agency (RISA).

The primary aim of ACEP is to support research priorities along the east and south coasts of South Africa as outlined in South Africa's Marine and Antarctic Research Strategy (MARS), Operation Phakisa – Oceans Economy, as well to address the knowledge gaps identified by South Africa's National Biodiversity Assessment.

ACEP has developed into a large platform which includes the following instruments:

ACEP Phuhlisa Programme: The aim is to provide a dedicated instrument to drive transformation and build capacity by supporting marine science at Historically Disadvantaged Institutions (HDIs).

ACEP Open Research Call: The objective of this research call is to provide competitive access to research funding, infrastructure, and technical support to all within the National System of Innovation (NSI). The call is designed to ask and answer key national research priorities as outlined in the South African MARS, Operation Phakisa – Oceans Economy, and South Africa's National Biodiversity Assessment.

ACEP Joint Marine Laboratories Programme: This aims to build research capacity at HDIs through the establishment and support of specialized laboratories at the partner universities. Currently laboratories are being set up at the University of Fort Hare (UFH), the University of the Western Cape (UWC) and the University of Zululand (UZ).

- University of the Western Cape – Micro-plastics laboratory (Dr Anusha Rajkaran)
- University of Zululand – Marine and estuarine ecotoxicology (Dr Ntuthuko Masikane)
- University of Fort Hare – Bio-discovery (Prof. Graeme Bradley)

ACEP Marine Platforms: The aim is to provide competitive access to marine research infrastructure which is not normally held at research institutions. The Marine Platforms serve both the ACEP open research call and the ACEP Phuhlisa Programme, as well as the broader marine science community. The following services are provided:

- Marine Remote Imagery Platform – MARIP (SAIAB)
- Acoustic Tracking Array Platform – ATAP (SAIAB)
- Coastal Craft Platform (SAIAB)
- Geophysics and Mapping Platform- GeMaP (SAIAB)

ACEP also facilitates competitive access to Sentinel Site data (SAEON)

ACEP research platforms have been further enhanced by the DSI: South African Research Infrastructure Roadmap programme (SARIR) which supports the Shallow Marine and Coastal Research Infrastructure (SMCRI) programme. The SMCRI programme was initiated in 2017 under management of SAEON and is providing support to ATAP and MARIP as well as investing in a new coastal vessel which was built in 2019 and commissioned in early 2020. The above platforms aim to support South African researchers in addressing the country's needs identified by South Africa's MARS as well as Operation Phakisa – Oceans Economy.

ACEP Phuhlisa Programme

At the beginning of 2016, the DSI requested the ACEP Phuhlisa Programme to extend support to the University of Zululand and University of the Western Cape. Subsequent to this expansion, the programme now supports 19 supervisors and 70 postgraduate students, and has resulted in marine science developing rapidly at the universities. This is testament to how a directed instrument, such as the ACEP Phuhlisa Programme, can drive transformation. The programme has numerous research disciplines, including marine biology, estuarine ecology, marine geology, marine microbiology, and marine biochemistry.

The ACEP Phuhlisa Programme has gained significant traction at University of Zululand (UZ), Uiversity of the Western Cape (UWC), Fort Hare University (UFH), and Walter Sisulu University (WSU) where it contributes substantively to transformative human capital development. The rapid growth in student numbers has necessitated the establishment of a formal partnership with the Human and Infrastructure Capacity Development Programme (HICD) at the NRF through which bursaries are paid to Phuhlisa-supported postgraduate students. These postgraduate student bursaries are awarded in line with the national imperative of equity and redress which prioritises support for appropriately qualified students from designated groups, that is, black, female, and persons with disabilities. The set equity targets are 90% black, 55% women, and 1% students with disabilities, as directed by the DSI Ministerial Guidelines on Equity and Redress (Ministerial Guidelines on Bursaries and Fellowships, 2013). Additionally, these guidelines are intended to assist the NRF to improve representivity, to expand the skills produced by the South African science system, and to assist the DSI to direct and coordinate the development of high-level skills in the system. The ACEP Phuhlisa Programme is a key transformation programme within the South African Marine Research Strategy and contributes directly to the Operation Phakisa Ocean Governance Laboratory.

ACEP Open Call Research

The 2021/22 ACEP started the support of four new Open Call research projects as well as completing two projects from the previous call. The new projects have a strong focus on MPA effectiveness and management and address gaps identified in the National Biodiversity Assessment of 2018. The four projects being supported for 2021-2023 are:

Dr Warren Potts (Rhodes University): SALPA Project – Assessing the role and efficacy of marine protected areas in maintaining the climate resilience of fish populations- A South African case study.

Prof. Mandy Lombard (Nelson Mandela University): SmartZone MPA – Using the new uThukela MPA as a case study, this multi-disciplinary project uses a rare time-sensitive opportunity to gain a socio-ecological baseline essential for future assessment of

achievement of MPA objectives.

Dr Natasha Karenyi (University of Cape Town): Agulhas Bank Connections – Agulhas Bank Connections (ABC) project aims to improve our understanding of land-sea connectivity, social-natural connectivity, biodiversity of mid-shelf ecosystems, ecological processes and population connectivity across the Agulhas Bank.

Prof. Kerry Sink (South African National Biodiversity Institute): Deep Connections – Deep Connections aims to increase and apply multi-disciplinary information on biological, physical and socio-cultural connectivity into spatial assessment and management of marine ecosystems, threatened species and biodiversity benefits by piloting new approaches across the biodiversity value chain.

These projects would not be achievable without access to the ACEP Marine Platforms. It is this access to infrastructure and technical support that makes the ACEP Open Call so attractive to researchers, and enables the cutting-edge research that is conducted by the research teams.

Research output from this and previous ACEP open calls continues to grow, reflecting the high standard of the research being achieved. Twenty-three new peer-reviewed articles were published in 2021, taking the total for ACEP to 247. Many more are expected to come from this and previous phases of the programme.

ACEP Joint Marine Laboratories Programme

ACEP is in the process of setting up three DSI/NRF-SAIAB Joint marine laboratories at four HDI campuses. The aim of this is to strengthen support for Historically Disadvantaged Institutions and enable capacity development at these universities through the twinning of expertise of the four partner universities with expertise of a DSI/NRF National Facility viz. SAIAB. These laboratories continue to build on existing research and laboratory activities at the Universities and ensures access by University staff to ACEP infrastructure, e.g., coastal vessels and research equipment. The laboratories will be jointly co-ordinated by the partner Universities and SAIAB.

The DSI/NRF Joint Marine Labs Programme (JMLP) aims to address key marine, social and economic opportunities and challenges facing South Africans. This also includes development of technical skills to co-manage these joint research platforms.

ACEP Marine Platform Provision

A key facet of ACEP is the provision of research infrastructure to the NSI. The Marine Platform was impacted heavily by COVID-19 lockdown restrictions, seeing complete closure of the platforms for parts of 2020, and then a phased ramp-up over the remainder of the year. This resulted in some projects being postponed until 2021 which has had a knock-on effect. This change has been factored into the 2021–23 ACEP schedule. Demand from the South African marine science community has necessitated the expansion of the platform, which has been done with the build of a new research vessel, *RV Observer*.

Marine Remote Imagery Platform – The MARIP hosts the ROV, the Stereo-Baited Remote Underwater Video (SBRUV) systems, a benthic drop-camera (dropCAM) for photographing benthic macro-fauna assemblages, and a deep-water BRUV Lander capable of operating to 1500 m. The ROV team conducted expedition field trips to East London, Algoa and St Francis Bays and Mossel Bay supporting the ACEP Deep Forests and Agulhas Bank Connections Projects, as well as the Rhodes University Marine Natural Products Programme. The platform is managed by Dr Anthony Bernard, who also supervises postgraduate students and trains them in the use of the equipment and associated analysis software.

Acoustic Tracking Array Platform – ATAP expanded its reach significantly and now has 16 major coastal sites and 22 estuarine sites, comprising 148 listening stations, between Cape Point and Ponta do Ouro. ATAP's manager, Prof. Paul Cowley, is a member of the Global Ocean Tracking Network (OTN) Steering Committee, and Dr Taryn Murray is a member of the OTN Data Management Committee.

Coastal Craft – The Coastal Craft platform is one of ACEP's most successful research platforms. To date, it consists of a 13 m LeeCat, *RV uKwabelana* based in Durban which is set up as a dedicated multi-beam survey vessel, a 15 m Legacy Cat, *RV Phakisa* based in Durban, and the *RV Observer* based in Port Elizabeth. The coastal craft are primarily accessed through the ACEP Open Call and also support. ACEP's partner platforms include the SAEON Sentinel Site and the SAIAB ATAP, GeMaP, and MARIP which are serviced on a regular basis by the Coastal Craft.

Sentinel Site data – ACEP is a principal partner in the SAEON Sentinel Site which provides shared platforms, integrated field operation protocols, and logistical support. The network involves six core, long-term research and monitoring programmes, with no less than 40 permanent in situ moorings, recording the physical properties of the coastal ocean between Port Alfred and Oyster Bay. The data have already contributed to multiple postgraduate projects, been implemented in decision-making processes by local government and other agencies, and are becoming increasingly important for validating ocean- and atmospheric-based models. SAEON are in the process of increasing the number of Sentinel Sites around the country and will receive logistical support by ACEP for the rollout and implementation of the Durban Sentinel Site.

Geophysics and Mapping Platform – The platform provides a new dimension for marine science in South Africa. The platform comprises a RESON SeaBat 7101 multibeam echosounder and mini sound velocity profiler, a Teledyne Digibar S sound velocity profiler, RESON SeaBat 7101 control and data acquisition PC, a Full HYPACK license and dongle for data acquisition and processing, SBG Apogee Inertial Navigation System, and a high-powered processing PC. The platform is well subscribed by the 2021–23 ACEP Open Call and is supporting Marine Spatial Planning on the uThukela Bank.

Relevance to Society

Pressure on the marine environment is increasing as we turn to the ocean for resources to grow South Africa's economy, and ocean systems are experiencing climate change caused by human activities. It is up to researchers to provide the country's leaders with the information they need to make decisions that will allow for sustainable development of the Blue Economy, and to predict the effects of and prepare for climate change. ACEP facilitates research that provides valuable data for Marine Spatial Planning to ensure that the ocean space can be utilised efficiently by a number of often incompatible sectors, and at the same time, ensure that the sensitive environment that underpins the ocean's capacity to sustain life is not compromised. ACEP also ensures that human capacity is developed to equip future generations to manage the changes that our planet is experiencing.

A hydroid on a mesophotic reef off East London filmed from the ROV

ACEP PHUHLISA PROGRAMME

Sharone Masi studying abalone larvae under the microscope

The ACEP Phuhlisa Programme

The Phuhlisa Programme is a strategic DSI transformation initiative in partnership with four Historically Disadvantaged Universities (HDIs), University of Fort Hare, University of Zululand, University of the Western Cape and Walter Sisulu University. The programme aims to assist in building capacity in Marine Science at partner HDIs with the goal of accelerating transformation of the marine science research community. Through this collaboration, research support is provided by SAIAB to enhance research and supervisory capability at partner universities. A dedicated SAIAB Human Capital Development Manager, Mr Garth van Heerden, provides the professional support needed to drive the programme.

This strategic initiative ensures the graduation of increasing numbers of black and female South African postgraduates. The ACEP open call has been designed as a split call to facilitate the initiative, whereby a third of ACEP funding is ring-fenced to support partner marine science researchers at HDI universities. The programme capacitates marine science researchers by providing access to National Facility research platforms which would otherwise only be available to scientists at research intensive universities.

The SAIAB research platforms currently on offer include offshore research vessels in Durban and Port Elizabeth, skippers, 4X4 vehicles, estuary boats, dive teams and submersible ROVs. Financial assistance is provided for Phuhlisa researchers to further their research as well as study bursaries for students in their groups, where required.

Custom training courses help students catch up on academic writing, presentation and other skills in order to address the articulation gap of students coming from a disadvantaged background. Supervisors and their postgraduate students are provided academic and professional development opportunities including supervisory, scientific and life skills training courses, like, swimming and driving lessons, skippers licences, and diving qualifications, as well as first aid training. Due to the Corona virus pandemic these courses were put on hold until conditions once again allow for these interventions.

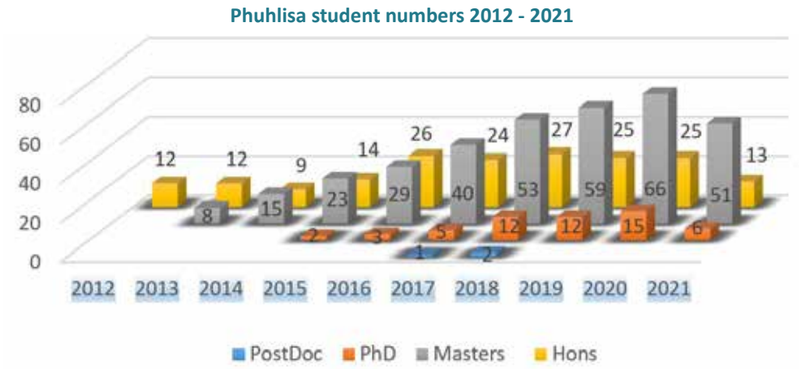
Critical to the success of the programme is that Phuhlisa follows a HDI researcher centred-approach. We believe that this is where the greatest potential for capacity development in the marine sector in SA lies.

Phuhlisa continues to work closely with NRF Human and Innovation Capacity Development (HICD) to secure Marine Science bursaries for most of the 70 postgraduate students and the 19 researchers receive project running costs funding for their postgraduate students. Researchers are also supported to attend conferences and training workshops to improve the technical skills required in their field of study. A big challenge of the programme is securing funding for postdocs who have successfully come through the programme and now need to give back by assisting with supervision of postgraduate students and also accelerate their career with publication of their research.

The ACEP Phuhlisa programme has not gone unaffected by the COVID19 lockdown. The Corona virus pandemic has once again highlighted the gross inequality which still persists among Institutions of Higher Education in South Africa, favoring researchers and student groups who are privileged enough to be at the better resourced universities of the country. This has again highlighted the necessity for interventions like the Phuhlisa programme. Student challenges during lockdown were further exacerbated by delays in students' bursary payouts at HDI. Studies for almost all MSc and PhD students have had to be extended by a further 12 months. HICD has given extension bursaries to a small group

of students and SAIAB has had to raise bursary money to see these postgraduate students over the line.

The programme is now in a position where the need for laboratory-based infrastructure at partner universities has been identified as a key gap in developing marine science at HDIs. The provision of infrastructure has to date been outside of the budget of ACEP. The DSI has recognized the need to address this gap and has made available an initial amount of R18 million for the establishment of four marine laboratories at the four partner universities.



Phuhlisa Programme challenges

Postdoc ring-fenced funding

DSI bursaries have been ring fenced for Marine Science Postgraduate bursaries, but excludes Postdocs from the call. Postdoc funding is required for 3 reasons:
Supervisory capacity is the most limiting factor at our partner universities, especially Walter Sisulu University in Mthatha. Making use of Postdoc opportunities is one manner of addressing this problem. Many of the researchers also only have a Masters' degree and postdocs would not only reduce teaching load but also free up researchers to further or complete their studies. Postdocs would also provide improved research rigor in the departments.
Limited supervisory capacity is the challenge in some departments, specifically WSU, where MSc students are asked to teach undergraduate courses due to lack of capacity. This causes major delays in students finishing on time or even finishing at all. We need to enable departments to rather make use of Postdoctoral fellows to assist with teaching marine science.
The Phuhlisa HCD pipeline is maturing well and the number of PhD students are growing. We need to cater for the PhDs graduates. We are therefore in discussion with Dr Mbulelo Ncango at HICD to have postdocs included.

Limited running expenses

Besides supervisory capacity, the next most limiting factor is running costs, currently paid from the ACEP Open Research Call which cannot support all postgraduate research projects to the required level any longer. In order to fund all projects we've had to reduce the amount of funding to PhD projects from R40K per annum to R25K per annum and for MSc projects from R25K to R15K per annum. Negotiations with DST need to factor in sufficient support to also cover running costs for research projects.

Sethu Mnqotho preparing limpets
for stable isotope analysis

A selection of Phuhlisa student reports

Investigations into the effects of diet on the culture of juvenile yellowtail, *Seriola lalandi*, in Recirculating Aquaculture Systems (RAS)

Student: Apelele Manjingolo **Degree and University**: MSc, UFH **Supervisor and Affiliation**: Prof. Nail Vine (UFH)

The use of Recirculating Aquaculture Systems (RAS) in South Africa for the aquaculture of marine finfish is still in its early stages, so research on the diet on cultured species is necessary. Juvenile yellowtail, *Seriola lalandi,* is one of the cultured species in South Africa. Research on the optimization of the diet of *S. lalandi* for cage culture has been done around the world (Matsunari et al., 2005; Bowyer et al., 2013; Le & Fotedar, 2013) as well as in South Africa. Although several diets have been formulated for aquaculture of *S. lalandi* in cages, no diets have been specifically formulated for RASs, which offer less economic and environmental risks than the more common sea cage culture method (DAFF, 2013). Advantages of RAS include better disease management, improved nutrient recycling and waste management, biological pollution control and better hygiene (Bregnballe, 2015). Therefore, RASs are a viable aquaculture method for marine finfish in South Africa and thus the study of diet and feeding regimes of juvenile yellowtail in RAS is vital.

The development of diets for carnivorous marine finfish such as *S. lalandi* requires a careful balance of the protein and energy requirements. Protein is a major component on *S. lalandi's* diet (>40%), a significant portion of which comes from fishmeal. Fishmeal is a finite resource and, with the growing terrestrial and aquaculture sectors, is becoming more and more expensive. Nutritionists are therefore constantly trying to improve (and reduce) the amount of protein to improve the profitability of farming the species. While reducing the protein content has direct cost implications on producing the diet, it is also important to assess the effect of this on the growth, survival and the Food Conversion Rate (FCR) of the fish. Fish use protein to build muscle but, if supplied in excess, protein is also be used to serve metabolic functions (i.e., the energy requirements) of the fish. With the high price of fishmeal, this can be unnecessarily expensive and therefore diet development must optimise the ratio of protein to energy. The aim of this study is to contribute to the optimization of the protein and energy levels of juvenile *S. lalandi* in RAS. The effect of dietary protein on survival, growth performance, and FCR of juvenile yellowtail fed iso-calorific formulated diets containing different dietary protein levels (38%, 44%, 50% and 56%) in RAS was investigated. Each diet was fed in triplicate to three RAS tanks holding juvenile yellowtail for 49 days. The effects of dietary protein and energy ratios survival, growth performance and FCR of juvenile yellowtail will be investigated. The best diet from the first experiment will be used as the reference diet, while protein:energy ratios will be adjusted for the remaining three diets. The trial will run for 6–8 weeks, or until the juveniles have doubled in weight. The research outcomes of the study will have an impact in the marine aquaculture sector by contributing to the optimization of a diet of juvenile yellowtail that will maximize growth and survival in RAS and so financially benefit the marine aquaculture sector.

Progress: The first experiment testing the effect of dietary protein on survival, growth and FCR of juvenile yellowtail has been completed. Data analysed for that experiment are reported below. I am currently analysing liver histology samples and await the proximate composition results being analysed at the Cedara College of Agriculture in KwaZulu Natal. Dietary protein levels did not have an effect on survival of juvenile yellowtail. In terms of growth performance, specific growth rate (SGR) (ANOVA: $F_{(3,8)}$=10, p=0.003) and weight gain ($F_{(3,8)}$=10, p=0.003) was greater in fish fed 56% protein than in fish fed 38% protein, but there were no differences between the 56%, 50% and 44% protein diets. Nor were there any differences in protein efficiency ratio (PER) between the four diets.

The Food Conversion Rate decreased with the increased protein level in fish fed the 56% protein, yielding the lowest FCR (1.26) compared to fish fed 38% protein (1.76) ($F_{(3,6)}$ = 13, p=0.003); however, there was no difference between the 44%, 50% and 56% protein levels. In terms of producing a diet with best growth at the lowest cost, a 44% protein diet is considered optimal for juvenile yellowtail in RAS. I am preparing to start my final experiment before the end February and hope to finish my project to graduate in September 2022.

Evaluation of the anti-diabetic activity of selected red marine algae found along South African coastal areas

Student: Bambo Karabo **Degree and University**: MSc, UFH **Supervisor and Affiliation:** Prof. Graeme Bradley (UFH)

The number of people worldwide who have diabetes and suffer from its complications is expanding at an alarming rate, with studies estimating that 552 million people may be likely to be diabetic by the year 2030. No satisfactory, effective therapy has yet been found to cure diabetes. The available injectable and oral blood-glucose-lowering drugs currently used to manage diabetes have many undesirable side effects and new plant-based therapies with fewer side effects are needed. Marine algae are a rich source of novel bioactive compounds with significant antioxidant and anti-diabetic potential which can be incorporated into drugs to treat many ailments, including diabetes.

This study evaluated the anti-diabetic, hyperglycaemic, and antioxidant activity of aqueous and methanol extracts of selected marine red algae (*Gelidium pristoides, Scinaia furcellata,* and *Portieria tripinita)* found along South African coastal areas. This research will contribute new knowledge relating to the development of new treatment therapy (from natural plant sources) for controlling diabetes.

Progress: Phytochemical assays were completed on both the aqueous and methanol extracts of all three species and indicated the presence of phenols, flavonols, flavonoids, tannins, saponins, and proanthocyanidins in the three species used in this study. Antioxidant assays were also conducted, including the ABTS and DPPH scavenging assays, FRAP, and a Nitric Oxide assay.

Both methanol and aqueous extracts of all three species showed scavenging activity against ABTS, and Ferric reducing power. DPPH scavenging activity was only positive for the extracts of *G. pristoides* and *S. furcellata.* Only the aqueous and methanol extracts of *P. tripinita* exhibited Nitric Oxide Scavenging activity. Antioxidant and cytotoxicity assays, conducted at NMU, revealed that only the *G. pristoides* and *S. furcellata* extracts showed slight inhibition to α-amylase, whereas all three red algae species showed inhibition to α-glucosidase. No significant effect on glucose uptake and utilization was observed on C3A cells following treatment with extracts of the species, with the exception of one extract of *S. furcellata*. Cytotoxicity was observed in methanol extracts of *G. pristoides* and *S. furcellata,* as well as aqueous extracts of *P. tripinita.* Overall, the research has established that *G. pristoides, S. furcellata,* and *P. tripinita* contain several bioactive compounds with notable antioxidants and potential antidiabetic activity.

The literature review was written and submitted for correction after attending the literature review workshop hosted by SAIAB in June 2019, and the workshop on scientific writing hosted by GMRDC in November 2019. Lab work has been concluded and results were analysed and reported. The final MSc dissertation was submitted for external examination, and the expected date for graduation is April 2022. A research paper on phytochemicals is expected to be published in 2022.

Spatial connectivity in intertidal rocky shore species between marine protected and adjacent unprotected areas along the east coast of South Africa

Student: Nkwelo Hlumela **Degree and University**: MSc, WSU **Supervisor and Affiliation**: Dr Thembinkosi Steven Dlaza (WSU)

This study is necessary because previous studies have never before looked at the connection between marine protected areas (MPAs) and the adjacent unprotected areas. The study aims to look at the relationship between MPAs and non-MPAs and discern how non-MPAs benefit from the MPAs. It also aims to look at the size difference in biomass and density of species between MPAs and non-MPAs. The study will investigate any connectivity between the MPAs and non-MPAs and determine if there is movement of species from the MPAs to the non-MPAs and *vice versa*.

Data collected from both MPAs and non-MPAs was used to visualize the relationship between MPAs and non-MPAs to determine any relationship between the two. Data was analysed using RStudio to visualize the connection between species and between MPAs and non-MPAs.

Progress: All field work and data collection have been completed. Data have been analysed using RStudio to look at the application of network visualization to depict limpet species connectivity across different sites, look at the seaweed connectivity in reserves and non-reserves along the Wild Coast, and to look at the limpet-seaweed interaction across protected and non-protected areas. Individual limpets found in MPAs were bigger than individuals found in non-MPAs caused by size-selective harvesting. Clear connectivity was evident between limpets found in protected areas and limpets found in non-protected areas. The study showed that seaweed species were more abundant in MPAs than in non-MPAs because MPAs are protected and not prone to harvesting for commercial purposes. The dissertation has been submitted to the external examiner for scrutiny.

Spatial distribution, diversity and economic value of marine organisms used for traditional medicine in Eastern Cape Province, South Africa

Student: Relebohile Lesuthu **Degree and University**: MSc, WSU **Supervisor and Affiliation**: Dr MDV Nakin (WSU)

Traditional medicine plays a major role in healing practices in the Eastern Cape. Although several studies have focused on ethnobotany in the province, little research has been done to document the use of marine resources in traditional medicine in the Eastern Cape Province. Modernization is rapidly eroding the traditional healing practices using animals, which calls for urgent action to document all related data before that knowledge is lost forever. The aim of this study was to investigate the economic value, diversity and distribution of marine organisms used for medicine in different geographical areas in the Eastern Cape Province of South Africa, with the following objectives: to document indigenous knowledge among traditional (*muthi*) market traders with regard to marine organisms used for traditional medicine; to quantify and compare the diversity of medicinal marine species sold in different sites; to record the economic value of marine species traded for traditional medicine; to determine factors that influence the economic value of marine species in the traditional medicine fraternity, and to map the geospatial distribution patterns of medicinally used marine organisms. Semi-structured interviews were conducted between November 2020 and May 2021. The data were analyzed using R version 4.1.0 and ArcMap 10.5. The data will be combined with the previous Honours project to produce a manuscript on ethnozoological studies. The paper will help to sustain indigenous knowledge as zoological knowledge is an important part of our cultural heritage and helps in developing sustainable management plans. The samples collected from traditional (*muthi*) market traders will later be verified for authentication of these marine organisms to help prevent overharvesting and smuggling of endangered species. To date, the fieldwork and data analysis have been completed. Fifteen marine species were recorded during the survey. Species diversity was higher in inland towns than in coastal towns. The results showed that shark was the most highly priced, and sea urchin the lowest of all the marine species in the *muthi* shops and stalls. The supply network of marine species traded in various *muthi* shops and stalls was widespread in the Eastern Cape Province. Covid 19 prevented attendance at any conferences last year. The virtual workshops were carried out within the university. The research project will be completed this month.

Zooplankton in and around South African kelp forests: community structure in relation to upwelling cycle

Student: Carlin Landsberg **Degree and University**: MSc, UWC **Supervisor and Affiliation**: Prof. AJ Smit (UWC)

Kelps form dense stands, referred to as kelp forests, in shallow waters in most temperate coastal waters. These kelp forests form the base of multiple marine ecosystems as a primary producer of kelp-derived detritus (KDD), a food source for marine organisms. Along with phytoplankton, KDD forms a soup of particulate organic matter (POM) making up the main nutrient source in these systems. Although filter feeders make up the bulk of the faunal biomass in kelp forests that use this POM as an energy source, knowledge about

Carlin Landsberg counting and identifying zooplankton samples by microscope

zooplankton in kelp forests is scant. We aim to describe the zooplankton communities in these kelp forests by examining how community composition of meroplankton and holoplankton change with proximity to kelp beds. Kelp forests on the west coast of southern Africa are directly exposed to the Benguela Upwelling System (BUS), and throughout the upwelling cycle, nutrient levels fluctuate. We thus aim to determine how zooplankton communities change through the upwelling cycle. This will allow us to determine whether it is the presence of kelp forests, or the processes associated with upwelling that influence zooplankton community composition and biomass in these kelp forests. Samples will be collected from both inside and outside the kelp forests at Kommetjie during upwelling and downwelling cycles, enabling us to determine nutrient concentrations and describe and quantify the zooplankton community in this area. The results of this study can possibly be applied to all areas along the west coast of South Africa, which is exposed to upwelling conditions and where kelp forests are present. The results may be used to determine how these communities would be affected by climate change (e.g., more frequent upwelling events) and consequently how commercial fish species could be affected by the knock-on effects, which could have socio-economic implications.

Progress: By the end of 2021, three of the proposed six field sampling days were completed with two days during upwelling cycles and the other during a downwelling cycle. Total suspended solids (TSS) have been determined and zooplankton counted and superficially identified from the collected samples. Results so far have shown that TSS is higher inside the kelp beds than in samples taken outside of the kelp beds. Additionally, species richness appears to be lower in samples taken outside the kelp beds than in those taken inside the kelp beds. By contrast, species abundance appears to be significantly higher in samples taken outside the kelp beds than in those taken inside the kelp beds. These are preliminary observations and may be subject to change once all samples are collected and analyzed.

Diversity and abundance of epiphytic diatoms and macrofauna associated with *Zostera capensis* in the Swartkops Estuary

Student: Kylen Brown **Degree and University**: MSc, UWC **Supervisor and Affiliation**: Prof. Anusha Rajkaran (UWC)

Estuarine habitats are critical nursery areas for many species of marine fishes during their early life stages in terms of food availability and structural complexity, which increase survival and growth rates. The nursery function of estuaries is an essential ecosystem service and is related to the presence of aquatic plant communities, particularly seagrass. This study aims to identify the food resources available to the estuarine-dependent fish species, *Rhabdosargus holubi* in the seagrass habitat of the Swartkops Estuary. This study investigates the diversity and abundance of epiphytic diatoms and faunal prey items (commonly found in the diet of *R. holubi*) on the leaves and in the sediment of seagrass beds. This study provides support for the resource value of the seagrass beds of the Swartkops Estuary as a suitable nursery habitat for *R. holubi* and highlights the connectivity of shallow-water habitats which are essential for maintaining healthy fish communities. Coastal marine fish are capable of utilizing multiple habitats during different life stages and are influenced by the structure and complexity of the seascape as a whole. Fish connect habitats through daily movement, larval dispersal, and ontogenetic migrations.

Progress: I analyzed the data for my first data chapter (Diversity and Abundance of Epiphytic Diatoms) and completed the laboratory work for my second data chapter (Macrofaunal Sorting) in addition to analyzing this data and identifying the species present. I continued with thesis writing and made corrections to different sections of my thesis. I also presented the work of my first chapter (Diversity and Abundance of Epiphytic Diatoms on the Leaves of *Zostera capensis* in the Swartkops Estuary) at the Southern African Society of Aquatic Scientists (SASAqS) Virtual Conference, which took place between 2–4 November 2021.

Quantification and characterisation of marine litter along the Wild Coast beaches in the Eastern Cape of South Africa

Student: Bahle Titi **Degree and University**: MSc (WSU) **Supervisor and Affiliation**: Dr Motebang DV Nakin (WSU)

Greater dependence on beaches for tourism, socio-cultural and religious activities has increased the littering in beaches. Increases in litter in recent decades have generated more interest in understanding its nature, its sources, and in solving the problems related to litter in the ocean and along coasts. Marine litter is a result of either intentional or unintentional human behaviour, and is categorised into ocean and land-based sources. The aim of the study was to quantify and characterise marine litter along the Wild Coast beaches. The study was conducted on three selected beaches: Port St John's, Presley's Bay, and Coffee Bay during the wet and dry seasons. It is anticipated that this study will provide information regarding marine litter management and create awareness as a way of minimising marine litter along the Wild Coast beaches. Within each of the selected sites, marine litter (data) within transects was collected and then taken to laboratory for further analysis and classification. Questionnaires were distributed and interviews conducted at each of the three selected beaches. The findings will enhance and complement the existing knowledge on marine litter management systems used on Wild Coast beaches of the OR Tambo District Municipality, and will protect marine species. **Progress:** Field work and data analysis have been completed. Corrections on the final dissertation are in progress.

Distribution, abundance, and health of the sand prawn (*Kraussillichirus kraussi*) in two estuaries

Student: Aamirah Botha **Degree and university**: MSc, UWC **Supervisor and affiliation**: Prof. Anusha Rajkaran (UWC)

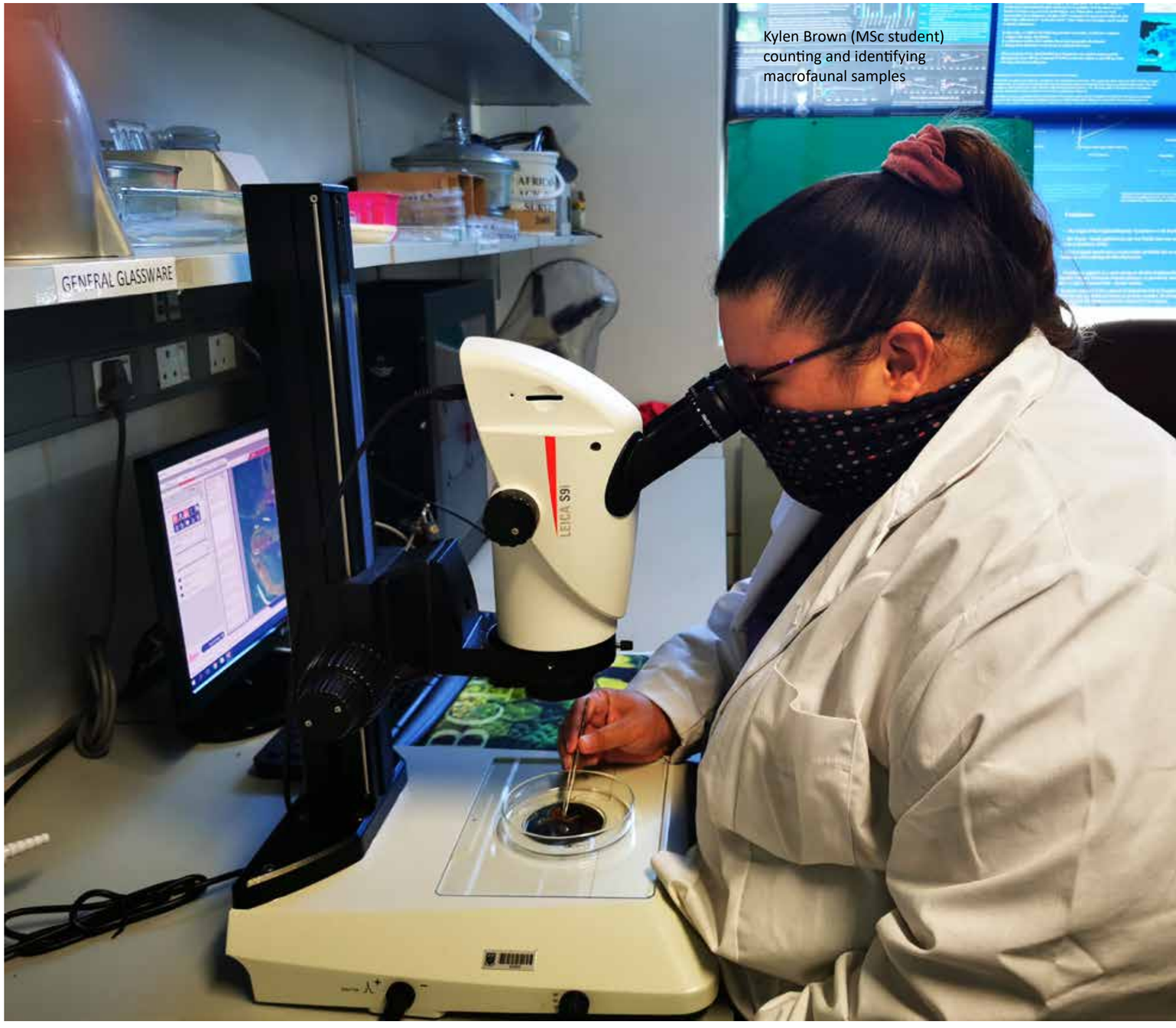
This study focuses on the distribution, abundance, and health of *Kraussillichirus kraussi* Stebbing (1900) in two estuaries: Zandvlei Estuary and Diep estuary, which are managed and owned by the City of Cape Town. They are the two largest estuaries and two of the last functioning estuaries in Cape Town. With both estuaries situated in highly urbanized areas, they are often faced with many external pressures. The Microplastics (MPs) present in estuaries threaten the aquatic environment and the wellness of the species residing in the estuary due to its non-biodegradable status. Organisms that form part of the benthos, such as the sand prawn, could potentially be exposed to negative effects caused by the coating

found on MPs. MP ingestion has not been well documented on invertebrates and benthic organisms (Bråte et al., 2017). Studies done by Claessens et al (2011) and Andrady (2011) have however, shown that coastal and estuarine sediments are becoming areas of significant microplastic accumulation. This indicates a high probability of sand prawn being exposed and potentially ingesting MPs throughout their lifecycle. This then makes *K. kraussi* the ideal candidate to study for MPs presence in these two estuaries mentioned (Duis and Coors, 2016).

Knowing the extent of MPs in both estuaries and whether they are being ingested by the sand prawn could assist in understanding the role that MP's might have on the health of these key species as well as further improve management plans in place. With both estuaries constantly facing ecosystem issues, whether it be from biological issues to surrounding urban issues, knowing the state of *K. kraussi* could create a major turning point in the overall management of the reserves.

The collection of data and monitoring of species presence and population is essential for determining the success of management actions as well as determining how far management actions should go. The aim of this study is to determine the state and health of *K. kraussi* along the stretch of both estuaries and to determine the physical-chemical properties that influence these populations. Unfortunately, due to the pandemic, communication regarding permits and ethics clearance was very slow and delayed field work considerably. Both estuaries were also closed, with the Diep still being inaccessible to both the public and researchers due to high concentrations of *E.coli*. Finally permits were eventually received in October 2021 and the first season (spring) was sampled at Zandvlei Estuary. Microplastics analysis in the lab commenced immediately after and samples were prepped to be sent off to a lab for heavy metal analysis. Lab work for the spring season is currently still underway and is halfway completed. The second season of sampling (summer) took place in January and sample analysis is starting now in February in conjunction with samples from the spring sampling to optimise time. So far from the spring sampling, it is evident that there are microplastic fibres present in both the water and sediment in the Zandvlei Estuary.

Results are yet to be compiled for analysis and comparison between the seasons. Various online webinars have been attended with the focus on marine research and microplastics. Most recently a plastics workshop called Plastic Materials and Processes hosted by WIOMSA was attended.



Kylen Brown (MSc student) counting and identifying macrofaunal samples

Ziyanda Mzozo setting up a tank system for abalone culture

Assessing levels of metals and polycyclic aromatic hydrocarbons and their biomarker effect in brown mussels, *Perna perna* from KwaZulu-Natal north coast

Student: Majola Ntando **Degree and university**: MSc, UZ **Supervisor and affiliation**: Mr HMM Mzimela (UZ)

Coastal environments are complex landscapes forming habitats for plants and animals and providing economic growth through tourism, recreational activities and storm protection. However, there has been growing concern in the recent years about contamination of harbours and estuaries from different anthropogenic sources. For example, municipal effluents release significant amount of contaminants such as pesticides, polycyclic aromatic hydrocarbons (PAHs) and heavy metals that can find their way to marine environments and harm aquatic biota. South Africa in particular is located along the primary global shipping route making its harbours, especially the east coast the largest and busiest ports in the world, making pollution a problematic environmental issue in South Africa.

This is supported by studies on coastal and estuarine regions of north-east KwaZulu-Natal (Vermeulen and Wepener, 1999; Mzimela *et al*., 2002; Wepener and Vermeulen, 2005) and also by recent studies (Majola *et al*., 2020; Izegaegbe *et al*., 2020). There has been growing concern about the increasing population and industrial developments along the coasts. In South Africa, approximately 30% of the population lives along the coastline and 63 licensed pipelines discharge about 800 000 m^3 of effluent in South African waters on daily basis.

The KwaZulu-Natal coastline is one of valuable natural assets used for commercial, residential and natural conservation purposes. However, most of KZN systems are subjected to contamination due to anthropogenic inputs. For example, The Mvoti and Thukela Estuaries are considered to be highly threatened with impaired ecological function including their ability to act as nursery grounds. The Mvoti Estuary in particular, is one of five estuaries which are considered functionally important because it supplies sediment, nutrients and detritus to the coasts. However, it has been described as one of estuaries in poor condition by previous health assessment as the result of treated sewage input from KwaDukuza via Mbozamo Swamp and activities in the lower uMvoti River which include different domestic uses by informal settlement, treated effluent disposal and agricultural irrigation.

The ecological health of the lower Thukela River near shore marine and Thukela Banks ecosystems has also deteriorated over the last few decades. The deterioration and impacts are associated with changes in anthropogenic land use within the catchment, alterations in timing, duration and volume of flows by abstraction and also by the association of the catchment with SAPPI and Isithebe industrial area. In contrast, Sheffield Beach is not associated with any major industrial impact so the rocky shores may serve as a comparison site for known impacted areas such as Thukela beach and Mvoti Estuary. Since these three aquatic systems have common species, and proper assessment of contaminant effects involves exposure of organisms measured through bioaccumulation and the biological effects as represented by biomarkers, it is then important to understand the effects of selected organic and inorganic pollutants to both exposed and reserved water systems and their effect on organisms along KwaZulu-Natal coasts.

The aim of this study is to determine the levels of selected organic and inorganic pollutants in water and sediment of Thukela beach, Mvoti Estuary and Sheffield Beach, assess their bioaccumulation and estimate their biochemical effects in tissues of selected marine invertebrates. By firstly assessing concentrations of selected PAHs in water and sediments, secondly, assessing bioaccumulation of metals in mussels, *Perna perna* and lastly by assessing the levels of Metallothionein, Acetylcholinesterase and Cellular Energy Allocation biomarkers in the mantle of brown mussels. The biomarker, PAHs and metal results will be investigated by the use of a parametric one-way analysis of variance (ANOVA) and $p<0.05$ will be considered statistically significant, followed by a Turkey's multiple comparison test to determine differences between results. The Principal Component Analysis (PCA) (CANOCO version 5) will be used to assess the patterns associated with sediment, water, bioaccumulation and biomarker responses. Apart from serving as a comparison study for other studies, the results will also display the possible impact of estuarine connected systems and their associated activity, and the pressures of the coastal developments on marine environments.

Progress: Sediments water and mussel samples were collected from Thukela Beach, Mvoti Estuary and Sheffield Beach during high and low flows. From the samples, metals have been analysed. Only one of the two biomarkers have been determined. The biomarker analysed is Acetylcholinesterase (AChE) activity and the mussel tissue chosen is the mantle. So far the results obtained correspond with some studies about Sheffield beach being less polluted and also with Mvoti Estuary being "grossly polluted".

An integrative morphological- molecular taxonomic study of marine copepods: building a DNA reference library for metabarcoding studies

Student: Aadam Rawoot **Degree and university**: MSc UWC **Supervisor and affiliation**: Dr Riaan B. Cedras (UWC), Prof. Johan Groenveld (ORI)

The project aims to develop a DNA barcode reference library on copepods species that occur in South African coastal waters. The study aims to determine how many copepod species have been verified to species level through microscopy, DNA barcode, upload DNA data to BOLD and using other DNA barcode libraries (GENBANK). The collection of copepod specimens from Kwa-Zulu Natal coastal waters are expected to be morphologically identified at the University of the Western Cape. Research protocols have to be developed to determine how to extract DNA from copepods without damaging their exoskeletons. And whether or not good quality DNA barcode records can be obtained from specimens after performing PCRs and DNA sequencing. Newly constructed DNA barcode reference library for copepods would benefit marine science in South Africa by rapidly identifying key indicator copepod species using DNA sequencing.

The objectives of this project include establishing a DNA reference library for copepods species that occur in the coastal waters of South Africa by developing an integrative morphological-molecular taxonomic approach to rapidly identify copepods collected in plankton tows. The reference library will comprise of DNA barcode sequences of individual species verified by morphological information and uploaded to the BOLD database.

Progress: I have done my literature review and I am in the process of submitting my

introduction of my thesis for chapter 1. I am able to identify copepods from samples. I am currently devising the method to extract DNA from copepods without damaging the specimens. I have done many PCRs on isolated DNA from copepod species but I am still trying to get good DNA barcodes for copepod species. The lab work is challenging and interesting. Hopefully, I will be able to compile a DNA reference library soon on copepod species, which will be the first for South Africa. I have attended and received my letter of completion for the SANBI Bioinformatics course held by UWC. I am currently busy with more lab samples which will be obtained by travelling to Durban as well as working on a layout for the final draft of my thesis. So far I have generated over 100 genetic sequences for copepods and my plan is to learn gap analysis in order to obtain more results. .

Culturing local marine copepods as live foods for marine fish larvae

Student name: Ngoepe Maphuti Eva **Degree and university**: MSc, UWC **Supervisor and affiliation**: Dr Riaan Cedras (UWC)

The importance of live food in marine larval finfish culture has become an essential study, as such the need to culture copepods is required to reduce expenses as production of imported sources of live feeds often leads to high production costs. Culturing of copepods does not only offer nutritional value but has been deemed an economically viable option. Moreover, conventional live food such as rotifers and brine shrimp does not improve the growth and survival rate of the larval finfish as compared to cultured copepods.

This project aims to develop an Integrated Multi-trophic Aquaculture System and an environment suitable for calanoid copepod as an option for live food production. The second aim of this study is to establish copepod ecology and physiological responsees for good growth and survival rates. Therefore, this research is designed to implement and establish the successful culture of calanoid copepod for marine larval finfish. The integrated multi-trophic aquaculture system built at Sea Point DAFF aquarium will be used to culture copepods even after the project is complete, which means that data attained will continue to offer insights on mass culturing of copepods in the aquaculture fraternity and thus offering and creating transformation and sustainability.

Progress: The follow has been acheiled: The capture of wild copepod species A*cartia sp.* from Kalk bay. The isolation of gravid females *Acartia sp,* development of protocols for the hatching of eggs and isolating grow out nauplii to adult stages, establishing a culture to further monitor growth and development. Determination of the most suitable environmental parameter necessary for the culture to thrive. Determination of algal production, suitable mixed algae and cell concentration as feed for the copepod. Established an experimental setup that enhances growth, development and continuous reproduction. Produced nauplii from as low as 100 to a 1000+ nauplii weekly from a culture setup of two 20L buckets weekly. Copepods were cultured in the laboratory under well maintained environmental conditions from May to December 2021.

Evaluation of the use of the 20/25L buckets and culture method to upscale the culture before the IMTA system is built. A lot of the data to be analysed as the experiments only came to an end in December. No conference/workshop were attended due to the pandemic.

Antimicrobial activity of *Ulva rigida* extracts against marine invertebrate and fish pathogens

Student: Nicole Okkers **Degree and university**: MSc, UWC **Supervisor and affiliation**: Prof. Gavin W. Maneveldt (UWC), Prof. Denzil R. Beukes (UWC), Dr Brett Macey (DFFE)

Aquaculture, and notably integrated multitrophic aquaculture (fish, seaweeds and invertebrates) has the potential to contribute significantly towards several key national priorities. Such priorities include rural development, increase in gross domestic product (GDP), job creation, food security, environmental sustainability and poverty alleviation. Sustainable production within the aquaculture industry is negatively affected by disease, which prevents growth of the aquaculture sector. This reduction in growth can amount to as much as 40% in the global capacity for some species as well as an estimated global impact of 6 billion US dollars per annum. Integrated aquaculture in South Africa is fairly well-established, where the green seaweed *Ulva rigida* is grown in abalone effluent water as a protein enriched feed for the abalone. Within this sector, disease outcomes are common, often caused by microbial pathogens, which often results in expensive and devastating consequences to aquaculture activities. Expensive antibiotics are used as treatment, increasing the risk of outbreaks of antimicrobial resistant bacteria as well as environmental contamination. The literature shows that *Ulva* species produce natural products that display several antimicrobial activity. Importantly, *Ulva* natural products have displayed resistance against pathogenic infection. The aim of this study was to determine if *Ulva rigida* extracts, grown in integrated systems, produce antimicrobial activity. Additionally we want to identify the specific compounds responsible for the activity. Prepared organic and aqueous extracts were tested against nine marine fish and invertebrate pathogenic microorganisms using disk diffusion antimicrobial bioassays and Minimum Inhibitory Concentration (MIC) tests. It is hoped that this project will generate new and relevant information regarding potential biosecurity implications of South African commercial integrated aquaculture systems, as well as bioremediation benefits.

Progress: I presented my honours project findings at the 32nd Congress of the Phycological Society of Southern Africa (PSSA) in January 2020. My honours project acted as a preliminary investigation, the results of which form the basis for my Masters project. The disk diffusion tests showed that the ethanolic and dichloromethane extracts displayed the most antimicrobial activity against the harmful marine pathogenic microorganism. Thus, *U. rigida* extracts can be a potential source of natural antibiotic. In the first year of my masters project, I repeated the disk diffusion tests as well as added a fourth extract, dichloromethane-methanol, in order to support my initial findings. During the second year of my Masters project, I spent time developing the methodology to complete the MIC tests. This proved a challenging task, as there were administrative issues in the lab as well as many failed trial and error attempts. Additionally, the Nuclear magnetic resonance (NMR) analyses of the extracts (that displayed activity with the disk diffusion method) showed some very interesting compounds that are responsible for the activity displayed. The NMR analyses showed that the ethanolic and dichloromethane-methanol extracts were the most active, confirming the potential of *Ulva rigida* as a source of natural antibiotics. I submitted an abstract to present a poster at the South African Marine Science Symposium (SAMSS) 2020. Due to COVID-19 the conference has been postponed to 2022. COVID-19 has, however, had a negative impact on my progression. The resulting National Lockdowns as well as the administrative lab issues caused an estimated twelve-month delay in some of my project lab work.

Evaluation of anticancer activity in selected red algae species from the Eastern Cape Coast against the HCC70 breast cancer cell line

Student: Afra Tsitsi Basera **Degree and university**: MSc, UFH **Supervisor and affiliation**: Prof. Graeme Bradley (UFH)

Breast cancer is one of the leading causes of cancer death, with 20 million new cases reported in 2021. Currently, breast cancer is treatment involves using invasive methods, including chemotherapy, which uses synthetic drugs. These synthetic drugs have adverse effects on the patients, including loss of hair, bruising, liver and heart problems, and anaemia. These effects have necessitated the search for natural sources of drugs. Marine algae are a good source of bioactive compounds. The study seeks to evaluate the anticancer potential of two red algae (*Gelidium pristoides* and *Laurencia natalensis*) species collected from Humewood beach, Port Elizabeth in the Eastern Cape, against breast cancer cells. The species were collected, identified using DNA barcoding and antioxidants extracted. The antioxidant and phytochemical potential was determined using the ferric reducing power, ABTS, DPPH, H_2O_2, Nitric oxide radical scavenging activity and phytochemical quantification assays. The extracts' cytotoxic effect against the HCC70 breast cancer cells was analyzed using the Resazurin cytotoxicity assay.

Progress: The Antioxidant activity and phytochemical content of the two red algae species were determined. The Phytochemicals-tannins, flavonols, phenols, and proanthocyanins were present in both species. Antioxidant activity is observed in both species. The methanol extract of Gelidium pristoides has the highest activity in the Ferric reducing power assay. *L. natalensis* (methanol and aqueous) has higher activity in the ABTS, DPPH, Nitric oxide, and Total Antioxidant activity assay. *L. natalensis* was cytotoxic towards cancer cells with an IC50 of 42.72ug/ml. After fractionation, fractions 4 and 1 of *G. pristoides* were cytotoxic against cancer cells with cell average survival of 64.8% and 91%, respectively. Further studies include the isolation and identification of the bioactive compound and the elucidation of the potential anticancer mechanisms. The dissertation was submitted to the external examiner and the expected graduation date is April 2022. The literature review chapter was written and submitted for editing.

The effects of salinity, temperature and nutrients on the nutrient contents and chemistry of *Ulva*

Student: Dhiren Vanmari **Degree and university**: MSc UWC **Supervisor and affiliation**: Prof. Gavin W. Maneveldt (UWC), Dr Mark Cyrus (DFFE)

This study aims to investigate the potential for producing high quality protein-rich *Ulva* and explore the effects of nutrient fertilization from eutrophic to oligotrophic conditions in an outdoor tank cultivation system. This study will generate useful information that may have important implications for aquaculture in the context of Integrated Multi-Trophic Aquaculture (IMTA) systems, and help better understand the growth dynamics and nutritional profile of *Ulva* in different nutrient/effluent conditions.

Progress: Four independent cultivation experiments were conducted, testing the effects of stocking densities, volume exchange rates, Pulse fertilization and Comparative nutrient

Lungelo Nsibande working in the laboratory

Afra Tsitsi Basera performing SPE Fractionation

administration on the growth, TAN uptake rates, pigmentation, and nutritional quality (micro and macro nutrient content including protein, ash, energy and carbohydrates) of *Ulva* sp. under aquaculture conditions. Over the past year (2021-Jan 2022) a comparative fertilization experiment was set- up (with numerous trial experiments) to test the influence of pulse fertilization vs. drip fertilization on growth, pigmentation and nutritional quality of the *Ulva*. Results showed differences in growth with pulse fertilized treatments yielding more Ulva compared to drip fertilized treatments.

The pigmentation among drip treatments and pulse-fed treatments were not different. Data on the proximate nutritional content of the samples from this cultivation trial are still lacking and is currently underway. An analysis of the water nutrient content was also conducted, testing the uptake rates of ammonium, nitrate and nitrite from each cultivation tank. Additionally, a proximate analysis (total lipid content, ash content and carbohydrates) of samples from the Volume exchange rate experiment and Pulse fertilization experiment (performed in 2019-2021) were analyzed. Results indicate that *Ulva* grown under higher Volume exchange rates and higher fertilization regimes tend to have lower carbohydrate contents and higher protein contents. Lipid and ash contents of *Ulva* cultivated at various volume exchange rates and fertilization regimes were not different. Data relating to the proximate nutritional (Protein, ash, Carbohydrates, fat, moisture) content of *Ulva* cultivated at two different fertilization methods (Comparative fertilization experiment) are currently underway. Upon completion of the remaining lab work (anticipated completion date: 01 April 2022), I will then commence with data analysis, and then finalise my thesis write-up. Thus far I have completed my introductory chapter, methods chapter and part of the results and discussion. These chapters are still, however, to be reviewed by my supervisors. If all goes according to plan, I intend to submit my thesis by the end of October 2022.

Evaluation of carbon stocks and associated threats at the Berg River Estuary

Student: Kezia Dreyer **Degree and university**: MSc, UWC **Supervisor and affiliation**: Prof. Anusha Rajkaran (UWC)

My project quantifies the blue carbon stock present in Berg River Estuary by collecting sediment cores. The sediment samples collected are analysed in the lab for organic carbon, moisture content, dry bulk density and living biomass above ad belowground. It also compares the amount of carbon stocks present in disturbed vs undisturbed areas as well as the change in vegetation cover over time. Blue carbon is the amount of carbon present in coastal vegetated systems and even though it covers less than 0.5% of the earth's surface it stores up to 55% of all biological carbon. This means it helps mitigate the effects of climate change and is therefore essential in this day and age.

Progress: All of the fieldwork (sediment collection) has been completed in 2021. The organic part of my lab work has been completed as well as redox and electrical conductivity measurements of the samples. The acidification portion of my lab work still has to be completed. For the lab work I completed graphs have been generated depicting my results. This includes graphs of dry bulk density, organic matter, moisture content and biomass. The trend of the results so far are similar to alike studies. I plan to complete chapter one by April and finish the rest of my thesis by year end. I also presented in an online conference (SASAQs) and the title of my presentation was: Evaluation of carbon stocks and associated threats at the Berg River Estuary. The conference was held from 2-4 November 2021.

Spatial distribution, diversity and economic value of marine organisms used for traditional medicine in Eastern Cape Province, South Africa

Student: Relebohile Lesuthu **Degree and university**: MSc, WSU **Supervisor and affiliation**: Dr MDV Nakin (WSU)

Traditional medicine plays a major role in healing practices in Eastern Cape. However, several studies have focused on ethnobotany in the province. Little research has been done in documenting the use of marine resources in traditional medicine in the Eastern Cape Province. The traditional knowledge is eroding very rapidly, which calls for urgent action to document all related data before the traditional knowledge is lost forever. The knowledge with the traditional healing practices using animals is fast disappearing due to modernization. The aim of the study was to investigate the economic value, diversity and distribution of marine organisms used for medicine in different geographical areas in the Eastern Cape Province of South Africa. This was achieved by the following objectives: To document indigenous knowledge among traditional ("muthi") market traders with regards to marine organisms used for traditional medicine. To quantify and compare the diversity of medicinal marine species sold in different sites. To record the economic value of marine species traded for traditional medicine. To determine factors that influence the economic value of marine species in the traditional medicine fraternity and map the geospatial distribution patterns of medicinally used marine organisms. Semi-structured interviews were conducted between November 2020 and May 2021. The data was analysed using R version 4.1.0 and ArcMap 10.5. The data will be combined with the previous honours project to produce a manuscript on ethnozoological studies. This paper is intended to help in sustaining indigenous knowledge as zoological knowledge is an important part of our cultural heritage and helps in development of sustainable management plans. The samples collected from traditional ("muthi") market traders was later verified for authentication of these marine organisms to help in preventing overharvesting of species and smuggling of endangered species. To date, the field work and data analysis have been completed. There were 15 marine species recorded during the survey. Species diversity was higher in inland towns than in coastal towns. The results showed that the shark had the highest price and sea urchin had the lowest price of all the marine species in the *muthi* shops and stalls. The supply network of marine species traded in various *muthi* shops and stalls was widespread in the Eastern Cape Province. The virtual workshops were carried out within the university. The research project has been completed and submitted this month for external examination. Preparations of manuscript for publication is in progress.

Characterisation of exposure and biological effects of contaminant of emerging concerns in Mhlathuze and Thukela River-Estuary

Student: Lungelo Nsibande **Degree and University**: Msc, UZ **Supervisors:** Dr N.F. Masikane (UZ), Mr H.M.M. Mzimela (UZ), Dr M. Thwala (CSIR)

The Thukela and Mhlathuze regions in the northern KZN are significant economic hubs as they support worthy industrial and agricultural activities, as well as a rising number of human settlements. Consequentially, anthropogenic pollution, including sewage derived pollution will likely increase and subsequently affects the health status of Thukela and Mhlathuze River-Estuary, these regions, therefore, present an ideal study case to examine the extent of this pollution in water of these two rivers. The project is examining the extent of pollution or contamination by contaminants of emerging concern (CECs) in the Thukela and Mhlathuze River-Estuary systems. This will be investigated by screening the presence, and quantification of concentrations of selected CECs (microplastics, pharmaceuticals, pesticides, engineered nanomaterials) in low salinity water samples from the Thukela and Mhlathuze River-Estuary using the source-to-sea approach and also by testing the potential bioaccumulation effects of metals and biomarker response acetylcholinesterase (AChE) using crabs as bioindicator organism. Microplastics, mainly fibres and film were detected composed of various polymers in both systems. Pharmaceuticals were confirmed, whereby 38 and 20 compounds belonging to 14 therapeutic classes at Mhlathuze and Thukela River, respectively. Pesticides were found in the Mhlathuze (13) and Thukela (14) River. A noteworthy result was the detection of CECs like atrazine, neverapine, acetaminophen, carbamazepine, and testosterone which are known for their endocrine disruptive activities. ENMs of irregular, sheet-like, spherical and hexagonal particles were observed. Elemental mapping showed the common presence of Si, Ti, Fe, Zn and Cu nanoparticles of which implies that environmental water samples are composed of various inorganic materials. The concentrations of Zn, Cr, Al, Pb detected in the studied water samples exceeded the threshold values of DWAF. This implies aquatic and human risk. Wide range of metals accumulated in crabs. Overall, AChE activity in gills of *Chiromantes eulimene* was reduced in both systems, which was a negative effect brought by organics and inorganics contaminants. Present data will be useful for legislation and policy makers as it will prioritize contaminants that are suspected for their environmental implications. The results will be further publishing two peer reviewed papers in two different reputable journals, titled: Exposure assessment of contaminants of emerging concern in the Mhlathuze and Thukela catchments, and accumulation of metals in water, crabs samples and their biomarker response in *Chiromantes eulimene* from the two systems. Moreover, the results of this data will be presented in both international and local conferences as follows. Nsibande L.R, Masikane N, Thwala M. and Mzimela H.M.M. 2019. Exposure assessment of organics in the uThukela and Mhlathuze River catchments, KwaZulu Natal. 2nd Africa Conference in Health Effects of Endocrine Disruptors: Sustainable Approaches to Healthy African Communities approaching at the rapid pace. Future Africa on the University of Pretoria's Hatfield campus, Pretoria. Poster presentation.

Nsibande L.R, Masikane N, Thwala M. and Mzimela H.M.M. 2021. Exposure assessment of microplastic contamination in surface waters of Thukela and Mhlathuze River catchments, KwaZulu Natal. The opportunities of crisis: resilience and change in the 21st century symposium, theme: Public health. Faculty of Science, Agriculture and Engineering Virtual Symposium. University of Zululand main campus.

Stable isotope analysis of selected seaweed and invertebrate species at Dwesa intertidal rocky shores, Wild Coast, South Africa

Student: Mdludlu Alizwa **Degree and university**: MSc WSU **Supervisor and Affiliation**: Dr Thembinkosi Steven Dlaza (WSU)

Isotopes are atoms with an equal number of protons and electrons but different number of neutrons. Typically, these isotopes are referred to as ratios that are articulated in the delta notation. The international periodic table of elements and isotopes (IPTEI) was generated and launched in 2011 by the International Union of Pure and Applied Chemistry (IUPAC)

in order to give knowledge about the existence and importance of isotopes of chemical elements. Isotopes are formally described as ZAE, where E is the element abbreviation, A is the atomic mass and Z is the atomic number equivalent to that of protons. Inorganic carbon, nitrogen and phosphorus are the main elements required by seaweeds for photosynthesis and growth (Roleda and Hurd, 2019). During photosynthesis, nitrogen is required for photosynthetic pigment generation (Dean and Hurd, 2007). During growth, nitrate is required for generating proteins that are required for active/fast growth rates (Dean and Hurd, 2007). For example, assimilation of nitrogen requires maintenance and activity of nitrite and nitrate while ammonia is metabolised to amino acids through glutamine synthetase and glutamine (Roleda and Hurd, 2019). Furthermore, it is important to know the ration of carbon, nitrogen and phosphorus ratios of seaweeds (Harrison and Hurd, 2001). Carbon plays a significant role in seaweed photosynthesis and growth by being involved in the generation of carbohydrates (Agarwai *et al.,* 2016).

The research question was, how do seasonal changes influence the isotope signatures of different seaweed and invertebrate species at Dwesa MPA rocky shore? It was predicted that if feeding mode and season influence seaweeds and invertebrate isotopes, then the species will display different signatures during different seasons. The aim of this project was to determine the degree of seasonal trophic relationships among the rock shore seaweed and invertebrate species of different feeding modes in Dwesa MPA. The main objective of this project was to quantify and compare the seasonal variations in Nitrogen (δ 15N) and Carbon (δ 13C) isotope ratios of different algal and invertebrate species across two habitats.

Progress: The summer season field sampling and collection on five sites, Mnyameni, Silaka nature reserve (PSJ), Mthatha mouth, Coffee bay and Qolora was completed by October 2020. By the end of October 2020, sample preparation has been done as well in the laboratory. The most interesting findings to date are the observations of the difference in rock formation, growth of vegetation and how the distribution of *G. pristoides* cover vs oysters and barnacles varied among the sites. Due to broken machines for analysis of stable isotpes at Ithemba labs, few changes were made on the dissertation. The project has been completed, however the results are not back from external examiner and the graduation date is not yet known.

Spatio-temporal and reserve effect on the biochemical composition of two patellid limpets of South Africa

Student: Sethu Mnqotho **Degree and university:** MSc, WSU **Supervisor and Affiliation:** Dr. TS Dlaza (WSU)

Along the east coast of South Africa, indigenous populations have long utilized the ocean as a source of food to supplement their largely agricultural diet. Large stock depletion caused by exploitation has a top-down effect and puts pressure on intertidal stocks and the community. Marine Protected Areas (MPAs) are seen as a tool for the conservation of biodiversity as well as managing fisheries. Ever since its inception, the concept of marine protected areas has gradually improved from just focusing on single reserves to a network of reserves that collaboratively produce a single centered impact. The problem that is normally associated with this idea, is the influence of biogeographic areas, which may have distinct biota, physical parameters, and economic activities. As such, biogeography needs

Majola Ntando dissecting mussels for metal analysis

Nicole Okkers pipetting an Ulva extract to test for antimicrobial activity against a variety of marine pathogenic microorganisms

to be assessed as a factor when assessing the influence of MPAs. Scientists have begun to appreciate the insights provided by biochemical information including ecological and physiological energetics on the effects of marine protected areas on protected organisms. A multifaceted approach was adopted to use both proximate and stable isotope techniques as tools to assess the efficacy of MPAs as well as for long-term spatial planning.

The study aimed to investigate the potential effects of MPAs, season, and the position along the coast on the biochemical composition of *Cymbula oculus* and *Scutellastra longicosta*. To achieve this, a 5-factor sampling design was adopted during both the dry and wet seasons. Samples were collected from the more warm-temperate (Amatole MPA in East London) and the subtropical (Dwesa-Cwebe MPA in Willowvale) biogeographic regions.

Limpets were sampled from two protected and two non-protected sites in both biogeographic regions. To assess variation within sites (i.e. small-scale variation), two designated areas were sampled approximately 100 m apart within each site across all sites. Both the proximate (protein, lipid, ash, and moisture) and stable isotope ($\delta^{13}C$, $\delta 15N$, C: N, C % and N %) laboratory analysis were completed in 2019.

Limpets from non-protected areas had higher protein levels compared to protected areas for both *C. oculus* and *S. longicosta*, however only in the subtropical biogeographic region. For *S. longicosta*, limpets from non-protected areas had a higher concentration of non-essential amino acids and the sum of the amino acids than limpets from protected areas in the subtropical region. In the subtropical region, lipid levels were higher in non-protected areas compared to protected areas during the dry and wet season for *C. oculus* and *S. longicosta*, respectively.

Seasonally for both species in both biogeographic regions, there was a sharp decline in the protein levels of both protected and non-protected limpets. Season also affected the $\delta^{13}C$ of *C. oculus*, with limpets showing differing food sources between the two seasons. This was reflected in the high ash levels of *C. oculus* in both protected and non-protected areas of the subtropical region during the wet season compared to the dry season.

The findings demonstrate the differences in exploitation patterns between the two regions—as a result, signs of protection and/ or exploitation were only pronounced in the more subtropical (Dwesa-Cwebe) region. Although non-protected limpets were shown to have better biochemical attributes, these results suggest a higher abundance of food (macro-algae) as a result of exploitation pressure on non-protected grazers (limpets). While the proliferation of grazers biomass in protected areas reduces algal biomass. The results also show the specificity of the reserve effect on the biochemical composition of limpets and that the effects of reserves are more dependent on the biology (i.e. territorial behavior) than just exploited against non-exploited limpets. These findings also suggest that regulations within MPAs, at least for limpets, should be based on territorial and not just overall.

The dissertation was completed and submitted in 2020, the degree was formally awarded in October 2021. A manuscript has been prepared for submission for publication. The study was originally accepted to be presented in the 2020 Southern African Marine Science Symposium and has been submitted for the 2022 symposium.

Environmental and engineering geology along the coastline of Port Elizabeth, Eastern Cape, South Africa

Student: Ntsoaki Lesala **Degree and university**: MSc, UFH **Supervisor and affiliation**: Prof. Ken Liu (UFH)

The project is aimed at studying and evaluating the morpho-dynamics of the beach and dune environments of the coastline of Port Elizabeth with respect to the environmental processes that are dominant and accountable for the current state of the coastline, the stabilization methods that have been and can be employed to stabilize the coast and minimize damage by daily natural processes and coastal hazards.

To achieve relevant, usable, and precise results, environmental and engineering branches of geology are paramount in the conservation of coastal environments as they have for years facilitated coastline reservation-related making of decisions by coastal scientists and managers and have been used to evaluate the impact and role of climatic, hydrodynamic, relief and topographical conditions and their impact on the wave, tide, and current action along the coastline of Port Elizabeth. These waves, tides and currents driven by the wind and water are the main agents of change along the coastline and are therefore studied in detail in this project with respect to their mechanisms, intensities, projection and impact that is studied through sediment size analysis, sedimentary structures and surface textures. The outcome of this project is expected to aid coastal managers and engineers in coastline environmental projects along the coastline in Port Elizabeth to make informed and risk assessed decisions by providing them with the relevant and necessary geological information about the coastline.

Progress: The proposal was drafted and presented in 2019 July at the Department of Geology where the topic was approved and further approved by the faculty of Science and Senate High Degree Committee. Data collection was completed in 2019 as well, samples were collected from the study area and analysed at the university of Fort Hare labs for the grain size parameters such as size, shapes, and mineral compositions. Sedimentary structures and grain size parameters were used for hydrodynamic analysis. Microscope studies were done to identify mineral compositions, whereas scanning electronic microscope (SEM) and Energy Disperse X-Ray (EDX) had been used for grain-shape, size, and surface texture studies. From field and lab analyses, we found that most of the sands are quartz minerals, plus some heavy minerals of hematite, magnetite, ilmenite, and tourmaline. Grain surface textures like the V-shaped percussion marks, etch pits, and upturn steps recorded the physical and chemical erosion and precipitation history of the sands. Most phases of the project have been successfully executed, the first draft has been submitted, corrections have been done, plagiarism report has been obtained and submitted, the thesis was also sent out to the UKZN for terminology examination and was sent back with an important comment which is that the topic is too broad and needs to be narrowed down therefore the topic is going to be narrowed down which will result in a lot of changes to the thesis for this reason expected graduation date is could be September. The thesis will be sent out for external examination as soon as the topic has been successfully modified.

The development of a novel bioflocculant sourced from a fresh water fish (*Oreochromis mossambicus*) and assessment of its effects on receiving waters

Student: Murendeni Cedrick Mavhungu **Degree and university**: MSc, UZ **Supervisor and affiliation**: Dr NF Masikane, Prof. Basson, Mrs Mpanza (UZ)

The project is aimed at isolating a bioflocculant producing microorganism, producing a novel bioflocculant and assessing the effect of the bioflocculant on the receiving environment using selected organisms.

Progress: Field work completed is completed. A bioflocculant producing microorganism was isolated and the optimal conditions required to produce the bioflocculant was assessed. The bioflocculant was found to be effective at a low dosage (state that low dosage). The impact of the purified bioflocculant on tilapia was assessed using the acute toxicity test. When assessing the impact of the purified bioflocculant on *O. mossambicus* it was found that there was no significant difference in the blood glucose levels between the control and test treatment. The same can be said about the level of serum cortisol. There are two experiments that are outstanding in this project and these include a cellular toxicity. These tests require external intervention. The cellular toxicity test was conducted in University of KwaZulu-Natal. All the lab work has been done and I am currently busy with final corrections on my dissertation before submitting the document for grading.

The status of PAH accumulation in Mhlathuze and Mlalazi estuaries and their effects on the physiology of *Chiromantes eulimene*

Student: Siboniso Marvin Ntsalaza **Degree and university:** MSc UZ

The construction of the Harbour in the Mhlathuze bay resulted in the development of an industrial complex in the catchment area of the Mhlathuze estuary. The Mlalazi River catchment area has practices like sugarcane farming and forestry activities. Previous studies have assessed contamination (e. g Heavy metals) in these systems, but there is no study evaluating the presence and levels of PAHs. The primary goal of this study is to generate baseline information of PAH pollution status by studying the occurrence, distribution and potential ecological risks of PAHs in these systems. This will be achieved by sampling at seasonal intervals. Water samples, sediment samples and *Chiromantes eulimene* will be collected then analysed for the presence and type of PAHs, and levels of those PAHs.

Progress: There have been a few setbacks to the project, one being the Covid-19 pandemic. There was also some trouble with the purchase of the reagents required for analyses of the samples, due to that no data have been analysed and therefore no interesting results achieved to date. The issue with the reagents have been sorted and about to start with analysing the samples.

Sediment grain-size distribution and environment protection along the coast of Port Elizabeth, Eastern Cape Province of South Africa

Student: Ntsoaki Lesala **Degree and university**: MSc, UFH **Supervisor and affiliation**: Prof. Ken Liu (UFH)

The project is aimed at studying and evaluating the morpho-dynamics of the beach and dune environments of the coastline of Port Elizabeth with respect to the environmental protection. Grain-size analysis, sedimentary structures and mineral composition analysis was used to characterize the geological and hydrodynamic conditions of the coastline beaches and dunes of Port Elizabeth. Mitigation methods for environmental protection along the coast of Port Elizabeth are also proposed. Coastline erosion had caused coast retreat in the past. Wave, tide and aeolian process are the major forces which caused the coastal erosion, and damage of infrastructure. A number of effective and usable mitigating and stabilization methods for coastal erosion for the industrial developmental area of the Port Elizabeth are proposed. The outcome of this project is expected to provide new insight in the hydrodynamics of coastline erosion and the usable methods for environmental protection. The research results will benefit to local government in the marking environmental law and coastline protection.

Progress: The proposal was drafted and presented in 2019 July at the Department of Geology where the topic was approved and further approved by the faculty of Science, as well as Senate High Degree Committee. Samples and field datum collection were completed in 2020, and most of lab work, such as grain-size analysis, mineral composition analysis and microscope studies were done in 2021 in the Department of Geology, University of Fort Hare. Due to Covid-19 pandemic, some laboratory work was still waiting to be completing, such as X-Ray diffraction (XRD), a part of Scanning electron microscope (SEM) and Energy Dispersive X-Ray (EDX) analyses will be finished in the early 2022, then write up the whole MSc dissertation. It is expected that all the research project and the MSc dissertation will be finished in/before the end of June 2022.

Harvest rate and rehabilitation of patches by seeding brown mussel *Perna perna* in the exploited sections of Dwesa-Cwebe MPA

Student: Maqalekana Olwethu **Degree and University**: MSc, WSU **Supervisor and Affiliation**: Dr TS Dlaza (WSU), Mr HD Kali (WSU)

Brown mussels *Perna perna* are found in marine environments where they attach themselves to hard substrates substrate such as rock. People use brown mussels for different purposes, some eat them, and some use the shell for medicinal purposes. The Wild Coast is characterized by high unemployment, poverty, and illiteracy which forces dependence on marine resources. The brown mussel is one of the species that alleviate poverty and if there is an increase in its number, communities along the coast will benefit. The aim of the study is to reduce the mussel patches by seeding the juveniles and see if they can grow when introduced to different habitats. The brown mussels were seeded by first collecting the juveniles left by the harvesters, then drilling the rock and put the

Tyla Goldman cleaning a rotary flask containing dry Ulva samples using a pasteurising pipette to gain optimum Ulva material

juveniles in the PVC pipes. If the data shows a positive growth of brown mussels, that will help in people Dwesa-Cwebe to seed more mussels to increase these species so that mussels don't go extinct. The project is more focused on reducing poverty and an increase in job opportunities, so the success of it will meet the needs of Dwesa-Cwebe people.

Progress: The sampling started on July 2019 was supposed to end on July 2020. I've managed to seed many PVC pipes from 2019 to 2021. The year 2020 was problematic because seeding could only happen for one month due to Covid19. Then when I was able to go there to check the progress, many mussels were gone and only one pipe was left with 15 mussels inside. From the data I have collected I have managed to identify the survival rate, growth rate and attachment rate. The brown mussels did attach after a month but some died and some were carried away with water. The length of the mussel shell showed an increase after a month which means mussels have grown. After the data analysis we found that the frequency at which harvesters went to harvest was more important for the number of harvested mussels than the total number of people harvesting at one time. We also found that there are specific seasons people harvest more and there are also seasons where people harvest less. We attended workshops for R-studio, on literature review writing and referencing. I managed to complete the data analysis as well as a write up in 2021. The graduation is supposed to be in this current year 2022.

Bioaccumulation of microplastics in brown mussel *Perna perna* and the rock oyster *Saccostrea cucullata* along the north coast of KwaZulu-Natal

Student: Sbusiso Cyril Mkhabela **Degree and university**: MSc, UZ **Supervisor and affiliation**: Mr HMM Mzimela (UZ), Dr NF Masikane (UZ)

Estuaries retain enormous amount of plastic waste derived from terrestrial, riverine and marine environments. Additionally, estuaries act as conduits, conveying macro and microplastic from rivers to the coastal environment. As such, research on microplastic pollution in SA's coastal and the marine environment has increased over the past few years. The bioavailability of microplastic to aquatic organisms is one of the major environmental problems associated with plastic pollution. Marine organisms such as bivalves are of particular interest as they directly ingest microplastic particles suspended in the water column. This is due to their sessile and non-selective filter feeding strategy. Laboratory studies done on mussels have demonstrated that microplastics can induce adverse effects on the cellular and tissue levels. In addition, microplastics are reported to cause structural changes in the gills and gastrointestinal system in mussels and oysters. The KwaZulu-Natal (KZN) coastal environment is highly impacted by human activities such as, urban development, coastal industrialization and recreation. These activities are directly linked with plastic pollution. This threatens the biodiversity along the coast as these plastic particles are likely to deteriorate natural ecosystems. For example, uMvoti and uThukela estuaries are amongst estuaries in the north coast of KZN that have been reported of being severely impacted by sewage and influent disposal derived from industrial, agricultural and local centres. However, information about microplastic pollution and their bioaccumulation in marine species in KZN coastline is limited. The aim of this study was to investigating the occurrence and distribution of microplastic pollution and their bioaccumulation in brown mussel *P. perna* and rock oyster *S. cucullata* along the north coast of KZN. This will be achieved by analysing water and sediment samples collected during wet and dry season. Thereafter, assess the accumulation of microplastics in *P. perna* and *S. cucullata*.

The overall microplastic abundance (microplastic. L^{-1}) in water samples was recorded as follows, uMvoti Estuary (86)> uThukela Estuary (76.75)> Sheffield Beach (54.25). In sediment samples, microplastic abundance (microplastics. $30g^{-1}$) was as follows uMvoti Estuary (263)> Sheffield Beach (158.74)> uThukela Estuary (122.5). Overall mussels were reported to have high microplastic accumulation (microplastics. g^{-1} w/w) compared to oysters. Microplastic abundance (microplastics. g^{-1} w/w) was high in mussels originating from uMvoti Estuary. Overall, microplastic typology was as follows, fibres>fragments>film. The overall colour composition was white>blue>black> and others.

The results of this study highlight that microplastics are ingested by marine organisms and their bioaccumulate in the tissue of marine species and are likely to induce adverse effects. In addition, this study also highlight the potential of *P. perna* and *S. cucullata* to be used as biomonitors of microplastic pollution in South Africa. Furthermore, it was noted that seasonality has an impact on microplastic pollution with wet season having the highest levels of microplastic due to increased runoff and fluvial input to estuaries. Additionally, this study indicates that estuaries are main conduit of microplastics to marine coastal environments.

The high level of microplastic pollution in both biotic and abiotic matrices at uMvoti Estuary indicate that this estuary is severely impacted by microplastic pollution. We have completed all the field work for this study and water, sediment and biological samples have been alalysed.

Developing a method for assessing chronic toxicity in marine and estuarine ecosystems using the endemic amphipod *Grandidierella bonnieroides*

Student: Blessing Xulu Mthokozisi **Degree and university**: MSc, UZ **Supervisor and affiliation**: Dr N Masikane (UZ)

Toxicity testing is the standard procedure to assess contaminants impact on the aquatic environment. In South Africa, there is no standardised organisms and methodology to conduct toxicity tests. This study will aim to determine the suitability of *Grandidierella bonnieroides* to toxicity testing and develop a standard method to assess toxicity. The *G. bonnieroides* will be exposed to different parameters including photoperiod, salinity, temperature, and sediment composition to assess its sensitivity and response. This study focuses on chronic toxicity testing, as it is environmentally realistic as compared to acute toxicity testing.

Progress: I have managed to conduct two experiments for photoperiod regime parameters, which were labelled range finders for actual concentrations to use during experiments. The experiment was conducted with Sodium dodecyl sulfate (SDS) with a concentration range of 0-7 mg/L. There was a high survival percentage indicating that concentrations were low for significant toxic effects. The range of concentrations suitable for the actual experiment after these tests and literature were concluded to be 0-45 mg/L.

Anti-cancer activities of red algae species found along the coastline of the Eastern Cape

Student: Faith Masilive Mshiywa **Degree and University**: PhD, UFH **Supervisor and Affiliation**: Prof. Graeme Bradley (UFH)

Cancer is the second leading cause of death worldwide, with breast cancer being the second most common cancer (approximately 2 million new cases diagnosed worldwide in 2018). Substantial progress in prevention and treatment options for cancer has been made in recent years. However, anti-cancer drugs involved in chemotherapy are cytotoxic to healthy cells and cause immunotoxicity. New anti-cancer drugs, with no or low side effects on the immune system are essential for the pharmaceutical industry. As a result, natural compounds from macro-algae have become a substance of great importance for cancer therapy. Among the macro-algae, red algae are regarded as the leading producers of halogenated compounds because of their unique biosynthetic pathways. This study aims to identify red algae species found along the Eastern Cape coastline and test their anti-cancer properties using triple-negative breast cancer cell lines (HCC70). This aim will be achieved by collecting various red algae species (~10 in total), identifying the species using DNA barcoding, optimising solvent extractions, screening for phytochemicals, and performing cytotoxic assays. Potential anti-cancer compounds from two selected red algae species (species with the highest cytotoxicity and species with intermediate cytotoxicity) will be extracted, and their anti-cancer mechanism of action will be identified. Findings from this study can add to the biodiversity database of red algae in South Africa, and assist pharmaceutical industries in developing anti-cancer drugs that have fewer or no side effects.

Progress: Phytochemicals (total phenols, flavonoids, flavanols tannins, terpenoids, alkaloids, proanthocyanidins, alkaloids and saponins) were screened for in the methanolic red algae extracts and were found to be highly cytotoxic to the Human Triple-Negative Mammary Carcinoma (HCC70) breast cancer cell lines used in this study. These extracts' radical scavenging activities were determined, including the Ferric Reducing Antioxidant Power, the ABTS (2,2'-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid)) inhibition activity, and the Nitric Oxide and the Hydrogen Peroxide Scavenging activity assay.

The HCC70 toxic red algae extracts were fractionated using solid-phase extraction chromatography (SPE), and the fractions obtained were tested for cytotoxicity with the resazurin assay. The dominant phytochemicals/antioxidants yielded from *Gelidium amansii* were total phenols, tannins and saponins. *G. pristoides*, on the other hand, yielded only moderate amounts of tannins, flavonols and saponins. The ABTS radical scavenging ability of *G. amansii* was 40% at 0.1 mg/ml, while that of *G. pristoides* was less than 20% at 0.1 mg/ml. The nitric oxide inhibition activity of *G. amansii* was higher than that of the standard antioxidants, Vitamin C and BHT, up to 90% at 0.4 mg/ml. Both *Gelidium* species had a low ferric-reducing antioxidant power as well as low H_2O_2 scavenging activity. *G. amansii* showed a higher cytotoxicity activity than *G. pristoides*; its IC_{50} was the lowest of all the species, which yielded a positive result for cytotoxicity. The compounds responsible for this activity may be either tannins, saponins or total phenols.

The single point cytotoxicity results of *G. amansii* fractions revealed high cytotoxicity from fractions 4 (80% MeOH fraction), 1 (20% MeOH fraction) and 5 (100% MeOH fraction), respectively. All fractions, except fraction 5, of *G. pristoides* were non-toxic.

The HCC70 cell inhibition percentages of the *G. amansii* fractions were 85.6%, 54.4% and 48% while *G. pristoides'* was 63.2%. The assays to determine the anti-cancer activity mechanism of the red algae extracts have not yet been done because reagents have not yet been purchased. No conferences/workshops were attended in 2021. One article is ready for publication; the second article is in preparation and will be ready for publication mid-2022.

Afra Tsitsi Basera cleaning seaweed samples in the laboratory

Ngoepe Maphuti Eva sorting copepods using a dissecting microscope

Indicators and the status of pollution in mangrove-dominated estuaries of the Eastern Cape

Student: Jaime Johnson **Degree and University**: PhD, UWC **Supervisor and Affiliation**: Prof. Anusha Rajkaran (UWC)

The overall aim of this study is to characterise the prevalence and distribution of selected pollutants within mangrove-dominated estuarine systems in the Eastern Cape, South Africa in order to understand the role of these habitats in accumulating and/or filtering anthropogenic pollutants. This will be achieved, firstly, by quantifying the concentration of nutrients and toxic metals within the sediment-water-plant interface in relation to the disturbances experienced across mangrove forests in South Africa (urban and rural). The aims of this collected data are to 1) determine the environmental fate and toxicity of metal pollution in estuaries located within rural and urban areas; 2) determine the effects/risks of metal pollution on mangrove ecosystem services. The findings of this chapter will be published. The aim of the second data collection chapter is to quantify and characterize the microplastics present in the sediment and overlying water of mangrove habitats in the Eastern Cape. These data will be used to 1) assess the density and distribution of microplastic accumulation within microhabitats, along the length of an estuary in response to natural drivers; 2) determine the hotspots for microplastic accumulation in these systems, and 3) determine the influence of biotic characteristics and anthropogenic factors on microplastic pollution within the estuaries. The findings based on the data from this chapter have been presented at two international conferences and will be published. Finally, to generate a greater understanding of the microplastic pollution on the fauna within mangrove-dominated areas, the biological indicators of microplastic pollution in South African mangrove-dominated estuaries will be identified and assessed. This aim will be achieved by assessing whether species such as *Austruca occidentalis, Cerithidea decollate* and *Chiromantes eulimene* are potential indicators of microplastic pollution within estuarine systems, by quantifying the amount and diversity of microplastics within the gut and organic tissue of fauna collected. The data and findings from this chapter will be published.

Progress: Field work is 90% complete. I have a sampling trip in February to complete the second half of data collection for the final objective. Seasonal data for microplastics have been captured and are being analysed. Seasonal data for heavy metals are being captured and will be analysed shortly. I attended and presented virtually at ECSA 58 and SETAC Africa September 2021. I have submitted a short communication to the *African Journal of Marine Science*. We await feedback.

Factors influencing the larval settlement of abalone (*Haliotis midae*): considerations for stock enhancement

Student: Ziyanda Mzozo **Degree and University**: PhD, UFH **Supervisor and Affiliation**: Prof. Niall Vine (UFH)

The South African Government's drive to build the Blue Ocean Economy aims to reduce poverty by creating job opportunities through the Operation Phakisa project. An abalone

(*Haliotis midae*) stock enhancement project has the potential to rehabilitate and enhance the natural stock and secure a long, sustainable harvest which will significantly contribute to the social development, revenue, and long-term sustainability of rural communities along the coast of South Africa. Stock enhancement using abalone larvae has been identified as an alternative to cut the cost of seeding cultured juvenile abalone. However, there is limited information on abalone larval development (*H. midae*) both in the hatchery and in the wild. Settlement and early survival rates in hatcheries are low, varying between 2 to 10% per seeding. To seed abalone larvae, understanding the factors that are important in increasing settlement and early survival required further investigation. The study aimed to better understand the factors which enhance settlement and early survival of *H. midae* larvae. The research will determine the effect of temperature on the development and settlement of abalone larvae (*H. midae*) for abalone hatchery management and stock enhancement. To identify hatchery-reared larvae that have been released into the sea, it is important to ascertain the optimum dose for staining the abalone larval shell without affecting settlement and survival by determining the optimal chemical cue using potassium chloride for enhancement of larval settlement and metamorphosis. Finally, I will assess the short-term success of seeding abalone larvae, *H. midae,* in the ocean. This information will provide a platform for potential commercial sea seeding of the species. This information could also be used in land-based farming hatcheries to enhance abalone settlement. Warmer temperatures (20–22 °C) increase development and settlement of *H. midae* larvae so larvae should be seeded in warmer temperatures to reduce the potential to disperse outside the seeding area. Staining larvae with calcein (50 mg\L) for 48 hours produces a bright, long-lasting marker on the shell of juveniles, which is suitable for field-based experiments because the brighter mark on the shell makes it easier to identify marked *H. midae* from wild abalone. Higher settlement occurred with larvae exposed to 10 mM potassium chloride and diatom (swimming) for 24 hours.

Publications: Ziyanda Brightness Mzozo, Sanet Hugo and Niall Gordon Vine. Effect of temperature on the development and settlement of the abalone larvae *Haliotis midae*: considerations for abalone hatchery management and stock enhancement. *Journal of Shellfish Research*, Vol. 40, No. 1, 119–125, 2021.

Assembly and annotation of the Nuclear Genome of *Gelidium pristoides* obtained from the Kenton-on-Sea region in South Africa

Student: Sitha Emmanuel Ntlokwana **Degree and University:** PhD, UFH **Supervisor and Affiliation:** Prof. Graeme Bradley (UFH)

The nuclear, mitochondrial and plastid DNA constitute the three types of genomes which play interconnected roles in an organism. Genome sequencing enables researchers to understand the regulation and expression of the various genes and the proteins they encode. It allows researchers to extract and analyse genes of interest for a variety of studies, including molecular, biotechnological, bioinformatics, and conservation and evolutionary studies. A few genomic studies of *Rhodophytes* have been conducted, particularly in South Africa where ocean economy has been identified as an essential sector that needs to be developed to sustain economic development. The mitochondrial and plastid genomes of *Gelidium pristoides* have recently been sequenced and annotated by the Marine Natural Products Research Group at the University of Fort Hare, and are currently the only annotated South African *Rhodophyta* genome sequences available. This study is a continuation of that study, and will focus on the sequencing and annotation of the *G. pristoides* nuclear genome which will complete the genome sequencing study for *G. pristoides*, and will serve as a foundation for future research projects, including genome comparison studies, gene regulation studies, and the identification, expression and characterisation of novel enzymes that may have medical or industrial applications. This study will generate new knowledge within the Ocean Economy Programme and provide essential information for the Marine Biotechnology and Medical Industry.

Progress: Currently busy with my research proposal and literature review to present by the end of February 2022.

Phuhlisa students collecting samples from a rocky shore

The Department of Biodiversity and Conservation Biology honours students participating in the field module on Marine Biology. Several of these students were Phuhlisa funded.

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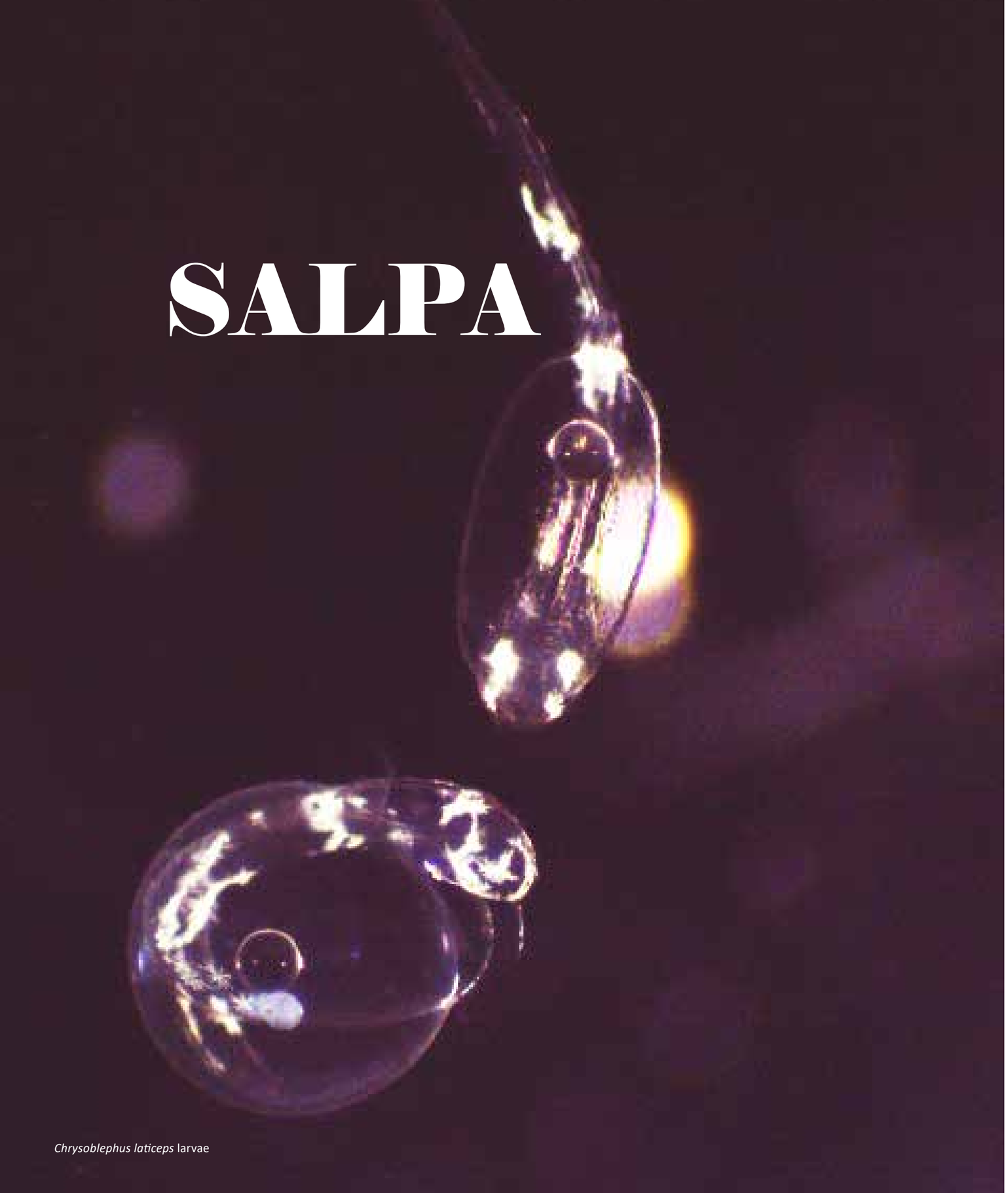


Chrysoblephus laticeps larvae

SALPA

Assessing the role and efficacy of marine protected areas in maintaining the climate resilience of fish populations - A South African case study

PI: Prof. Warren Potts (DIFS) **Co-investigators and affiliations**: Dr Amber Childs (DIFS), Prof Nicola James (SAIAB), Dr Romina Henriques (UP) **Collaborators and affiliations**: Prof. Clive Truemann (University of Southampton), Dr David Kaplan (IRD) **Students** (degree and University): Xolani Nabani (MS, RU), Nonhle Mlotshwa (MSc, RU)

Fish are facing increasing threats from the combined impacts of climate change and exploitation. Our research group has recently shown that exploitation removes high performance physiological phenotypes (HPPP) from populations and this has a negative impact on fish populations during thermal extremes. This suggests that exploited populations may be at greater risk in a changing environment and highlights the potential value of marine protected areas (MPA) in maintaining and exporting HPPPs to promote population resilience. However, before we proclaim MPAs as the panacea for population resilience, we need to better understand the mechanisms driving the observed patterns and whether our findings apply beyond a single species and a single MPA. To do this, an interdisciplinary research team aims to: 1) build on our knowledge of the value of MPAs in promoting the resilience of fishes to climate change; 2) assess the efficacy of South Africa's MPA network in maintaining and exporting this resilience and 3) improve the fishers' perceptions of, and compliance to MPAs. To achieve this, we will make use of the Small Coastal Craft, Remote Imagery Platform – stereo Bruvs, Acoustic Tracking Array Platform and the Aquatic Ecophysiology Research Platform. We will employ a range of contemporary techniques including laboratory respirometry, otolith microchemistry, baited remote underwater video, acoustic telemetry, genomics, larval distribution modelling and pro-environmental behavioural interventions.

Besides the production of new scientific knowledge, the information on this project will be used to inform the marine spatial planning process and will be included into the National Biodiversity Assessments. The outcome of this inclusion will be an improvement in the resilience of fishes and fisheries to climate change and therefore, this project will contribute significantly to poverty reduction and zero hunger. Other contributions to the SDGs include the role that the findings of this project will play in terms of climate action and the by improving our understanding of life below water.

Progress: We have made excellent progress this year. We obtained ethical clearance for all of our biological and human experiments. We completed a thermal physiology experiment on fish from an exploited area (Cape St Francis) as part of an MSc study. These

findings will be compared with data from fish from an unexploited area (Goukamma Marine Reserve), which will be completed early in 2022. We completed the preparation of the acoustic telemetry study and are due to initiate these in the next two weeks. The student has undertaken extensive data analyses training, using similar datasets so that she can rapidly analyse the data after collection. We have developed a range of larval dispersal models for reef fishes to understand the dynamics of this process in the coastal zone and to develop optimal spatial plans for conservation. This will be submitted for publication early in 2022. In terms of the genetic component of the project, we have collected over 100 genetic samples from individual fish. Each of these fish has either been categorized by its thermal performance, or its behavioural performance (or both) at a range of temperatures and this will allow us to gain some kind of understanding on the heritability of physiological and behavioural traits. Similarly, we have collected over 80 otolith samples from individuals from which we have physiological and/or behavioural thermal performance information. These otoliths will be used to ground truth the isotope data and allow us to effectively measure the field metabolic rate of any fish captured, without conducting extensive physiology or behavioural experiments. In terms of our human dimension component, we have acquired and collated the comments by recreational anglers on the recently promulgated marine protected areas. We have used this to identify impediments to further MPA development and to design potential social interventions to improve the perceptions and attitudes of recreational fishers towards these areas.

Outreach activities: Face-to face outreach activities have been limited, primarily because of the pandemic. However, the project leader has given six public talks, where the importance of Marine Protected Areas to fish stocks have been highlighted to recreational anglers. Our lab website has profiled our new MSc students that are working on the ACEP project. The project leader has also made several contributions to a range of angling Facebook groups on the role and importance of MPA's for maintaining fish stocks.
We contributed to a video to showcase the activities of the Aquatic Ecophysiology Research Platform for National Marine Week. This video highlighted several of our AERP activities that were conducted last year and was disseminated through social media (Twitter, Facebook) platforms and the SAIAB and SAFER lab websites.

Outputs:

Our peer reviewed paper: Bailey L, Childs A-R, Duncan MI, Winkler AC and Potts WM (accepted) Links between behaviour and metabolic physiology in fishes in the Anthropocene", has been accepted for publication in Reviews in Fish Biology and Fisheries.
We are about to submit an additional publication entitled: "Larval dispersal modelling of exploited marine species along the southern coast of South Africa- connecting dispersal models and field observations." for review.
In terms of conferences, Cuen Muller attended the International Marine Connectivity Conference in Paris, France to discuss his work on the larval connectivity along the southern coast with reference to barriers for dispersal and potential subpopulations for this region.
We have also submitted several abstracts in response to the call for the South African Marine Science Symposium.

SALPA Student Projects

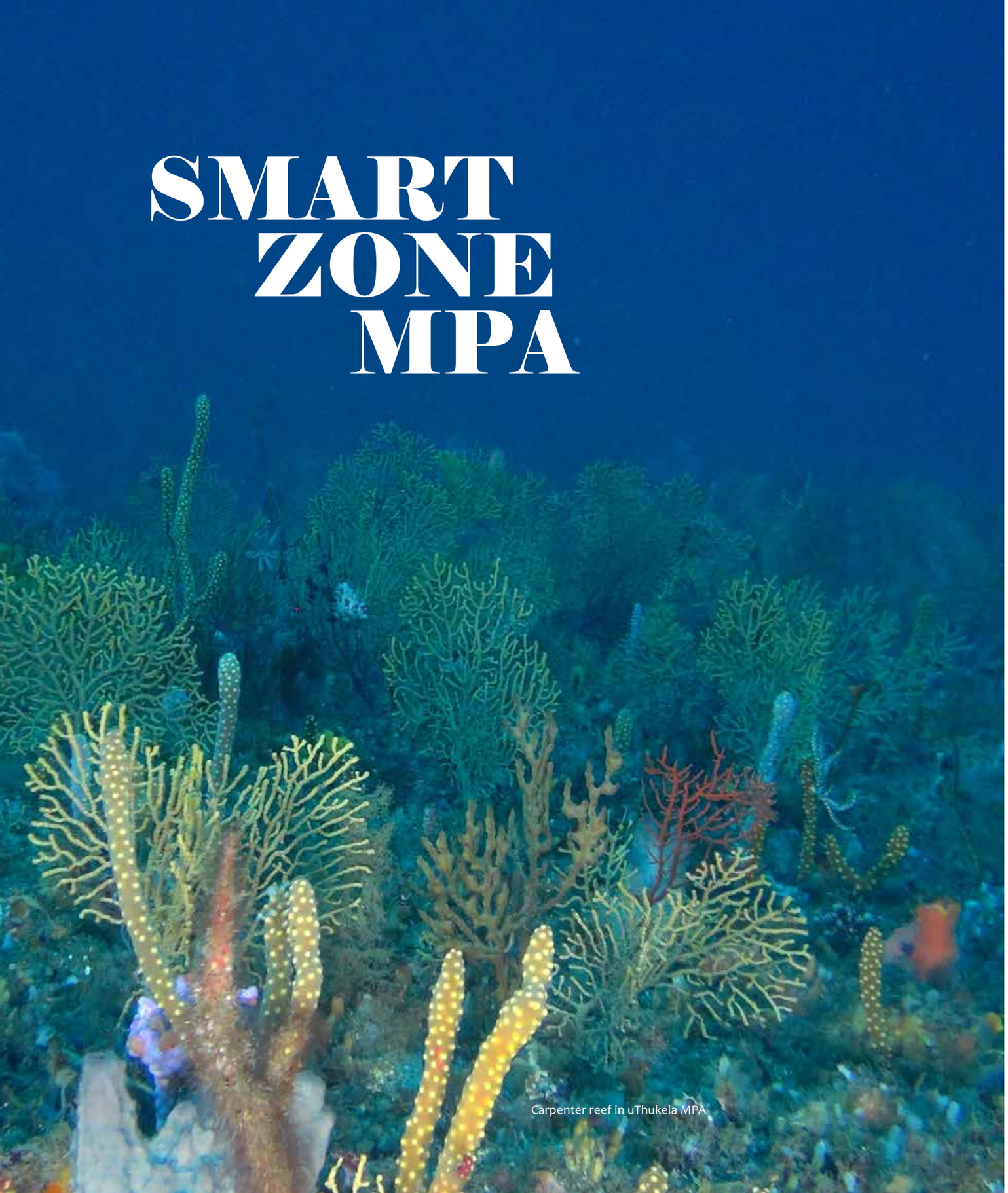
Estimating the impact of exploitation on the acceleration and home range of Roman, *Chrysoblephus laticeps* using acoustic telemetry

Student: Nonhle Thubelihle Mlotshwa **Degree and university:** MSc, RU **Supervisor and affiliation**: Dr Amber Childs (DIFS), Prof Warren Potts (DIFS)

The effects of climate variability on the marine environment have the ability to cause massive shifts in fish communities, leading to an imbalance in ecosystem trade-offs and synergies. This has often resulted in fish individuals being less resilient to environmental perturbations. Changes in water temperature are thought to influence the growth, reproduction and physiology of marine organisms, as changing temperature is considered the greatest stressors among fish communities. The effects of exploitation amplify these impacts as fishing selects high performance physiological phenotypes with robust resilience and tolerance to environmental stressors; causing an instability in community structures, as it reduces mean body sizes, resulting in early maturation of fishes as means to compensate for this imbalance. The aim of this study is to 1) assess the synergistic impacts of thermal variability and exploitation on the reactive capacity and resilience of red roman, Chrysoblephus laticeps in an exploited (Cape St Francis) and protected (Goukamma Nature Reserve) site and 2) To test the theory that Marine Protected Areas (MPAs) provide increased resilience to thermal variability holds true. This will be achieved using acoustic telemetry that will aid in assessing the acceleration of the fish (to determine their activity) and their home range (to determine their movement behaviour) when faced with thermal variability in both exploited and protected site. The results of this study will be analysed in R studio using generalised linear models to assess the activity and 3D kernel density utilization to determine the space use patterns/home range of *C. laticeps* across a range of temperatures. The results from this study will provide insight on how fisheries selectively affect the fitness and physiology of fishes and how this affects the resilience of fishes to climate change perturbations. The information collected during this study will be combined with similar previous studies to gain a better understanding of the impacts of exploitation on climate resilience of fishes and the potential role of MPAs to mitigate these. This will in turn change the way in which we adapt or respond to climate change and give insight into the effectiveness and efficiency of MPAs, thus conserving fish stocks for future generations and communities that rely on them as a source of protein and income.

Progress: The fieldwork for this project has not yet started as we were waiting for the primary upwelling season (Jan-Apr), however it is set to commence mid-February. I have attended several data analysis courses, analysed a similar dataset (from Tsitsikamma and Noordhoek) as practice for my data and prepared a draft publication on the response of an exploited and unexploited population of red roman to an intense upwelling event. I have completed my ethics application for my experiment and prepared all of the telemetry equipment and the fieldwork planning for the experiment. No workshops/conferences have need attended and no publications as yet.

SMART ZONE MPA



Carpenter reef in uThukela MPA

SMART Zone Marine Protected Area

PI: Prof. Amanda Lombard (NMU) **Co-investigators and affiliations:** Dr Jean Harris (WILDTRUST), Dr Shael Harris (UZ), Dr Anthony Bernard (SAIAB), Dr Hayley Cawthra (CGS), Dr Tamaryn Morris (SAWS), Prof. Ursula Scharler (UKZN), Dr Nicola Carrasco (UKZN), Dr Errol Wiles (SAIAB), Prof. Juliet Hermes (SAEON), Prof. Lucy Woodall (University of Oxford), Dr Jennifer Olbers (EKZN), Dr Toufiek Samaai (DFFE), Dr Welly Qwabe (WILDTRUST), Dr Lauren de Vos (WILDTRUST), Dr Angus MacDonald (UKZN), Prof. Cathy Sutherland (UKZN), Prof. Bernadette Snow (University of Strathclyde) and Joe Phadima (EKZNW) **Collaborators and affiliations**: Ryan Palmer (SAIAB), Nikki Chapman (WILDTRUST), Prof. Leon Visser (UZ), Ruth Mthembu (WILDTRUST), Sandile Ntuli (WILDTRUST) **Students (degree and University)**: Student bursaries will be released by the NRF in 2023.

Using the new uThukela Marine Protected Areas (MPA) as a case study, this multi-disciplinary project uses a rare time-sensitive opportunity to gain a social-ecological baseline essential for future assessment of achievement of MPA objectives. We will generate data to underpin an evidence-based approach to adaptive management of the MPA in a “SMART” framework. This framework defines Specific objectives for the MPA; develops Measurable success indicators; sets Achievable goals given limited resources for management; ensures monitoring findings are Relevant for biodiversity and people; and provides Time-bound outputs. Focussing on the upper mesophotic zone (40-70m), we will survey geology, benthic biodiversity, ichthyoplankton and mero-zooplankton and fish of soft-coral and sponge-dominated reefs. We have chosen upper mesophotic reefs not only because they are priority ecosystems in the National Biodiversity Assessment (2018), but also because they lie in the only depth zone that spans all MPA management regimes and are prime reefs for line-fishing. We will assess the zonation plan for balanced representation of reef types across management zones and outside the MPA so that analysis of future long-term monitoring results is not flawed by a priori differences due to zone boundary selection. The MPA boundary and zonation plan are products of stakeholder consultation, notably mining, oil/gas and fishing, that modified initial proposals mainly for conservation objectives. Our balanced sampling design will initiate an “in situ experiment” that in time investigates effects of different management regimes on reef ecosystem structure and tests the value of no-take areas for fisheries support and ecosystem resilience. Notably, we will view this study through a social-ecological systems lens. By active stakeholder engagement and socio-economic research parallel to ecological studies, we will develop measurable indicators for multiple objectives across different interests.

The need to understand the economic, ecological and social benefits of MPAs is relevant in terms of South Africa’s drive for an “oceans (or blue) economy”. Demonstrating the role of MPAs as

ecosystem restoration and fish recovery mechanisms, and critical climate change inhibition and mitigation assets, and local economic stimulators, is important. Appetite of decision-makers for further expansion of South Africa's MPAs to meet our global commitments (CBD Target 6 and SDG Target 14: 10 % by 2020), and the scientifically recommended 30% by 2030 target, will no doubt be influenced by the extent to which MPAs are effectively managed (i.e. are not "paper parks") and perceptions by stakeholders of the value of and benefits from MPAs.

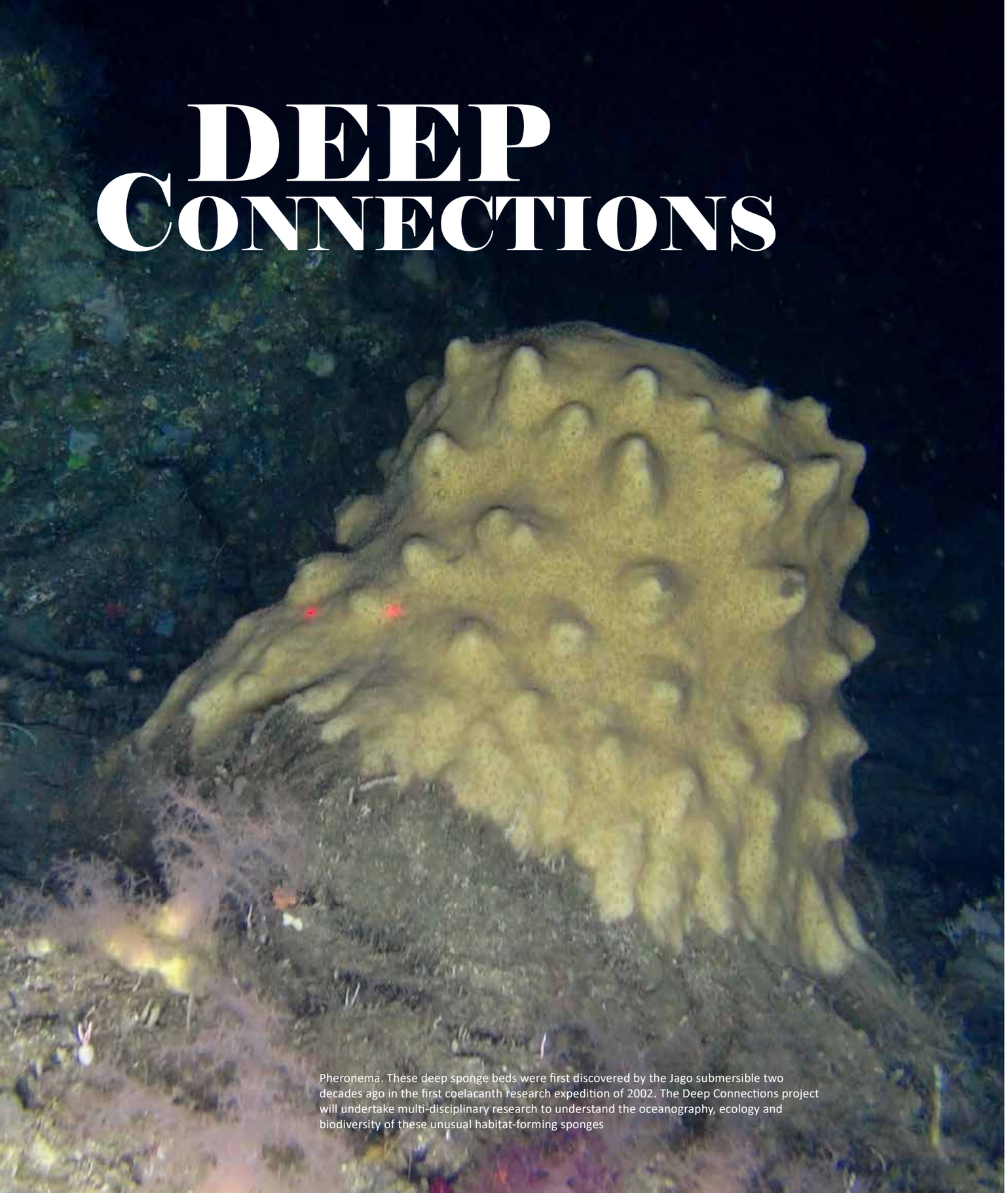
Progress: The focus in this first year of the project was to prepare the equipment and detailed protocols needed for the field sampling and to conduct at-sea sampling using two research vessels: *RV Angra Pequena* and *RV uKwabelana*, for plankton and eDNA sampling and multi-beam surveys, respectively. Multibeam Bathymetry Surveys were conducted on the following dates in 2021 when weather was suitable: 28 July; 30 July; 5 August; 9 September; 29 September; 19 October; 3 November; 13 November. Location: Between Durban and Richards Bay. Area: 77 km2 of seafloor was surveyed and the data are being processed/interpreted by PhD candidate Mr Wanda. Vessel: *RV Ukwabalana.* Plankton sampling was completed between Durban and Richards Bay from 07/06/2021 – 16/06/21 at 12 of the 14 planned reef sites across the different MPA zones. Methodology involved sampling at three stations (three tows per station) at each of the reef sites. Thirty-seven stations (from 12 completed sites and one incomplete site), each had three plankton net deployments and a total of 111 individual samples were collected. eDNA sampling was undertaken at each of these sites for fish larvae and reef fish signatures. One hundred and eleven plankton tows were conducted, along with 12 deployments of the Niskin/CTD rosette. The plankton and eDNA samples were successfully stored and are awaiting processing. In the first DNA collections trip 12 sites were sampled (see Cruise report attached). The samples are in storage (with metadata backed up). The samples will be extracted once the second set of collections has taken place in order that the samples are subjected to the same protocols in generating the libraries.

Outreach activities:Science awareness and communication to the youth and members of the public through social media and online science sessions.

Outputs: Grorud-Colvert K, et al. 2021. The MPA Guide: A framework to achieve global goals for the ocean. Science 373(1215): 1-10.

(Right) 6. Wesley Dalton (Chief scientist aboard) and Kevin van Rensburg (Deck officer), preparing a sample that had just been collected so that it could be transferred to a storage jar (Left) Makolobe Mabotja, a WILDOCEANS Ocean Steward, doing a plankton net study

DEEP CONNECTIONS



Pheronema. These deep sponge beds were first discovered by the Jago submersible two decades ago in the first coelacanth research expedition of 2002. The Deep Connections project will undertake multi-disciplinary research to understand the oceanography, ecology and biodiversity of these unusual habitat-forming sponges

Deep Connections

PI: Prof Kerry Sink (SANBI) **Co-investigators and affiliations**: Dr Sean Porter (ORI), Prof Stefano Mariani (Liverpool John Moore University), Dr Natasha Karenyi (UCT), Dr Dylan McGarry (RU), Dr Tamaryn Morris (SAWS), Dr Gwynneth Matcher (SAIAB), Dr Anthony Bernard (SAIAB), Dr Judy Mann (ORI), Dr Bruce Mann (ORI), Prof Peter Teske (UJ) **Collaborators and affiliations**: Dr Kira Erwin (DUT), Prof Michael Schleyer (ORI), Prof Marc Humphries (WITS), Prof Rosemary Dorrington (RU), Dr Merle Sowman (UCT), Dr Juliet Hermes (SAEON), Dr Denham Parker (DAFF), Dr Kerry Howell (Plymouth University), Tamsyn Livingstone (EKZNW), Prof Rachel Wynberg (UCT), Dr Lara Atkinson (SAEON), Dr Ntuthuko Masikane (UZ), Prof Colin Attwood (UCT), Prof Matthew Upton (Plymouth University) **Students (degree and University):** Caroline Manare Sejeng (PhD, UCT), Jody-Carynn Oliver (PhD, RU)

The Deep Connections Project is a multi-disciplinary and multi-institutional project that aims to build knowledge on genetic, physical, and socio-cultural connectivity for the improvement of biodiversity monitoring, spatial assessment and prioritisation. This will be achieved by piloting novel approaches across the biodiversity value chain.

The project is making science easily accessible, through theatre, children's stories, an exhibit and social learning to foster an emotional connection to the ocean whilst increasing socio-cultural exchange and advancing research on human dimensions of marine protected areas (MPAs).

This project contributes to nine Sustainable Development Goals. The greatest being to the "Life below water" goal in terms of supporting the maintenance of marine biodiversity at the genetic, species and ecosystem level. The genomic work on seabreams to support linefish assessments and management, and the MPA network expansion contributes to the "Zero hunger" goal in terms of long term food security and fisheries sustainability. Alignment with the "No poverty" goal, the project will work with the Mbazwana Creative Arts Theatre Company to develop empatheatre skills and pilot a program to boost the local economy by selling marine inspired crafts and prints, with tourism links to MPAs. The project contributes to "Quality education" goal through postgraduate students, training, work experience, mentorship and curriculum content. Additionally supporting inclusive and equitable learning opportunities to reach children, students, MPA staff, communities and decision makers. The project also supports transformation through opportunities to previously disadvantaged postgraduate students and researchers, and providing mentorship, targeted training, new teaching material, essentially contributing to the "Reduced inequalities" goal. Since the project is led by a woman, and by supporting female postgraduate students and scientists it contributes to the "Gender equality" goal. The social science

and engagement component of the project contributes to the “Sustainable cities and communities” goal in the plans to address current gaps in spatial planning and in addressing current challenges affecting the expansion and management of the diversified the benefits from MPAs.

Through the co-production, mobilisation and sharing of knowledge, expertise, and technology across the multitude of local and international partnerships, this project aligns with the “Partnerships” goal. The Emotional connection to the ocean component of the project contributes to the “Good health and well-being” goal. The collection and research on deep water sponges may contribute to drug discovery and access and benefit sharing.

Progress: Despite the field operation delay during year 1 due to the Covid-19 global pandemic and challenges in platform access, molecular, species and ecosystem and y teams have made good progress. The molecular team advanced the piloting of DNA enhanced methods to biodiversity assessment using environmental DNA by designing and successfully conducting in situ testing of the coelacanth Latimeria chalumnae primers and collecting tissue samples of the expected fish species that occur around the Pheronema sponge grounds. Additionally, the team extracted the genomic DNA of the first batch of seabream fin clip samples. The oceanography team produced many map layers in support of the oceanographic context for all 41 MPAs around South Africa and is working to understand the effects of meso-scale features such as eddies across the MPA network. The empatheatre team made advancements in the social learning research component and knowledge co-production around iSimangaliso MPA through a dedicated mapping workshop. In terms of spatial planning and community engagement, significant progress was made at Aliwal Shoal with the transdisciplinary team piloting new approaches in stakeholder engagement and developing joint recommendations to solve the deep challenges associated with this MPA’s design, implementation, and management.

Project members participated in a workshop to pilot the identification and mapping of culturally significant areas, subsequently providing a platform for information sharing, interrogating complex concepts and building collaborations with researchers on the CoastWise and One Ocean Hub projects. Excellent progress in science engagement outputs were made with the development of children’s stories with Cyril the coelacanth in English and Zulu being one of the most popular. The project made contributions to the MzanSea Ocean literacy project with outputs being used in schools and provided online.

Outputs

Worm B, Elliff C, Graça Fonseca J, Gell FR, Serra-Gonçalves C6, Helder NJK7, Murray8, Hoyt Peckham H, Prelovec L and Sink K (2021). Making ocean literacy inclusive and accessible. Ethics in Science and Environmental Politics. Vol. 21: 1–9, 2021. https://doi.org/10.3354/esep00196

Kirkman SP, Mann BQ, Sink KJ, Adams R, Livingstone TC6, Mann-Lang JB, Pfaff MC, Samaai T, van der Bank MG, Williams L and GM Branch (2021). Evaluating the evidence for ecological effectiveness of South Africa’s marine protected areas. African Journal of Marie Science 43 (3).

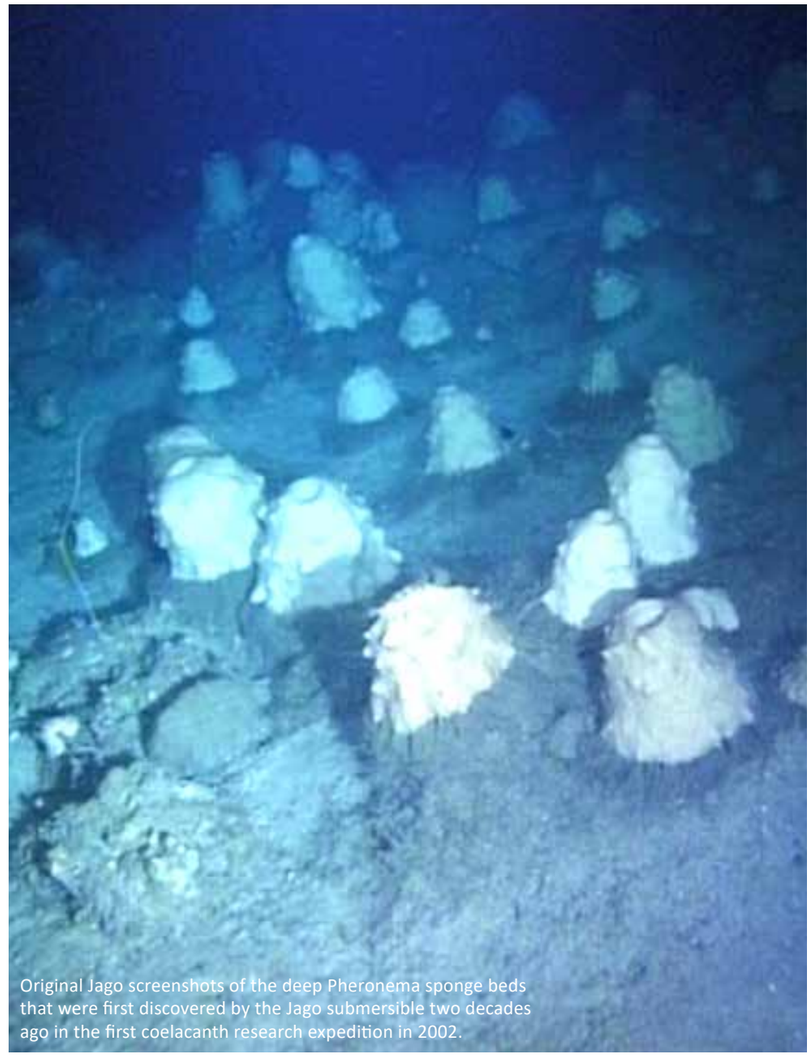
Mann-Lang JB, Branch GM, Mann BQ, Sink KJ, Kirkman SP and R Adams (2021) Social and economic effects of marine protected areas in South Africa, with recommendations for future assessments. African Journal of Marie Science 43 (3).

Harris LR, Sink KJ, Holness SD, Kirkman SP, Majiedt P and Driver A (2021). National Coastal and Marine Spatial Biodiversity Plan, Version 1.1: Technical Report. Nelson Mandela University, Department of Forestry, Fisheries and the Environment, and South African National Biodiversity Institute, South Africa. 212 pages.

UNEP-Nairobi Convention and WIOMSA. 2021. Western Indian Ocean Marine Protected Areas Outlook: Towards achievement of the Global Biodiversity Framework Targets. UNEP and WIOMSA, Nairobi, Kenya, 298 pp. (Contributions from Kerry Sink – see authors and Operation Phakisa case study)

Deep Ocean Stewardship Initiative 2021. The Necessity of Traditional Knowledge for Management of Deep-Seabed Mining. DOSI policy brief. 6 pages.

Sejeng C, Halo I, Sink K, Ansorge I and Hermes J . 2021. Incorporating and connecting multi-scale oceanographic features in marine spatial planning and management. Presentation at the Marine Protected Area Forum. Gqeberha, December 2021.



Original Jago screenshots of the deep Pheronema sponge beds that were first discovered by the Jago submersible two decades ago in the first coelacanth research expedition in 2002.

Deep Connections Student Projects

Incorporating and connecting multi-scale oceanographic features in marine spatial planning and management

Student: Caroline Sejeng **Degree and university**: PhD, UCT **Supervisor and affiliation**: Dr Laura Braby (SAEON), Prof. Kerry Sink (SANBI), Assoc. Prof. Juliet Hermes (SAEON), Dr Issufo Halo (DFFE), Prof. Isabelle Ansorge (UCT)

The role of oceanographic and ecological connectivity in the effective design and management of MPA networks is gaining attention in the field of marine conservation. This PhD study is mainly about the oceanography of South Africa's MPAs at multiple scales. Despite substantial national efforts in oceanography, few oceanographers have collaborated in the design and management planning of MPAs or South Africa's emerging marine spatial planning (MSP) framework. This study provides a fundamental baseline for the environmental and oceanographic communities, bridging these disciplines together in the context of spatial planning and management including MPAs and MSP. This study includes a focus on oceanographic features (mesoscale and sub-mesoscale dynamics) and their influence on MPAs especially within the recent 20 MPAs implemented in South Africa. Key connectivity aspects that will be considered include ocean currents, eddies and jets and other transport mechanisms for eggs, larvae and potential pollutants. Enhancing and accounting for connectivity among MPAs can improve spatial planning and management promoting biodiversity, population persistence and resilience, improving capacity to cope and adapt to environmental change, and support fisheries management for improved sustainability. Well-connected networks of MPAs can help people, species and ecosystems adapt to climate change by protecting climate refugia or providing "safe landing places" for species undergoing range shifts. The study will not only fill a gap in academic knowledge, but it will also provide insights that are relevant outside of academia, such as co-operative management and governance. Importantly, this these is being used to improve the oceanographic information in existing and updated MPA management plans.

Progress: At the broadest scale, the domain of interest covers three oceans (Indian, Atlantic and the Southern Ocean but with finer scale work focused on the eastern and southern margin. The area includes an extension of the Agulhas Current system around southern Africa; the Agulhas Current, Agulhas Return Current, Agulhas Retroflection and Agulhas Leakage. The eastern boundary current; Benguela Current is also well represented in the domain in the West coast. For further analysis of the oceanographic features and a clear overview of the MPAs, the domain is subdivided into different regions, i.e East (from Port Alfred to Cape St Lucia), South (from Cape Agulhas to Port Alfred) and West coast (from Luderitz to Cape Agulhas). Altogether, these regions exhibit varying dynamics as a result of their differ shelf and slope morphology and current systems. As a result of already available satellite products, no field operations have yet been conducted although opportunities for sampling in the Amathole MPA are being sought. An automated eddy detection algorithm was applied on satellite derived maps of absolute dynamic topography, daily gridded at ¼ox¼o, distributed by Copernicus Marine Environmental Monitoring Services, to assess eddy characteristics across the network. Furthermore, the influence of kinematic properties on mesoscale eddy dynamics and their influence on marine protected areas has been investigated. The Isimangaliso, Amathole, Port Elizabeth (Gqeberha) Corals and SW Indian Seamounts MPA exhibit high Mean Kinetic Energy (500 – 1500 cm2s-2). The Amathole MPA is influenced mostly by Natal Pulses with further work needed to link oceanography to observed biodiversity patterns. The variability in kinematic properties has an implication in the mixing of hydrographic properties, nutrient distribution and larval dispersal, which improves our understanding in the connectivity between the physical conditions and ecological connectivity within and among MPAs.

To date the following workshops and conferences have been attended; The Western Boundary Current-Subtropical Continental Shelf Interactions Workshop (Presentation), Marine Connectivity Conservation "Rules of Thumb" for MPA and MPA Network Design (Talk), National Pelagic Bioregionalisation workshop, Modelling for Ocean Forecasting and Process Studies (Course), Marine Protected Area Forum (Presentation) & Ocean Innovation Africa Conference (Volunteer). Applications have been sent through for the upcoming SANBI Research Day and SAMSS conference.

The use of cutting-edge molecular tools in the monitoring and management of priority marine fishes

Student: Jody-Carynn Oliver **Degree and university:** PhD, RU **Supervisor and affiliation:** Dr Gwynneth Matcher (SAIAB), Prof. Kerry Sink (SANBI), Prof. Stefano Mariani (Liverpool John Moore University), Prof. Peter Teske (UJ)

Novel, rapid but cost-effective methods are urgently needed to better assess and monitor marine biodiversity, with next-generation sequencing approaches showing great promise. In South Africa, the generation of such data, and the skills required to analyse them, remain limited in marine biodiversity assessment, monitoring and resource management. This project will employ two recently developed molecular methods, environmental DNA (eDNA) metabarcoding and population genomics, in the detection and monitoring of priority South African fishes. The eDNA contained in water and in sponges (which are natural eDNA samplers) will be used to assess the presence of coelacanth and key seabream species (family Sparidae) along South Africa's eastern coastline, using species-specific markers. Additionally, a population genomic approach will be employed to investigate population connectivity of two seabreams about which too little information exists for effective assessment and management, namely *Polysteganus undulosus* (seventy-four seabream) and *P. lineopunctatus* (trawl soldier). Potential impacts of this project are comprehensive information on distributions and population connectivity of the study species that can significantly improve the knowledge, fisheries assessments, and their management. Collectively, the findings will inform spatial planning and MPA design in South Africa, while the focus on coelacanth will provide a unique opportunity to pave a new way for the non-invasive monitoring of iconic species, potentially having a local and international impact. This research will also be applied in updating South Africa's coelacanth management plan.

Progress: To build South Africa's marine fish barcode reference library, progress has been made in compiling a list of expected fish species that occurs in one of the project sampling areas, and subsequently procuring most of the tissue samples through SAIAB's collections department. Additionally, successful in-situ testing of the newly designed African coelacanth primers was conducted. The primers successfully detected coelacanth DNA at low DNA concentrations and did not cross amplify other species, but due to sampling delays, the primer set has yet to be tested with water samples from known coelacanth locations. Plans have been advanced for a research cruise in April 2022 and Pheronema and other sponges will be collected to test for coelacanth and other fish DNA.

Sunrise and people (Credit Kerry Sink) Human connections have not been well considered in marine spatial planning and management in South Africa to date. The Deep Connections project is engaged in transdisciplinary research to support improved stakeholder engagement, knowledge exchange and innovation in the human dimensions of spatial planning and management.

AGULHAS BANK CONNECTIONS

The ABC team with the ROV on board the *RV Observer*

Agulhas Bank Connections

PI: Dr Natasha Karenyi (UCT) **Co-investigators and affiliations**: Ms Nikiwe Solomon (UCT), Dr Lara Atkinson (SAEON), Prof Kerry Sink (SANBI, NMU), Dr Emma Rocke (UCT), Ms Nancy Job (SANBI), Dr Stephen Lamberth (DFFE), Dr Lara van Niekerk (CSIR), Dr Jock Currie (SANBI), **Collaborators and affiliations:** Dr JD Filmalter (RU), Dr Marie Smith (CSIR), **Students** (degree and University): Shakirah Rylands (MSc, UCT), Yi-Ting Ho (MSc, UCT), Humeshni Pillay (MSc, UCT), Matthew Farthing (Postdoc, NMU)

The multi-disciplinary Agulhas Bank Connections (ABC) project aims to improve our understanding of land-sea connectivity, social-natural connectivity, biodiversity of muddy ecosystems, ecological processes and population connectivity across the Agulhas Bank. Further, ABC aims to incorporate these elements into ecosystem mapping, assessment and spatial management. The project also addresses the common public misconception that water flowing from the river into the ocean is wasted. Rivers carry sediment the estuaries and the ocean, likely sustaining marine mud ecosystems which are essential for commercial fish species such as hake and sole.

The ABC project aligns with seven Sustainable Development Goals, with the greatest contribution to goal 14 “Life Below Water” in terms of supporting the maintenance of marine biodiversity at the genetic, species and ecosystem levels. This woman-led project has “Gender Equality” and “Reduced Inequalities” at its core as evidenced in the diversity of women co-investigators (7) and students (3) on this project. The work to support the management of sole, hake and kob species makes a contribution to sustainable fisheries to support food and job security (“Zero Hunger”). The social science and engagement components will integrate human communities along the river in the project leading to more sustainable communities (“Sustainable Cities and Communities”). The project exemplifies the multi-stakeholder partnerships enshrined in Goal 17 “Partnerships for the Goals”.

Progress: Our fieldtrip to Mossel Bay was our first experience of the Agulhas Muddy Mid-shelf ecosystem between Still Bay and Mossel Bay on the Agulhas Bank. In total 39 stations were sampled using different combinations of sampling methods including ROV, dredges, grabs and cone dredges. The mud ecosystem proved challenging to sample visually with the ROV due to a thick layer of turbid water above the seafloor in shallower waters, but visibility improved beyond 65 m. This made the area unsuitable for inclusion in Shakirah Rylands’ MSc project on trawl impacts.

We therefore prioritised grab sample collection to explore macro-infauna communities, microbe samples for investigations into molecular diversity, and sediment samples to confirm mud characteristics. These samples will be processed in a PhD project that will start in 2022. Observations on-board the *RV Observer* included an interesting tube polychaete species in the Maldanidae family. It was fairly common in the samples and had very large sticky mud tube that was difficult to break apart. Footage of these tube worms may assist in understanding its habitat and behaviour. Hake and sole were also observed on the muds.

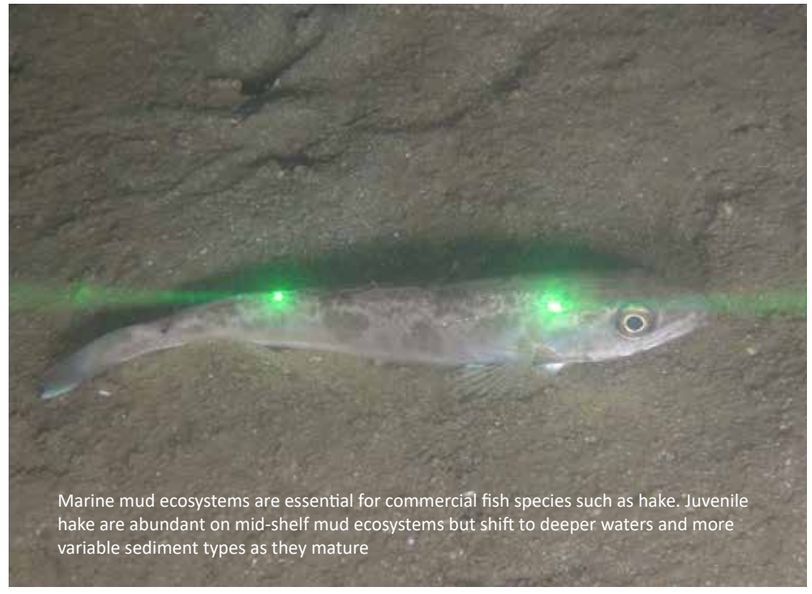
The aggregating sea cucumber *Hemiocnus insolens* commonly found on both the Agulhas Bank and the west coast shelf of South Africa was collected with a dredge. This is the focal species for investigating genetic connectivity across the Agulhas Bank and the Benguela. This particular species displays as three colour morphs, i.e. white, red and yellow, dependant on their location. New colour morphs were observed during the fieldtrip including orange and mixed yellow and red specimens. Yi-Ting Ho (MSc) has progressed to DNA extraction from collected specimens, ready to perform the DNA sequencing.

Land-sea connectivity work has also commenced through research carried out by Humeshni Pillay on determining sediment loads and phytoplankton concentrations in river plumes of rivers adjacent to the Agulhas Muddy Mid-Shelf ecosystem. Initial work is on simulated data to develop the a machine learning model as the basis of this work.

Muddy mid-shelf sediments in the Gqeberha vicinity have also been identified through the ACEP Deep Forests project and are being included as sites for further study in the ACEP ABC project in 2022.

Outreach activities: Two Youtube videos have been produced by students on the project to share their research on a public forum.
https://www.youtube.com/watch?v=33fQ8GwvxoU
https://www.youtube.com/watch?v=O4GqhlGTXhg
A student profile of Shakirah Rylands as the ambassador for muddy shelf ecosystems can be found on the MsanSea website (https://mzansea.org/ecosystems/muddy-shelves/). Following this Shakirah was a speaker at a Woman in Science event at Rustenburg High School where she engaged with more than 200 learners and teachers.
Fun fact and activity sheets were developed and include information on the iconic South African marine species, hake and sole, that are dependent on muddy ecosystems.

Outputs:
Two Fun Fact and Activities sheets were produced to highlight the importance of muds for sole and hake species.
Both Humeshni and Shakirah presented their research at UCT’s Biological Sciences Department Research Day in 2021 where Shakirah won best multi-media presentation for her youtube video about her research (https://www.youtube.com/watch?v=O4GqhlGTXhg). Humeshni also presented her work at the Centre for Statistics in Ecology, Environment and Conservation (CSEEC) Student Symposium in 2021.



Marine mud ecosystems are essential for commercial fish species such as hake. Juvenile hake are abundant on mid-shelf mud ecosystems but shift to deeper waters and more variable sediment types as they mature

Sampling Agulhas Bank muds (left) Shakirah & Ferdy deploying the ROV (right)

ABC Student Projects

Trawling impacts and benthic ecosystem assessments on inshore soft sediment habitats of South Africa

Student: Shakirah Rylands **Degree and university:** MSc, UCT **Supervisor and affiliation:** Dr Natasha Karenyi (UCT), Dr Jock Currie (NMU, SANBI), Prof. Kerry Sink (SANBI)

International research demonstrates that bottom trawling is commonly associated with alterations to sediment characteristics and the destruction and/or removal of emergent seabed structures, both physical and biological. Notably, three-dimensional habitat-forming structures created by living organisms, which contribute to the complexity of the seabed and essential functioning of ecosystems, are impacted. These alterations could impact commercially important fish species having close associations to physical and biogenic habitat forms. Recent studies indicating significant restructuring of demersal fish assemblages over the Agulhas Bank, have pointed towards trawl-induced changes to benthic habitats as a potential cause. However, investigation of trawling impacts on benthic habitats has received limited attention in South Africa. This study aims to investigate demersal trawling impacts and benthic habitat variability occurring in inshore areas of the Agulhas Bank and to apply those results in an ecosystem condition assessment. The project aims to undertake visual surveys (remotely operated vehicle) and sediment sampling across unconsolidated sediment habitats to characterise and compare the physical and biogenic habitat complexity between adjacent trawled and protected areas within south coast bays. This research will improve our understanding of understudied benthic ecosystem types on the Agulhas Bank, specifically those vital to important fish species such as hake and sole. Insights gained can support biodiversity assessment for improved management of the South African hake trawl fishery which is certified under the Marine Stewardship Council and may inform marine spatial planning priorities.

Progress: Deep Forests: Since registration in 2021, all visual sampling was completed during a two-week fieldwork expedition that built onto the Deep Forests sampling sites of 2019. Our research team completed 46 remotely operated vehicle (ROV) surveys for my MSc study. This culminated to approximately 1300 quadrat images with additional video for analysis of which 28 sites in the Cape St Francis Bay area will be analysed for the trawling impacts chapter. Sediment samples were collected by cone dredge at all 46 stations as well.

A great achievement was the completion of an underwater quadrat survey whereby a gridded metal quadrat was filmed by the ROV on the seabed at 76 m depth to support the improved estimation of the photo-quadrat area of the ROV during image and video analyses. This was an important activity for the development of standardised underwater visual surveys. Under-studied muddy ecosystems on the south coast were surveyed under the ABC project during June 2021. This work intended to supplement my MSc project initiated under Deep Forests by surveying an additional trawl closure site at Still Bay or Mossel Bay. Initially, four sites within and outside of the Still Bay trawl closure were surveyed with ROV however, the sites had consistently high turbidity proving unsuitable for visual survey techniques. Similarly, many sites surveyed in the Mossel Bay area were deemed not feasible. Out of the 10 trawling impacts sites surveyed, only 3 could potentially be used for analysis. Thus, the trawling impacts study in this new area was abandoned as the inshore sites were too murky.

Other potentially worthwhile sites to survey with the ROV were identified to build onto the knowledge base of unconsolidated sediment ecosystems. Subsequently, historically dredged sediment sites and reef areas were surveyed, and potential sites to collect sea cucumbers for a genetics MSc study were explored. In total, 18 sites were surveyed with the ROV. Priority was then given to collecting grab samples with 32 grab conducted (at least 3 replicates at each site = 107 grabs total) aligning to the original ABC project objectives. Additionally, 13 cone dredge samples were collected of which 10 will be used to compare the sediment type detected between cone dredge and grab methods. Thirteen dredges were deployed, of which 3 were specifically directed at sea cucumber collections incorporating occurrence records for biodiversity mapping. Comprehensive cruise reports were collated for both projects, describing all activities completed during both research expeditions, along with detailed fieldwork datasheets, maps, a visual imagery and video collection for all sites, and an extensive collection of macrofauna, sediment and eDNA samples. All ROV images for my MSc study were processed in the open-source program BIIGLE, and image data reports have been downloaded for analysis. Scripts are currently being developed to analyse the image data and the processing of sediment samples is well underway. Knowledge of underwater camera systems used to sample benthic invertebrate communities was improved by attending the WIO-Regional Benthic Imagery Workshop in August/September 2021.

A Marine Ecosystem Condition Assessment workshop was attended in October 2021 to gain understanding of various ecosystem condition frameworks and the methodologies of application for use in the second chapter of my study. My research was communicated on various platforms to various stakeholders. The annual Biological Sciences Research Day at UCT was attended and presented at and first place prize for the multimedia video presentation was achieved. The research was also introduced to high school learners as part of a Women in Science Careers talk to inspire young minds to pursue science-related careers.

Pictures opposite: Top- The benthic grab sampling team on the ***RV Observer***, Jock, Ferdy, Silke and Shakirah (left to right). Bottom- Shakirah Rylands (left) and Silke Brandt (right) sorting and taking photographs of organisms collected by dredge sampling in the Agulhas Muddy Mid-Shelf Ecosystem.

Cryptic Species or Not? Population Genetics of the Red-chested Sea Cucumber *Hemiocnus insolens*

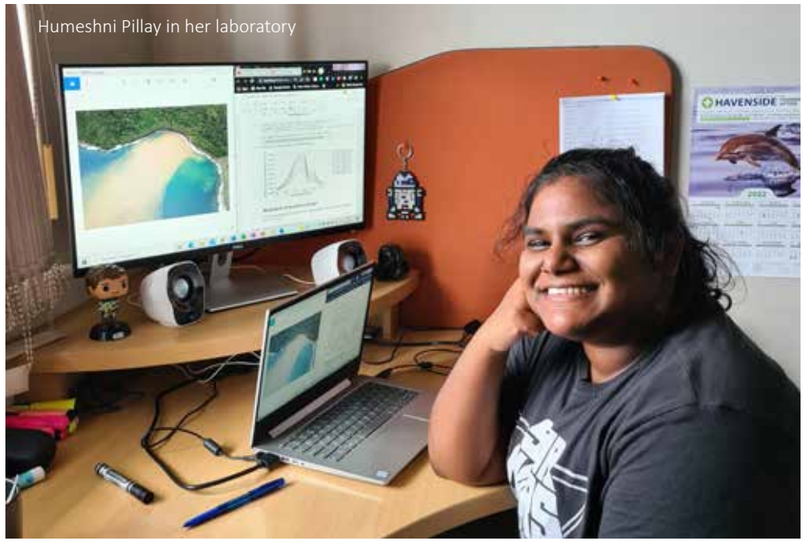
Student: Yi-Ting Ho **Degree and university:** MSc, UCT **Supervisor and affiliation:** Dr Emma Rocke (UCT, MARIS), Dr Natasha Karenyi (UCT, MARIS)

Echinoderms play a major regulatory ecological role within benthic communities; however much of their population genetics is unknown. The study aims to describe and understand the population structure and genetic connectivity of major nursery and spawning grounds, the Agulhas Bank and Benguela system, in South Africa by investigating the endemic red-chested sea cucumber *Hemiocnus insolens* (pic below). The species is endemic to the west and south coasts of South Africa, occurring in three colour variations, namely, red, yellow, or white. Currently, these colour variants of ***H. insolens*** are considered to be one species; however, with genetic studies, the possibility of cryptic species can be confirmed thus providing taxonomic and species information for echinoderm and sea cucumber databases.

Metagenomes for each colour variant will be sequenced by using the MinION sequencing device (Oxford Nanopore Technologies) to compare colour variants in order to investigate their genetic relationship. This will clarify their gene pool size and their vulnerability to exploitation in environments experiencing heavy anthropogenic activities.

Progress: Completed field work (sample collection) in Mossel Bay, June 2021. The introduction and literature review serving as the first chapter of the dissertation was completed in May 2021. Laboratory work commenced in June 2021. All samples acquired from field trips and organisations were processed in the laboratory such that each specimen was individually bottled and washed, and a piece of the specimen's tissue was excised for DNA extraction. Samples were photographed in high resolution prior to excision for species identification on photo-based species identification databases. All samples (128) were extracted; however, 124 were successful. These samples were sent for DNA quality checks (assessing the lengths of DNA strands by running it through systems which generate a graph displaying the lengths of DNA present in the sample).

Successful DNA samples showed high concentrations of long-stranded DNA which were further cleaned through the process of size selection where short-stranded DNA are removed and retaining long-strands (≥1000 base pairs each). These long-stranded DNA were sent for quality check for assurance. Results and data have not been generated yet, therefore; no data has been analysed yet.



Humeshni Pillay in her laboratory

Monitoring river plume phytoplankton and sediment concentrations using satellite data and machine learning techniques

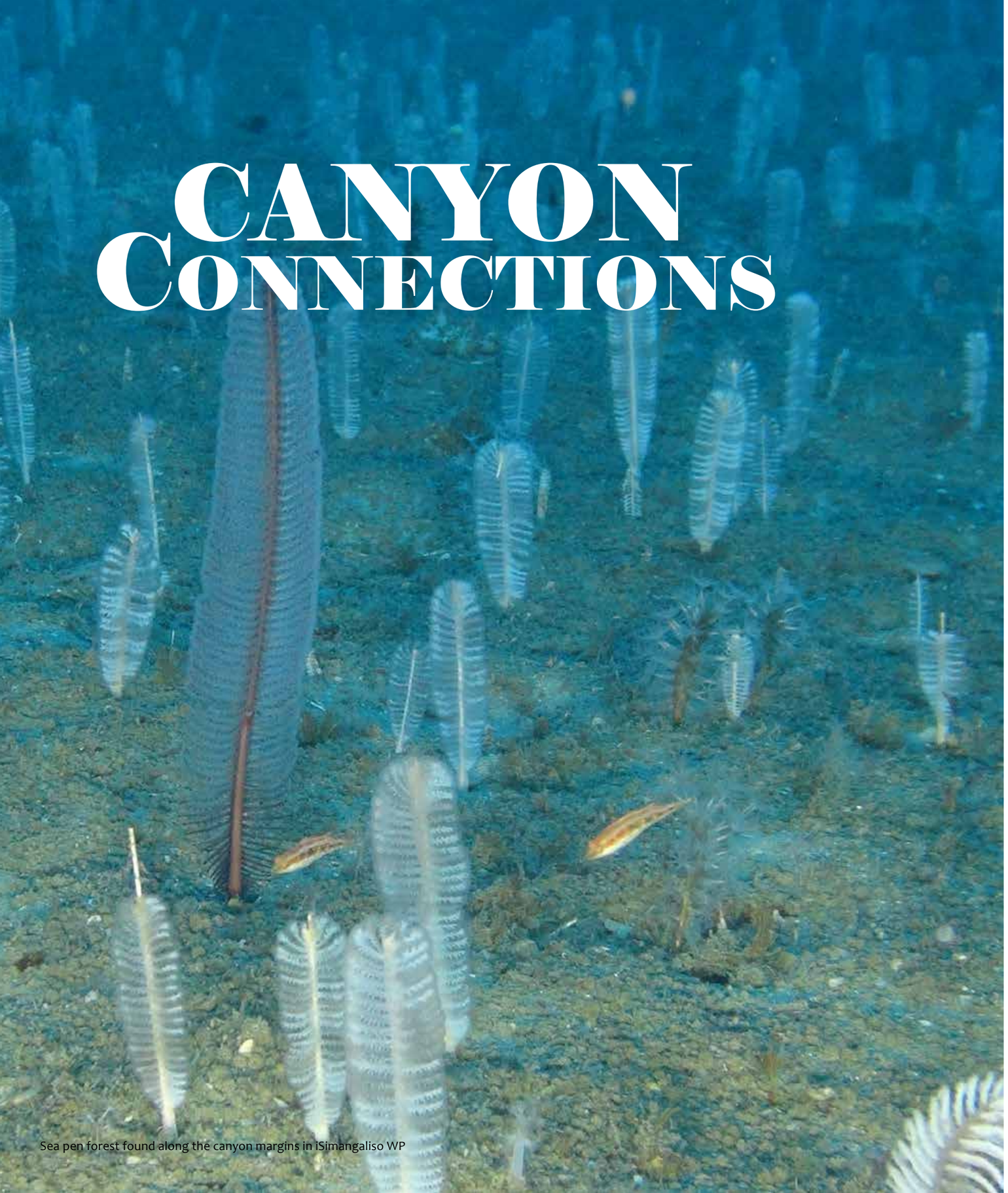
Student: Humeshni Pillay **Degree and university:** MSc, UCT **Supervisor and affiliation:** Dr Natasha Karenyi (UCT), Dr Marie Smith (CSIR)

River plumes play a major role in connecting the land to the sea. Riverine nutrient and sediment deposits into marine and estuarine environments help support phytoplankton growth and the formation of marine muddy ecosystems. Remote sensing can be used as a tool to monitor and quantify riverine sediment deposits and phytoplankton assemblages in the study region (Agulhas Bank). This study uses a synthetic dataset which models the inherent optical properties (IOPs) of phytoplankton, dissolved organic matter and sediment. In-situ aquatic and marine optical properties for the region were collected and added to the bio-optical model to create another cohort of synthetic data which better represent the optically complex region. This dataset was used to train and test a multi-layer perceptron model, an artificial neural network (ANN). The model output gave robust results of chl-a and suspended solid material concentrations. Access to higher computation resources can allow for the training of deeper neural networks with a larger synthetic dataset. This study is an example of the potential of using machine learning techniques and synthetic datasets to create aquatic monitoring remote sensing products. The trained model can be used with satellite data to routinely monitor the Agulhas bank river plume deposits and associated phytoplankton assemblages.

Progress: My first steps in this project were completing a literature review and completing both a machine learning course and satellite training course to provide me with the basic knowledge and skills to conduct this kind of research. I have started working with the synthetic dataset which I am currently using to train a deep learning neural network. In addition, I have presented at the UCT biological sciences research day 2021 where my presentation was well received https://www.youtube.com/watch?v=33fQ8GwvxoU&t=2s

ACEP
Open Call Projects
2018 - 2020

Corals - Project scientists led by Dr Toufiek Samaai published a book chapter on South Africa's animal forest such as the Amathole Lace Corals which are beautiful and fragile lace and stony coral habitats on the shelf edge off East London



Sea pen forest found along the canyon margins in iSimangaliso WP

Canyon Connections

The Ecological Role of Submarine Canyons on the East Coast of South Africa

PI: Prof. Amanda Lombard (NMU) **Co-investigators and affiliations:** Dr Jean Harris (WILDOCEANS), Dr Shael Harris (UNIZUL), Tamsyn Livingstone (Ezemvelo), Dr Jenny Huggett (DFFE), Dr Anthony Bernard (SAIAB), Dr Hayley Cawthra (CGS), Prof. Thomas Borman (SAEON), Dr Tamaryn Morris (SAWS), Dr Matt Dicken (NSB), Prof. Ursula Scharler (UKZN), Prof. Kerry Sink (SANBI), **Collaborators and affiliations**: Prof. Mark Gibbons (UWC), Hendrick Mzimela (UNIZUL), Dr Nicola Carrasco (UKZN), Ryan Palmer (SAIAB) **Students** (degree and University): Abigail Rhode (MSc, UKZN).

The Canyon Connections project is focussed on the submarine canyons off the coast of KwaZulu-Natal, within the iSimangaliso, Protea Banks and Pondoland Marine Protected Areas (MPAs). Through this collaborative multi-institutional, multi-disciplinary project, the team is investigating the influence of sub-marine canyons on the distribution and nature of biological communities along the shelf edge and the geological and oceanographic processes that underpin observed patterns.

Knowledge on canyon biodiversity, uniqueness and productivity, will allow us to refine our MPA expansion strategies and rationales and inform marine spatial planning for the east coast of South Africa. This project also aimed to monitor the presence of coelacanths in Jesser Canyon, the first (and most frequent) site they have been observed in the iSimangaliso Wetland Park. Furthermore, the project aimed to examine the geological structure of submarine canyons that have been previously unstudied, with a focus on the Pondoland MPA.

The novel results of this project will directly inform policy for MPA expansion/design and contribute to South Africa's capacity to achieve its commitment to protecting at least 10 % of the ocean within highly protected areas (Aichi Target 11 of the Convention on Biological Diversity), SDG14 of the United Nations Sustainable Development Goals (Conserve and sustainably use the oceans, seas and marine resources), and will support the objectives of the Nairobi Convention (for the western Indian Ocean region). Building marine science capacity is a key aspect of the project and is achieved through partnership with the WILDOCEANS Ocean Stewards Program. Capacity building is integrated into all project components (field research, post-graduate student support, science outreach and conservation awareness). Through the Ocean Stewards Program, WILDOCEANS aims to nurture a new generation of leaders that are passionate about conservation of our oceans and qualified to pursue career paths in the fast-emerging Blue Economy in South Africa.

A collage of images taken during the Canyon Connections sampling fieldwork cruise showing the ROV set up, scientists, students and crew members all working together during a sampling operation, and a variety of snapshot images taken from the ROV video of the deep reefs of KZN

Progress: 2021 was devoted to completing outstanding sea-based field-work (delayed due to COVID restrictions and weather), and analysis of data for use in the modelling component and integrative combined publications which are planned for 2022.

Key achievements include:

Boomer sub-bottom profiling of canyon heads broadly located between Protea Banks and Port St Johns.

Processing of ROV data for three canyons and non-canyon sites for the modelling component.

Completion of one MSc in 2021.

Outreach activities

Education and training interventions (including both formal and informal education-based initiatives), to provide young marine scientists and science students with offshore research experiences to augment their formal university training, and grow their understanding about the threats to the marine environment and potential solutions.

Outputs:

Rautenbach G. 2021. Upwelling Over Submarine Canyons: An In-Situ and Modelling Approach. MSc dissertation. Nelson Mandela University, Gqeberha, South Africa. 106 pp.

Obura DO, Katerere Y, Mayet M, Kaelo D, Msweli S, Mather K, Harris J, Louis M, Kramer R, Teferi T, Samoilys M, Lewis L, Bennie A, Kumah F, Isaacs M & Nantongo P. 2021. Integrate biodiversity targets from local to global levels: A shared Earth approach links biodiversity and people. Science 373(6556): 746-748.

Kelp forect on the Agulhas Bank (Geoff Spiby)

Deep Forests

Taxonomy, phylogeny, habitat, ecology and benefits of deep coral and seaweed habitats in South Africa

PI: Prof. Kerry Sink (SANBI) **Co-investigators & affiliations**: Dr Hayley Cawthra (CGS), Ms Zoleka Filander (DFFE), Dr Lara Atkinson (SAEON), Dr Kerry Howell (Plymouth Uni), Dr Theminkosi Dlaza (WSU), Prof. Rosie Dorrington (RU), Prof. Gary Williams (California Academy of Sci), Dr Stephen Cairns (Smithsonian) **Collaborators & affiliations:** Dr Denham Parker (DFFE), Dr Mark Rothman (DFFE), Dr Sven Kerwath (DFFE), Dr Toufiek Samaai (DFFE), Dr Wayne Florence (iZiko), Dr Shirley Parker Nance (SAEON), Dr Ant Bernard (SAIAB), Dr Amanda Lombard (NMU), Ms Georgina Jones (SURG), Ms Carol Poole (SANBI), Dr Christoher Mah (Smithsonian) **Students** (degree & University): Talicia Pillay (PhD, NMU), Danielle de Vos (MSc, RU), Loyiso Dunga (MSc, UCT), Mari-Lise Franken (PhD, UCT), Tarron Potts (MSc, RU), Sinothando Shibe (MSc, UKZN), Laura Weston (PhD, UCT), Jock Currie (Postdoc, NMU)

The overall aim of the project is to develop an understanding of the taxonomy, phylogeny, habitat, ecology, impacts, benefits and multi-sectoral management options of deep coral and seaweed habitats. Building this knowledge base is supporting an improved understanding and management of sensitive offshore ecosystems dominated by habitat forming taxa. Benefits of these ecosystems and species include provision of complex habitat for species of fisheries importance (including kinkglip, sole, south coast rocklobster, jacopever and hake) and new work that is highlighting the role of these ecosystems in carbon sequestration. The project is building research capacity and multidisciplinary teams and extending this capacity into increasingly deeper water.

A key focus of the Deep Forests project is to help the South African hake trawl fishery meet emerging new Marine Stewardship Council eco-certification standards in habitat management for eco-certification. This is important because eco-certification provides economic benefits through access to more lucrative markets. The current worth of this fishery is R4 Billion and analysis shows that loss of certification will decrease the Net Present Value of the fishery by 35-40% over a 5-year period, with a potential loss of about 12,000 jobs. Vulnerable Marine Ecosystems (VMEs) are those sensitive or fragile ecosystem types that are comprised of animals (including slow growing, long lived species) that create habitat such as cold water coral reefs, sponge grounds and dense seapen beds. These animal forests can take a long time to recover from activates that can damage the seabed such as mining, trawling and anchoring. In order to support eco-certification of South Africa's hake trawl fishery, new work is underway to classify, map and manage potential VMEs. New move on rules have been developed and a new map of potential Vulnerable Marine Ecosystems has been produced.

This project is contributing to the following SDG goals:

Goal 2 Zero Hunger- through work to secure key fisheries areas and management for long term food and job security.

Goal 4 Quality Education- the project promotes inclusive and equitable quality education and lifelong learning opportunities for all. Project ocean literacy initiatives are reaching children, students, skippers, industry, managers and government officials.

Goal 5 Gender Equality – this project is led by women and has or is supporting six female post graduate students (Pillay, Franken, Shibe, Potts, de Vos and Filander)

Goal 12 Sustainable consumption and production – this project is supporting improved fisheries sustainability and ecosystem based management and education in this context.

Goal 14 Life in the Ocean – This project is increasing scientific knowledge, developing research capacity and transferring marine technology to improve ocean health and to enhance the contribution of marine biodiversity to the development of South Africa.

Goal 17 Partnerships – this project spans the biodiversity knowledge chain from foundational research to improved management and this depends on the efforts of a diverse team, multiple institutions, industry partnerships and international collaborations. This exemplifies the multi-stakeholder partnerships that mobilise and share knowledge, expertise, technology and financial resources, to support the achievement of the Sustainable Development Goals in a developing country.

Progress: The key area of progress in 2021 included advances in capacity including the team reaching maximum ROV operating depth and first collections of seapens, lace corals and seafans in 2021. The team undertook two field expeditions in 2021 and advanced deep water coral taxonomy; ecosystem research, mapping and management advice for Vulnerable Marine Ecosystems and work to understand the impacts of demersal trawling. This builds on successes in 2021 in habitat classification and assessment, kelp mapping and assessment and research to document marine species used in medicine and ritual. In terms of Vulnerable Marine Ecosystems (VMEs), there has been excellent student progress and important steps to advance research into the policy and management arena. In collaboration with the South African Deepsea Trawl Industry Association (SADSTIA), the VME scientific and management working groups have improved the mapping, monitoring and management of Vulnerable Marine Ecosystems. Identification materials and a creative video collaboration with Rap artist Kro-Barz are supporting these efforts with arts based approaches and multi-disciplinary research using diverse methods and modern technology to advance this area of work. Good data to support the understanding and management of invertebrate trawl bycatch and South Africa's deep animal forests are being collected and can iteratively improve management measures including thresholds for VME detection and management.

Outreach activities:
We have been active on social media (see MzanSea on Instagram and #ACEPDeepForests, #YouthforGeoscience), produced two videos (DiepRespek) and Deep Forests: a story of two emerging marine researchers Luther and Loyiso. MSc student Shakirah Rylands won an award for her video presentation that includes a trawl impact study with data provided by the ACEP Deep Forest project https://www.youtube.com/watch?v=O4GqhlGTXhg&t=3s.

Outputs: Filander ZN, Kitahara MV, Cairns SD, Sink KJ, Lombard AT. 2021. Azooxanthellate Scleractinia (Cnidaria, Anthozoa) from South Africa. ZooKeys 1066: 1–198.

Pillay T, H.C. Cawthra, A.T. Lombard, K. Sink. 2021. Benthic habitat mapping from a machine learning perspective on the Cape St Francis inner shelf, Eastern Cape, South Africa, Marine Geology 440, 106595.

Button R, Parker D, Coetzee V, Samaai T, Palmer R, Sink K and S. Kerwath. 2021. ROV assessment of mesophotic fish and associated habitats across the continental shelf of the Amathole region. Scientific Reports. 11. 10.1038/s41598-021-97369-2.

Samaai T, Sink K, Kirkman S, Atkinson L, Florence W, Kerwath S, Parker, D and D Yemane. 2021. The Marine Animal Forests of South Africa: Importance for Bioregionalization and Marine Spatial Planning. 10.1007/978-3-030-57054-5_2. In:Perspectives on the Marine Animal Forests of the World pp 17-61. Springer.

Sink K 2021. South Africa's Fossil Forest. In Secretariat of the Convention on Biological Diversity (2021) Special Places in the Ocean: A Decade of Identifying Ecologically or Biologically Significant Marine Areas. 68 pages.

Harris, L.R., Sink, K.J., Holness, S.D., Kirkman, S.P., Driver, A. 2021. National Coastal and Marine Spatial Biodiversity Plan, Version 1.1: Technical Report. Nelson Mandela University, Department of Forestry, Fisheries and the Environment, and South African National Biodiversity Institute, South Africa. 221 pages.

UNEP-Nairobi Convention and WIOMSA. 2021. Western Indian Ocean Marine Protected Areas Outlook: Towards achievement of the Global Biodiversity Framework Targets. UNEP and WIOMSA, Nairobi, Kenya, 298 pp. (Contributions from Kerry Sink – see authors and Operation Phakisa case study)

Japp D and Sink K. 2021. Deep-sea Drumming Quest Vol. 17. No. 1, 11-14.

Pillay T, Cawthra H and MacHutchon M. 2021. Using Machine Learning to Derive Benthic Habitat Maps. Online article Hydro-international. https://www.hydro-international.com/content/article/using-machine-learning-to-derive-benthic-habitat-maps-article

Pillay T. 2021. Merging geoscience and biological science with machine learning: a marine mapping context GeoClips. Council for Geoscience. Volume 64. Pg 9-11. https://www.geoscience.org.za/images/GeoClips/GeoClips-Vol64March2021.pdf

Deep Forests Student Projects

A multi-disciplinary approach to search for bioactive secondary metabolites from marine invertebrates and their associated microbiomes

Student: Tarryn Potts **Degree and university**: MSc, RU **Supervisor and affiliation**: Prof. Rosemary Dorrington (RU)

Antibiotic resistance is an ongoing concern as it is claiming more deaths annually. The discovery and development of new antibiotic scaffolds has been unsuccessful and has resulted in the surfacing of numerous antibiotic resistant bacterial pathogens (Rissolini et al, 2014). According to Sipkema (2016) the marine environment is untapped in terms of its resources, it is well known that marine invertebrates and their associated microbiomes produce bioactive secondary metabolites, however the marine environment remains largely unexplored. Survival in the marine environment requires adaption mechanisms which differ largely to those of terrestrial organisms, most marine invertebrates are sessile, hence the need to produce bioactive secondary metabolites as these chemicals are the only form of protection again predation, overgrowth, UV radiation, bacterial and fungal infections and other threats (Lindequist et al, 2016). Due to the role these chemicals have to play in the marine environment surrounded by copious amounts of water they have enormous potential in drug discovery. Marine macrofauna are not a sustainable resource for drug development as there is not an endless supply, continuous collection could potentially harm the marine environment (Lindequist et al, 2016). Hence the need for these invertebrates to be researched and an alternative method of producing the bioactive compounds needs to be investigated, such suggestions include chemical synthesis/modification and marine biotechnology techniques such as aquaculture, genetic engineering, enzymatic synthesis/modification amongst others (Lindequist et al, 2016; Lindequist and Schweder, 2001; Leal et al, 2013). Initially it was believed that the origin of marine derived bioactive compounds was as a result of the collected organism's biomass. However, recently, there has been a shift in

this thinking, it is increasingly believed that the associated marine microbes are responsible for the biosynthetic origin of these compounds (Gerwick and Fenner, 2014; Piel, 2009). If this is the case, then the supply of bioactive compounds can be addressed by growing the bacteria on a culture.

According to Sipkema (2016) diving deeper is essential for the discovery of new bioactive marine natural products, as deeper depths of the oceans have not been explored, most of the species in the deep-sea are undescribed. The conditions for survival in the deep-sea are extreme, therefore it is expected that the marine invertebrates and their associated microbiomes are novel compounds and their species remain to be described. This project aims to explore the potential of deep water invertebrates and their associated microorganisms to produce novel bioactive small molecules, focusing on the Agulhas Bioregion.

Progress: Samples collected for this project were collected using SAIAB platforms including the *RV Observer* and the ACEP ROV. During the 2021 Deep Forests expedition, samples were collected by both diving and by ROV at depths ranging from 50m to 131m, off the coast of Gqeberha (Port Elizabeth) and East London. Samples collected for screening focused on sponges, building on a long history of research in this context. In 2021, new animals that were collected for screening included stylasterine lace corals, seafans and stony corals. Samples were extracted and initially screened using bioassays and liquid chromatography coupled with mass spectrometry (LC-MS). All samples that had activity against the antimicrobial assays were identified for further analysis. The samples that are currently being pursued are samples that are not active against the cell toxicity and *E.coli* assays, but do display staph aureus activity. These compounds are currently being purified using HPLC and other forms of column chromatography.

ACEP Deep Forests Team 2021. Back (left to right). Koos Smith, Ferdinand Jacobs, Ryan Palmer, Jock Currie front Kerry Sink, Shakirah Rylands

ACEP MARINE PLATFORMS

The *RV Observer*

COASTAL CRAFT

Mari-Lise Franken, Sinothando Shibe & Ferdi Jacobs deploying the ROV off *RV Observer*

The ACEP coastal craft platform comprises of a fleet of three coastal craft, each capable of taking researchers into the offshore environment on trips of up to 36 hours. The craft can work up to 40 nautical miles offshore, and operate from any commercial port in the country.

RV uKwabelana, a 13 m LeeCat Fibreglass catamaran hull boat was built in 2009, and is based in Durban. The typical range of operation is between St. Francis Bay and Port Alfred, but the boat has worked further afield out of Durban and East London. She can carry eleven scientists on board, and has proved to be a very valuable platform for diving operations, plankton and oceanographic research, mooring deployments and ROV operations. She is currently set up as a dedicated multi-beam vessel for the GeMAP platform.

RV Phakisa, a 15 m LegacyCat aluminium catamaran hull boat, was built in 2016, and is based in KwaZulu-Natal, operating from Durban and Richards Bay harbours. This larger, highly manoeuvrable vessel with jet propulsion and a hydraulic A-frame and winch has proved exceptionally capable for ROV work, BRUV deployments, benthic grabs, and other heavy work.

RV Observer, a 15m LegacyCat aluminium hull boat, was build it 2019 and commissioned in early 2020, is based in Port Elizabeth. She has been operating from East London, Port Elizabeth, and Mossel Bay depending during the past year. With similar capabilities as *RV Phakisa*, *RV Observer* provides exceptional research capacity to the Eastern Cape. She has proven to be particularly effective for ROV, benthic grab work allowing work to 300m depth.

The proof of concept and the success of the platform has led to a high demand for this type of vessel and subsequent expansion of the platform. The coastal craft platform is currently used by all four of the ACEP Open Call projects, and is used regularly by SAEON for long-term ecological monitoring and continuous monitoring platforms, and by SAIAB's Acoustic Tracking Array Platform.

Highlights for the Coastal Craft during 2021/2 include:
3-week ROV expedition to East London for ACEP Deep Forests Project.
3-week ROV work in Algoa and St Francis Bay for ACEP Deep Forests Project.
3-week ROV and benthic grab work in Mossel Bay for ACEP Agulhas Bank Project.
Multi-beam surveys off Durban and uThukela Bank for ACEP SmartZone MPA project.
Specimen collections using ROV for Marine Natural Product research.

Coastal Craft Platform Projects

Fate and behaviour of released and rehabilitated pinnipeds

PI: Dr Greg Hofmeyr (Bayworld) **Co-investigators and affiliations**: Prof Marthán Bester (UP), Prof Tommy Bornmann (SAEON), Dr Francois Lampen (Sea World), M'du Seakamela (DFFE), Dr Jennifer Veitch (SAEON), Dr Mia Wege (UP) **Collaborators and affiliations**: Bianca Favaretto (Bayworld), Cherie Lawrence (Bayworld), Dr Andrew Mackay (Mount Croix Animal Hospital), Imtiaaz Malick (SAEON), Lungi Mbhele (Bayworld), Dr Liezl Pretorius (Afrivet), Yvonne Sanders (Université de La Réunion), Claire Taylor (Two Oceans Aquarium), Hayley Tennant (Sea World), Dr Dave Zimmermann (SANParks)

While Cape fur seals are the only species of seal that breeds on the South African coast, a number of other species come ashore. South Africa borders the Southern Ocean, and thus the habitat of seven species of seals from the Subantarctic and Antarctic. Five of these species have been recorded on the South African coast. Subantarctic fur seals and southern elephant seals are regular vagrants, while Antarctic fur seals, and crabeater and leopard seals are rare vagrants. These species spend most of their lives at sea, hauling out at isolated locations. Studying them is expensive and difficult. Therefore, arrivals on the South African coast are an opportunity to learn more about these species, even though sample sizes are low and the individuals are unusual. Many vagrants are in poor condition when they come ashore. They are therefore captured and taken to the rehabilitation facilities at Bayworld. This combined museum and oceanarium has the facilities and staff to support their recovery. When healthy they are released offshore into the waters of the southward moving Agulhas Current. The SAIAB vessel, the *RV Observer* is the perfect platform for this.

But is this work justified? Are we looking after and then releasing animals that will not survive? We have thus followed the survival and behaviour of many released seals through attached satellite linked tags. The movements of these animals have inspired fan clubs of school students and others, who have avidly followed their tracks as they have swum south. Learning an engaging biology lesson in the process. A thus, pinnipeds superstars have be born, such as Bear the Antarctic fur seal, who swam 10 000 km, from Algoa Bay to the island of South Georgia. Or Selso the elephant seal, whose travels to Antarctica and back were followed for two years. Or Ziggy, the ellephant seal who was born in Algoa Bay.

This year three very unusual seals came ashore on the South African coast. Crabeater seal are very infrequent visitors and to have three ashore in one year is exceptional. But also an opportunity. The three starving seals, named Sebastian, Ragnar and Pearl, were all nursed back to health. During which time samples, and data concerning their behaviour was collected. They were set free some 40 nautical miles south of the city of Gqeberha, Sebatian and Ragnar at the end of February, and Pearl in August. Unfortunately post release data was not promising. While other species have swum south, and have been followed for months, all three crabeaters immediately returned to South African waters. At least one of the seals was confirmed dead ashore, and we suspect the others did not survive. While this outcome is very sad, we have at least collected considerable data about these seals. And we have gained a greater understanding of what is possible when it comes to dealing with vagrant seals. Perhaps we can use this to improve the chances of survival of other crabeater seals.

Outputs: Shabangu F, Hofmeyr GJG, Probert R, Connan M, Buhrmann C, Gridley G (in review) In-air sounds and acoustic behaviour of wild juvenile crabeater seals during rehabilitation. Bioacoustics

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Satellite tags track crabeater seals' long journey home. By Guy Rogers. The Herald (23 February 2021). https://www.heraldlive.co.za/news/2021-02-23-satellite-tags-track-crabeater-seals-long-journey-home/?fbclid=IwAR2xUoV20m2sX0HvA4kt1PD999FIzwKkM0kPg0rJIW0-FA95Ft0s2G6CU7M
Crabeater seals: a tale of two atypical adventurers. By Caryn Dolley. The Daily Maverick (1 March 2021). https://www.dailymaverick.co.za/article/2021-03-01-crabeater-seals-a-tale-of-two-atypical-adventurers/
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Pearl the seal's long journey home ends in tragedy. By Guy Rogers. The Herald (8 September 2021). https://www.heraldlive.co.za/news/2021-09-08-pearl-the-seals-long-journey-home-ends-in-tragedy/
Crabeater seal spotted off SA waters. SABC TV News (2 February 2022). https://www.youtube.com/watch?v=d7WNJM74GKc
Crabeater conundrum, but Bayworld is on the trail. By Guy Rogers. The Herald (20 July 2021). https://www.heraldlive.co.za/news/2021-07-20-crabeater-conundrum-but-bayworlds-on-the-trail/
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Our beautiful girl, Pearl. By Linda Sparg. Mossel Bay Advertiser (16 July 2021). https://www.mosselbayadvertiser.com/News/Article/General/our-beautiful-girl-pearl-202107161131

GEO-BIO: Blood reef

PI: Kaylee Smit (SANBI/UCT) **Co-investigators and affiliations**: Dr Errol Wiles (SAIAB), Dr Hayley Cawthra (CGS), Dr Talicia Pillay (CGS), Dr Anthony Bernard (SAIAB)

The project includes the write-up of a paper for peer review publication. The paper seeks to assess relationships between geological, geomorphological and biological parameters to better understand coastal marine reef ecosystems on Blood Reef. Bathymetric derivatives and geomorphological characteristics, derived from GeMaP data, will be used to better understand the fine-scale drivers of fish and benthic communities on Blood Reef (a reef complex near the Port of Durban). Biological Indicators have been calculated from baited

remote underwater stereo-video (stereo-BRUV) footage including community composition, species diversity, relative abundance and biomass of fish communities, among others. Furthermore, benthic community indicators, based on morphological characteristics, have been calculated from forward-facing images extracted from stereo-BRUV samples. Drop camera images are also available from 5 transects on Blood Reef, and other photoquadrats collected for Hayley's PhD thesis. The relationship of physical and geomorphological characteristics of the Blood Reef area and fish and benthic community structure will be determined using generalized linear and additive models

Outputs: Proposed outputs include a publication in a peer-reviewed journal, submitted in 2022 and an oral presentation at the South African Marine Science Symposium (SAMSS).

Practical Research Skills in Marine Biology

PI: Dr Charles von der Meden (UKZN)

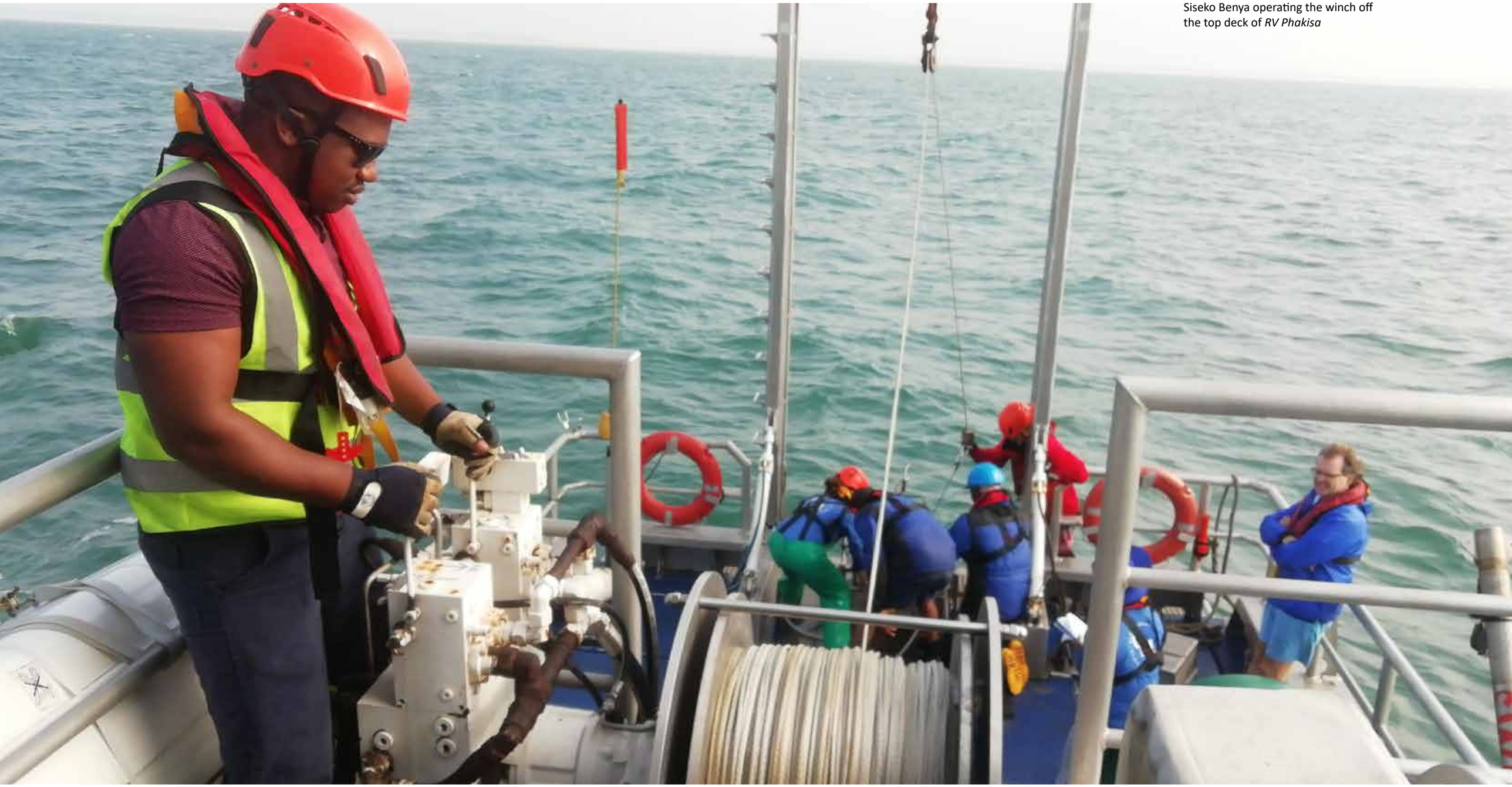
Linking theoretical knowledge with hands-on field experience in undergraduate teaching of marine science is crucial, and even more so for offshore and deep-sea science. The University of KwaZulu-Natal has addressed this through a new third year module (BIOL310) which was run for the first time in 2021. The module prioritises practical skills in marine science covering project design, data management, rocky and sandy shore ecology, and estuarine and offshore components .

Access to the ACEP platform enabled Dr von der Meden's inaugural Offshore class to get out to sea on the *RV Phakisa* off Durban, giving students their first direct experience of at-sea research. During this field work, the students put into practice what they had learnt during lectures about sampling design, in-field record keeping, selection of deep-sea research equipment, and hands-on deployment of key pieces of the platform's benthic research equipment. Specifically, students deployed the underwater drop-camera to take visual samples of seafloor biodiversity, and used the Van veen benthic grab to collect samples of sediment and infauna. This fieldwork formed the basis of the students' main assignment, requiring them to process the samples they had collected and produce a full scientific report on findings. Students relied on their newly developed skills in image processing, sediment particle-size analysis and benthic invertebrate identification.

The ability to get students accessing the offshore environment and learning these kinds of skills has made a significant contribution to ensuring students are better prepared for the new challenges of sustainable development within the context of the Blue Economy.

Outputs: Nineteen students participated in the module with pleasing overall results, including three certificates of merit awarded for overall grades on the course. Many, if not most, of these students had never been on a research vessel, and the enthusiasm and interest that this fieldwork generated was welcome respite from the difficulties of online-only teaching during the past year of the pandemic. At least two of these students have continued to Honours level at UKZN and it is hoped that many others will have been encouraged to pursue careers in marine science.

Nomfundo Mseleku spotting whales off Cape Vidal



Siseko Benya operating the winch off the top deck of *RV Phakisa*

MARIP

Marine Remote Imagery Platform

Sea pens, corals, sponges and a host of fishes at 55 m in iSimangaliso (BAF/SAIAB/OCEANS ALIVE)

The marine remote imagery platform provides access to a variety of underwater imaging equipment that can be used to conduct exploratory and quantitative surveys of benthic, demersal and pelagic marine biota.

The equipment includes a SAAB Seaeye Falcon remotely operated vehicle (ROV) capable of working down to 300 m depth and is fitted with a 12 megapixel still camera, a high definition video camera and a 5 function manipulator arm for collecting specimen samples. The platform offers a broad variety of stereo-video camera systems including tethered (4K video cameras; depth rating of 350m; n=16) and untethered (HD video cameras; depth rating of 1000m; n=5), baited remote stereo-video systems (stereo-BRUVs), and pelagic stereo-BRUVs (4K video cameras; depth rating of 380 m; n=6). In addition, the platform offers two multi-imaging drop cameras, rated to 350m depth each fitted with a downwards facing 20 megapixel mirrorless still camera and oblique facing 4K stereo-video cameras, as well as diver operated still camera systems. To facilitate the use of the equipment in the field, the platform provides access to a 8.5 m Stingray Searider rigid hulled inflatable boat fitted with heavy-duty lifting systems together with a towing vehicle (4.5L v8 Land Cruiser 79) to enable access to remote locations within South Africa and it's neighbouring countries. The platform includes a computer laboratory with all the required software for processing of the imagery data, a large network attached storage system for the long-term archiving of all imagery samples and a comprehensive biodiversity data management system linked into the Specify Software system used for managing biological specimen collections.

MARIP is currently involved in three of the new ACEP Open Call projects with research activities set to start in 2022. Work carried out in 2021 included the planning for the new ACEP projects and research support for the other SAIAB infrastructure platforms (e.g. ATAP, AGRP), and independent research projects. The independent projects currently supported by the platform include: (1) Assessments and long-term monitoring of South Africa's Marine Protected Areas (MPAs), (2) Testing the effectiveness of the environmental DNA (eDNA) for surveying subtidal reef fish assemblages, (3) Investigating essential habitats for threatened sharks in South Africa, (4) Assessment of elasmobranchs in the Western Indian Ocean, (5) Monitoring reef fish populations in the Tofu marine reserve in central Mozambique, and (6) Assessment of the mesophotic ecosystems at Vamizi Island in Northern Mozambique. Numerous fieldtrips were carried out in 2021 for the supported research projects, including baseline surveys of the Robburg, Dwedsa-Cwebe, Hluleka, and Protea Banks MPAs, and eNDA and stereo-BRUV research in and adjacent to the Tsitsikamma, Bird Island, and Wild Coast MPAs.

National institutions using the MARIP include Rhodes University, Nelson Mandela University, University of KwaZulu Natal, University of Cape Town, South African National Biodiversity Institute, Oceanographic Research Institute, Elwandle and Egagasini nodes of the South African Environmental Observation Network, Cape Nature, Ezemvelo KZN Wildlife, WildOceans, South African Shark Conservancy, Department of Agriculture, Forestry and Fisheries, and SAIAB.

International institutions using the MARIP include the Australian Institute of Marine Science (Australia), Wildlife Conservation Society (Madagascar), Marine Megafauna Foundation (Mozambique), NEKTON Foundation (United Kingdom), Coastal Oceans Research Development – Indian Ocean (Kenya), University of Comoros (Comoros), Comoros Fisheries Department (Comoros), Oxford University (United Kingdom), University of Miami (United States of America).

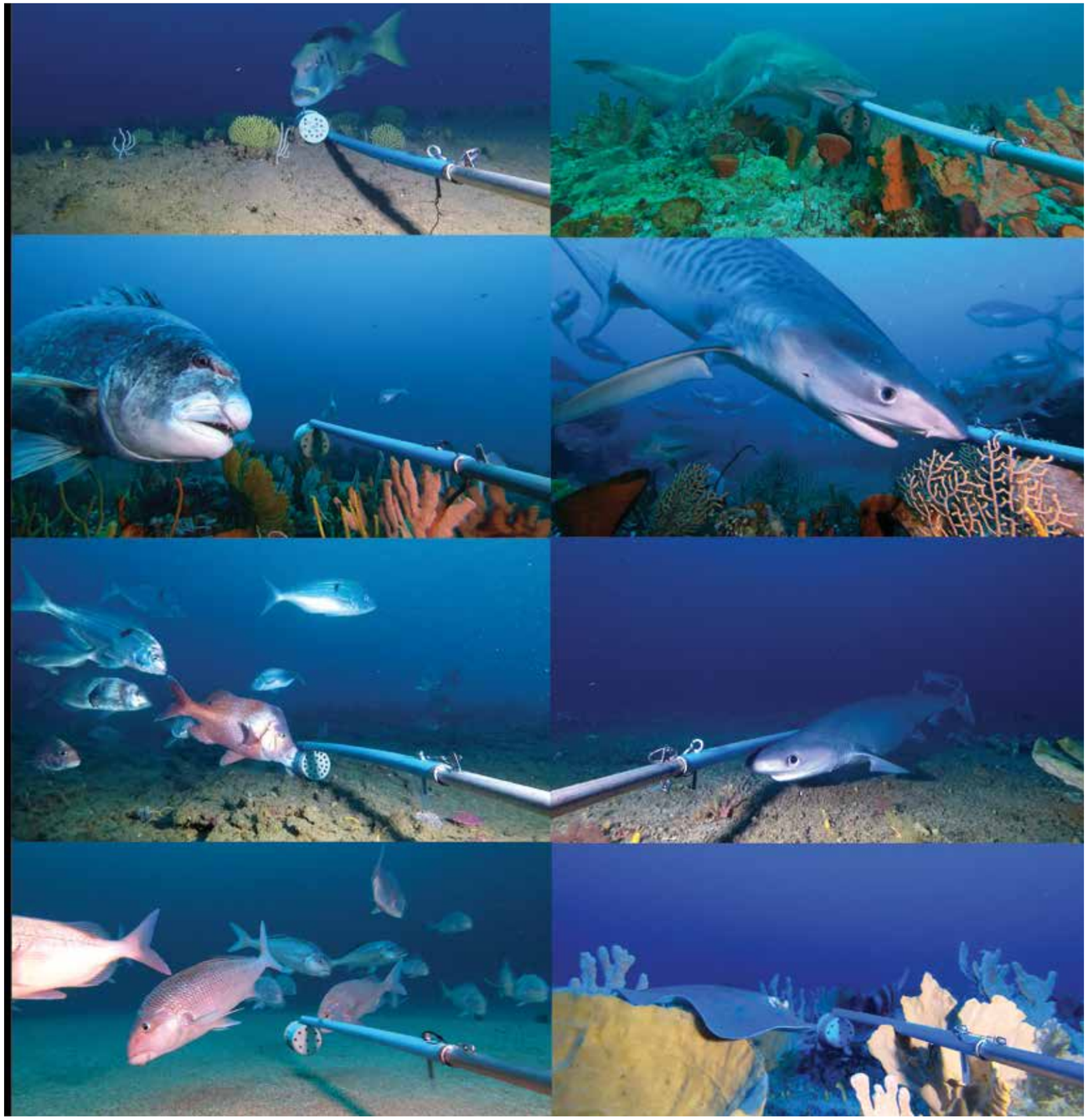
MARIP Projects

OCEANS ALIVE: Strengthening management and expanding coverage of marine protected areas to build socio-economic and ecological resilience in the South-West Indian Ocean

Co-investigators and affiliations: Dr Welly Qwabe (WILDTRUST), Dr Lauren De Vos (WILDTRUST), Dr Anthony Bernard (SAIAB), Mr Ryan Palmer (SAIAB), Prof Paul Cowley (SAIAB), Dr JD Filmalter (SAIAB), Dr Ryan Daly (ORI), Dr Tessa Hempson (OWB), Dr Andrea Marshall (MMF), Dr Melita Samoilys (CORDIO) **Collaborators and affiliations**: Dr Jennifer Olbers (WILDTRUST), Dr Lucy Woodall (Oxford University), Dr Ronel Nel (NMU) **Students (degree and University)**: Natalie dos Santos (Hons, UKZN), Jessica Ferreira (MSc, Universidade de Aveiro), Ocean Stewards (x6, UKZN)

The OCEANS ALIVE Project is funded by the Blue Action Fund and aims to deliver improved management and expanded formal protection at regionally important, and ecologically connected, marine biodiversity hotspots in South Africa and Mozambique. This means focusing on increasing the level of protection and strengthening marine biodiversity management at the iSimangaliso Wetland Park World Heritage Site (iSimangaliso) MPA in north-eastern South Africa, while improving livelihoods of adjacent communities and the sustainability of fisheries. The project also supports surveys and monitoring efforts at connected sites in the Quirimbas in the north, and the Bazaruto MPA and Inhambane areas, of Mozambique.

The purpose of these surveys and monitoring is to bring to light new information about some little-known, but incredibly important areas of our oceans. The depth zone between 40 and 250 m in the ocean (called the “twilight” zone) is known to be a highly productive area of the oceans, essential for supporting shallower ecosystems and the sustainability of both inshore and offshore fisheries. The OCEANS ALIVE Project focuses on improving our understanding of the distribution and movement of endangered species (turtles, sharks, rays and groupers) between and at sites in South Africa and Mozambique, identifying essential habitats for their protection, and conducting surveys on the deeper reefs about which we know so little. This information will inform both protected area expansion and management planning processes for the MPA sites in South Africa and Mozambique,



WILDOCEANS team aboard the research vessel ***RV Angra Pequena*** preparing to release the drop camera equipment for the benthic surveys in the iSimangaliso Wetland Park. Photo Credit: Thembelani Zula. WILDOCEANS intern under Shark Conservation Fund (SCF) project.

contributing to Sustainable Development Goal 14 (to conserve and sustainably use the oceans, seas and marine resources for sustainable development) and Aichi Target 11 (to conserve 10% of coastal and marine areas).

Outputs: Results from the stereo-BRUVs surveys conducted in 2020 were presented by Dr Jennifer Olbers at the Southern African Shark and Ray Symposium and by Dr Lauren De Vos at the Conservation Symposium in November 2021. A new student, Jessica Ferreira, joined the project in partnership with Shark Life in Sodwana Bay and is supervised by Dr Lauren De Vos and Dr Anthony Bernard.

A 14-day fieldtrip to Sodwana Bay in iSimangaliso Wetland Park was achieved between 1 – 18 May 2021. Partner organisations tagged 11 grey reef sharks (*Carcharhinus amblyrhynchos*). Grey reef sharks are listed as Endangered on the International Union for the Conservation of Nature (IUCN) Red List of Threatened Species. They were specified as a priority species for the OCEANS ALIVE tag allocation, to help track their movement patterns over the coming years and contribute to a current data gap. The team installed 3 new acoustic receivers (listening stations) and rolled-over (changed the batteries and downloaded the data) 8 receivers in the iSimangaliso network. In addition to the 11 grey reef sharks tagged on the iSimangaliso fieldtrip in May 2021, 9 bull shark pups were tagged in St Lucia (iSimangaliso) earlier in 2021. The preliminary results were accepted as a short note in the African Journal of Marine Science (AJMS) and are available under the following citation: R Daly, P Le Noury, TN Hempson, M Ziembicki, JM Olbers, GM Brokensha & BQ Mann (2021). Bull shark, *Carcharhinus leucas,* recruitment into the St Lucia Estuary, South Africa, after prolonged mouth closure, and the first observation of a neonate bull shark preyed on by a Nile crocodile, *Crocodylus niloticus.* African Journal of Marine Science, DOI: 10.2989/1814232X.2021.1964599

The project partners for the Mozambique Acoustic Telemetry Network – the Marine Megafauna Foundation (MMF), under the direction of Dr Andrea Marshall, the Oceanographic Research Institute (ORI), under the direction of Dr Ryan Daly, and Ocean Without Borders (OWB), under the direction of Dr Tessa Hempson- deployed 7 new receivers to the array which spans along the coastline of southern Mozambique from the Bazaruto Archipelago in the north, to Ponta do Ouro in the south. These were added to the 28 existing or partner receivers previously installed along this coastline. A total of 7 different shark and ray species have been tagged to date in southern Mozambique since the start of this collaborative BAF project.

Notably, a smalleye stingray was tagged by MMF researchers in June 2021, represented the first acoustically tagged individual for that species globally. Five wedgefish were tagged in the Bazartuto Seascape in 2021, 4 bottlenose (*Rhynchobatus australiae*) and 1 bowmouth guitarfish (*Rhina ancylostoma*), which represent to our knowledge the first individuals of these species in southern Africa.

A 23-day fieldtrip to Bazaruto in Mozambique was achieved between 29 September – 21 October 2021. In this time, the team of partner organisations including Africa Foundation through the Oceans Without Borders (Africa Foundation), ORI and Universidade Lúrio (UniLúrio) tagged 16 individuals from 2 species; 3 grey reef sharks (*Carcharhinus amblyrhynchos*) and 13 giant trevally (*Caranx ignobilis*). While not listed as endangered, Giant Trevally are an important reef predator that have been shown to travel over 600 km to reach large annual breeding aggregations. This makes this species particularly vulnerable

to potential overexploitation during this period of their lifecycle, and the information gained from movement tracking data allows us to effectively target conservation efforts to ensure their protection. During this fieldtrip, 2 new VR2W acoustic receiver stations were also deployed on reefs on the eastern side of Bazaruto Island (5 mile and Sailfish Bay), bringing the total number of receivers to 23 throughout the Inhambane Province. Receiver maintenance of the entire acoustic array (data download and battery replacement) was also carried out in September/October 2021 in a joint effort between all Mozambican partners, including the Marine Megafauna Foundation (MMF), Africa Foundation through the Oceans Without Borders programme, the Oceanographic Research Institute (ORI), and Universidade Lúrio (UniLúrio).

The SAIAB's drop camera equipment was used to achieve image-based surveys of benthic macroinvertebrates and their habitat in iSimangaliso Marine Protected Area between 14 and 29 May 2021. This non-invasive imaged-based sampling technique was used in addition to Remotely Operated Video surveys undertaken in 2020 in collaboration with SAIAB. The sampling was conducted from WILDOCEANS research vessel, *RV Angra Pequena* in the mesophotic zone between 40 to 60 m across different management zones. It allowed for rapid determination of potential areas that require conscientious investigation by the ROV sampling. In total, twenty-six transects were recorded for 64 minutes on average per transect. Collected benthic data during 2020 and 2021 surveys in collaboration with SAIAB is being processed by WILDOCEANS scientists and will be used towards improving the park management, but also be published in the peer reviewed journal.

Shark and Ray Protection Project

PI: Dr Jean Harris (WILDOCEANS/NMU) **Co-investigators and affiliations**: Dr Jennifer Olbers (WILDTRUST), Dr Lauren De Vos (WILDTRUST), Prof Paul Cowley (SAIAB), Dr Anthony Bernard (SAIAB), Dr John Filmalter (SAIAB), Dr Bruce Mann (ORI), Dr Ryan Daly (ORI), Geremy Cliff (ex KZNSB), Markus Burgener (TRAFFIC), Simone Louw (TRAFFIC), Kevin Pretorius (Greenlaw Foundation), Johann Vermeulen (Greenlaw Foundation), Dr Dave Ebert (Moss Landing Marine Labs), Dr Victoria Goodall (NMU), Nina Faure Beaulieu (WILDTRUST, NMU), Dr Aletta van der Merwe (SU) and Grant Smith (Sharklife). **Collaborators and affiliations:** Dr Charlene da Silva (DFFE), Dr Sven Kerwath (DFFE), Sonje Meintjies (DFFE), Jacques Du Toit (DFFE), Stephen Lamberth (DFFE), Sarika Singh (DFFE), Zintle Langa (DFFE), Matshidisho Malatjie (DFFE), Siyabonga Dlulisa (DFFE), Daisy Kotsedi (DFFE), Dr Alison Kock (SANParks), Dr Andrea Marshall (MMF), Tessa Hempson (Africa Foundation), Ashleigh Dore (EWT), Dr Mark Bond (Florida International University), Prof Nick Dulvy (IUCN SSG), Craig Mulqueeny (EKZNW), Prof Amanda Lombard (NMU), and Karen Sack (Oceans Unite). **Students (degree and University)**: Laylaa Teixeira Sampaio (MSc, UKZN)

The overarching aim of the shark and ray protection project is to improve the protection of sharks, rays and chimaeras (chondrichthyans), found within South Africa's EEZ, prioritizing listed threatened and/or protected (Vulnerable, Endangered, and Critically Endangered) species including regional endemics.

The specific objectives within this overarching aim are to
1) improve knowledge and scientific information about status, ecology and threats by collating all available information on species within South African waters;

2) to advance legal protection through strengthening statutory provisions to reflect the conservation status of the species by preparing information packs to enable effective communication with key decision-makers, and influential bodies that advise the national Minister (such as Environmental Portfolio Committee and Scientific Authority, while reviewing legal provisions for protection of South Africa's IUCN Red List threatened and endemic shark and ray species in both the Threatened or Protected Species Regulations (MTOPS) and the Marine Living Resources Act (MLRA), furthermore identifying effective conservation for sharks and rays in the marine protected areas network;

3) by achieving effective implementation and enforcement of adopted conservation and management measures through training and trade implications, and

4) to mobilize public support and action for increased legal protection and effective implementation and enforcement, through a campaign called *Shark Attack*.

The particular aim of the BRUV component of this project is twofold:
1) to improve the understanding of shark & rays populations, spatial distribution and conservation of at least 10 endemic or threatened sharks and rays occurring on the south and east coast (10-100 m depth, <15 nm offshore) of South Africa; and

2) to provide knowledge that can contribute towards improved monitoring, management and conservation of threatened sharks (including benthic species) in marine protected areas. So far, over the 3-year project a total of 2600 samples, inside and outside 13 marine protected areas along the South African coast were collected.

So far over the 3-year project a total of 2600 samples, inside and outside 13 MPAs along the South African coast have been collected. A total of 72 species of chondricthyans of 4000 individuals were recorded. Approximately 190 000 presence/absence records were generated for the entire Exclusive Economic Zone for South Africa. These data, contributed to the Shark and Ray Conservation Plan. Despite COVID restrictions, a field trip was undertaken between November and December 2021, in a 2-week field trip to Protea Banks on the vessel *Hispidus*. During this field trip, the team recorded scalloped hammerhead sharks (*Sphyrna lewini*), a bigeye sixgill shark (*Hexanchus nakamurai*), tiger sharks (*Galeocerdo cuvier*), hound sharks (*Mustelus* spp), and ragged-tooth sharks (*Carcharius taurus*) within the Protea Banks MPA.

Outputs: Data has been extracted and used towards the shark and ray conservation plan. Two papers are currently in preparation and drafts are expected within the life of the project ending in July 2022.

Pic overleaf: A tagged grey reef shark is released into the iSimangaliso Wetland Park. This individual, together with the ten other individuals tagged on this trip, will continue to provide information on grey reef shark movement patterns. These data will be downloaded towards the end of 2021, and into the beginning of 2022, where the first tracks will be available for review. The accumulation of years' of tracking data from 2021 onwards, will provide a much more mature dataset that can show longterm patterns and trends. These datasets will be critical to management input for both South Africa and Mozambique in the years to come. Photographer Copyright ©: Dr Ryan Daly, BAF (WILDTRUST through its WILDOCEANS programme, NRF-SAIAB, SAAMBR-ORI, iSimangaliso Wetland Park Authority, Ezemvelo KwaZulu-Natal Wildlife) |OCEANS ALIVE Project | 2021.

Speckled klipfish (*Clinus venustris*) taking refuge in high complex reef habitat

MARIP Student Projects

The importance of structural complexity for nursery provision within a mosaic of habitats in a temperate rocky cove

Student: Mihle Gayiza **Degree and university**: MSc, RU **Supervisor and affiliation**: Dr Nicola James (SAIAB), Dr Paul-Pierre Steyn (NMU), Dr Anthony Bernard (SAIAB)

Coastal and estuarine habitats are highly productive and serve an important nursery function for coastal fish species. The value of estuaries as nurseries has been attributed to the provisions of structurally complex habitats, such as seagrass, mangroves and saltmarsh, which have been well studied in South Africa. In the absence of seagrass meadows and mangroves, other structurally complex habitats in the nearshore, such as shallow reefs dominated by algae, may provide important nursery areas for juvenile fish in temperate nearshore areas, particularly in sheltered bays where wave action is reduced.

This research aimed to investigate the potential nursery function of shallow (< 5 m) nearshore macroalgae habitats at a temperate nearshore area in South Africa. The objectives of this research are to map and assess macroalgae and potential nursery habitats at the study site, Flat Rock, which lies in the western sector of Algoa Bay.

To do this, burst images of the macroalgae habitat were captured using a GoPro camera to determine a habitat assessment score (HAS). Remote underwater stereo-video systems (stereo-RUVs) were deployed to quantify the juvenile fish assemblages associated with these habitats.

Progress: Burst images of macroalgae habitat were collected from the study site, Flat Rock, using a GoPro camera. The distortion in the images was removed using GNU Image Manipulation Program (GIMP) and cropped out in frame to get a square image. Based on the burst images, habitat complexity variables were given a score to measure their level of complexity.

Using a tape-and-chain method substrate rugosity was measured and the study sites were divided into three patches (profiles) low reef profile, high reef profile and sand patch. Remote underwater stereo-video systems (stereo-RUVs) were deployed for one hour in the three different patches to observe fish assemblages and behaviour.

Preliminary results show that juvenile fish abundance and species richness positively correlate with habitat complexity. Fifteen different seaweeds species observed on the study site were identified to the lowest taxa and their structural branching was described. The seaweed found in the low reef profile was mostly geniculated coralline seaweed and the one found in high profile reef was upright fleshy seaweed suggesting that structure and habitat complex have an influence in juvenile fish choosing a habitat.

Further analyses will look at the fish behaviour and the different fish size observed in each of the habitat types.

The MARIP research team on the SAIAB vessel *RV Observer* following the completion of the surveys at Bird Island

Evaluation of the application of environmental DNA for the assessment of reef fish community structure and spatial ecology

Student: Mpilonhle Nyawo **Degree and university**: PhD, RU **Supervisor and affiliation**: Dr Anthony Bernard (SAIAB), Dr Gwynneth Matcher (SAIAB)

Marine ecosystems and the substantial biodiversity they support are under increasing threats from indirect and direct human disturbances. With the increase in these threats, there is recognition of the strong benefits of non-destructive and non-invasive scientific sampling methodologies. Advances in molecular research have provided a solution to this problem with environmental DNA (eDNA) being able to provide comprehensive assessments of biodiversity. Environmental DNA refers to “DNA that can be extracted from environmental samples (such as water, soil or air), without first isolating any target organisms”. Although eDNA has emerged as a potentially powerful tool to assess aquatic community structure, the method still lacks field tests that evaluate its effectiveness and practical properties as a biodiversity monitoring tool in the South African context.

The aim of this research is to determine if eDNA can be used to analyse spatial and temporal patterns in reef fish biodiversity and community structure through field experiments and comparisons with baited remote underwater stereo-video systems (stereo-BRUVs). The main objectives of this research are to (1) formulate and optimise a protocol for the collection and processing of near-reef eDNA water samples and (2) compare the fish diversity recorded in stereo-BRUVs samples to that detailed from eDNA water samples collected at the same time and location as that of the stereo-BRUV recordings.

Progress: The research carried out in 2020 focussed on data collection and laboratory analysis to determine the optimal sampling protocols for eDNA from euphotic and mesophotic demersal habitats. The key result was that 4L seawater samples allowed for the detection of two to three times the number of fish species compared to filtering only 1L of seawater. Research that was conducted in 2021 adopted the findings from the protocol development and sampling was conducted to determine if eDNA could answer questions related to fish ecology, while carryout some additional field experiments for protocol development.

To address the ecological questions related to management impacts we sampled inside and outside of three marine protected areas (Dwesa-Cwebe, Bird Island, Tsitsikamma). To address the ecological questions related to habitat and depth we collected data from euphotic (10-30 m) and mesophotic (50-100 m) depths and sand and reef habitats. To advance the sampling protocol development we aimed to determine the comparability of the eDNA samples collected from the surface and bottom over the euphoic and mesophotic depth gradient.

At present, all of the collected data are being processed and we will begin answer the questions towards the end of 2022. The final field sampling to address the ecological question related to diel patterns in fish assemblage structure will be conducted in early 2022.

Effects of Robberg MPA on the chondrichthyan community

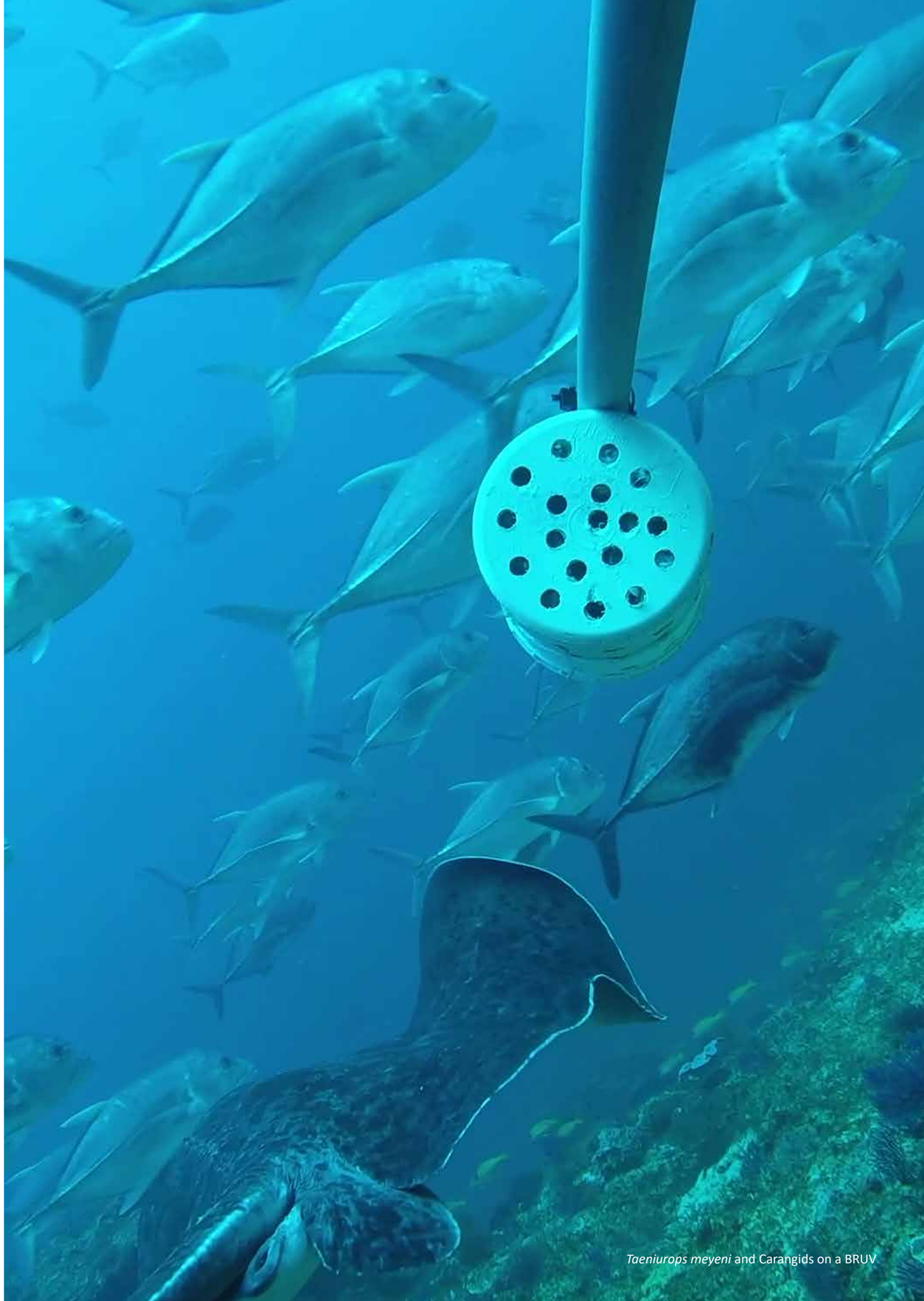
Student: Paolo Cortelezzi **Degree and university**: MSc, University of Milano- Bicocca (UNIMIB) **Supervisor and affiliation**: Dr Anthony Bernard (SAIAB), Guy Paulet (SASC)

Chondrichthyan (sharks, rays and chimaeras) populations are declining worldwide due to anthropogenic pressures and their decline can result in serious negative consequences on food webs. In South Africa, chondrichthyans are caught in several different fisheries, and are targeted both directly, for their meat and liver oils, and indirectly as a product of bycatch. Conservation tools that are often used to protect chondrichthyan populations are Marine Protected Areas (MPAs). However, the effect of MPAs on chondrichthyan populations is still unclear, with some studies showing positive effects and other no effects or even negative effects. Further research is required to advance our understanding of the potential benefits that marine reserves have on chondrichthyan assemblages. As such, the aim of this project was to assess the contribution of the small, partially protected Robberg MPA to the conservation and management of chondrichthyans in the Garden Route, South Africa, and to understand what factors influence the presence of chondrichthyans.

To achieve this, relative abundance, diversity and size of chondrichthyan species were compared inside and outside the MPA using baited remote underwater stereo-video systems (stereo-BRUVs), on different substrates and at different depths, with a total of 79 sites sampled.

Progress: Fieldwork was completed 20 March 2021 and the data analysis started on 25 June 2021 and completed 13 July 2021. The data analysis included the analysis of one hour of video for each site using the software EventMeasure to obtain the relative abundance of each species, the species richness of a specific group and the body size measurements with which the biomass can be calculated. All the statistical analysis were conducted in R.

The results obtained showed that the MPA is beneficial to different groups, such as batoids (rays, skates and guitarfishes), threatened species (in the threatened categories of the IUCN) and endemic species. The presence of a bay is also another factor that affects the presence of cartilaginous fishes, with more observations chondrichthyans, and in particular sharks and threatened species, in the bay rather than in the areas exposed to high wave action. The other factor influencing the community was depth, with all groups showing a significant decrease in relative abundance and species richness as depth increased. Furthermore, a high number of juveniles of different chondrichthyan species were observed, suggesting that the area might be used as nursery ground for several species. A paper including the data and results of this project should be submitted soon. This project led to the production of a master thesis which was defended on 19 November 2021.



Taeniurops meyeni and Carangids on a BRUV

ATAP

Acoustic Tracking Array Platform

Vuyo Mxo holding a receiver, Kowie Estuary, Eastern Cape (M Parkinson)

South Africa's Acoustic Tracking Array Platform (ATAP), hosted by the South African Institute for Aquatic Biodiversity (NRF-SAIAB), provides a backbone of acoustic telemetry hardware to facilitate the large-scale, long-term monitoring of acoustically-tagged marine animals. Since inception in 2011, the ATAP has had a mean of 179 (± 43) active acoustic receiver stations per year (currently ~250 receivers), and currently spans approximately 2200 km of the South African coastline. The focal monitoring sites are three large coastal embayments (False Bay, Mossel Bay and Algoa Bay), with additional receivers deployed in the nearshore environment along the majority of the South African coastline, including (from west to east) Walker Bay, Gansbaai, Plettenberg Bay, Port Alfred, Port St Johns, Protea Banks, Jesser Point and Ponta do Ouro at the South Africa-Mozambique border, as well as 21 estuaries throughout the region. Together these receivers allow for the assessment of localised movement patterns, including residency and site fidelity; habitat and estuarine-marine connectivity; and large-scale coastal movements and migrations. Additionally, temperature loggers are deployed at selected sites, which allows the influence of temperature on animal movement to be assessed, which is crucial given the ectothermic nature of the majority of acoustically-tagged species.

Despite the ongoing global COVID-19 pandemic which has hampered some aspects of fieldwork, we were able to retain normal functioning of the network. Over 186 receivers were successfully retrieved and downloaded, together amassing almost 1.6 million detections. An additional 96 animals from 14 species were tagged, including 21 bronze whaler sharks *Carcharhinus brachyurus (*Vulnerable), 13 whitespotted wedgefish *Rhynchobatus djiddensis* (Critically Endangered) and 12 grey reef sharks *C. amblyrhynchos* (Endangered). Together, this brings the total number of animals tagged and monitored to 1 597 from 48 species (including nine rays and 22 shark species). Of those, 43 species are still being monitored, of which 63% fall into IUCN Red List Threatened categories (15 Vulnerable, 6 Endangered, 6 Critically Endangered).

ACEP projects served: Infrastructure and data management support is being provided to one newly-funded ACEP project managed by the Southern African Fisheries and Ecology Research Lab (https://www.safisheriesecologyresearchlab.com/) and Rhodes University that is aiming to tag at least 20 red Roman *Chrysoblephus laticeps* at two sites along the southern coastline of South Africa. One site at Cape St Francis, and another at the Goukamma Nature Reserve, will serve as exploited and protected sites, respectively. The main aim of this research is to determine how exploitation impacts the resilience of this species against temperature variations using acoustic telemetry. This work follows on from previous work that was conducted on the same species in the Tsitsikamma National Park Marine Protected Area (and was published on the Save Our Seas Foundation blog: https://saveourseas.com/update/fitbits-for-fish/).

Institutions using the ATAP: Currently the ATAP provides support to no less than 58 individuals from 27 different organizations. Projects include work on apex predators such as bull sharks *Carcharias leucas*, white sharks *Carcharodon carcharias* and tiger sharks *Galeocerdo cuvier* (Shark Spotters, Dyer Island Conservation Trust, Oceans Research Institute, Oceanographic Research Institute, Department of Forestry, Fisheries and the Environment, KwaZulu-Natal Sharks Board, NRF-SAIAB), commercially important species such as smoothhound sharks *Mustelus mustelus*, soupfin sharks *Galeorhinus galeus* and bronze whaler sharks (University of Cape Town, South African Shark Conservancy, NRF-SAIAB), valuable tourism species including potato bass *Epinephelus tukula*, giant kingfish *Caranx ignobilis*, several turtle species (green, hawksbill, loggerhead) (NRF-SAIAB, Oceanographic Research Institute, Bayworld), and Critically Endangered rays including

whitespotted wedgefish, duckbill rays *Aetomylaeus bovinus* and eagle rays *Myliobatis aquila* (NRF-SAIAB, Oceans Research Institute, Oceanographic Research Institute, Wildlife Conservation Society, Rhodes University).

Any other projects serviced using the platform: The ATAP continues to provide infrastructure and data management support to two newly-funded projects managed by the WildOceans programme of the WILDTRUST that aims to tag over 200 new animals in order to investigate the movements and migrations of selected South African threatened endemic elasmobranchs, as well as transboundary movements (between South Africa and southern Mozambique) and MPA connectivity by selected species. To date, animals from at least seven different species have been tagged, with significant tagging effort planned for 2022. The ATAP has also recently joined teams with Sea Search – an NGO whose primary focus is to produce high quality, internationally recognised research in the marine realm which can then feed into management via policy recommendations, and into education (http://seasearch.co.za/). Dr Simon Elwen, a marine mammal researcher from Sea Search, deployed hydrophones in Saldanha Bay and St Helena Bay along the west coast of South Africa to gain a better understanding of noise levels in the vicinity prior to some industrial work being conducted in the area. The ATAP assisted by loaning Sea Search VR2ARs – acoustic releases with a built-in release – on which their hydrophones could be attached. Through this collaboration, our listening power along the west coast has expanded with very little cost from the ATAP.

Student supervised by platform personnel: In 2021, the ATAP team was either directly involved in supervising, or was providing data to, a number of postgraduate students, including three honours (BSc Hons) students, six masters (MSc) students and three doctoral students (PhD). These are listed below.

Christine Barrow, BSc Hons UCT: The influence of temperature on coastal fish movement in Algoa Bay, South Africa

Aiden du Toit, BSc Hons RU: Movement behaviour of juvenile river snapper, *Lutjanus argentimaculatus* in the Kosi Bay Lake System, KwaZulu-Natal, South Africa

Jessica Robertson, BSc Hons RU: Assessing a novel acoustic telemetry technique: bridging the passive-mobile divide

Russell Dixon, MSc RU Movement patterns of the iconic giant kingfish *Caranx ignobilis* from southern Africa

Guy Logan, MSc UKZN Investigating the spatial ecology of three ecology important predatory reef fish species – green jobfish (*Aprion virescens*), potato bass (*Epinephelus tukula*) and giant trevally (*Caranx ignobilis*) – within the iSimangaliso Wetland Park

Vuyolwethu Mxo MSc RU Coastal movement patterns of leervis *Lichia amia*: results from long-term acoustic tracking

Godfrey Padare, MSc UFH Movement patterns of an important fishery species, *Pomadasys commersonnii* (Haemulidae), in relation to a no-take zone in the Goukou Estuary, South Africa

Bantony Ziko, MSc UFH Movement behaviour and reproductive biology of adult spotted grunter (*Pomadasys commersonnii)* in the Breede Estuary

Dinah Mukhari, MSc RU The biology and movement patterns of non-native common carp, *Cyprinus carpio* (L.) in Groenvlei, South Africa

Melissa Pollard, PhD NMU Shallow-water seascape connectivity: Micro-habitat utilization by two common estuarine-associated juvenile fish species

Toby Rogers, PhD UCT Investigating the spatial and trophic ecology of the copper shark (*Carcharhinus brachyurus*)

Ralph Watson, PhD RU Movement behaviour and trophic ecology of two endemic catsharks (Scyliorhinidae) from South Africa

Outreach activities: The ATAP continues to engage with the public in many ways, but over the last almost two years has primarily been communicating via social media platforms. Our numbers of followers on our social media pages (Facebook, Twitter and Instagram) continues to steadily grow, reaching 1 923 follows on Facebook (ATAP – Tracking fish movements), 1 215 followers on Twitter (@ATAP_ZA) and 576 followers on Instagram (@atap_za). The ATAP also took part in a number of awareness weeks including Shark Awareness Week and National Marine Week, producing video content for both initiatives. Our Instrument Scientist, Dr Taryn Murray, also gave a seminar reflecting on the first decade of aquatic animal tracking in South Africa, which has received 66 views on SAIAB's YouTube channel (https://www.youtube.com/watch?v=jhVaFcQHwj0).

Vusi Mtembu and the ORI dive team rolls over an acoustic receiver. Image: Ryan Daly

ATAP Platform Projects

iSimangaliso Wetland Park reef fish connectivity

PI: Ryan Daly (ORI) **Co-investigators and affiliations**: Bruce Mann (ORI), Prof. Colin Attwood (UCT) **Collaborators and affiliations**: Dr Camilla Floros (ORI), Prof. Paul Cowley (SAIAB) **Students (degree and University)**: Guy Logan (MSc, UCT)

This project started in 2013 to investigate the connectivity of two ecologically important reef fish species (green jobfish and potato bass) within the iSimangaliso Wetland Park (IWP) in order to determine the effectiveness of the Marine Protected Area network for these species. In 2013, there were six acoustic receivers deployed and 41 fish tagged. This later expanded to the deployment of 14 receivers in the IWP (with the addition of 3 receivers from ATAP at Jesser Point) as well as a total of 75 fish tagged which bolstered the initial study.

Since 2014 the Oceanographic Research Institute (ORI) has maintained the receiver array to collect 9 years of data on these fishes movements within the IWP and abroad that included the first transboundary records of these fish into Mozambique. In 2020, UCT Masters student Guy Logan began to analyze all of the data that will be incorporated into his MSc by the end of 2022. **Outputs**: MARG Final Report.

Mossel Bay shark spatial ecology

PI: Dr Enrico Gennari **Co-investigators and affiliations**: Prof. Paul Cowley (SAIAB), Prof. Mark Gibbon (UWC) **Students (degree and University)**: Allison Haywood (MSc, UWC), Ralph Watson (PhD, RU)

This umbrella project includes different research projects which have been running for a few years now and will carry on in the future. This project aims to tag sharks and rays with acoustic tags and aim to track the coastal movement of those specimens. The aim is to publish and feed management suggestion to local and national governments.

So far we have tagged Blue stingray 1, Bronze whaler sharks 20, Diamond rays 2, Duckbill rays 3, Eagle ray 1, Leopard catsharks 10, Pyjama catsharks 25, Sevengill sharks 9, Smooth hound sharks 28, Spotted gully sharks 2, St Joseph shark 1, white sharks 29, and 1 white spotted smooth hound shark.

Hammerhead shark spatial ecology

PI: Dr Enrico Gennari **Co-investigators and affiliations**: Prof. Paul Cowley (SAIAB) **Students (degree and University)**: Adam Trotter (MSc, RU)

A previous study on the genetic diversity of smooth hammerheads in South Africa identified two subpopulations with moderate to high levels of genetic differentiation with low connectivity: a warm-temperate (South coast) and a subtropical (East coast) one (Kuguru et al. 2019). Currently, the spatial limits of the range of either subpopulation are unknown. The East coast subpopulation occurs throughout the year and few studies have looked at the population trend (Dicken et al. 2018) and its coastal movement patterns through conventional mark-recapture methods (Diemer et al. 2011). Nevertheless, little is known about the southern subpopulation with the exception of reports of young cohorts commonly observed at the surface in near-shore waters mainly during the summer months. This peak in presence in inshore water makes this species in this region highly prone to overexploitation, commercially as by-catch or caught by the recreational fishery. Despite the national regulations and the presence in South Africa of multiple Marine Protected Areas (MPAs), the little data on hand appear to support the concern of many conservationists and researchers about the apparent decline in sightings and catches of juvenile smooth hammerhead sharks along the South coast of South Africa observed over the last 10-15 years. There is an urgent need to identify conservation and management priority areas to better protect species like the smooth hammerhead shark. While managing fisheries' pressures, especially in a third-world country, can be a long and heavily debated process, in particular when a stock assessment is not available, the parallel identification of critical refuge habitats, either already protected (MPAs) or eligible for better protection (as nurseries), might also serve as an important spatial fishery management tool.

Because of the inability to reliably find along the coastline, and therefore tag and track, the subadult and adult portions of the population, this project specifically focuses on the early life history stages of smooth hammerheads within two specific embayments inhabited by the southern subpopulation. Considering that young-of-the-year (YOY) and earlier cohorts are found here in higher abundances in both areas during summer, the first objective is to investigate whether these areas meet the criteria of a shark nursery. According to the National Plan of Action for sharks, this is a requisite to engage in further conservation actions. Due to the lack of a stock assessment, the second objective is to quantify the efficacy of existing coastal MPAs in protecting focal life stages in these areas.

Elucidating the connectivity between key areas and determining the migration patterns of smooth hammerheads is a fundamental step in guiding proper management and conservation decisions for this vulnerable species, in the absence of a stock assessment.

Across different years, a high degree of genetic differentiation was identified suggesting a temporal variation in the use of coastal waters by different part of the populations likely following a biennial reproductive cycle (Kuguru et al. 2019). The same study stated that such a temporal variability could either buffer or amplify the negative effects of potential over-fishing depending on the degree of panmixia (random mating) or drift between the temporal stocks, and therefore, a better understanding of the inter-annual movement patterns of the sub-population is needed to effectively protect it.

Finally, understanding the variability in habitat use in relation to contrasting levels of protection and human development could be used by the South African government to justify its effort to exceed the UN's Sustainable Development Goal recommendation. Part of a 20 year-plan, outlined in the National Protected Area Expansion Strategy target to protect at least 25% of inshore waters and 20% of offshore waters within MPAs, with 15% of these waters being strict no-take zones, including a significant portion of all South African marine bioregions.

Giant trevali shoal at Ponta do Ouro (Pic Ryan Daly)

ATAP Student Projects

Linking movement patterns and reproductive biology to assess habitat connectivity in spotted grunter *Pomadasys commersonnii*

Student: Bantony Ziko **Degree and university**: MSc, UFH **Supervisor and affiliation**: Prof. Paul Cowley (SAIAB), Dr Taryn Murray (SAIAB), Dr JD Filmalter (SAIAB), Mr Lukhanyiso Vumazonke (UFH)

The South African spotted grunter (*Pomadasys commersonnii*) population, an overexploited estuary-dependent fishery species, is known to spawn at sea along the KwaZulu-Natal coastline, with no records of spawning in the Eastern and Western Cape. However, recently, ripe running fish were recorded in the Breede Estuary in the Western Cape. Therefore, an investigation into its reproductive behaviour was necessary as was gaining a greater understanding of its movements between the estuary, the sea and other connected habitats – information which is essential for the development of sustainable fisheries. Acoustic telemetry was used to assess habitat use and seasonal movement patterns in relation to reproductive activity, which was assessed using a combination of histology and the Gonado-somatic index (GSI), for spotted grunter in the Breede Estuary. Additionally, the movements of spotted grunter tagged in the Goukou (50 km east, Western Cape) and Sundays (470 km east, Eastern Cape) estuaries were also assessed to determine inter-habitat connectivity linked to the spawning period.

Progress: Tagged individuals were monitored by locally deployed receivers as well as by receivers of the Acoustic Tracking Array Platform. Breede-tagged fish (n = 7) displayed high levels of residency, spending 83.5% of the study period (November 2016—March 2020) within the estuary. Estuary-sea movements were more common in summer and coincided with the peak of the spawning period (maximum GSI values: 4.04 ± 1.97 SD). Adult spotted grunter opportunistically tagged in other estuaries – Sundays (n = 8) and Goukou (n = 6) – displayed similar behaviour, with estuary-sea movements also being observed more in summer. Departures and arrivals of the fish out and into the Breede Estuary significantly occurred in January and at night. Generalized linear mixed modelling revealed fish to more likely be at sea during warmer months (i.e. summer) and during periods of high river flow. These findings highlight the importance of estuaries in the life history of adult spotted grunter and the role of reproductive activity in habitat connectivity, which have implications for the management.

Movement patterns of an important fishery species (*Pomadasys commersonnii*) (Haemulidae) in relation to a no-take zone in the Goukou Estuary, South Africa

Student: Godfrey Padare **Degree and university**: MSc, UFH **Supervisor and affiliation**: Prof. Paul Cowley (SAIAB), Dr Taryn Murray (SAIAB), Mr Lukhanyiso Vumazonke (UFH)

Knowledge on the movement behaviour, area use patterns and home range size of exploited fishery species is important for management initiatives, such as the design and optimisation of no-take protected areas, which are well recognised as tools for managing fisheries. Acoustic telemetry has proven to be an effective method to investigate the movement patterns of fish species, and the results of many studies have provided the means to inform policy makers in development of appropriate management strategies. This study aimed to evaluate the effectiveness of an established no-take zone in the Goukou Estuary, Western Cape, and assess the potential of area closures as an alternative fisheries management tool (as opposed to traditional measures) for spotted grunter *Pomadasys commersonnii*.

Progress: Fourteen spotted grunter were tagged in the Goukou Estuary in February 2013 and monitored for one year. Tagged fish displayed high levels of estuarine fidelity, spending, on average, 93 ± 11% of their time within the estuary. Fish also remained resident to small stretches of the estuary, spending the majority of the study period within 1.5 km of their release sites. Despite these high levels of residency, fish were also recorded undertaking sea trips, ranging in length from 0 to 62 days. Overall, all fish spent, on average, more time within the no-take zone (60 ± 16.43%) compared to the open zone. This was also the trend per season, with fish spending more time in the no-take zone. These results further confirm the site fidelity of this fish species and therefore their vulnerability to over-exploitation if there are no effective management strategies. No-take estuarine protected areas could therefore offer a high level of protection to these estuary-dependent, resident fishery species.

Coastal movement patterns of leervis *Lichia amia*: Results from long-term acoustic tracking

Student: Vuyolwethu Mxo **Degree and university**: MSc, RU **Supervisor and affiliation**: Prof. Paul Cowley (SAIAB), Dr Taryn Murray (SAIAB), Mr Matthew Parkinson (SAIAB)

Longshore movement patterns and migration phenology in fishes is poorly understood and is difficult to quantify due to the challenges associated with multi-year monitoring. Information on the movement of fishes provides insights into their ecological role and is vital for the development of appropriate conservation and management measures. In recent years, passive acoustic telemetry has become a popular method to monitor fish movement behaviour and migrations. With technological advances, acoustic transmitters can now have a battery life of up to 10 years, which allows for the collection long-term behavioural data, including multi-year migratory behaviour. The movement behaviour of leervis *Lichia amia* – an estuary-dependent fishery species whose stock is considered to be collapsed – is relatively well understood. Acoustic telemetry revealed juvenile leervis to be largely dependent on estuaries but capable of undertaking large coastal movements. Similarly, dart tagging and seasonal catch data suggest that adults undertake annual migrations. However, such large-scale longshore movements have not yet been investigated using acoustic telemetry, as well as the importance of estuaries to adult leervis. This study will make use of long-term acoustic telemetry data collected on the nationwide Acoustic Tracking Array Platform (ATAP) to (i) quantify seasonality and spatial extent of movements, (ii) investigate whether all adults undertake a spawning migration every year, and (iii) assess the role of estuaries in the life history of adults (i.e. assess habitat connectivity).

Progress: Telemetry data from 79 leervis tagged in three coastal regions (Western Cape, Eastern Cape, and KwaZulu-Natal) between May 2011 and January 2017 will be analysed

JD Filmalter releasing an adult dusky kob in the Breede Estuary

for this study. More than 600 000 detections from 74 (94%) leervis had been recorded on the nationwide ATAP. Preliminary results indicate that the majority of leervis undertake an annual migration to KwaZulu-Natal and return to tagging regions; however, some leervis overwinter in these tagging regions, not migrating with the rest of the population. This suggests that leervis partake in partial migration. Additionally, estuaries appear to still be important habitats for adult leervis. Since this overexploited species is important in recreational and subsistence fisheries, new insights into their movement behaviour will contribute towards their future management needs.

Movement patterns of the iconic giant kingfish *Caranx ignobilis* from southern Africa

Student: Russell Dixon **Degree and university**: MSc, RU
Supervisor and affiliation: Prof. Paul Cowley (SAIAB), Dr Taryn Murray (SAIAB), Dr Bruce Mann (ORI)

Giant kingfish *Caranx ignobilis* are global icons as apex marine predators, possessing great ecological, economic, cultural, and recreational value. Their largest spawning aggregation in the world has been documented in southern Mozambique, and the majority of these individuals form part of the South African transboundary stock. Although aspects of their spawning aggregation dynamics have been studied in southern African waters, little is known about their longshore movement patterns. Another large annual aggregation occurs in the Mtentu Estuary in the Pondoland Marine Protected Area (MPA). This aggregation is a mystery, as has been documented by BBC Natural History and narrated by Sir David Attenborough. As such, this study will make use of mark-recapture data collected by the Oceanographic Research Institute's Cooperative Fish Tagging Project (ORI-CFTP) and long-term acoustic telemetry data collected by the Acoustic Tracking Array Platform to interpret long-term and intensive short-term movements of this species along the coastline of South Africa, as well as in and around the Mtentu Estuary. This will provide valuable insights into their movement behaviour and will help understand mysterious aggregations in other species. The findings will be valuable for the management of the stock and the Pondoland MPA, as well as benefiting the local community by promoting tourism around this iconic species.

Progress: Mark-recapture data collected by the ORI-CFTP were used to explore their spatiotemporal movement patterns of giant kingfish in South Africa. A total of 3732 giant kingfish

were tagged along the South African and Mozambican coastline since 1984, with 144 recaptures being recorded (3.9% recapture rate). While 74% of recaptures were recorded <1 km from the tagging location, long-distance movements of up to 419 km were also recorded. Adults moved significantly greater distances than juveniles ($p < 0.01$) and showed significantly greater average speeds ($p = 0.02$). Adults tagged near the southern distribution limit displayed considerable northward movements, which were most common in summer. No movements across the international border, however, were recorded. This highlights the need for improved spatial coverage using acoustic telemetry, especially considering that giant kingfish from South Africa are known to participate in the world's largest recorded spawning aggregation in southern Mozambique.

Movement behaviour and trophic ecology of two endemic catsharks (Scyliorhinidae) from South Africa

Student: Ralph Watson **Degree and university**: PhD, RU **Supervisor and affiliation**: Prof. Paul Cowley (SAIAB), Dr Enrico Gennari (Oceans Research)

Nowhere else in the world is the endemism of catsharks (Scyliorhinidae) higher than off the coast of southern Africa. Despite having over 16 species of catsharks, of which 10 are endemic, knowledge of these animals is severely lacking. Many of these endemic species have overlapping distributions which results in shared habitat niches. Species exploiting similar niches are expected to either compete or coexist with one another. Therefore, this study examined the ecological (dis)similarity between the endemic pyjama catshark *Poroderma africanum* and leopard catshark *P. pantherinum* in Mossel Bay, South Africa. Three concurrent methods were used between October 2016 and April 2018 to evaluate the coexistence of these sympatric species: baited remote underwater video (BRUV) surveys, gastric lavage and acoustic telemetry. Using this multi-method approach, a number of research questions are being addressed to gain a better understanding of the spatial and trophic ecology of these ubiquitous, yet understudied, catshark species.

Progress: The deployment of 197 BRUVs yielded an assemblage of 63 teleost, chondrichthyan, mammal, and bird species. The two *Poroderma* species were positively associated with each other, co-occuring more often than if their distribution/presence overlapped randomly. There BRUV surveys revealed a seasonal, higher Relative Abundance for *P. africanum* (RA = 0.52), while *P. pantherinum* showed a lower, unseasonal Relative Abundance (RA = 0.20). Examination of diet composition through gastric lavage determined that *P. africanum* had a generalist diet, dominated by teleosts and cephalods and was susceptible to anthropogenic influences, while *P. pantherinum* was a more specialist predator, with a diet dominated by cephalopods.

Lastly, acoustic telemetry on 11 *P. africanum* and 10 *P. pantherinum* individuals across an array of 18 acoustic receivers deployed in Mossel Bay revealed a high intra-specific variation in residency and movement behaviour for both species, identifying various areas of importance, influenced by a complex combination of tidal and diel rhythms. This study showed an interesting co-occurrence between the two species, revealing a separation on a trophic, temporal basis, with a difference in space use.

The demise of an iconic species: Do site fidelity and habitat dependence drive the vulnerability of adult dusky kob *Argyrosomus japonicus* in coastal fisheries?

Student: JD Filmalter **Degree and university**: Postdoctoral fellow, SAIAB **Supervisor and affiliation**: Prof. Paul Cowley (SAIAB)

The dusky kob *Argyrosomus japonicus* is arguably the most iconic recreational fishery species in South Africa. It is also one of the most imperilled due to its slow growth, late maturation and habitat preferences. The dusky kob stock was considered collapsed more than 20 years ago with no reports of recovery. Large adults are essential for maintaining populations and crucial for stock recovery, yet very little is known about their movement habits and resultant vulnerability to fisheries.

Current management of this estuarine and coastal fishery species considers the entire population as a single, well-mixed stock; however, there is some evidence suggesting that adult movements may be more limited than previously believed. Making use of acoustic telemetry this study aimed to provide insights into the movement behaviour and habitat use patterns of adult dusky kob in the Breede Estuary and surrounding coastal environment.

Progress: Forty adult (114 – 172 cm TL, mean = 131 cm) and 10 juvenile (65 – 75 cm TL) were tagged in the Breede Estuary in 2016 and 2017 and monitored by 16 acoustic receivers deployed along the length of the estuary as well as four in the adjacent marine environment surrounding the estuary mouth.

Active tracking was also conducted over multiple seasons when tagged animals were present within the estuary. Since then, the project expanded by extending the receiver array into the neighbouring De Hoop Marine Protected Area (MPA), and tagging an additional 27 fish (85 – 152 cm TL) in 2018 and 2019. This was done to gain a better understanding of the refuge role that the MPA plays for the dusky kob population in this region, as well as to examine the exchange between the MPA and the Breede Estuary. Passive monitoring began in 2015 and is ongoing. Larger movements along the coastline and visits to other estuaries were monitored via the Acoustic Tracking Array Platform's network of receivers.

Results indicate high levels of philopatry to the Breede Estuary over multiple years, with more than 80% of the tagged fish returning to the estuary during the spring and summer months. It is highly likely that these movements are linked to spawning behaviour in the proximity of the estuary mouth. Alarming results on the fishing pressure this stock faces have also emerged. Since tagging, 40% of the juveniles tagged in the Breede Estuary have been recaptured. For adults, this figure currently stand at 11%. Preliminary results also suggest critical linkages between the Breede Estuary and the De Hoop MPA.

The findings of this project this far have shed new light on the vulnerability of this species, and suggests that the adult population has considerable spatial structure along its distribution and is likely comprised of discreet sub-units that rarely mix.

The distribution patters and spatial ecology of selected batoids along the South African coastline

Student: Dr Chantel Elston **Degree and university**: Postdoc, SAIAB **Supervisor and affiliation**: Prof. Paul Cowley (SAIAB)

Determining the movement of a species is vital to understanding the ecology of that species and in ensuring that management and conservation practices occur at appropriate spatio-temporal scales. Rays (Batoidea) remain one of the least studied but most vulnerable vertebrate groups. Seventy-nine different species of rays are reported to occur along the South African coastline and a quarter of these species are considered at risk for extinction. Many ray species in South Africa are listed as *Data Deficient* or *Least Concern* on the IUCN Red List of Threatened Species. While some biological information is available, knowledge on the ecology, particularly the movement patterns, for almost all rays is largely unknown; data which are vital for the development of appropriate management and conservation measures. Over 90 individual rays of four different species and varying sizes and sexes (diamond ray *Gymnura natalensis* (n = 34), duckbill ray *Aetomylaeus bovinus* (n = 25), blue stingray *Dasyatis chrysonota* (n = 27) and eagle ray *Myliobatis aquila* (n = 6)) are currently being tracked in South Africa using passive acoustic telemetry. Rays were surgically implanted with long-life (10 years) acoustic transmitters and movements are being monitored by the Acoustic Tracking Array Platform (ATAP).

Progress: This project makes use of previously-collected information from the ATAP. To date, over 10 000 detections have been recorded and various behaviours have been identified, including site fidelity to coastal bays or estuaries and long-range partial seasonal migrations. Both inter- and intra-specific differences in movement were present. The site fidelity displayed by a large number of individuals indicates these species may be suitable for spatial protection if applied correctly.

Investigating the spatial and trophic ecology of the copper shark (*Carcharhinus brachyurus*)

Student: Toby Rogers **Degree and university:** PhD, UCT **Supervisor and affiliation**: Dr Alison Kock (SANParks), Prof. Justin O'Riain (UCT)

Copper sharks (*Carcharhinus brachyurus*) have a patchy distribution across the northern and southern hemisphere, inhabiting warm temperate and subtropical coastal waters. Genetic analyses have revealed that these populations may be discrete with limited to no movement between them. Similar to other large elasmobranchs, copper sharks are slow growing, attain a large size at maturity (Total Length > 3m) and have a low reproductive capacity. Consequently, they have a limited ability to recover when their numbers are reduced by anthropogenic activities which has led to the species being classified as *Near Threatened* on the IUCN Red List. Yet, they are important top predators, forming large schools (>100 individuals) when predating upon shoaling prey species and serve as important mediators in several ecosystems, playing a vital role in trophic connectivity. In South Africa, winter aggregations of copper sharks have been closely linked with the sardine run on the East Coast. Seasonal shifts to temperate shallow inshore bays, including areas such as False Bay and Gansbaai, during the spring and summer months have been documented through landings data from both commercial fishers and recreational anglers.

Banthony Ziko in the field deploying recievers

However, little is known about the potential drivers of these seasonal movements, and the connectivity of the population between the east and west coast waters of South Africa, both of which are critical to inform the management of this vulnerable shark. As such, the overall aim of this research is to understand the spatial distribution, movements and trophic ecology of the copper shark at known aggregations sites (False Bay & Gansbaai) as well as wider scale coastal movements around South Africa using conventional dart tagging, acoustic telemetry and fishing effort data. Identifying and understanding population connectivity and movements, alongside site fidelity and trophic positioning will play a key role in providing the quantitative support essential for effective management of the species throughout their range.

Progress: More than 10 000 bronze whaler sharks have been dart tagged as part of the Oceanographic Research Institute's Cooperative Fish Tagging Project, with 329 recaptures (3% recapture rate) to date. The average distance moved is 160 km with the maximum recorded distance being 1 790 km. Forty-three bronze whaler sharks have been acoustically tagged since November 2015. To date, more than 50 000 detections from 31 sharks (72% of tagged animals detected) have been recorded on receivers deployed between, and including, False Bay and just north of the Eastern Cape/KwaZulu-Natal border – a distance of approximately 1 500 km. This year (2021) will see more bronze whaler sharks being equipped with long-life acoustic transmitters.

Investigating the spatial ecology of three ecology important predatory reef fish species – green jobfish (*Aprion virescens*), potato bass (*Epinephelus tukula*) and giant trevally (*Caranx ignobilis*) – within the iSimangaliso Wetland Park

Student: Guy Logan **Degree and university**: MSc (UCT) **Supervisor and affiliation**: Dr Ryan Daly (ORI), Prof. Colin Attwood (UCT)

Fish movements and migrations are extremely important processes in marine ecology. The magnitude, frequency, and time of occurrence of these movements/migrations can also affect the threats and resilience of a species to both naturally occurring and anthropogenic changes/impacts. Reliable data can aid in determining the relative effectiveness of conservation efforts. Therefore, a better understanding of movement, migrations and connectivity between and among different management zones aids in the chances of successfully implementing a conservation and management plan of fish stocks that are of socio-economic and ecological value and/or those of conservation concern. This project is currently investigating the movements of three such species within the iSimangaliso Wetland Park (IWP) using acoustic telemetry: nine *Caranx ignobilis*, 37 *Aprion virescens* and 38 *Epinephelus tukula.* These species were chosen as they are all ecologically important top reef predators within the IWP. The presence of which often indicates a healthy reef system. All three species have differing levels of protection within and outside of the IWP making this study important for the effective management of these species. Using a matrix of 48 acoustic receivers (VR2W's) from Southern Mozambique to the Eastern Cape, acoustic telemetry data (detections) was collected for the three species. We aim to investigate the extent of the movement and connectivity between and among different management zones within the IWP Marine Protected Area (MPA) as well as any along-shore movements outside the MPA using network and connectivity plots, as well as a range of dispersal metrics. Identifying the movement type in each case as best described as migration, ranging, commuting or station keeping (following Dingle's classification) may also help form a standardized framework for categorizing these species movement patterns.

Progress: Seven years of acoustic data have been collected from multiple receivers (i.e. 48 moored receivers rolled-over annually). I have sifted through these data from multiple sources and concatenated it all into a single spreadsheet in a format that can be easily imported and analysed by Vtrack and Animal Tracking Toolbox packages within R. All redundant, incorrect and non-useful data has been removed. We have begun the first steps in analysing these data through basic dispersal and detection summary statistics as well as network plots. Initial results are indicating that both *A. virescens and E. tukula* are highly resident species with very little long-shore movement. This differs from *C. ignobilis* which has shown multiple long-shore movements with greater movement within the IWP and the highest number of stations detected (17).

The influence of temperature on coastal fish movement in Algoa Bay, South Africa

Student: Christine Barrow **Degree and university**: Hons, UCT **Supervisor and affiliation**: Prof. Juliet Hermes (SAEON), Dr Taryn Murray (SAIAB), Dr Chantel Elston (SAIAB)

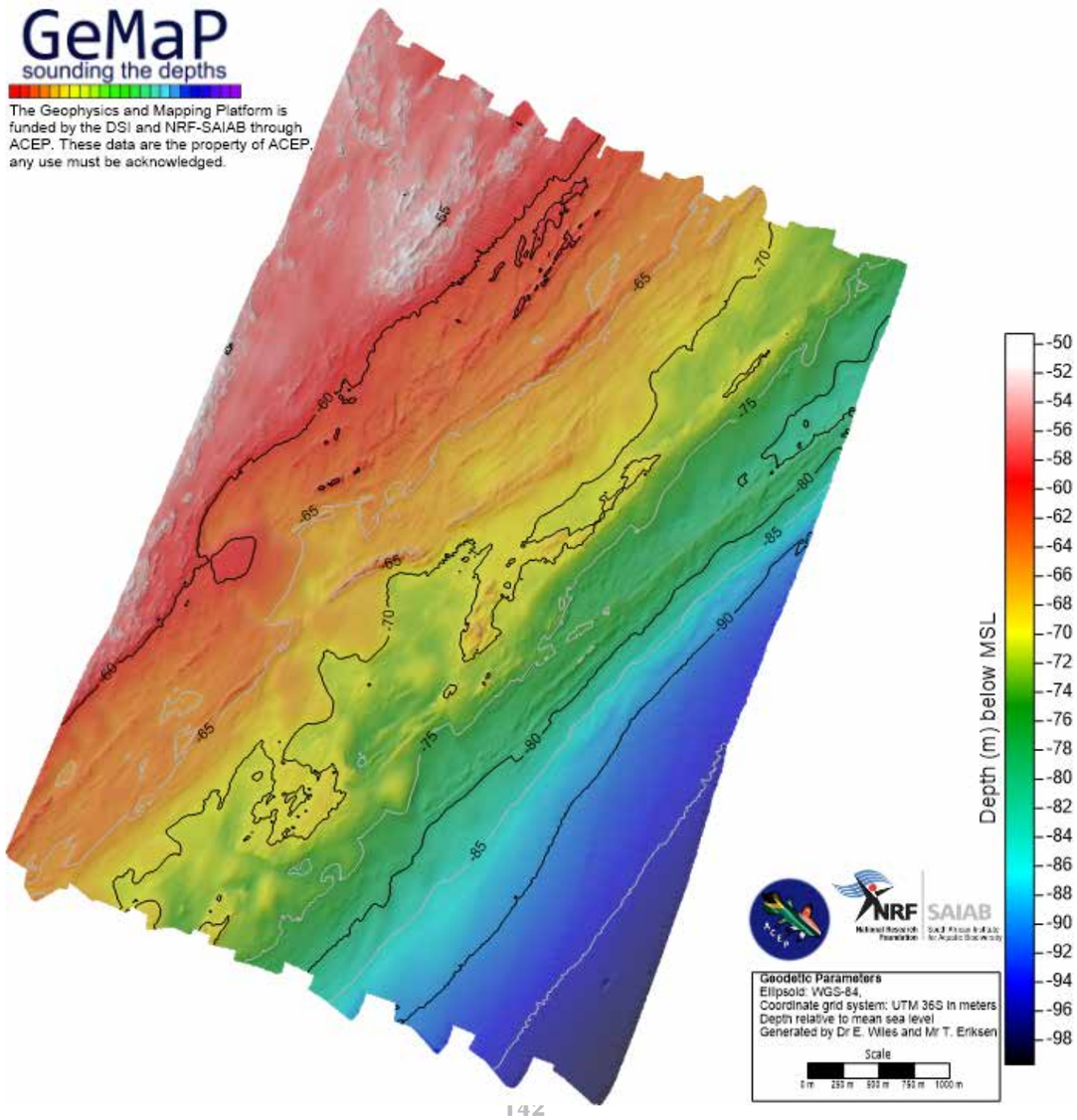
Understanding the relationship between temperature and animal movement is important to understand how animals may react to extreme temperature events and how species distributions may change over time. Acoustic telemetry data allows for an efficient way to understand these movements in relation to temperature. The aim of this study was to understand the influence of water temperature on coastal fish movement, using two tagged white steenbras individuals in Algoa Bay, South Africa as the case study. White steenbras are endemic to South Africa and the population has experienced large declines in their population size, with the stock being collapsed. This was project was investigated using hourly, in-situ seawater temperature data in Algoa Bay to understand temperature cycles. Acoustic telemetry data was used to understand the movements of the two white steenbras. The relationship between temperature and movement patterns was then determined. This study made use of acoustic telemetry data collected on the nationwide ATAP to understand white steenbras movement in relation to temperature in Algoa Bay.

Progress: Two white steenbras were tagged at Woody Cape, the one individual was tagged in February 2010 and was monitored in Algoa Bay from April 2011 to December 2013. The other individual was tagged in December 2015 and was monitored in Algoa Bay from July 2019 to March 2021. White steenbras were observed avoiding cold water temperatures by moving to more thermal tolerant areas. In summer they remained closer inshore, when upwelling and cold temperatures are present further offshore, and in winter they moved further offshore when the thermocline broke down and temperature conditions were more homogenous throughout Algoa Bay. It was also found that the number of receivers used in analysis does significantly influence the results obtained. It is recommended for future projects using acoustic telemetry data to consider increasing listening power (amount of receivers), when investigating fine-scale movements and to better understand the effect the surrounding environment plays.

An ATAP reciever in the Mtentu Estuary (R Daly)

GeMaP

Geophysics and Mapping Platform



The Geophysics and Mapping Platform (GeMaP) aims to support geophysics and marine mapping to answer specific research questions and generate/disseminate knowledge. The platform achieves this primarily though the support of NRF Open-Call projects and marine scientific research that leads to peer reviewed papers in ISI journals, conferences, public engagement, and postgraduate student training. When not in use by Open-Call, the platform may be available on an ad hoc basis for defined, registered and approved scientific purposes.

The Reson SeaBat™ 7101 system covers a 150° (maximum) across track swath with a transmit beam of 1.5° along track. The receive beam covers 15° along track; 101 1.5° x 1.5° beams (= 511 beams). Typical operating depths range from 20 to 350 m, however, resolution and backscatter intensity will degrade with depth. For typical operations along track coverage of 2-3x water depth should be anticipated. Weather conditions, vessel speed, bottom type and topography will all impact swatch width and data quality. The complete systems comprise a Reson SeaBat™ 7101 multi-beam echo-sounder, Teledyne Digibar-V mini sound velocity profiler, Valeport SWIFT sound velocity profiler, Reson SeaBat™ 7101 control and data acquisition computer, Full HYPACK Max license and dongle for data acquisition, processing and final products and a SBG Systems Apogee Navsight Inertial Navigation System.

The GeMaP is currently focused on supporting the competitively SMART ZONES MPAs project and associated consortium of collaborators, and various pilot projects in collaboration with the University of Zululand which investigate the use of shallow water mapping technologies to investigate estuarine ecosystems and their functioning.

Institutes receiving GeMaP support include: SAIAB, SANBI, ORI, UKZN, UCT, University of Stirling, NMU, Wildtrust, UCT, DFFE, NMU, UP, and UniZulu.

The GeMaP has secured a NRF-funded PhD candidate, Mr Thamsanqa Wanda, who will pursue a PhD in marine geology with a focus on geomorphological habitat. The project, registered at NMU is titled: The geology and geomorphology of the Thukela Bank: towards ground-up marine spatial planning. Mr Wanda is supervised by Dr Errol Wiles (SAIAB/NMU) with support from co-supervisors Dr Hayley Cawthra (SAIAB/NMU); Dr Anton De Wit (NMU).

In-house GeMaP training was provided to ACEP staff and students, while external training was provided to UniZulu Staff. This included both theory and practical components and covered the basics of marine geology and hydrographic surveying for marine biological research purposes.

GeMaP
sounding the depths

GeMaP Student Projects

The geology and geomorphology of the Thukela Bank: towards ground-up marine spatial planning

Student: Mr Thamsanqa Wanda **Degree and university**: PhD, NMU **Supervisor and affiliation**: Dr Errol Wiles (SAIAB/NMU) **Co-supervisor and affiliation:** Dr Hayley Cawthra (CGS/NMU), Dr Anton De Wit (NMU)

Knowledge-based, multifaceted marine spatial planning lies at the heart of the Blue Economy. The Smart Zone MPAs project was designed with this in mind: The research workplan is divided into eight work packages which each focus on critical project components. The GeMaP will focus on multibeam bathymetric mapping using the ACEP multibeam echosounder system. Multibeam bathymetry surveys will cover nine reef complexes, and their surrounds, in the 40-100 m depth zone within, and adjacent to, the uThukela MPA. Thus research will be the first effort to strategically map the reef and habitat of the recently proclaimed uThukela MPA.

The high-resolution bathymetry charts produced will inform subsequent biological and oceanographic sampling efforts, allowing research teams to target specific regions of the extensive reef complexes. This is a significant improvement over using low-resolution as now the reef and its geomorphological character can be visualized digitally and in three dimensions. Furthermore, the reef habitat can be defined and classified in terms of the geomorphological character. This is a vital step in being able to accurately quantify marine biodiversity by seafloor area within and outside the MPA.

The culmination of this work will allow for meaningful and unparalleled quantification of seafloor habitat and associated biodiversity. With this knowledge MPAs can be better managed thus provide improved natural services and increased value to tourism, fisheries, and food security.

Progress: Hydrographic surveys commenced in mid-2021. To date, approximately 100 km^2 of bathymetry data have been collected from five reef complexes between Richards Bay and Durban, KZN. The data have been processed and interpretation will soon commence.

Outputs:

Wanda, T., Wiles E., Cawthra, C., de Wit, A. 2021. Taking a closer look at the seafloor: Multibeam bathymetry as a basis for marine spatial planning. WIOGEN Conference on Ocean Governance

Wanda, T., Wiles E., Cawthra, C., de Wit, A. 2021. Taking a closer look at the seafloor: Multibeam bathymetry as a basis for marine spatial planning. The Conservation Symposium

Wanda, T., Wiles E., Cawthra, C., de Wit, A. 2021. Taking a closer look at the seafloor: Multibeam bathymetry as a basis for marine spatial planning. NRF-SAIAB STUDENT SYMPOSIUM

Thamsanqa Wanda and Errol Wiles settgin up equipment (bottom) and performing hydrographic surveys (top)

ACEP JOINT MARINE LAB

ACEP Joint Marine Laboratory Platform

"Taking excellence to the people"

The next phase of the Phuhlisa programme involves the development the DSI/NRF- SAIAB Joint Marine Laboratories Programme (JMLP) at the HDI campuses. The objective of the Joint Marine Labs Platform is the twinning of expertise of the four partner universities with expertise of a DSI/NRF National Facility viz. SAIAB. These laboratories continue to build on existing research and laboratory activities at the Universities and ensures access by university staff to ACEP infrastructure, e.g., coastal vessels and research equipment. The laboratories will be jointly co-ordinated by the partner universities and SAIAB.

The DSI/NRF Joint Marine Labs Programme (JMLP) aims to address key marine, social and economic opportunities and challenges facing South Africans. This also includes development of technical skills to co-manage these joint research platforms.

SAIAB has finalized MOAs and is in the process of establishing joint marine laboratories with our partner Universities:

UNIZULU – Marine ecotoxicology: Dr Masikane is upgrading the laboratory to undertake ecotoxicology to study issues such as anti-foulants, outfalls, land based pollution, port management, etc. He is in the process of procuring a Total Oxygen and Carbon/Total Nitrogen (TOC/TN) analyzer as well as an Inductively Coupled Plasma- Optical Emission Spectrometry (ICP-OES).

UWC - Microplastics: Prof Anusha Rajkaran is setting up a clean lab with associated instrumentation. Refurbishment of the lab space is complete and procurement of a FT-IR spectrometer is at an advanced stage. Opening of the lab is planned for July 2022.

UFH – Bio-discovery: Professor Bradley is setting up a tissue culture laboratory and associated Ultra High Pressure Liquid Chromatography (UPLC) for Novel compound research. The UPLC has been commissioned and the launch is planned for the 10th March 2022.

WSU – Coastal livelihood & Ecology: WSU has plans to rebuild their marine field station at Dwesa nature reserve and money has been secured via the DHET. DSI will twin with DHET to provide the scientific infrastructure for the field station. The WSU team is working closely with ECPTA senior management to get the EIA underway. This project has a longer time frame and is envisaged to be completed by March 2023.

Ecotoxicology Lab – JML Marine and Estuarine Ecotoxicology Laboratory

The Marine and Estuarine Ecotoxicology Laboratory is split into two sections:
The Analytical Lab is where all the analysis will take place. This is also the place where all the capital equipment will be housed. Some of the capital equipment in this lab will included the ICP spectrophotometer, the TOC analyser, microwave digester, AA spectrophotometer and the water purification system.

The Exposure Laboratory is where all the experiments (ecophysiology experiments, marine and estuarine bioassays) will be conducted. The major equipment in this laboratory includes existing infrastructure (e.g. controlled environment rooms) as well as small equipment (e.g. micro-osmometer, microplate reader).

Status update: The first step in establishing a fully functional laboratory required refurbishing the identified spaces for the 2 laboratories. The analytical laboratory was prioritized for refurbishment, which required a complete overhaul (replacing carpentry work, electrical work and plumbing). UniZulu procurement procedures required that a proper lab space be available and ready to accommodate major equipment, hence prioritizing this lab space. Refurbishment of this lab is now complete.

Challenges and future plans: The refurbishment of both labs took longer than expected. This is partly due to COVID-19 (unavailability of some supplies) and KZN-wide looting incident. For example, the replacement of all the carpentry work with stainless steel shelves and cabinets was delayed due to contractors refurbishing most of the big commercial stores in Durban. Refurbishment of the Exposure Lab has now been done. With regards to future plans, procurement for all equipment identified for Invoice 1 have been processed and delivery of these equipment is expected soon. High level approval for procuring the ICP and TOC analyser (Invoices 2 & 3) has been obtained and purchase orders will be submitted to SAIAB soon. We envisage that the JML Marine and Ecotox Lab will be completed by October 2022.

UWC – Microplastics Lab

Status update: The identified room has been refurbished. The laboratory has new desktops, shelves, cupboards and sink area. The design of the lab will allow for a laminar flow unit (purchased and received) as well as a water system (purchased waiting for delivery). Procurement of the new digestion tubes for the existing microwave facility is completed. Purchase of more sieves (a major need for the analysis of sediment and water) is also done. The laboratory is ready for students and some have begun to use the space. We currently have 1 registered PhD, 1 registered MSc, and 1 PhD who will register next year using the lab. The majority of students are female (coloured). Estimated date of completion is July 2022 but this depends on the challenges presented below.

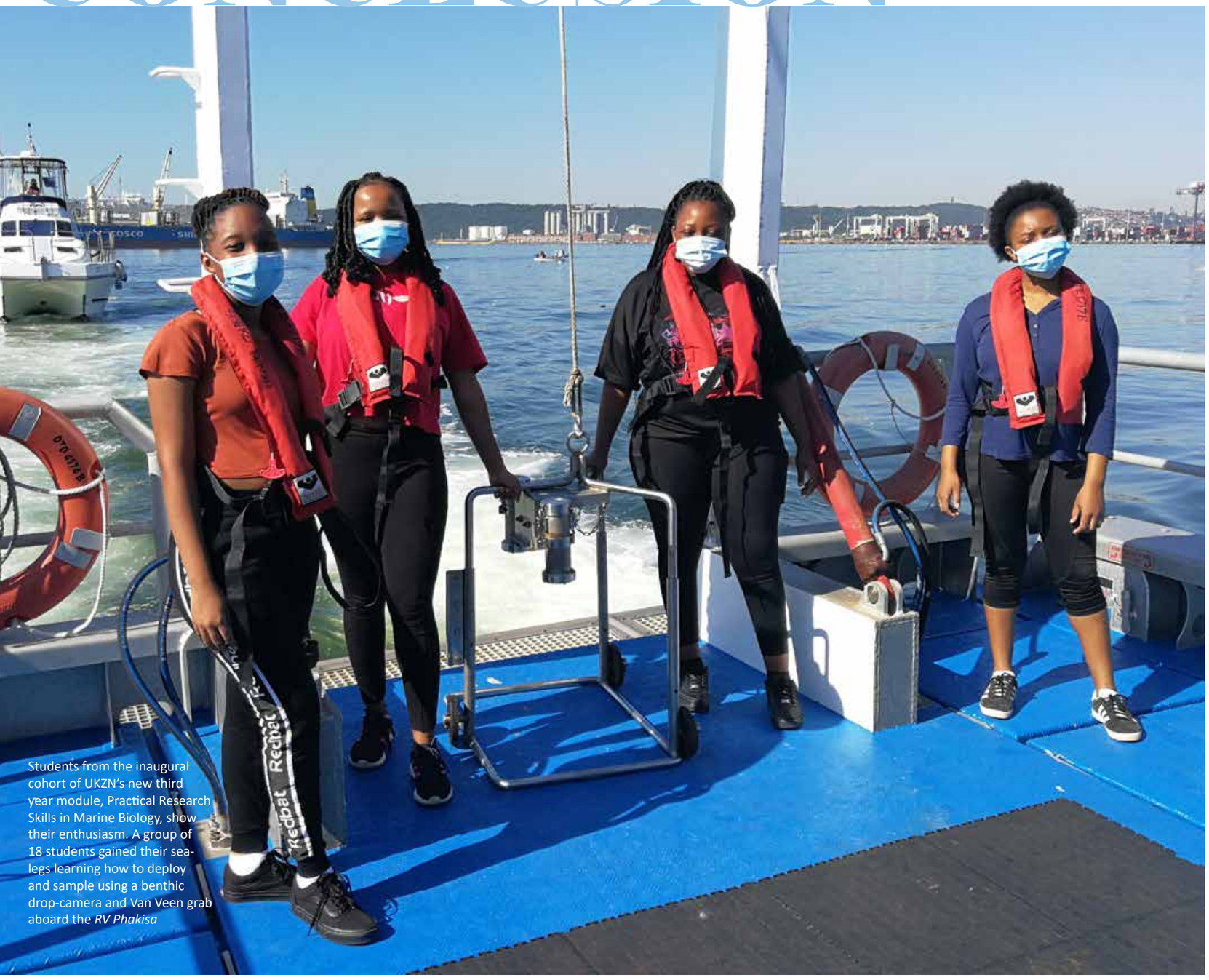
Challenges and successes: The main challenge has been the process of getting the Fourier Transform Infrared spectrometer (FTIR). The main success was the approval of the NRF Marina and Coastal grant for 2022- 2024. The main focus of this will be generating the baseline data of MP in estuaries and estuarine biota as well as understanding the plastisphere. A new PhD student has been identified who will run with that aspect once his MSc is complete. We will submit a short communication in the next weeks on some of our data. We have also started working with Stephen Lambert (DFFE) on some of the fish data.

UFH – Bio-discovery

Status update: Laboratory has been prepared for the equipment and all lab signage has been mounted. Main equipment, UPLC, has been delivered and commissioned. Planned date for the launch is 10th March 2022.

Challenges/Successes: The lab will be functional early 2022, 4 black females to be trained and 1 black female (Dr Ntombekhaya Nqumla) is to be appointed as technician to run the instrument.

CONCLUSION



Students from the inaugural cohort of UKZN's new third year module, Practical Research Skills in Marine Biology, show their enthusiasm. A group of 18 students gained their sea-legs learning how to deploy and sample using a benthic drop-camera and Van Veen grab aboard the *RV Phakisa*

ACEP performed well in the 2021-22 year and continues to deliver effectively on the NRF and DSI mandate. Specifically, ACEP has contributed to the DSI-led MARS as well as the DEA-led Operation Phakisa – Oceans Economy. The programme has actively driven transformation and is a key tool in the DSI's drive to ensure research is both relevant and performed by all South Africans. The 2021–23 ACEP Open Call is supporting four multi-disciplinary projects, is fully subscribed and highly active; the Marine Platforms are well utilised by the Open Call projects, Phuhlisa Projects, partner platforms, and are growing in scope and activity. The Phuhlisa Programme expanded significantly (70 students), and the Science Awareness platform reached learners, undergraduate students and the public.

The macro-economic environment in the country will not allow for an expansion of ACEP for the forthcoming period so ACEP will consolidate and entrench the gains made in the last few years by expanding Phuhlisa and the Marine Platforms Programmes. In 2021/22 ACEP established the Joint Marine Laboratories Programme which is in the progress of setting up specialized marine laboratories at three HDIs. The next phase will continue to offer the four key platforms: Open Call, Marine Platforms, Phuhlisa, and grow the Joint Marine Laboratories. In order for ACEP to continue to be successful, the South African Marine and Coastal Infrastructure programme headed by SAEON has partnered with the ACEP Marine Platforms, enabling expansion of the platform through the procurement of a new research vessel, and NRF-HICD will continue to support black students at HDIs through the Phuhlisa Programme.

ACEP Phuhlisa

Objective: Redressing the imbalances in the demographic structure of marine science through a dedicated ring-fenced programme at HDIs. The Phuhlisa Programme doubled in size in 2015 with UWC and UniZulu joining the programme, and has continued to grow year on year. The period 2017–2021 has been a consolidation period and the programme has been limited to supporting up to 20 researchers and up to 100 students (currently 19 supervisors and 70 students). The next three years will see the programme extending its support in terms of access to infrastructure

to the participating institutions. The role that NRF-HICD plays in this programme is pivotal to its success, as ACEP Phuhlisa provides running costs and technical and academic input, while HICD provides bursaries. Support at the universities is being increased through the development and investment in laboratories at these universities (Joint Marine Laboratories).

ACEP Open Call

Objective: Open, competitive access to marine research infrastructure, technical support, bursaries and running costs. The current Open Call is supporting four multi-disciplinary, multi-institutional projects, two in the Eastern Cape and two in KwaZulu-Natal, involving 67 researchers. Projects were all allocated funding for running costs and bursaries, and have access to the ACEP Marine Platforms, infrastructure that is not typically available or affordable to such projects. The focus of the projects supported by the Open Call are mainly aimed at providing information needed for effective Marine Spatial Planning. This includes understanding the identification of unique habitats, connectivity between habitats and MPAs, the benefits of MPAs to the resilience of species and habitats to global and climate change. These focus areas are easily translated into societal benefits as they underpin the sustainable growth of South Africa's Blue Economy.

A call went out in 2020 inviting projects to compete for support for the 2021–2023 period. Focus areas for this call continue to be driven by societal needs. Four projects were selected for support, which will get underway in 2021. Projects are well aligned.

ACEP Platform Provision

Objective: Providing cutting-edge research platforms on a competitive basis to South African researchers. ACEP will provide the following platforms:

Coastal craft fleet
- *RV uKwabelana*
- *RV Phakisa*
- *RV Observer*

Acoustic Tracking Array Network (ATAP)
- 148 submerged listening stations between Cape Town and Ponta do Ouro
- National ATAP database

GeMaP- Geophysics and Mapping Platform
- Multibeam sonar

Marine Remote Imagery Platform (MARIP)
- Stereo-baited Underwater Video Platform (SBRUV)
- Remote Operated Vehicle (ROV)
- Benthic Landers
- National Imagery Platform

Competitive access to other national marine platforms
- Algoa Bay Sentinel Site (SAEON Elwandle)

The ACEP Platform provision continued to be supported by the SMCRI with the highlight being the building of a new aluminium research craft for the Eastern Cape, which was commissioned in early 2020, as well as the expansion of the Acoustic Tracking Array Platform (ATAP) and the rolling out of additional Sentinel Sites and satellite Sentinel Sites around the coast of South Africa. This has added valuable capacity to the Marine Platforms, allowing for increased support of research and capacity building within the marine science sector and, in turn, greater support of sustainable development within the Blue Economy.

Science Advancement

Objective: Raising awareness and educating the public, learners and students about marine science. This phase will be orientated around the following key programmes:
- SciFest Water World – Leaners and public
- Working World Exhibition
- HDI field trips – UFH, WSU and UZ.
- Summer School

Acknowledgments

A programme of this scope and magnitude would not be possible without the hard work and dedication of a range of individuals. While there are many folk involved with ACEP, the following individuals are specifically thanked:

Department of Science and Innovation (DSI)
- Dr Yonah Seleti
- Dr Gilbert Siko
- Dr Dipuo Kgotleng

National Research Foundation (RISA)
- Ms Tracy Klarenbeek (NRF-KFD)
- Ms Lerato Thokoane (NRF-GMSA)
- Dr Mbulelo Ncango (NRF-HICD)

ACEP Management and Technical Team (SAIAB)
- Dr Angus Paterson
- Mr Koos Smith
- Mr Matt Parkinson
- Mr Ryan Palmer
- Mr Ferdy Jacobs
- Dr Taryn Murray
- Dr Errol Wiles
- Dr Anthony Bernard
- Mr Thor Eriksen
- Prof. Paul Cowley

ACEP Phuhlisa Team
- Mr Garth van Heerden
- Mr Zipho Canda
- Mr Lucky Dlamini

ACEP would also not be possible without all the partner organisations giving their time and access to their research platforms. The following are thanked for ensuring research equipment is available to all on a competitive basis:

Department of Forestry and Fisheries and Environment (DFFE)
- Dr Kim Prochazka
- Mr Ashley Naidoo

SAEON
- Prof. Tommy Bornman
- Prof. Juliet Hermes
- Ms Nozipiwo Hambaze

ACEP 2021 statistics

Phuhilsa

4 HDIs

nineteen supervisors

4 **open call projects** 2021-2023

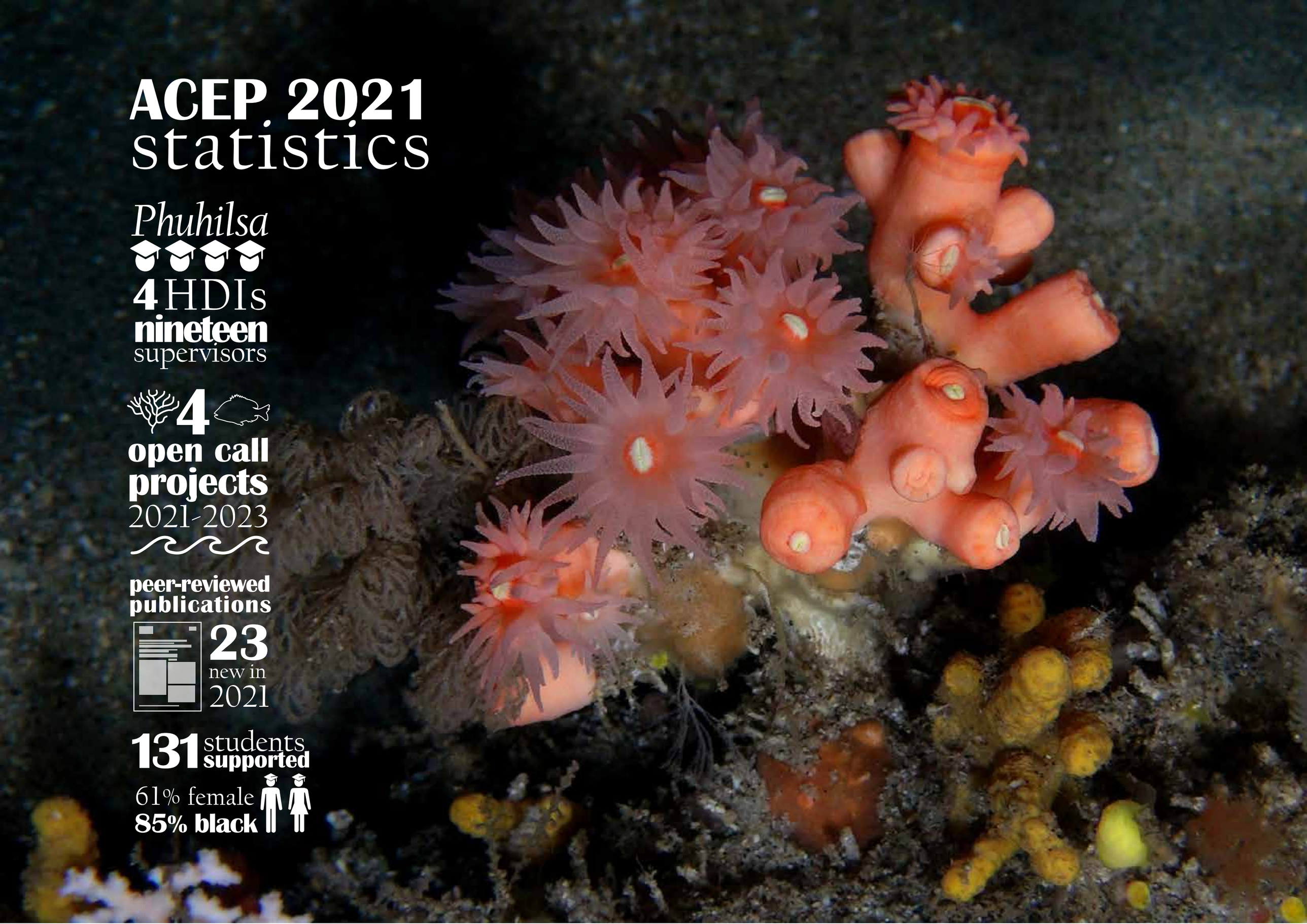
peer-reviewed publications

23 new in 2021

131 students **supported**

61% female

85% black



A school of coachmen and snapper around an OTN reciever

ACEP Publications 2021

ACEP has produced total of 225 peer reviewed papers before 2021. These publications specifically acknowledge ACEP and include publications that only benefitted from ACEP funding.

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Acronymns & Abbreviations

ACEP	African Coelacanth Ecosystem Programme
ATAP	Acoustic Tracking Array Platform
BRUV	Baited Remote Underwater Video
BUS	Benguela Upwelling System
CECs	Contaminants of emerging concern
CGS	Council for Geoscience
CPUT	Cape Peninsula University of Technology
CTD	Conductivity, Temperature and Depth
DFFE	Dept. of Forestry, Fisheries & Environment
DIFS	Dept. of Ichthyology & Fisheries Science
DSI	Department of Science and Innovation
EBSAs	Ecological and Biological Significant Areas
EDX	Energy Dispersive X-Ray
EKZNW	Ezemvelo KwaZulu-Natal Wildlife
ENMs	Engineered Nanomaterials
EWT	Endangered wildlife Trust
FAO	Food and Agricultural Organisation
FCR	Food conversion ratio
GeMaP	Geophysics and Mapping Platform
GIS	Geographic Information Systems
HCD	Human Capacity Development
HDI	Historically Disadvantaged Universities
HICD	Human and Innovation Capacity Development
HPPP	high performance physiological phenotypes
IMTA	Integrated Multi-Trophic Aquaculture
IPTEI	International periodic table of elements and isotopes
IUCN	International Union for Conservation of Nature
IUPAC	International Union of Pure and Applied Chemistry
KDD	Kelp-derived detritus
KZN	KwaZulu-Natal
KZNSB	KwaZulu-Natal Sharks Board
MARIP	Marine Remote Imagery Platform
MARS	Marine and Antarctic Research Strategy
MIRAI	Macro Invertebrate Response Assessment Index
MLD	Mixed Layer Depth
MMF	Marine Megafauna Foundation
MPA	Marine Protected Area
MSP	Marine spatial planning
MTL	Mean Trophic Level
NBA	National Biodiversity Assessment
NDSI	Normalised Difference Salinity Index
NMU	Nelson Mandela University
NRF	National Research Foundation
NSI	National System of Innovation
ORI	Oceanographic Research Institute
OTN	Ocean Tracking Network
PAH	Polycyclic Aromatic Hydrocarbon
PetroSA	Petroleum Agency of South Africa
POM	Particulate Organic Matter
RAS	Recirculating Aquaculture Systems
RISA	Research and Innovation Support Agency
ROV	Remotely Operated Vehicle
RS	Remote Sensing
RU	Rhodes University
SAEON	SA Environment Observation Network
SAIAB	SA Institute of Aquatic Biodiversity
SAMSS	South African Marine Science Symposium
SANBI	South African National Biodiversity Institute
SARIR	SA Research Infrastructure Roadmap
SASAqS	SA Society of Aquatic Scientists
SASSI	Southern African Sustainable Seafood Initiative
SAWS	South African Weather Service
S-BRUV	Stereo Baited Remote Underwater Video
SDG	Sustainable Development Goal
SEM	scanning electronic microscope
SI	Salinity Index
SMCRI	Shallow Marine and Coastal Research Infrastructure
SNP	single-nucleotide polymorphism
SPE	Solid-phase extraction chromatography
SST	Sea Surface Temperature
SU	University of Stellenbosch
SURG	Southern Underwater Research Group
TSS	Total Suspended Solids
UCT	University of Cape Town
UFH	University of Fort Hare
UJ	University of Johannesburg
UKZN	University of KwaZulu-Natal
UP	University of Pretoria
UTR	Underwater Temperature Recorder
UWC	University of the Western Cape
UZ	University of Zululand
VME	Vulnerable Marine Ecosystem
WRC	Water Research Commission
WSU	Walter Sisulu University
XRD	X-ray Diffraction

Using the ROV manipulator arm to collect a Gorgonian

WILDOCEANS team aboard the research vessel ***RV Angra Pequena*** preparing to release a drop camera equipment for benthic surveys in the iSimangaliso Wetland Park. Photo Credit: Thembelani Zula. WILDOCEANS intern under Shark Conservation Fund (SCF) project.

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