ACEP

AFRICAN COELACANTH ECOSYSTEM PROGRAMME

PROJECT OVERVIEWS 2020/21

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 Environment, Forestry and Fisheries (DEFF)
National Research Foundation - Knowledge Fields
Development (NRF-KFD)

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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 Environment, Forestry and Fisheries (DEFF), 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 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 – MarRIP (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 MarRIP as well as investing in a new coastal vessel which was built in 2019 and commissioned in early 2020.

ACEP Outreach: The aim is to introduce marine science to learners, undergraduates, and the public through an internship programme, Summer School, exhibitions, workshops, and initiatives such as the WILDOCEANS Ocean Stewards programme.

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 (UniZulu) and University of the Western Cape (UWC). Subsequent to this expansion, the programme now supports 19 supervisors and 100 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 UniZulu, UWC, UFH, and 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 2020/21 ACEP continued support of four Open Call research projects. Good headway has been made in these projects and 19 postgraduate students and postdoctoral Fellows have been supported by ACEP Projects awarded supported on the current call, which have a strong focus on MPAs and are contributing to implementation of the Operation Phakisa MPA Network.

Dr Warren Potts (Rhodes University): SALPA Project – Fisheries-induced evolution on fish physiology.
Prof. Mandy Lombard (Nelson Mandela University): Canyon Connections – The ecological role of submarine canyons on the east coast of South Africa.
Dr Sean Fennessy (Oceanographic Research Institute): CAPTOR – Connectivity and dispersal between MPAs.
Prof. Kerry Sink (South African National Biodiversity Institute): Deep Forests – Taxonomy, phylogeny, habitat, ecology, and benefits of deep coral and seaweed habitats in South Africa.

These projects would not be achievable without access to the ACEP Marine Platforms. All four projects use the Coastal Craft to gain access to their study sites; three are subscribed to the ATAP, with dedicated receivers being strategically positioned for the projects, and all four make use of various MarRIP equipment, conducting Baited Remote Underwater Video (BRUV) and/or Remotely Operated Vehicle (ROV) surveys. 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. Nineteen new peer-reviewed articles were published in 2020, taking the total for ACEP to 224. Many more are expected to come from this and previous phases of the programme.

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 from April to August, 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 MarRIP 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 spent a month in 2020 supporting the Blue Action Fund Oceans Alive project led by WildOceans, 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 14 major sites 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, a 15 m Legacy Cat, *RV Phakisa* based in Durban, and the *RV Observer* based in Port Elizabeth. The ACEP Open Call 2018–2020 has had all four funded projects subscribing to the Coastal Craft platform. These are Prof. Mandy Lombard's Canyon Connections Project in KZN, Prof. Kerry Sink's Deep Forests Project off Cape St Francis, Dr Sean Fennessy's CAPTOR Project in KZN, and Dr Warren Potts's SALPA Project in Algoa Bay, as well as the continuation of Prof. Rosemary Dorrington's Pharmaceutics Project in Algoa Bay. ACEP's partner platforms include the SAEON Sentinel Site and the SAIAB ATAP 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 licence 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 will be 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.

ACEP PHUHLISA

ACEP Phuhlisa Programme Overview

In 2012, the Department of Science & Innovation (DSI) initiated the Phuhlisa Programme, a dedicated human capital transformation initiative that forms a key part of the DSI's East Coast marine flagship research programme, the African Coelacanth Ecosystem Programme (ACEP). ACEP is managed through the South African Institute for Aquatic Biodiversity (SAIAB) a National Facility of the National Research Foundation (NRF).

Since 2012, the Phuhlisa Programme has grown substantially and in 2020 supported over 100 postgraduate students and 20 supervisors at four coastal Historically Disadvantaged Institutions (UWC, UNZUL, UFH and WSU). This strong strategic initiative ensures that black and female South African postgraduates are trained within the marine sector and that Marine Science is entrenched more deeply at these historically disadvantaged institutions. The ACEP Open research call was designed as a split call to facilitate this initiative. Two thirds of the funding goes to an open call and a third of the funding is ring-fenced to support Marine Science researchers and their students at HDI universities. The programme, foremostly, capacitates HDI marine science researchers by providing access to National Facility research platforms and expertise which would otherwise only be available to scientists at research intensive universities.

These platforms include offshore research vessels in Durban and Port Elizabeth, boat skippers, 4X4 vehicles, estuary boats, dive teams and submersible ROVs. Financial assistance is provided in the form of running costs for student research projects as well as study bursaries, where required.

In 2020, the DSI/NRF initiated the next chapter of this exciting programme by providing support to the ACEP Phuhlisa to assist in the development of four marine laboratories at the participating Historically Disadvantaged Institutions. The programme is known as the DSI/NRF- SAIAB Joint Marine Labs Programme (JMLP). The objective of the JMLP being the twinning of the expertise of each of the four universities with the expertise of a DSI/NRF National Facility viz. SAIAB. These laboratories will build on existing research and laboratory activities at the Universities and will ensure access by University staff to ACEP infrastructure e.g., coastal vessels and equipment. The laboratories will be jointly co-ordinated by the University and SAIAB.

The DSI/NRF Joint Marine Lab Programme (JMLP) will all aim to address key marine social and economic opportunities and challenges facing South Africa. The laboratories are as follows:

Walter Sisulu University: Rural livelihoods and food security
University of Western Cape: Marine Micro-plastic pollution
University of Zululand: Marine Ecotoxicology
Fort Hare University: Marine Bio-economy.

ACEP Phuhlisa Supervisors Reports

Prof. G Bradley

UFH, Department of Biochemistry and Microbiology

Students supervised: Mr A Otigbu (PhD), Ms S Mangali (Hons & MSc), Ms N Siza (MSc), Ms FM Mshiywa (Hons, MSc and PhD), Ms K Bambo (MSc), Ms AT Basera (MSc), Ms P Gowo (Hons)

The ACEP Phuhlisa Programme's support for the development of supervisors and black South African students in Marine Sciences started at the University of Fort Hare in 2012. Initially the programme supported only four supervisors (Dr Anna Clarke, Dr Caryll Tyson, Prof. Ken Liu and Mr Lukhanyiso Vumazonke) and nine postgraduate students. In 2013, the number of supervisors grew to seven and fourteen postgraduate students. Over the period 2012 to 2020, the support has grown consistently, and currently supports six supervisors (Prof. Graeme Bradley, Dr N Ndou, Mr Phila Sibandze, Prof. Ken Liu, Mr Lukhanyiso Vumazonke and Prof. Niall Vine) and a total of thirty postgraduate Marine Sciences students.

The success of the ACEP Phuhlisa Programme can further be seen through the increasing number of Doctoral students registering for Marine Sciences at the University of Fort Hare.

This increase in Marine Sciences postgraduate students would not have been possible if the University had not received support from the ACEP Phuhlisa Programme and developed the resultant collaborations with the SAIAB staff and access to SAIAB infrastructure and equipment.

Through the ACEP Phuhlisa Programme, all the Marine Sciences postgraduate students have received additional career training through annual workshops, including how to write literature reviews, proposals, Theses/Dissertations, and research articles; they have learned communication skills, including oral presentation of their scientific results. Annual life skills training was also offered, including swimming lessons, skipper's licences and, where relevant to the project, scuba lessons. The students and supervisors were also exposed to a range of experienced Marine Scientists from SAIAB and SAEON who were involved in co-supervision and field trips.

This experience has equipped the supervisors to grow their Marine Sciences research projects at the University of Fort Hare, enabling them to graduate an increasing number of Honours, Master's and Doctoral students in Marine Sciences, publish in peer-reviewed international and national journals, and present at national and international conferences. During the period 2012–2020, several of the supervisors have been promoted to the level of Associated Professor, as well as applying for NRF rating.

The success of the ACEP Phuhlisa Programme can further be seen through the increasing number of Doctoral students registering for Marine Sciences at the University of Fort Hare. Initially most of the Phuhlisa students were registered for Honours or Master's, whereas currently (2020) there are seven registered PhD students with many of the current Master's students indicating that they want to continue in 2021 with a PhD in Marine Sciences.

The ACEP Phuhlisa Programme has been very successful not only in developing the current six UFH supervisors (10 in total since 2012) involved in this programme, but also in allowing them to grow their Marine Science projects to the extent where they are now able to attract and supervise more Doctoral students in the Marine Sciences, so making a significant contribution to the pool of black South African Marine Scientists. This development will only be possible if the ACEP Phuhlisa Programme continues at the University of Fort Hare.

Dr NF Masikane

UniZulu, Department of Zoology

Students supervised: Ms LR Nsibande (MSc), Mr MC Mavhungu, Mr MB Xulu (MSc), Mr N Ngubane (BSc Hons)

Support from ACEP Phuhlisa through the provision of bursary and running costs has been greatly welcomed and appreciated; this support has been critical in the time of the COVID-19 pandemic. Our university is located in the King Cetshwayo District Municipality, one of the hotspots of the pandemic, which meant that students had to work from home for most of the time and travel to university only as and when it was critical. The bursary became very important in assisting with travelling as well as purchasing data that helped them access the internet. For example, Mr Ngubane was able to complete his Honours degree, mostly working from home, and Ms Nsibande had to travel for more than 200 km (on two occasions) to campus so that she could complete two field trips. Mr Xulu also managed to complete the proposal and literature review for his MSc, mostly working from home.

Mr Phila Sibandze

UFH, Department of GIS and Remote Sensing

Students supervised: O Maja (Hons), ST Merile (Hons), L Makalima (Hons)

The ACEP Phuhlisa Programme has benefited the department by contributing the much-needed financial and technical support to strengthen our efforts to expand research in Marine Sciences, using satellite-based technologies. The 2020–2021 postgraduate students had a challenging academic year, but ACEP Phuhlisa has guaranteed research support. As the department of GIS and Remote Sensing, we are indeed grateful for the continued support from the programme.

Prof. Ken Liu

UFH, Department of Geology

Students supervised in 2020: Ms Salmina Mokoele (PhD), Ms Nomveliso Caku (PhD), Mr Mthulisi Mpofu (PhD), Mr Lutho Best (MSc), Mr Sithembele Zangqa (MSc), Mr Ayabulela Pezisa (MSc), Ms Ntsoak Lesala (MSc), Ms Afika Nyamambi (MSc)

Phuhlisa is a wonderful platform where our students, particularly black students, receive training opportunities and personal development.

We have been fortunate to have the opportunity to participate the ACEP Phuhlisa programme since it was initiated. Phuhlisa is a wonderful platform where our students, particularly black students, receive training opportunities and personal development. The Programme provides our students with bursaries for university education and to cover running costs to do research work. The students have many other training opportunities, too, such as project proposal writing, swimming lessons, literature review workshops, and life skills development. Our students are very grateful for the many development opportunities.
As a supervisor, I have graduated more than 15 postgraduates through this programme, and there are eight more students currently working on their research. I have expanded my research area from inland to offshore, and from traditional geology to marine and environmental geology. Some of our students have matured into professional geologists through the Phuhlisa programme, and several have made important findings in offshore petroleum exploration. Our students are very grateful for the Phuhlisa Programme; we hope it will continue and generate further successes in the future.

Publications 2020

Baiyegunhi T, Liu K, Gwavava O & Baiyegunhi C. 2020. Textural characteristics, mode of transportation and depositional environment of the Cretaceous sandstone in the Bredasdorp Basin, off the south coast of South Africa: Evidence from grain size analysis. *Open Geosciences*, *12*: 1512–1532.

Baiyegunhi T, Liu K, Gwavava O & Baiyegunhi C. 2020. Petrography and Tectonic Provenance of the Cretaceous Sandstones of the Bredasdorp Basin, off the South Coast of South Africa: Evidence from Framework Grain Modes. *Geosciences (Switzerland)*, *2020* (10): 340–362. https://doi.org/10.3390/geosciences10090340.

Baiyegunhi T, Liu K, Gwavava O & Baiyegunhi C. 2020. Impact of Diagenesis on the Reservoir Properties of the Cretaceous Sandstones in the Southern Bredasdorp Basin. *Offshore South Africa Minerals 2020*, 10 (9): 757–769. https://doi.org/10.3390/min10090757.

Baiyegunhi T, Liu K, Gwavava O, Wagner N & Baiyegunhi C. 2020. Geochemical evaluation of the Cretaceous mudrocks and sandstones (wackes) in the southern Bredasdorp Basin, offshore South Africa: Implications for hydrocarbon potential. *Minerals 2020, 10* (7): 595–612. https://doi.org/10.3390/min10070595.

GW Maneveldt

UWC, Department of Biodiversity and Conservation Biology

Students supervised: C Grootboom (Hons), T Nero (Hons), T Johnson (Hons), D Vanmari (MSc), N Okkers (MSc)

My research encompasses three thematic areas:
1) Coralline algal taxonomy and systematics;
2) Marine ecology and conservation biology; and
3) Integrated aquaculture.

While students who registered in 2020 only participated in the latter two thematic areas (marine ecology and conservation biology, and integrated aquaculture), my primary research area (coralline algal taxonomy and systematics) was supported by Phuhlisa in previous years, notably the PhD studies of Courtney Puckree-Padua. All the publications emanating from that thesis were published only in 2020, with the remaining ones planned for 2021. Thus, some of the funds associated with that PhD study were carried over and used during 2020 for various research expenses related to specimen posting (couriered to international partners for sequencing, and housing in international herbaria) and various publications costs. The funds related directly to 2020-funded projects were used solely for research expenses for travel costs (conference registration and attendance – see list of presentations; travelling to research locations/study sites), project materials (infrastructure and equipment around experimental set-ups), and chemicals (laboratory analyses and procedures).

Phuhlisa funded outputs during 2020

Publications (These were from a PhD student funded in previous years)

Puckree-Padua CA, Gabrielson PW, Maneveldt JR & GW. 2020. DNA sequencing of type material reveals *Pneophyllum marlothii* comb. nov. from South Africa and *P. discoideum* comb. nov. (Chamberlainoideae, Corallinales, Rhodophyta) from Argentina. *Journal of Phycology* 56: 1625–1641; doi: 10.1111/jpy.13047-20-081.

Puckree-Padua CA, Haywood A, Gabrielson PW, Maneveldt JR & GW. 2020. Reassignment of some South African species to *Chamberlainium*, with a comment about the recognition of families of Corallinales (Rhodophyta). *Phycologia* 59(6): 464-496; doi: 10.1080/00318884.2020.1795797.

Puckree-Padua CA, Gabrielson PW, Maneveldt JR & GW. 2021. DNA sequencing reveals three new species of *Chamberlainium* (Corallinales, Rhodophyta) from South Africa, all formerly passing under *Spongites yendoi*. *Botanica Marina*, in press; doi: 10.1515/bot-2020-0074.

Conference presentations

Etwarysing L, Bolton JJ, Beukes DR, Macey BM, Cyrus MD, Vanmari D & Maneveldt GW. Effects of nutrient variation on aquacultured *Ulva*: A lipdomic approach to investigate the lipid and fatty acid composition of *Ulva rigida*. 32nd Congress of the Phycological Society of Southern Africa, Wavecrest, Eastern Cape, South Africa, January 2020.

Maneveldt GW, Puckree-Padua CA, Gabrielson PW & Jeong S-Y. Resolving cryptic diversity in South African non-geniculate coralline algae (Corallinophycidae, Rhodophyta). 32nd Congress of the Phycological Society of Southern Africa, Wavecrest, Eastern Cape, South Africa, January 2020.

Okkers N, Braaf E, Etwarysing L, Macey BM, Maneveldt GW & Beukes DR. The effects of *Ulva* extracts on the growth of invertebrate pathogens: implications for integrated aquaculture. 32nd Congress of the Phycological Society of Southern Africa, Wavecrest, Eastern Cape, South Africa, January 2020.

Vanmari D & Maneveldt GW. Mechanisms of interference and exploitation competition in a guild of encrusting algae along a South African rocky shore. 32nd Congress of the Phycological Society of Southern Africa, Wavecrest, Eastern Cape, South Africa, January 2020.

Vanmari D, Maneveldt GW, Cyrus MD, Bolton JJ, Etwarysing L, Macey BM, Cyster L & Beukes DR. The effects of fertilization on the nutritional biochemistry of *Ulva*: implications for aquaculture production. 32nd Congress of the Phycological Society of Southern Africa, Wavecrest, Eastern Cape, South Africa, January 2020. *Poster*.

Siyamtemba Madyibi

WSU, Biological and Environmental Sciences

Students supervised: P Mbengo (BSc Hons)

Phuhlisa has brought about huge changes to the department; we a now able to attract many students (both Honours and MSc) in the marine field. The Phuhlisa Programme has provided logistical support for field trips, student programmes/training, staff/supervisor development programmes, research equipment, etc. All this support has enabled our students graduate in record time. This support contributes significantly to ensuring students graduate as an advertisement for the programme to attract incoming students.

ACEP Phuhlisa Honours Project Overviews

Distribution patterns of *Cerithidea decollata* in two Eastern Cape estuaries

Student (Degree): Fiki Sinoxolo (Hons, WSU) Supervisor: Dr MDV Nakin (WSU)

The population of *Cerithidea decollata* depend on mangroves for their survival and are threatened by the exploitation of these trees. The aim of this project was to investigate the distribution patterns of *C. decollata* in two Eastern Cape estuaries in order to anaylyse the population dynamics of this species. This was achieved by determining the mean density and size structure and also comparing the mean and maximum size of *C. decollata* between the two estuarine study sites. The relationship between the trunk diameter, snail size and number of snails on *Avicennia marina* trees between the sites was also examined. Sampling was conducted in Mthatha Mouth and Mbhashe Estuary in November 2020. The data were analysed using R Studio version 3.6.1 (2019-07-30). Results from one-way ANOVA tests revealed significantly higher densities and larger sizes of *C. decollata* in Mthatha Mouth than the Mbhashe Estuary. The trunk diameter of *A. marina* was also significantly larger in Mthatha Mouth than in the Mbhashe Estuary. These results highlight variations in density and size distribution patterns of this species between these two estuaries and have implications for the management of the species. No workshops or conferences were attended due lockdown during the COVID-19 pandemic. Currently, the project is at the writing-up stage for final submission in mid-February and intended graduation in May 2021.

Application of network analysis in depicting the interaction of species along the intertidal rocky shore

Student (Degree): Gcam-gcam Qaqamba (Hons, WSU) Supervisor: Dr Thembinkosi Steven Dlaza (WSU)

Species interaction may be commensal, parasitic, competitive, mutualistic or amensal. Over the years, interest in the study and application of networks on ecology has increased. This project aimed to use network analysis to visualize the strength of interaction between seaweed and invertebrate species found in different habitats along the intertidal rocky shore. The main objective was to compare the effects of both the habitat and tidal zone on the interaction strength of species at different sites.
Sampling was done in the Cwebe section of Dwesa-Cwebe MPA and Coffee Bay rocky shores. Parallel line transects were stretched from low shore through mid-shore to high shore, with 0.5 x 0.5 m^2 rectangular quadrats being laid along each transect. Species identification and counting was conducted per quadrat. The data from the two sites were compiled and analysed using various packages in R Studio.
The introduction and literature review have been completed. The materials and methods section has been completed. The results have been analysed from which four networks (high shore, mid-shore, low shore and overall) were produced for each site. Site comparison networks were produced for the different tidal levels. The discussion and conclusions sections will be started soon. I intend to finish the research project for submission on the 28 February 2021. Unfortunately, there were no workshops or conferences that I attended owing to COVID-19.

Is recovery of saltmarsh possible after long-term disturbances caused by vehicles at the Berg River Estuary in South Africa?

Student (Degree): Kezia Uriel Phillipa Dreyer (Hons, UWC) Supervisor: Dr Anusha Rajkaran (UWC)

This project focussed on monitoring the dynamics and recovery of the saltmarsh near the Carinus bridge. Prior to 2018, vehicle driving on a saltmarsh site on the Berg River Estuary reduced the habitat significantly, but in December of 2018 driving was blocked. Since then, we have monitored the soil and plant species for signs of recovery. The Berg River Estuary is an ecologically important estuary as it has the most diverse wetlands (both saline and freshwater) of any permanently open estuaries on the west coast and in South Africa. Besides being one of the biggest estuaries in South Africa, it also supports the biggest saltmarsh area in the country. This estuary is essential to many birds, both permanently present and migratory birds. Fishermen and other estuary visitors driving on the saltmarsh had resulted in the loss of vegetation. The recovery of the saltmarsh sites was monitored using transects and quadrats to determine percentage coverage of each species present, hydrological dynamics and sediment properties (which were analysed in the lab). This project is will likely to be continued by another Honours student.
The most abundant plant species present at the study site are *Bassia diffusa* (average percentage coverage 21.4%) and *Salicornia pillansii* (average percentage 21.8%). Saltmarsh plants *Limonium decumbens, Lycium cinereum, S. tegetaria, Triglochin striata, B. diffusa* and *S. pillansii* are present in each season. No significant differences were found between percentage coverage of species between seasons. The highest number of seedlings recorded at this site was in spring 2019 at Transect 3 (approximately 3000 seedlings per m^2). In summer 2020, Transect 3 also contained the lowest number of seedlings ever recorded. The number of seedlings per m^2 was not significantly different between transects ($df = 3$, $F = 0.739$, $p = 0.558$) or across seasons ($df = 2$, $F = 1.996$, $p = 0.192$).
It is evident that the tyre tracks that remained from 2018 untill winter of 2019 have started to disappear and that the prohibition of vehicles has had a clear, positive impact on the vegetation at the study site. Over time more seedlings, fish and crabs were noticed at the site. The permanent pools of water are connected with the estuary during spring high tides and this is a major driver for plant growth and animal survival. Another issue present there and at other areas of the Berg Estuary is the erosion of banks that leads to the loss of salt marsh. No workshops were attended for this project and I am set to graduate in April 2021.

The influence of zinc on the osmoregulatory strategy of *Neosarmatium africanum* from Mhlathuze Estuary and Bhizolo Canal

Student (Degree): Kwanele Mzwakhe Khuzwayo (Hons, UKZN) Supervisor: Mrs NS Mpanza, Mr MMH Mzimela (UKZN)

The study is essential as it provides more information about the ecophysiology of *Neosarmatium africanum* at the Mhlathuze Estuary and Bhizolo Canal. Very few studies have focussed on this crab in the KwaZulu-Natal estuaries, yet they are important in estuarine environments. The presence of *N. africunum* in the marine intertidal zone is crucial, as they feed on leaves, increasing nutrient levels and, at the same time, decreasing sulphide in sediments. The crab is responsible for 30–88% of decomposed leaf litter through shredding, eating, and burying leaves, so preventing loss of nutrients, and making those nutrients accessible to bacteria and meiofauna in sediments. During burrowing they modify sediments into a smaller size, formulating microhabitats of other fauna, and increasing the levels of nutrients.
Not only is it interesting to understand how *N. africanum* from Mhlathuze Estuary and Bhizolo Canal respond to intertidal changes and different salinities, but also to investigate how they respond to concentrations of heavy metal (zinc) as these study sites are exposed to metals and fertilisers by surrounding industries.
The project investigated the influence of zinc on the osmoregulatory strategy of *N. africanum* in the Mhlathuze Estuary and Bhizolo Canal by collecting crabs from the study sites, acclimatizing them in the laboratory under environmental conditions, and exposing them to different salinities and zinc concentrations for 96 hours. Hemolymph osmolality was extracted and measured using an osmometer. Weight was measured using a Mettler balance, and length measured using a Vernier calliper. Data will be used in the future to further study *N. africanum* and the Mhlathuze Estaury and Bhizolo Canal in terms of environmental conditions in relation to species and climate change.
It was observed that crabs were tolerant of salinity ranging from 0 to 75ppt, but Mhlathuze Crabs were more tolerant than Bhizolo Canal crabs. The control crabs from Mhlathuze Estuary and Bhizolo Canal had a similar osmoregulatory strategy; they had a strong regulatory ability at lower salinities before passing the isosmotic point, and weaker regulatory ability after passing the isosmotic point. In terms of the effects of zinc, Mhlathuze Estuary crabs were significantly influenced by zinc and salinity when compared with the control, while Bhizolo Canal crabs were not influenced by zinc. Mhlathuze Estuary crabs are not used to living in an area with high concentrations of heavy metals as concentrations of heavy metals Mhlathuze are lower than they are at Bhizolo Canal. Therefore, Mhlathuze Estuary crabs were sensitive under stress, and had to save energy in order to regulate zinc concentration, whereas Bhizolo

Canal crabs are used to a harsh environment with a higher concentration of heavy metals, and they thus acclimatized and regulated zinc under different salinities.
Due to COVID-19, we were unable to collect samples in time using the university resources, and Mr MMH Mzimela assisted with his car. The project is complete and graduation date, if all modules are passed, will be in July 2021.

A temporal comparison of the ratio of tropical and temperate ichthyofaunal composition of the Mngazana Estuary

Student (Degree): Lanah Murray (Hons, UWC) Supervisor: Dr Anusha Rajkaran (UWC), Dr Nikki James (SAIAB)

This study was a necessary step to reassess the process of tropicalisation on the east coast of South Africa since an earlier study conducted in 2005. The project compared the temperate and tropical species abundances and richness using data obtained from the 2005 study as well as underwater video footage obtained from unpublished 2015 data. The summer and winter data were used to determine whether tropicalisation is occurring in the Mngazana Estuary. The findings of this study add to existing evidence of the occurrence of tropicalisation and can be a reference point when conducting more long-term, standardised studies at different sites along the estuary.
The percent abundance data obtained in winter and summer from the study conducted in 2005 in the Mngazana Estuary was compared with the summer and winter abundance data obtained from an unpublished study in 2015 in the same estuary. One of the interesting patterns that emerged from this study was that, in 2005, there were no increases or decreases in the species composition between the summer and winter seasons, whereas in 2015, there was a clear increase in the proportion of tropical species from summer to winter, which may have been a result of seasonal distribution shifts. The main result obtained from the study was that tropical species are becoming increasingly dominant within the Mngazana Estuary in terms of species richness as well as abundance. Graduation date: Semester 1, 2021.

Using morphological characteristics to determine spatial distribution and density of invertebrates

Student (Degree): Lugongolo Aphiwe (Hons, WSU) Supervisor: Mr HD Kali, Dr TS Dlaza (WSU)

Studying the intertidal rocky shores is ideal for climate change monitoring since they are an interface between ocean and land. The combined oceanic and atmospheric conditions influence the distribution and density of organisms living in rocky shores. The study was designed to investigate how latitude influences density and distribution of invertebrates between the two sites. The main objective was to compare vertical and horizontal invertebrate distribution in intertidal rocky shores.
The sampling was done in the Cwebe MPA and Coffee Bay (non-MPA) rocky shores during November 2020. The data was analysed using ArcGis version 10.5 map interpolation; kriging was performed to detect hotspot areas of high density and cold spot areas of low density. Different statistical packages were used in R studio version 1.3.1093 to compare the average of invertebrates between and across the two sites. Results from one-way ANOVA tests revealed significantly higher densities in Cwebe than in Coffee Bay. The results of density variation between the two sites showed the possibility of human impacts in Coffee Bay since it is a non-MPA. This finding has implications for conservation and management of rocky shore invertebrates to limit risks of overexploitation. No workshops or conferences were attended owing to the COVID-19 restrictions, which delayed field data collection. Currently, the project is in the writing-up stage for final submission before the end February with graduation expected in May 2021.

GIS use in mapping spatial distribution of sea stars and sea anemones on intertidal rocky shores

Student (Degree): Mbengo Phumlani (Hons, WSU) Supervisor: Mr S Madyibi (WSU)

Sea stars and sea anemones are both medically important in that chemical extractions from sea anemones are used in pharmacological industries for products that act as mammalian heart stimulants. Extractions from sea stars are also used for cosmetic products and in the food industriy, and dried specimens are sold as souvenirs in tourist shops.
The study was conducted on two selected sites (Cwebe and Coffee Bay) on the Wild Coast and was designed to determine the habitat preference of both sea stars and sea anemones along the rocky shores; the density and diversity of these organisms across the shoreline of the selected sites, and to map their distribution. This project was designed to contribute to a larger project of recording the species diversity along the Wild Coast rocky shores. In this study, 0.4 m^2 square quadrats were placed randomly throughout the intertidal area (specifically: rock pools, crevices and furrows), the number of species and number of individuals was recorded, the depth of the pool/crevice, and GPS coordinates.
Data analysed thus far include site preference of the study organisms, distribution, abundance and diversity. The preliminary results show that these organisms do not follow any particular vertical or horizontal distribution patterns but are, instead, found in patches, either in high or low densities. Density and diversity analysis across sites revealed that diversity and density of sea anemones was higher at Cwebe than at Coffee Bay. Sea stars were denser at Cwebe than at Coffee Bay, although there was no difference in the diversity across the two sites. At the Coffee Bay rocky shores, the study revealed that both sea stars and sea anemones were found only in crevices and rock pools. At Cwebe rocky shores, sea stars only occurred in rock pools while sea anemones occurred in furrows, rockpools, crevices and gullies. Sea stars were more abundant in rock pools than in crevices in Coffee Bay. Anemone density was similar in both habitats at Coffee Bay, while the order of abundance was furrows, rockpools, crevices and gullies at Cwebe.
To date no presentations or publications have come from this work; however, a scheduled departmental progress report presentation will showcase these results. At present, we are working on the interpretation of results and discussion section of the report and will make a final submission by end of March 2021 with graduation scheduled for May 2021.

Investigating the sediment quality assessment of Mlalazi and Mhlathuze estuaries using the Amphipod/Polychaete ratio

Student (Degree): Nkululeko Ngubane (Hons, UKZN) Supervisor: Dr NF Masikane (UKZN)

Sediment contamination is an ongoing concern in South African estuaries, but most sediment assessment methods developed to date are applicable primarily to fresh or salt waters, not to estuarine waters, nor do they take into consideration the biology of the system (i.e., these methods rely on the chemistry of the system). Because of this, it is necessary to test the applicability of internationally developed indices before we embark on developing yet another index, which is both data- and time consuming.
The purpose of this study was to determine the historical ecological sediment quality status (EcoQs) in the Mlalazi and Mhlathuze estuaries using the Amphipod/Polychaete ratio. The two indices selected for this project were the Benthic Annelid Amphipod index (BO2A) and Benthic Polychaete Opportunistic Families Amphipoda (BPOFA). Both systems are protected estuaries, and the Mlalazi Estuary has always been regarded as being in good ecological condition owing to the lack of industries in its catchment. However, the catchment is intensively agricultural and is also home to an aquaculture facility. By contrast, Mhlathuze Estuary is regarded as being in moderate to poor condition owing to its proximity to the Richards Bay Harbour and industries. Assessing the historical ecological status of these systems will determine if such assumptions hold true or not. This project has been completed.

Evaluating the coastal vegetation distribution in relation to soil salinity using Sentinel-2, Hamburg, Eastern Cape

Student (Degree): Yolanda Zenande Sidondi (MSc, UFH) Supervisor: Dr Ndou (UFH)

Approximately 20% of the world's population lives within 100 km of the coastline and accounts for around 61% of the world's total Gross Domestic product (GDP) (Millenium Ecosystem Assessment, 2005). About 70% of the Earth's surface is occupied by maritime ecosystems (Covich et al., 1999). However, coastal ecosystems, including plants, are deemed the most disturbed ecosystems worldwide (Covich et al., 2002). Existence of these plants along the coasts are not accidental; they play an important and significant role in environmental and ecosystem functioning, and their existence must be protected to attain environmental and ecosystem sustainability.
The project is investigating the distribution of coastal marine vegetation in relation to soil salinity at Hamburg, Eastern Cape. The investigation will be achieved by assessing the spatial distribution in coastal vegetation, mapping the spatial patterns in soil salinity levels and determining soil salinity spatial pattern in vegetation condition. The current study will inform scientists, community and government about the different factors affecting the coastal vegetation, including climate, human activities, and especially salinity. This study will not only investigate the degradation of coastal vegetation, but will also provide solutions on how the above mentioned factors can be solved because conservation of soil is the effective management of coastal vegetation restoration. Ultimately, scientists in other regions will be able to evaluate the outcome of this study and adopt similar methods in addressing similar problems.
The data, which included plant and soil samples, were analysed at Department of Rural Development and Agrarian Reform at Dohne Analytic Lab. The parameters included moisture, total nitrogen, crude protein, crude fibre, TDN, P, Ca, Mg, K, Cu, and Zn for plant samples; for the sample density, acid saturation, pH, exchange acidity, P, K, Ca, Mg, Zn and Cu were assessed. The results were achieved through the spatial pattern analysis using the average nearest neighbour and spatial autocorrelation tools for coastal vegetation distribution. The spatial pattern maps were completed for soil indices such as Normalised Difference Salinity Index (NDSI), Salinity Index 1(SI), Salinity Index 2 (SI2), Salinity Index 3 (SI3), Salinity Index 10 (SI10), Salinity Index 12 (SI12). The above-mentioned objectives were computed and achieved on ArcGIS 10.5 software.

I attended the following workshops in 2019: SAIAB Literature Review Workshop, 5th Atmospheric Remote Sensing Education and Training workshop; and I was a delegate to the SA GeoTech 2019.

ACEP Phuhlisa Masters Project Overviews

Movement behaviour and reproductive biology of adult spotted grunter *Pomadasys commersonnii* in the Breede Estuary

Student (Degree): Bantony Ziko (MSc, UFH) Supervisor: Prof. PD Cowley (SAIAB)

The project aimed to assess the influence of the reproductive behaviour of the spotted grunter on its movements in the Breede Estuary and adjacent habitats. The spotted grunter is an overexploited estuary-dependant fishery species which has been recorded as a top spawner in KwaZulu-Natal but not in the Eastern or Western Cape.

For this project, seven adult spotted grunter fish were captured in the Breede Estuary and equipped with long-life acoustic transmitters to monitor their movements in the estuary and adjacent habitats. Acoustic receivers were placed in the Breede Estuary, the adjacent marine habitat, and selected estuaries and offshore habitats along the South African coast. Gonad specimens from adult fish captured in the Breede Estuary were analysed for their maturation cycle using histology and the gonadosomatic index. The information obtained from this study will help in understanding the ecology of the spotted grunter; information which will be useful in management and conservation of this overexploited fishery species. Both movement data (November 2016 to March 2020) and gonad maturation cycles (August 2018 to July 2019) were analysed. The results have shown that the spotted grunter is mostly resident in the estuary and makes short-timed movements to the sea, mostly during summer. This pattern is similar to spotted grunter tagged in the other two estuaries: Goukou (Western Cape) and Sundays (Eastern Cape). The summer period also coincided with the timing for spawning, possibly initiated by a rise in water temperature. The results indicate the importance of estuaries for adult spotted grunter; protecting them will help to conserve this overexploited species. Information about its reproductive behaviour helps in understanding its life history and, where possible, in advising fisheries managers to implement seasonal bans in summer when the species is at its spawning peak. Part of the results of this project were presented virtually at a postgraduate conference at the University of Fort Hare in November 2020. The project is in the final stages of writing up and the intention is to submit before the deadline set by the University (28 February).

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

Student (Degree): Carlin Landsberg (MSc, UWC) Supervisor: 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) as a food source for marine organisms. KDD, along with phytoplankton, form a soup of particulate organic matter (POM) making up the main nutrient source in these systems. Although filter feeders make up most of the faunal biomass in kelp forests that use this POM as an energy source, knowledge about 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). Throughout the upwelling cycle, nutrient levels fluctuate. We thus aim to determine how zooplankton communities change in the upwelling cycle. The results 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 both inside and outside the kelp forests at Kommetjie during upwelling and downwelling cycles. We will then 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 has kelp forests. 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 the knock-on effects on commercial fish species could have socio-economic implications.

In 2020, two of the proposed six field sampling days were completed under upwelling conditions. From these collected samples, total suspended solids (TSS) have been determined and zooplankton has been counted and superficially identified. Results so far have shown that TSS is higher inside the kelp beds than in samples taken outside the kelp beds. Additionally, species richness appears to be lower in samples taken outside the kelp beds than those taken inside the kelp beds. However, species abundance appears to be significantly higher in samples taken outside the kelp beds compared to those taken inside the kelp beds. These are preliminary observations and may be subject to change once all samples are collected and analysed.

Habitat effects on the size, structure and nutritional value of *Ecklonia radiata* and associated sea urchins

Student (Degree): Culumanco Sibotoboto (MSc, WSU) Supervisor: Dr TS Dlaza (WSU), Mr HD Kali (WSU)

Kelp species are large brown macroalgae which form extensive forests or beds and are broadly grouped into three morphological guilds, namely: canopy kelps, stipade kelps, and prostrate kelps. The *Ecklonia* genus falls within the stipade morphological guilds and reaches a maximum height of approximately 2 m. Apart from providing habitat, food, and nursery areas for a number of species, kelp species influence the structure of understory invertebrate and macro-algal assemblages through alteration of light and water motion. They also have a diverse range of uses to humans as a source of food, animal feed, fertilizers, as a source of gels, and in medicine. Their variable protein content also makes studying them of vital importance.

The aim of this study was to investigate the influence of biogeography and habitat differences on the size, structure and nutritional value of *E. radiata* and its associated sea urchins. This aim was achieved by collecting *E. radiata* species and their associated sea urchin species across six different sites (Hluleka, Dwesa, Nqabara, Qolorha, Gonubie and Kayser's Beach) at two different habitats from each site (rock pools and gullies). The collected kelp species were measured for specific morphological properties on site in order to compare how the morphology differed across site and habitat. Certain parts of the thallus were collected from each site, per habitat, and oven dried before milling into powder for nutritional analyses. The sea urchin species were dried and ground for nutritional analyses as well.

Site visitation and field work for this research was completed in 2019, including all lab work for the morphological chapter. In 2020, the main aim was to perform statistical analysis for the data obtained; to take the collected samples that had been ground for nutritional analysis, and complete the rest of the thesis by developing a general discussion and conclusion based on all the chapters. Because the methodology for the morphological analysis chapter had been completed, statistical analysis was performed for this data and general results were obtained, leaving very little polishing left for that chapter to be completed. It was extremely unfortunate that the unforeseen circumstances of the pandemic created much delay with regard to the progress of this research. The closure of the country indirectly signified the closure of part of this research because it occurred just when I was in the process of making requisitions to take my samples for nutritional analysis. It was unfortunate that the year ended with those requisitions still unfinished owing to the necessary processes and background checks required by my sponsor before a lab could be approved. Most of my research is still hanging as the rest of the thesis depends on the nutritional analysis results.

In terms of morphology, the stipe diameter, stipe weight, stipe length, primary blade length, primary blade thickness, secondary blade width, secondary blade thickness and primary blade weight were higher in gullies than in rock pools. By contrast, more primary blade twists and wider primary blades were recorded in pools than in gullies. There was no significant difference between the secondary blade thickness and primary blade thickness across the habitats. It was concluded that latitudinal gradient was more important than habitat difference when it came to its contribution to the differences in the morphology of these species.

As previously mentioned, the pandemic meant that many of the 'normal' plans and activities had to be changed and, in some instances, completely cancelled, attendance at workshops and conferences being one of them. At the beginning of the year, I planned to attend several workshops and conferences but

was unable to do so. Many conferences were cancelled altogether, others were moved to an online platform, but this required internet connectivity which was not always available owing to financial constraints. The only scientific activity that I was able to participate in was the Famelab science talk.

My study focuses on two properties: morphology and nutrition. In terms of morphology, I have completed all the field research that is needed, completed statistical analysis and obtained general results from which discussions have evolved and conclusions been drawn. The samples that were collected during the field trips have been dried and ground for analysis of their nutritional content. The dried samples need to be taken to a laboratory that specialises in the analysis of the nutritional properties of interest, that is, the carbon, nitrogen and phosphorus concentrations, as well as the protein content in order to make comparisons between the sites and the habitats, and detect the patterns that arise with changes in geographical gradient and habitat. A funded field trip where I could analyse these samples in a laboratory that specialises in analysis of the nutritional properties would be vital to this work because it is the main obstacle blocking the progress of this research.

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

Student (Degree): Dhiren Vanmari (MSc, UWC) Supervisors: Prof. GW Maneveldt (UWC), Dr M Cyrus (DEFF)

This study aimed to investigate the potential for producing high quality protein-rich *Ulva* (sea lettuce) and explore the effects of nutrient fertilisation from eutrophic to oligotrophic conditions in an outdoor tank cultivation system. The research 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.

Four independent cultivation experiments were conducted, testing the effects of stocking densities, volume exchange rates, fertilisation concentrations and methods of nutrient administration on the growth, uptake rates, pigmentation, and nutritional quality (micro and macro nutrient content, including protein, ash, energy, and carbohydrates) of *Ulva* sp. under aquaculture conditions.

Two independent preliminary experiments were performed to determine the optimal stocking density and volume exchange rate for the particular cultivation system. Results indicated an optimal stocking density of 100 g of FW *Ulva* per tank and a volume exchange rate of 30 volume exchanges per day based on yield. *Ulva* grown at higher stocking densities and high-volume exchange rates were darker and greener than *Ulva* grown at lower stocking densities and lower volume exchange rates. *Ulva* cultivated at higher volume exchange rates also yielded greater protein content than *Ulva* grown at lower volume exchange rates. Using the optimal stocking density of 100 g FW *Ulva* and volume exchange rate of 30 volume exchanges per day, a pulse fertilisation experiment was set up for two weeks (administering various fertiliser concentrations in single doses over a period of 24 hours on the first and fifth day of the experiment) to test the influence of fertilisation treatments on the growth/yield, pigmentation and nutritional quality of *Ulva*. Results showed no differences in growth/yield and micro nutrient content among fertilisation treatments. However, *Ulva* cultivated at 200% fertilisation had 10% more protein than unfertilised *Ulva* (0% fertilisation - control treatment). *Ulva* cultivated at higher fertilisation treatments were also significantly darker and greener than *Ulva* from unfertilised treatments.

Additionally, a comparative fertilisation experiment was conducted, testing the influence of pulse fertilisation (administering 50% and 100% fertiliser over a 24-hour period) vs. drip fertilisation (administering 50% and 100% fertiliser in smaller doses over a 5-day period) on growth, pigmentation and nutritional quality of the *Ulva*. Results showed no differences in growth and pigmentation between drip treatments and pulse-fed treatments. The findings of the fertilisation experiment were presented at the Phycological Society of Southern Africa Congress, Port Elizabeth, January 2020 and the poster presentation won the award for best student poster.

Food resources available to the Cape stumpnose (*Rhabdosargus holubi*) in seagrass beds of the predominantly open Swartkops Estuary

Student (Degree): Kylen Brown (MSc, UWC) Supervisor: Dr A Rajkaran (UWC), Dr L Human (SAEON), Dr G Rishworth (SAEON)

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 increases 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 will be investigated by examining 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*. The project also highlights the connectivity of shallow-water habitats which is essential for maintaining healthy fish communities. Coastal marine fish are capable of utilising multiple habitats during different life stages and are, therefore, influenced by the structure and complexity of the seascape as a whole. Fish connect habitats through daily movement, larval dispersal and ontogenetic migrations.
I completed sampling during summer (24–28 February 2020) at Swartkops Estuary in Port Elizabeth. I practised different digestion methods in order to prepare the epiphytic diatom samples for microscopy. I prepared diatom microscope slides for samples collected during winter and spring 2019 and started analysing these slides under a microscope in order to measure the abundance and diversity of diatom species. The slides were analysed using a Zeiss Axioplan microscope at 1000x magnification. So far we have counted 15 diatom species across all sampling seasons. Dominant species include *Mastogloia fimbriata*, *Cocconeis britannica*, *Nitzschia dissipata* and *Tabularia* sp., and rare species include *Placoneis* sp. and *Cyclotella* sp. I started the process of sorting faunal samples into different taxonomic groups, from being stored in formalin and estuarine water to being stored in ethanol, so that the abundance and diversity of these samples can be analysed at a later stage. Epiphyte chlorophyll *a* data were analysed for the first data chapter.

Spatial distribution and species association modelling along the intertidal rocky shores of the Wild Coast

Student (Degree): Lihle Majiyezi (MSc, WSU) Supervisor: Dr TS Dlaza (SAIAB)

The intertidal rocky shores are biologically rich environments with heterogeneous habitats that support a variety of organisms. These 'natural laboratories' are useful for studying intertidal ecology and other biological processes since spatial distribution is influenced by both physical and biological factors. Spatial distribution in rocky shores therefore looks at the arrangement of organisms in terms of their physical locations, where they occur, and how they relate to each other.
Some of the most challenging work in ecology is represented by the prediction of species and habitat distribution through numerical models. These static species distribution models are probabilistic and demonstrate the relationships between species distributions and habitats, together with the environmental variables that influence such relations. Because time is a determining factor to many activities and science keeps changing as the environment and ecology changes, there is a constant need for new knowledge. This project is important because, through the use of these models, it will provide new scientific knowledge, determine how the future will be impacted and, therefore, assist in finding relevant

conservation strategies as one of the steps to effective management of coastal and marine resources. It will also predict the influence that climate change has on these resources.
This project aimed to model spatial distribution and species association along the intertidal rocky shores through 1) collecting binary (presence/absence) and ordinal data for modelling; 2) comparing epilithic and epibiotic biota models, and 3) modelling linkages between habitats and attached biota in six different sites during low spring tide. At each site, line transects were laid 10 m apart perpendicular to the shoreline from low to high shore level. A square quadrat of 0.5 x 0.5 m^2 was then placed randomly alongside the starting point of each transect at low shore level. At one-metre intervals, the quadrat was flipped forward, and then to the opposite side of the transect depending on the side of the previous point. This systematic side-to-side flipping of quadrats was done from the low shore level to high up on the shore at the end of each line transect. GPS coordinates were recorded for each quadrat. Within each quadrat epibiotic and epilithic flora and fauna were identified, physically quantified and their abundance was expressed as invertebrate density and percentage cover, concurrently.
The habitats in which the flora and fauna were found were also described, for example, whether in outcrops or rock pools. The collected raw data set consisting of recorded observations will then be statistically analysed using computer software (ArcGIS, MaxEnt and R-studio).
A total number of three field trips were made in 2019: Dwesa-Cwebe MPA (29 August–01 September), Hluleka Nature Reserve (10–15 September) and Dwesa-Cwebe MPA (23–28 November). The purpose of the field trips was to collect raw data for the project to be statistically analysed using ArcGIS, MaxEnt and R-studio. Spatial distribution and species association modelling along the intertidal rocky shores of the Wild Coast requires physical data collection of recorded observations only, rather than collected samples.
During the last trip of 2019 to Dwesa-Cwebe MPA, data were collected at Nqabara and Human's Rock. However, because the GPS device failed, there was insufficient data from Dwesa-Cwebe MPA. Another field trip was scheduled for early 2020, but had to be cancelled because we were unable to access a GPS device. T
he final attempt later in 2020 to collect data was cancelled owing to the COVID-19 pandemic. All field trips and conferences were cancelled in 2020 owing to COVID-19. There are currently no interesting results available from this project as the process of data cleaning and analysis is still ongoing.

Mangrove habitats as nursery grounds for fish species in the Mlalazi Estuary (KwaZulu-Natal)

Student (Degree): Lindelani Simo Mkhombo (MSc, UniZul) Supervisor: Prof. L Vivier (UniZulu)

Mangroves are predominantly intertidal habitats that occur worldwide in the tropics and subtropics along shallow and sheltered coastlines; they contain a diverse and abundant assemblage of fish species. The fish species that utilise the mangrove habitats make wide use of the availability of the food resources found in the surrounding environment.
In various parts of the world, mangroves are considered to be the most important nursery grounds for a wide range of fish species. Mangrove coverage has declined in many coastal areas throughout the world due to pollution and coastal developments, as well as from indirect impact such as changes in inland freshwater management.
In South Africa, many coastal studies involving estuaries and fish community have been mostly done in the western region of the country, but relatively few in the eastern region, and little at all has been done on fish utilisation in the Mlalazi Estuary mangroves. No studies have been done in the Mlalazi Estuary regarding the nursery importance of mangrove habitats for fish species.
This study aims to determine the composition of the fish community inhabiting mangrove canals in the Mlalazi Estuary and to evaluate the importance of these areas as nursery grounds for the fish species.
The proposed research planned at the beginning of 2020 had to be cancelled because of the COVID-19 pandemic.
Poor network coverage at home made it impossible to continue with my research. Nevertheless, my research proposal is up to date, but I was not able to finish in time to present my work to the faculty board for ethical clearance. Without ethical clearance I cannot start the data collection.

Characterisation of exposure and biological effects of contaminants of emerging concerns in Thukela and Mhlathuze River systems

Student (Degree): Lungelo Rejoice Nsibande (MSc, UniZulu) Supervisor: Dr N Masikane, Mr HMM Mzimela, Dr M Thwala

The Thukela and Mhlathuze regions in northern KZN are significant economic resources as they support important industrial and agricultural activities, as well as a rising number of human settlements which are expected to continue to rise as Provincial authorities have earmarked industrial growth in these regions. As a result, anthropogenic pollution, including sewage-derived pollution, will probably increase and affect the health of the Thukela and Mhlathuze river catchments. Hence, the region presents an ideal case study to examine the extent of pollution in the water of these two rivers.
The project examines the extent of pollution or contamination by contaminants of emerging concern (CECs) in the Thukela and Mhlathuze river-estuary systems, specifically in the lower reaches.
This will be investigated by screening for the presence of and quantifying selected CECs, such as microplastics, pharmaceuticals, pesticides, and engineered nanomaterials (ENMs) in water samples from the Thukela and Mhlathuze rivers, using the source-to-sea approach. Testing the potential bioaccumulation effects of pharmaceuticals, pesticides and ENMs (silver nanoparticles and titanium dioxide) using crabs as the bioindicator organism will also be carried out.
Preliminary investigations have detected 70 compounds of organics including nevirapine, acetaminophen, carbamazepine, atrazine and testosterone in the study area. These compounds are known for their endocrine-disruptive activities. Analyses of microplastics in water samples collected in August 2019, February 2020, October 2020 revealed about 193, 306, 157 microplastics particles per litre in the Mhlathuze River, and 193, 192, 203 microplastic particles per litre in the Thukela river, respectively.
The microplastic particles detected comprised different types of microplastics: films, fibres of different colours. Fibres were the dominant type in all samples.
The results will be used to publish two peer-reviewed papers in two different reputable journals, provisionally titled: "Prioritisation of contaminants of emerging concern in Mhlathuze-Thukela river-estuary systems", and "Exposure assessment of contaminants of emerging concern in the Mhlathuze and Thukela catchments, Kwazulu-Natal (KZN)". The results of this data will be presented at both international and local conferences.
Water samples were collected in August 2019, February 2020 and October 2020 from the Thukela and Mhlathuze river-estuary systems and analysed for compounds present, and for microplastics. Compounds that were present were grouped according to their classes, for example, pharmaceuticals and pesticides.
Crab samples were collected in November 2020 and the organisms were dried and digested for analyses of metals. A poster presentation was given at the 2nd Africa conference on the health effects on EDCs, 2019.
There have been no publications to date. Graduation is expected to be in 2022.

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

Student (Degree): Nicole Okkers MSc UWC Supervisors: Prof. GW Maneveldt (UWC), Prof. DR Beukes (UWC), Dr B Macey (DEFF)

The aquaculture industry is an important part of the Ocean's Economy. Aquaculture, notably integrated multi-trophic aquaculture (fish, seaweeds and invertebrates) has the potential to contribute significantly towards several key national priorities. Such priorities include rural development, 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 local and international growth of the South African 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 US$6 billion 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. As a consequence of re-circulation procedures on aquaculture farms, disease outbreaks are common. Such outbreaks are caused by microbial pathogens, and often result in expensive and devastating consequences to aquaculture.

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 activities. Importantly, *Ulva* natural products have exhibited resistance against pathogenic infection.

The aim of this study was to determine if *U. rigida* extracts, grown in integrated systems, produce antimicrobial activity. An additional aim was 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. 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.

I presented my Honours project findings at the 32nd Congress of the Phycological Society of Southern Africa (PSSA) in January 2020 (12–16 Jan 2020). My Honours project acted as a preliminary investigation, the results of which form the basis for my Master's 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 Master's project, I repeated the disk diffusion tests and added a fourth extract, dichloromethane-methanol, in order to support my initial findings. Additionally, the nuclear magnetic resonance (NMR) analyses of the extracts that displayed activity with the disk diffusion method revealed 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, but, due to COVID-19 the conference has been postponed to 2021. COVID-19, has, however, had a negative impact on my progress, causing an estimated eight-month delay in some of my project lab work, and limited wifi access during those times (most of my access was via the campus network) also limited my writing abilities.

Connectivity in intertidal rocky shore species between Marine Protected Areas and adjacent unprotected areas along the east coast of South Africa

Student (Degree): Nkwelo Hlumela (MSc, WSU) Supervisor: Dr T Dlaza (WSU)

The point of this study is to understand population biology and evolution in natural systems. This study will also help us understand the connectivity of marine populations; such an understanding is vital for conservation and fisheries management, particularly for the strategic design of marine systems. According to Palumbi (2003), connectivity is defined as the extent to which populations in different parts of a species range are linked by the movement of eggs, larvae or other propagules, juveniles or adults (Bauer & Hoye, 2014). Estimating connectivity depends on the extent of spatial genetic variation, and it is a key determinant of ecosystem functioning (Levin & Lubchenco, 2008).

The project aims to investigate whether there is connectivity between MPAs and adjacent non-reserves. It also aims to determine whether the size and morphology of species in the different geographical areas is different. The connectivity test will be conducted using network analysis which reveals inter-relations between genes and pathways so that data can be analysed in a defined way. Network analysis also helps in planning, designing, controlling and co-ordinating decision making when designing MPAs. The aims of network analysis indices are to characterise the overall structure of the ecosystem and assess both direct and indirect relationships between compartments. We will use GIS to track the spatial distribution of species in the different geographical areas.

The study will be published and used to increase the knowledge of students and researchers about connectivity and so fill a gap in the knowledge about connectivity, especially in the conservation and ecology fields. This study also aims to improve knowledge about MPAs which are areas intended to protect all or part of a marine ecosystem. There are now over 1300 existing MPAs and hundreds, perhaps thousands, more are in the planning stages globally (Kelleher et al. 1995). Even though MPAs have shortcomings, their implementation has become one of the most widely advocated tools for the management and conservation of coastal marine ecosystems, with the main aim of promoting biodiversity and the recovery of severely exploited species (Bruner *et al*., 2001; Claudet, 2011). Thus, MPAs act as tools

for conservation while also providing larvae and mobile adult individuals to unprotected areas (Gell & Roberts, 2003). They meet a wide range of human needs, including education, recreation, research and generation of wealth.
COVID-19 has hampered analysis of the data; collected samples should have had their DNA extracted and examined using a spectrophotometer at the SAIAB lab, but the lab was closed before analysis could be undertaken. Instead of looking at the DNA, I will be looking at the effect of the habitats, tidal zone and sites on the connection of the species on the different geographical areas.

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

Student (Degree): Ntsoaki Lesala (MSc, UFH) Supervisor: Prof. K Liu (UFH)

The aim of the project is to investigate the coastal system dynamics with respect to the most dominant environmental processes that are responsible for the current state of the coastline, and the hard and soft engineering methods that have and can be employed for shoreline protection. The research will study soil and rock types along the coastline, their properties and their ability to support structures, or to be used in engineering works, and will also study geographical features and sedimentary structures along the coastline which may help understand the past events and background of the coastline.
The research proposal has been written up, presented in the Department of Geology, UFH, and been approved by the Science Faculty and Senate Higher Degrees Committee. Data and samples have been collected and analysed for grain size, shape and mineral composition. Sedimentary structures and grain size parameters were used for hydrodynamic analysis. Microscope studies were done to identify mineral compositions, and scanning electronic microscope (SEM) and Energy Dispersive X-Ray (EDX) were used for grain-shape, size and surface texture studies. Field and lab analyses showed 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 are yet to be made, and the work is yet to be externally examined.

The estuarine mud crab, *Neosarmatium africanum*, as a potential bio-indicator of metal contamination in the Mhlathuze Estuary.

Student (Degree): S'khumbuzo Lungisani Ndwandwe (MSc, UniZulu) Supervisor: Mrs SN Mpanza (UniZulu), Mr HMM Mzimela (UniZulu)

There has been growing concern over the rapid increase of metal contamination in the Mhlathuze Estuary. Many studies have been conducted on metal accumulation in the water and sediment, but the measurement of metals without biota as a bio-indicator is inconclusive and inadequate. The project investigates the feasibility of using the estuarine mud crab, *Neosarmatium africanum*, as a local bio-indicator of metal contamination. The proposed study intends to protect and conserve aquatic biota by evaluating metal contamination and thus alerting industries and local residents to mitigate their metal contribution. It also intends to discover an appropriate local bio-indicator to be used in the Mhlathuze catchment in order to obtain the current ecological status of the estuary. The study will examine the bioaccumulation of metals in *N. africanum* tissues, water and sediment samples collected in all seasons from the Mhlathuze Estuary. A positive relationship between metal concentration in the crab tissues and the medium will confirm that *N. africanum* is a good bio-indicator. Crabs are also exposed to different metal concentrations and salinities to access their physiological responses. The study will conclude that *N. africanum* are the appropriate bio-indicator if they show changes as the salinity increases or when they are exposed to metal. At least two papers will be published: "Seasonal variation of heavy metal concentrations in water, sediment and crab samples from Mhlathuze Estuary", and "Influence of various salinities and heavy metals on the physiology of the mud crab, *N. africanum*." It is anticipated that these papers will be published in accredited journals such as *African Journal of Aquatic Science*, *Estuarine, Coastal and Shelf Science*, *Bulletin of Environmental Contamination and Toxicology*.
The results from the study will also be presented at local conferences, and be presented to the

communities surrounding the Mhlathuze Estuary, particularly the consumers and industries. Three seasons have been sampled, only one season remains. All samples collected were analysed for metal concentration in the laboratory. The salinity tolerance test is complete and only the metal toxicity test remains. By June 2021, I will begin writing up, to submit by December 2021. There are no publications yet, but they will be available as soon as the thesis has been submitted and approved. The proposed graduation date is May 2022. I attended a Literature Review workshop at SAIAB, presented the research proposal to the faculty board, and attended 2019 SEAmester IV.

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

Student (Degree): Sbusiso Mkhabela (MSc, UniZulu) Supervisor: Mr HMM Mzimela (UniZulu)

The KwaZulu-Natal (KZN) province is the second most highly populated province in South Africa, and during summer, this province receives an increased number of beachgoers. This result in an increase plastic litter on the coast which is carried into the ocean via currents, waves and winds. Rivers within KZN are urbanised and industrialised, and industrial and household effluent, and municipal waste are discharged directly to the catchments which feeds estuaries. Plastic particles are likely to be disposed in rivers and transported to estuaries, and microplastics have been reported in freshwater and estuarine environments. However, the use of bioindicators to assess microplastic pollution is not well studied in KwaZulu-Natal, and studies done on microplastics within the province are based on the south coast. The current study aims to classify, by type and size, the

microplastics found within selected sites (north coast) and investigate the bioaccumulation of microplastics in two bio-monitors (rock oyster and brown mussel). The objectives of the study are to: examine brown mussel, *Perna perna*, and rock oyster, *Saccostrea cucullate*, for microplastics; analyse sediment and surf-zone water samples for microplastics; compare the size and type of microplastics between water, faunal (*P. perna and S. cucullate*) and sediment samples; compare microplastic abundance between systems (i.e., Mvoti Estuary, Thukela Estuary and Mission rocks), and compare microplastic abundance between seasons, that is, the dry and wet seasons. The knowledge produced by this project will be presented at both local and provincial conferences, and also be published in accredited journals like *Estuarine, Coastal and Shelf Science*, *African Journal of Aquatic Science* and *Bulletin of Environmental Contamination and Toxicology*. The sampling for this study was not achieved in 2020 as it was not possible to get ethical clearance on account of COVID-19. Once ethical clearance has been granted, we can proceed with the field work and then the lab analysis.

The ecology of marine nematode communities along two South African west coast beaches

Student (Degree): Shandrè Jill Dreyer (MSc, UWC)

The phylum Nematoda consists of small, multi-cellular, cylindrical worms with tapered ends. Nematodes are free-living or parasitic, highly diverse and present in many environments, yet only a small sample are globally known. Information about African west coast marine nematode communities is scarce. The first extensive ecological study was undertaken in Saldanha Bay, while introductory studies were conducted

in False Bay.
Bloubergstrand and Kommetjie beaches were selected to investigate nematode communities. Both beaches are typical of the western coastal sites of the Cape Peninsula, with extensive kelp beds that border sandy beaches. This study will significantly increase our knowledge about taxonomy and ecology of the nematode communities in the shallow-water environments along the west coast.
Field sampling will follow the well-established protocols of the nematode laboratory and collections will occur seasonally during low spring tide, for both the nematodes and sediments. At each site, four stations will be identified. Sediments will be partitioned for firstly, nematode identification, and secondly, for determining sediment grain size and chemical composition.
The nematode samples will be analysed using the three-stage protocols of the nematode laboratory. Statistical analysis will be conducted using SPSS or STATISTICA and PRIMERv6. EstimateS and Curve Expert will be used to create species accumulation curves. All field work has been completed. The grain size analysis for the two selected study sites (Kommetjie and Bloubergstrand) beaches for summer and winter have been completed and the grain size data have been computed using the relevant software. The nematode extraction analysis for the two selected beaches, for summer and winter have been completed, as has the nematode extraction analysis. The chemical analysis of the sediment samples for both sites and the statistical analyses are also complete. The project write-up is currently underway. Owing to the COVID-19 pandemic, no access to the laboratory was granted. Remote consultations were scheduled in an attempt to keep the project moving forward, and a working space was designed at home to accommodate academic writing during the lockdown period. The intention was to attend the Southern African Marine Symposium (SAMSS) 2020 for a poster presentation. However, the symposium was postponed to 2022 as a result of the pandemic.

The status of polycyclic aromatic hydrocarbon (PAH) accumulation in Mhlathuze and Mlalazi estuaries and the effect on physiology of *Chiromantes eulimene*

Student (Degree): Siboniso Marvin Ntsalaza (MSc, UniZulu) Supervisor: Mrs SN Mpanza (UniZulu)

The study aims to determine the polycyclic aromatic hydrocarbon (PAH) levels in the Mhlathuze and Mlalazi estuaries and to study the physiological effects of PAHs on *Chiromantes eulimene* because there no similar projects have been conducted in the two estuarine systems chosen as the study sites for this project. In 2020 I wrote the proposal for the project but COVID-19 made it impossible to obtain ethical clearance. With the institution closed, all workshops attended were online workshops from WildOceans.

Geological and geophysical studies on the hydrocarbon resource in the Durban Basin, South Africa

Student (Degree): Sithembele Zangqa (MSc, UFH) Supervisor: Prof. K Liu (UFH)
The study of hydrocarbon resources in Durban Basin is necessary since this Basin is made up of variously aged lithological layers with different compositions. Other layers within the Durban Basin contain fossils which were buried millennia ago, and the Durban Basin contains hydrocarbon-potential reservoir rocks of the late Cretaceous with an Aptian-Albian age matured source rock. This project will investigate hydrocarbon resources by integrating geological and geophysical studies from the selected wells.
In order to achieve the aim of the project, the potential sandstone reservoirs were identified. From the selected reservoirs, the clay volume, porosity and water saturation was determined, the seismic lines/ images to produce thickness map were interpreted, and the facies and the effects of clay, water saturation, porosity and mineral compositions on the reservoir properties were identified.
The proposal for this project was presented in the Department of Geology at UFH in May 2019, and approved by the Higher Degrees Committee of the Faculty of Science and the Senate Higher Degrees Committee of UFH. The literature review was done between March and September, and based on the readings, the relevant chapter of my MSc dissertation was written up. Data collection from the Petroleum Agency of South Africa (PetroSA) at Cape Town was carried out in December 2019. Rock samples was collected from Durban Basin from the Jc-B1 well, and processed for SEM and XRD analyses. Over 300

thin sections from PetroSA were studied under petrographic microscopy to examine the mineral types, percentages and rock textures. This work was done in December 2019 and XRD, SEM, EDX and further microscope studies were completed in 2020. A paper based on the study will be published in 2021. A draft of the MSc dissertation has been written up.

Chemical analysis of selected mollusc shells for medicinal use along the Eastern Cape coast

Student (Degree): Viwe Paya (MSc, WSU) Supervisor: Dr Nakin, Prof. Oyediji (SAIAB)

The use of biological resources to derive traditional medicines provides an alternative source of medicines used to cure various skin problems in traditional societies because of the high cost, low availability and detrimental side-effects of clinically manufactured drugs. Marine biodiversity, particularly mollusc species, have become the main target because their rich source of bioactive compounds produce a number of secondary metabolites that can be useful in deriving traditional medicines.

In recent years, marine molluscs, *Perna perna*, *Scutellastra longicosta*, *Saccostrea cucullata* and a great variety of other shelled marine species had been widely used in traditional medicines and have also generated an interest in food industries. These marine invertebrates have long provided a source of traditional medicines across different societies where their administration involves direct application to the skin, or they are prepared as a concoction mixed with other additives.

This study sought to investigate the chemical composition of the mollusc species used in ethno-medicine along the Eastern Cape coast. Although such researchers as Voultsiadou (2010), De Zoysa (2012) and Ahmad *et al*/ (2017) have information on this practice, most existing literature focuses on the flesh and haemolymph of molluscs, while shell, and particularly, the traditional use of mollusc shell in ethno-medicine have received very little attention. This study seeks to close this gap as it looks at the chemical analysis of selected mollusc shells (both shell and flesh) for their medicinal potential.

The study is being conducted along the Eastern Cape Wild Coast, particularly in Port St. Johns, Hluleka and Dwesa-Cwebe. We administered standard structured questionnaires at all three sites to gauge commonly used mollusc species to derive traditional medicines. Subsequently, these species were collected, based on the responses.

This study will publish findings which will help improve people's knowledge of the cosmetic potential of mollusc shells, and it will also help in further development of pharmaceutical industries that sell shell-derived cosmetics. At the end of this study, I would like to develop my own patent or product, based on my understanding of the chemical composition and cosmetic potential.

Data have been collected from the field, particularly from all three sites including Port St. Johns, Hluleka and Dwesa, and 40 questionnaires were administered per site. Lab work followed, and samples (*Perna perna, Scutellastra longicosta* and *Saccostrea cucullata)* were prepared and sent out for cytotoxicity study at the University of Western Cape. The toxicity test assessed the effect of these mollusc extracts when used in ethno-medicine.

Results of subsequent tests suggest that the samples are non-toxic and safe for human use as medicines. The cytotoxicity abstract was submitted for presentation in Experimental Biology in United States of America and was accepted. Further lab work experiments are underway and I have received quotes for heavy metals analysis and antimicrobial study. Samples were sent out for the antimicrobial study at Vaal University of Technology and I await the permission for the heavy metals study. Interesting results achieved include that of cytotoxicity where mollusc extracts were subjected to the cytotoxicity assay using human keratinocyte (HaCaT) and human fibroblast (KMST-6) cell lines which were treated with various concentrations ranging from 0.033 to 10 µm/ml mollusc species for 24 hours, after which cell proliferation was measured by MTT assay. The concentrations that inhibit cell proliferation by 50% (IC_{50}) were calculated using Graph Pad Prism software. IC_{50} values could not be obtained for the non-cancerous KMST-6 treated cells. The data was analysed by Graph Pad Prism 5 and showed significant moderate cytotoxicity activities for samples treated with cancerous (HaCaT) cells. Since the IC_{50} values were not obtained for the non-cancerous (KMST-6), it can be deemed safe to use these mollusc species for cosmetic and other therapeutic purposes.

I will be graduating in September 2021. I have attended several workshops, including Literature Writing held in Makhanda and the 5th South African Marine Line fish Symposium. Other workshops, such as the Earth and Environmental Sciences International Virtual conference, FameLab, Virtual Paper coaching, Harvesting Session and National Student Entrepreneurship week were virtually attended.

Stable isotope analysis of selected clean and seaweed-fouled intertidal rocky shore invertebrates along the east coast South Africa

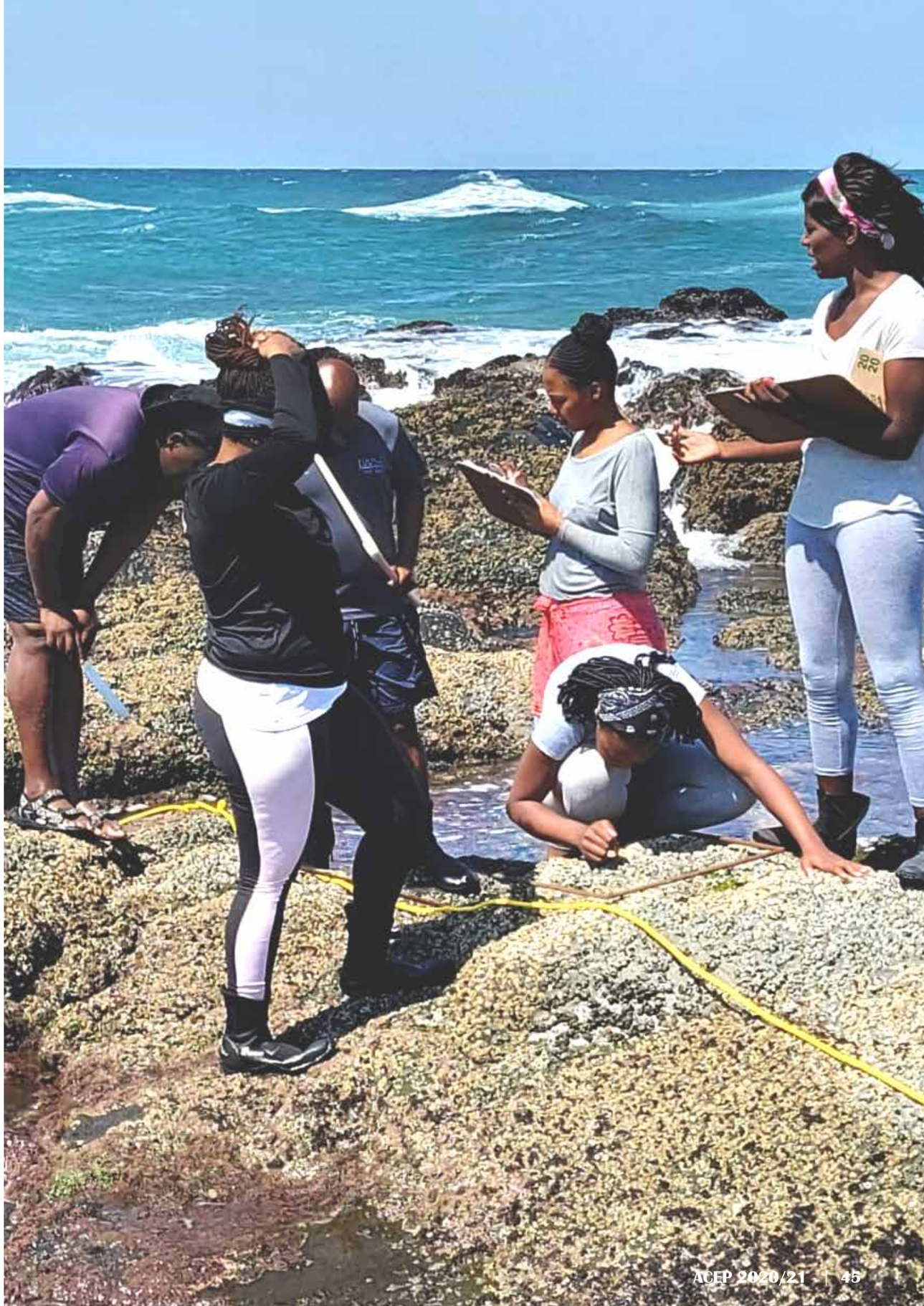
Student (Degree): Mdludlu Alizwa (MSc, WSU) Supervisor: Dr TS Dlaza (NRF)

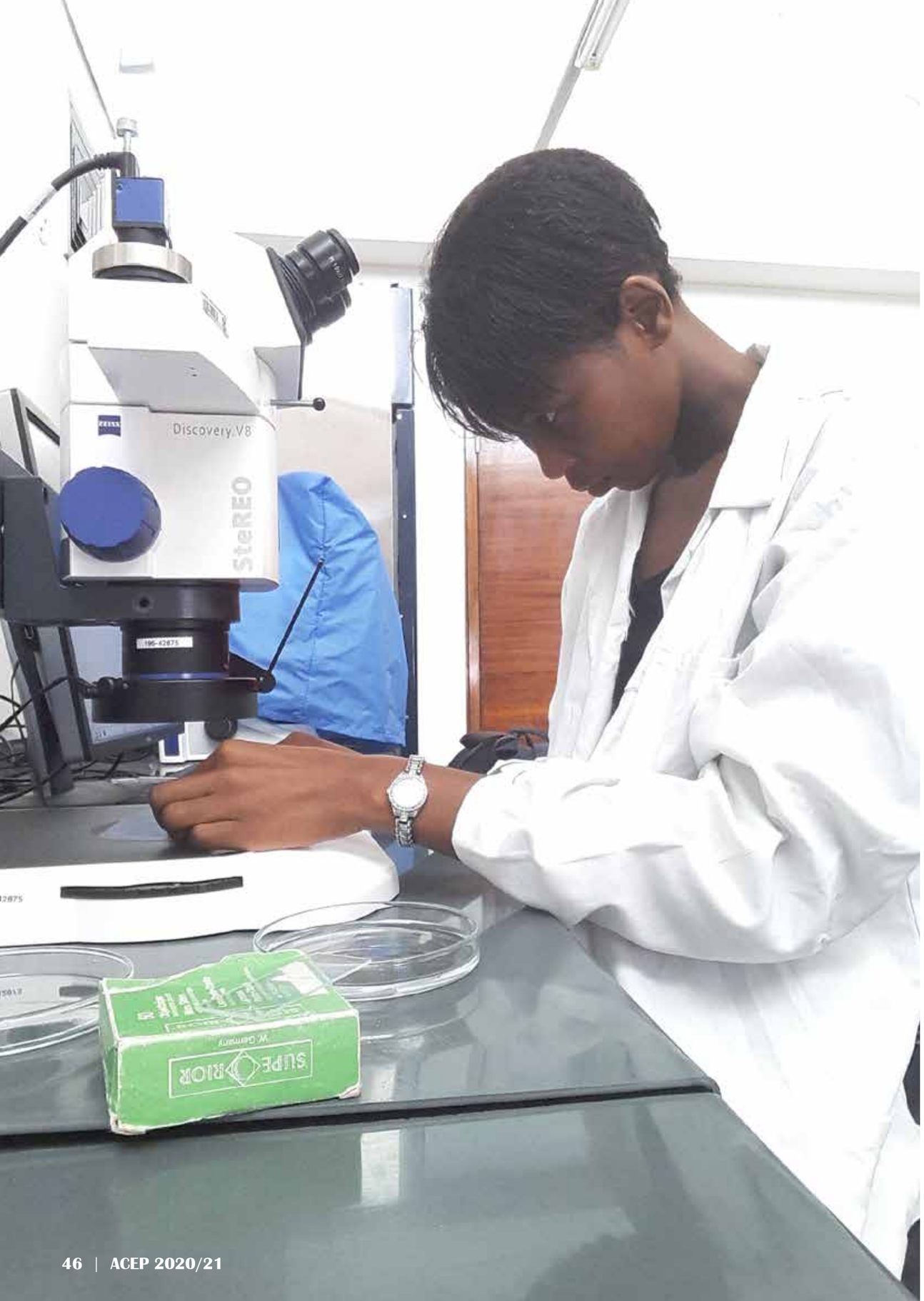
Isotopes are atoms with an equal number of protons and electrons but different number of neutrons and are, typically, referred to as ratios that are articulated in the delta notation. This, therefore, affects the atomic mass number which determines the physical properties such as boiling, density, and melting of the isotopic element, although it does not affect the nature of chemical reaction but, rather, influences the rate of reactions. The international periodic table of elements and isotopes was generated and launched in 2011 by the International Union of Pure and Applied Chemistry in order to provide knowledge about the existence and importance of isotopes of chemical elements.

Inorganic carbon, nitrogen and phosphorus are the main elements required by seaweeds for photosynthesis and growth. During photosynthesis, nitrogen is required for photosynthetic pigment generation; during growth, nitrate is required for generating proteins that are required for active/fast growth rates. 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. Furthermore, it is important to know the ration of carbon, nitrogen and phosphorus ratios of seaweeds. Carbon plays a significant role in seaweed photosynthesis and growth by being involved in generating carbohydrates. For example, some seaweeds elevate carbon dioxide concentrations internally around the active site of ribulose-1-5-bisphosphate carboxylate and use the abundant external bicarbonate as source of inorganic carbon. However, nitrogen is the element that is frequently redeemed to limit growth, although in some cases, phosphorus may be limiting. The inability of some species to use bicarbonate as an inorganic carbon source may lead to carbon limitation, as inorganic carbon in seaweeds occurs primarily as bicarbonate. As a result, carbon limiting occurs, especially among subtidal and tide-pool species. Seaweeds can take up a substantial proportion of their nitrogen from invertebrates and fish with which they are associated.

Considering the high density of *G. pristoides* along the entire Eastern Cape coastline, and the absence of studies of this species along the Wild Coast, the current study was designed to close such the knowledge gap through sampling different parts of the Wild Coast during different seasons. The full study aims to analyse the stable isotopes to acquire the degree of trophic energy transfer. Whereas oysters are used as a source of food and decoration, seaweeds can use rocks or limpets as a source of substrate and can, therefore, help in understanding trophic energy transfers in marine systems. This thesis asks: "Is there a spatial or temporal trophic relationship between seaweeds and filter-feeding organisms in intertidal rocky shores along the Wild Coast?". The hypothesis to be tested states that there is no trophic relationship between seaweeds and filter-feeding organisms, therefore, stable isotope signatures will differ between these groups along a spatial scale during different seasons. It is predicted that if seaweeds and filter-feeding organisms have a trophic relationship, then a similar isotope signature will be detected in these two groups in different geographic areas and seasons. The overall aim of this thesis is to determine the degree of trophic transfer in intertidal ecosystems in geographical regions along the Wild Coast of South Africa by stable isotope analysis of seaweeds and filter feeders. This aim will be achieved by establishing a direct trophic relationship between seaweeds and filter feeders. Comparison of isotope signatures will be conducted for seaweeds and filter feeders within and across sites during different seasons.

The summer season field sampling and collection was done at the beginning of October 2020 on five sites (Mnyameni, Silaka in Port St Johns, Coffee bay, Mthatha mouth and Qolora). By the end of October 2020, sample preparation had been done in the laboratory. To date, the interesting part up to date are the observations of the difference in rock formation, growth of vegetation and how the layout *G. pristoides* upon substitution of substrate from rock to oysters and barnacles varied among the sites. Owing to COVID-19, no conferences or workshops have been attended yet. There are been no publications because the project has not yet been completed.





Analysis of morphological diversity, genetic diversity and population density of mud prawns *Upogebia africana* in the estuaries of the Wild Coast.

Student (Degree): Monde Ndamase (MSc, WSU) Supervisor: Dr TS Dlaza (WSU)

Upogebia africana is a soft-bodied mud dweller inhabiting the benthic zone to the intertidal zone of the estuaries. It is one of the most abundant species of the family Upogebiidae. The species has ecological and economical value, but is reported to be overexploited as bait by line fisherman. This study aims to investigate the morphological and genetic diversity, and the population density of *U. africana* in the estuaries of the Wild Coast to provide an insight into how the species is able to adapt in local conditions and to understand the genetic and morphological variations across selected estuaries of the Wild Coast. The project aims to establish if there is any morphological diversity, genetic diversity or any difference in population densities of *U. africana* between the selected estuaries of the Wild Coast. Six estuaries (three temporarily closed/open and three permanently open estuaries) were selected for the research. Comparison will be made between the different reaches within the estuaries, between the intermittently closed and permanently open estuaries, and between these estuaries and the other two which are at a distance in order to investigate the geographic influence.

Samples ranging from 30 to 45 species have been collected from each of five stations at five sites; four of the stations were in the estuarine tidal zone and one was located outside the tidal zone, in the rough mud zone. We used spades to dig the mud prawns at a depth of 30 cm in a 50 x 50 cm quadrant. Coordinates were taken at each of the stations we worked on. We used 75% ethanol to preserve the species, which were subsequently examined under a dissecting microscope to investigate morphological densities. By February, when all the sites have been sampled, tissue samples will be sent to the lab for genetic analysis. Four of the estuaries have already been sampled and the analysis of morphological characteristics of the samples has been completed. Data analysis has started.

The study is critical for adding knowledge in the component of biodiversity in the Wild Coast and thus it will be important for interpreting evolutionary history and be vital for conservation of the species. From the 1980s up until the present, the former Transkei region received little scientific attention owing to the political conditions of the time, and researchers have worked hard to bridge that gap. Now that there are talks about developing the coastline, more inventory of the species is needed more than ever, because without knowledge of the current state of the species biodiversity in this region before the developments actually begin, conservation efforts have no scientific foundation.

The data analysis for the already sampled sites has started, even though we began with data visualisation to try and understand the relationship between the factors which were observed in the data table and what these relationships could tell us about the data. This analysis has allowed us to understand the relationship along the estuarine profile in order to understand the significance of habitat to morphological differences. A very important factor noted was that the temporary open/closed estuaries exhibit less density of the *U. africana* than the permanently open estuaries. So far, the results are still being analysed, and it is difficult to tell the whole story, since there are two estuaries which are yet to be sampled. I attended a workshop on academic writing by Prof. Chrissie Boughey, a university proposal presentation by a PhD candidate Nokubonga on teams, and a virtual PhD presentation by Olwethu Duna. The research is an extension of my Master's research. Currently, there are no publications.

The effect of the Pongolapoort Dam on the macroinvertebrate community of the Pongola River floodplain under high and low flow conditions; implications for coastal management

Student (Degree): Mthokozisi Z Nsele (MSc, UniZulu) Supervisor: Prof. L Vivier (SAIAB)

The Pongolapoort Dam comprises almost 50% of the total storage capacity in KwaZulu-Natal, yet there is little information in the literature on the effect of the dam on the ecological integrity of the river ecosystem, particularly on the lower Pongola River and its floodplain. Since its completion in 1973, there has been no comprehensive assessment of the effect of the dam and its associated modified flows on macroinvertebrate diversity, or on the impact on the ecology of the downstream environment; past and current pressures on the downstream environment are poorly understood.

Water abstraction, impoundment, rapid population expansion and informal settlements put ever-

increasing pressure on the lower Pongola River. There is an urgent need to assess the current ecological status of this important ecosystem and its biotic communities in relation to the impact of the Pongolapoort Dam on the downstream habitat quality and on the biotic community. Since the introduction of the new National Water Act (1998) and the Ecological Reserve, the demand for conservation and restoration of the ecological health and functioning of our rivers for the benefit of people and biodiversity has increased.
The aim of the study is to determine the effect of the Pongolapoort Dam on the macroinvertebrate community structure of the lower Pongola River and its floodplain during high and low flow conditions, using biomonitoring indices (SASS5 and MIRAI). The research output from this study will include at least two papers in accredited journals, such as *Water SA* and *African Journal of Aquatic Sciences*. Feedback on the results of the study will be provided to the DAFF, DWS and DEA as part of the required annual report for the sampling permit, to be incorporated into the national database. At this point, all the sampling, the lab work, the sorting of river data from DWS (for SASS5 and MIRAI) and the verification of the invertebrate identification (by Dr Christa Thirion, DWS) is complete. I am currently working on the last part of the results section, and writing up the discussion. I will need to re-register so that I can also apply to renew my ethics certificate from the ethics committee (UniZulu), since it has expired. I attended the SASS5 course in 2018, for which I received a certificate of accreditation issued by the DWS and the Water Research Commission. As part of the project, only SASS5-accredited practitioners may do biomonitoring using SASS5 and report on the results for publication.

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

Student (Degree): Murendeni Cedrick Mavhungu (MSc, UniZulu) Supervisor: Dr NF Masikane, Prof. Basson, Mrs Mpanza (UniZulu)

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. 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. The impact of the purified bioflocculant on *Oreochromis mossambicus* was assessed using the acute toxicity test. Assessment of the impact of the purified bioflocculant on *O. mossambicus* revealed no significant difference in the blood glucose levels between the control and test treatments. The same can be said about the level of serum cortisol. Two experiments still outstanding in this project are the cellular toxicity and daphnia acute toxicity tests, both of which require external intervention. The cellular toxicity test will be conducted at the University of KwaZulu-Natal once the COVID-19 and university protocols allow. The *Daphnia* test will be conducted once an alternative supplier for *Daphnia* has been identified. I am currently writing a publication together with the dissertation for the sections that have been completed.

Culturing local marine copepods as live foods for marine fish larvae

Student (Degree): Ngoepe Maphuti Eva (MSc, UWC) Supervisor: Dr Riaan Cedras, UWC

Live food in marine larval finfish culture has become important in aquaculture, and the culture of copepods is necessary to reduce high production costs driven by expensive imported sources of live feed. Culturing copepods provides not only nutritional value but has also been deemed an economically viable option. Copepods improve the growth and survival of larval finfish more successfully than conventional live food, such as rotifers and brine shrimp.
This project aimed to develop an Integrated Multi-trophic Aquaculture System and environment suitable for calanoid copepod as an option for live food production. The second aim of this study was to establish copepod ecology and physiological response for good growth and survival rate. 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 DEFF's Sea Point Aquarium will be used to culture copepods continuously, even after the project is complete, which means that data obtained will continue to provide insights on mass culturing of copepods in the aquaculture community and thus offer and create transformation and sustainability. Wild copepod species, *Pseudodiaoptomus hessei*, have been captured from Zandvlei estuarine in False Bay and the gravid females isolated. Protocols for hatching the eggs, isolating and growing out nauplii to adult stages are being established, as is a culture to further monitor growth and development. Copepods are cultured in the laboratory under well-maintained environmental conditions for more than 80 days of the project. More field work needs to be done before and after the multi-trophic aquaculture system is constructed to see which other calanoid species we can find. The project is still running and no conferences or workshops were attended owing to the pandemic.

ACEP Phuhlisa PhD Project Overviews

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

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

Cancer is the second leading cause of death worldwide, with breast cancer being the second most common cancer, with approximately two million new cases diagnosed worldwide in 2018. Substantial progress has been made in recent years to prevent and provide treatment options for cancer. However, the 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 extremely important substances for cancer therapy.

Of 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 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 few or no side effects

Phytochemicals (total phenols, flavonoids, flavanols tannins, terpenoids, alkaloids, proanthocyanidins, alkaloids and saponins) were screened for in the methanolic red algae extracts which have been found to be highly cytotoxic to Human Triple-Negative Mammary Carcinoma (HCC70) breast cancer cell lines used in this study. The radical scavenging activities of these extracts 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 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*, and 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). 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 will be completed during 2021. The thesis write-up will be completed by July for submission to the external examiners. No conferences/workshops were attended in 2020 due to the COVID-19 regulations. Two articles are being written up for submission by mid-year 2021.

Geological and structural analyses for groundwater resources and quality in Port Alfred area, Eastern Cape Province, South Africa

Student (Degree): Mthulisi Mpofu (PhD, UFH) Supervisor: Prof. K Liu (UFH)

One of the most pressing issues of concern in South Africa is the availability and quality of groundwater as a natural resource, critical for human and industry development. South Africa overexploits its groundwater resources at a national level. This means that, based on the best estimates of current water withdrawal and supply, national water withdrawals for municipal, industrial and agricultural sectors exceed levels of sustainable supply. One possible solution to this problem of water demand in South Africa is increasing reliance on groundwater. Groundwater is a potential source of water for many water-scarce areas where surface water is unavailable or is too costly to tap.

In the case with Port Alfred, which is located in a water-scarce region, little is known of the natural phenomena that govern several aquifers and groundwater pathways. Groundwater quantity and quality are equally important factors in the context of modern water management. Quality of water is affected by pollution from different sources, and in coastal areas, the major cause of groundwater pollution is seawater intrusion. Over-exploitation is a severe problem that affects the potability of water.

The main aim of this project is to investigate the quantity and quality of groundwater, and the pollution and salt water intrusion in Port Alfred, Eastern Cape. The main objectives are to delineate fault boundaries; target potential zones for groundwater exploration; investigate the network of fractures, their density and connectivity; determine groundwater aquifer hydraulic properties; delineate the extent of saltwater intrusion and identify where seawater mixes with freshwater zone, and assess the effects of groundwater flow with rock porosity.

Different techniques will be applied in the study area for better characterisation of saltwater intrusion and a detailed knowledge of aquifer geometry by integrating geological, geochemical and geophysical data. This research will contribute to the availability of suitable water resources in Port Alfred.

This research is an effort to achieve management and sustainable development of groundwater resources in the coastal aquifers of Ndlambe. Assessments and management of groundwater resources in the coastal areas of Ndlambe Municipality will contribute to the availability of suitable water for different economic purposes, with specific reference to improvements in the tourism sector.

The following results will be achieved by end of the research: delineation of the extent of saltwater intrusion; potential zones for potable groundwater identified; hydrogeochemical characteristics of the study area described; geological, geophysical and structural characteristics of the study area described; modification of pumping patterns to re-establish a stronger, seaward, hydraulic gradient; groundwater management plan produced.

The project proposal has been written up and presented in the Department of Geology, UFH. The project proposal was approved by Faculty and the Senate Higher Degrees Committee. The draft for Chapters 1, 2 and 3 is complete. Geological mapping and structural lineament analysis of the study area using QGIS software has been completed. I have enrolled in an online training with the Centre for Science and Environment for QGIS and water quality course as it forms part of the methodology. I presented at an International Conference on Coastal Hazards in Africa on the topic: Assessment of groundwater quality relative to saltwater intrusion in Ndlambe Municipality, Eastern Cape, South Africa. I also participated in the Blue Economy course hosted by the University of Seychelles to enhance my methodology skills in the field of Coastal Geology. Fieldwork to collect data and samples will commence in March 2021.

Hydrocarbon resource evaluation of the eastern Outeniqua Basin, South Africa

Student (Degree): Salmina Phuti Mokoele (PhD, UFH) Supervisor: Prof. K Liu (UFH)

South Africa is on the brink of major developments in the upstream petroleum industry, and the next few years will be key in determining the country's future energy profile. The goal of this project is to evaluate the hydrocarbon potential of the eastern Outeniqua Basin (Gamtoos and Algoa) by integrating seismic, well, and geochemistry data using legacy data from Petroleum Agency SA, according to quality and availability. The data is used to evaluate characteristics of the source and reservoir rocks by using newer, effectively applied methods in the global upstream petroleum industry. These methods are: seismic

interpretation, well log analysis, core studies, petrography and geochemical interpretation. A total of 18 original wells were selected, eight pseudo-wells were created, and 42 seismic lines were selected for this study. The data were used to quantify the reservoirs and analyse the source rocks. Source rock models were generated for each well to delineate the maturity levels and burial history. Furthermore, Vitrinite, TOC and Rock Evaluation Pyrolysis cross plots and logs were generated against depth to evaluate the different stages of petroleum generation in the source rock. Reservoir quality was evaluated by using seismic facies, lithofacies and petrography. Depth, interval velocity and two-way time maps were generated from seismic data for syn-rift and transitional successions.

Due to data restrictions and project clashes in the study area, all the important set objectives could not be achieved. The originally selected methods were highly dependent on legacy data availability and quality from Petroleum Agency SA. The objectives of the research were adjusted owing to the following unforeseen circumstances: data restrictions, poor quality of data, and clashes in similar projects.

Therefore, some adjustments were implemented to improve the quality of the project by using different methods to obtain the same goals. The new adjustment plan was to select new and advanced methods to achieve the same goal, attend training courses to learn newer and advanced methods used globally to evaluated petroleum systems, extend the study area to cover the deep-water systems and the western part of the Algoa Basin, and request all the additional data needed to achieve the new objectives from Petroleum Agency of South Africa.

Everything listed above has successfully been achieved. Source rock evaluation has been completed successfully and consists of two lengthy chapters, but reservoir analysis is still in progress as a result of COVID-19 regulations and delays. The chapters required outsourcing of core samples for geochemical analysis as well as petrography and core logging at the Petroleum Agency SA. These analyses mainly depend on the collaborative institutions' COVID-19 protocols. The delays have pushed the project back by at least six months and the delayed analyses are currently underway. The three-year (for MSc) confidentiality contract signed with PASA for data acquisition has lapsed, thus two publications from my MSc project are underway.

My PhD is an extension of my MSc, therefore, I am currently negotiating more collaborative publications with PASA from my current project. Most of the conferences planned for the year 2020 were either cancelled or postponed owing to the pandemic. The following virtual training courses, webinars and conferences have been attended; AAPG webinar (13 July 2020); Women in the Energy Industry by DMRE (8 August 2020); Elsevier Geofacets & Knovel training (19 August 2020); Offshore and Onshore Basin Modelling Workshops by PASA (25 August–5 September 2020), Africa E&P Summit (16–17 September 2020) and AAPG-ACE (28 Sept-1 October 2020). I am currently registered to present virtually at the international pavilion showcase on 22 February 2021 with the following title: Petroleum prospectivity of deep-water systems offshore South Africa. The graduation date is estimated to be September 2021.

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

Student (Degree): Ziyanda Mzozo (PhD, UFH) Supervisor: Prof. N Vine (UFH)

The South African government is driving the Blue Ocean Economy to reduce poverty by creating job opportunities through the Operation Phakisa Project. An abalone stock enhancement project has the potential to rehabilitate and enhance the natural stock and secure a sustainable, long harvest which will significantly contribute to the social development, revenue, and long-term sustainability of rural communities along the coasts of South Africa.

Stock enhancement using abalone larvae has been identified as the alternative option 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. In hatcheries there is a low settlement, and early survival which varies between 2–10% per seeding. To seed abalone larvae successfully requires understanding the factors that are important in increasing settlement and early survival. The study aimed to better understand those factors which enhance settlement and early survival of *H. midae* larvae.

A first step in considering abalone hatchery management and stock enhancement is to determine the effect of temperature on the development and settlement of abalone larvae (*H. midae*). It is also important to identify hatchery-reared larvae that have been released into the sea, and to determine the optimum dose for staining the abalone larval shell while not affecting settlement and survival. I will determine the optimal chemical cue using potassium chloride for enhancement of larval settlement and metamorphosis and, finally, I will assess the short-term success of seeding abalone larvae, *H. midae* in the ocean.

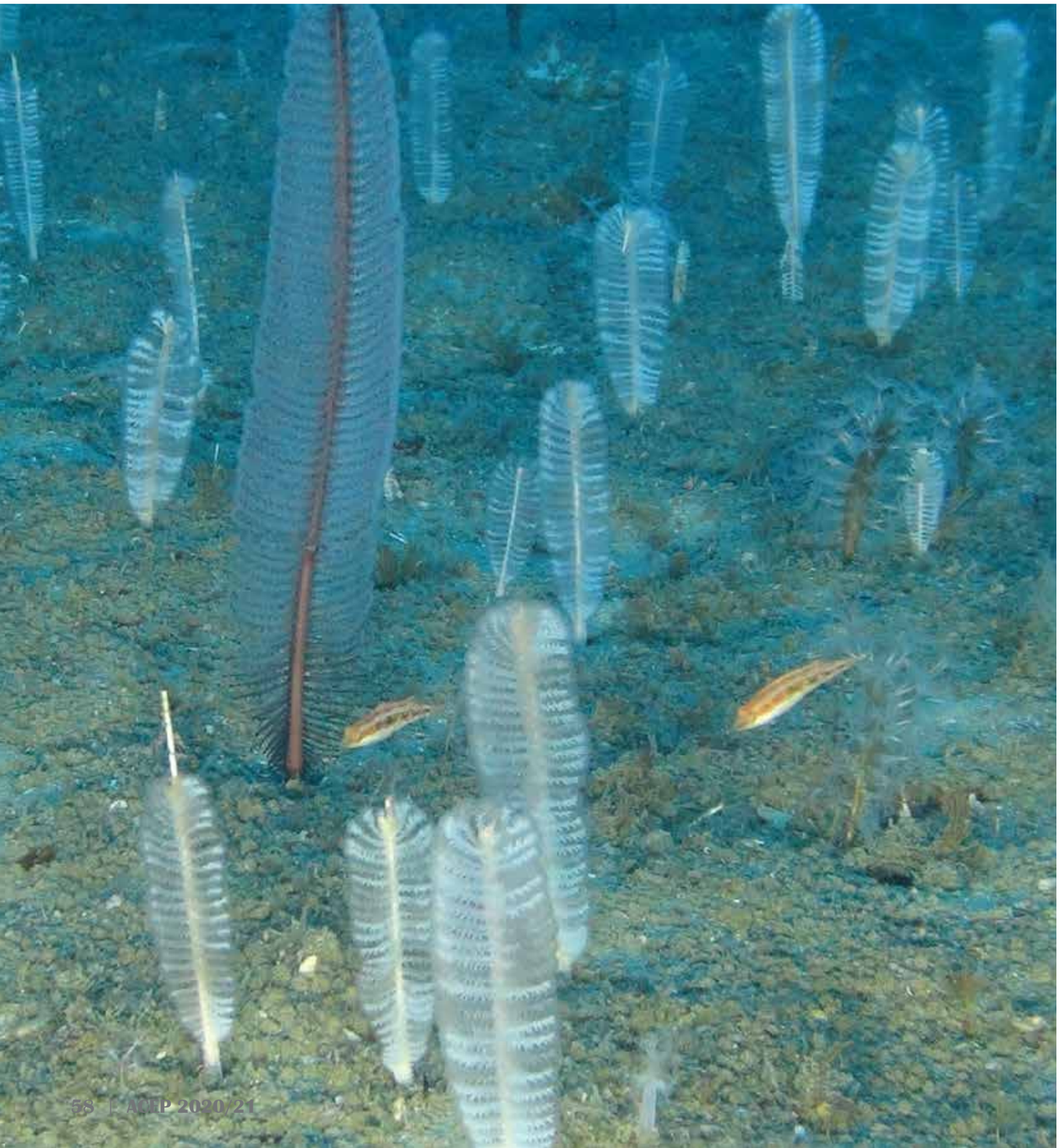
This information derived from the research will lay a foundation for potential commercial sea-seeding of the species. The information could be used in land-based farming hatcheries to enhance abalone settlement.

Interesting results achieved to date: warmer temperatures (20–22°C) increase development and settlement of *H. midae* larvae; larvae should be seeded in warmer temperatures to reduce the possibility of dispersal beyond 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 assists in field-based experiments because a brighter mark on the shell makes it easier to identify cultured *H. midae* among wild abalone. Higher settlement occurs with larvae exposed to 10 mM potassium chloride and diatom (swimming) for 24 hours.

I was accepted to present at the Aquaculture Association of South Africa (AASA) conference and the South African Marine Science Symposium (SAMSS) (postponed due to COVID-19). A manuscript on the effect of temperature on larval development is in the final stages. Thesis is due for submission at the end of 2021.

ACEP Open Call

CANYON CONNECTIONS



The ecological role of submarine canyons on the east coast of South Africa

PI: Prof. Amanda Lombard (NMU)

Co-investigators: Dr Jean Harris (WILDOCEANS), Dr Shael Harris (UNIZUL), Tamsyn Livingstone (Ezemvelo), Dr Jenny Huggett (DEFF), Dr Anthony Bernard (SAIAB), Hayley Cawthra (Council of GeoScience), Dr Thomas Borman (SAEON), Tamaryn Morris (SAWS), Matt Dicken (NSB), Ursula Scharler (UKZN), Dr Kerry Sink (SANBI)

Collaborators: Mark Gibbons (UWC), Hendrick Mzimela (UNIZUL), Nicola Carrasco (UKZN), Ryan Palmer (SAIAB)

Students (degree): Nobuhle Mpanza (Hons, UWC), Gustav Rautenbach (MSc, NMU), Shanice Ramanooj (MSc, UKZN), Njabulo Mdluli (MSc, UKZN), Mpilonhle Nyawo (MSc, RU), Hlanganani Shange (MSc, NMU), Abigail Rhode (MSc, UKZN)

The Canyons Connections project is focussed on the submarine canyons off the coast of KwaZulu-Natal, within the iSimangaliso, Protea Banks and Pondoland MPAs. Through this collaborative multi-institutional, multi-disciplinary project, the team is investigating the influence of submarine canyons on the distribution and nature of biological communities along the shelf edge, and the geological and oceanographic processes that underpin observed patterns. Knowledge of canyon biodiversity, their 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 for the presence of coelacanth in Jesser Canyon, the first (and most frequent) site where they have been observed in the iSimangaliso Wetland Park. The project also 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 will 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 by partnership with the WILDOCEANS Ocean Stewards programme.
Capacity building is integrated into all project components (field research, postgraduate student support, science outreach and conservation awareness). Through the Ocean Stewards Programme, WILDOCEANS aims to nurture a new generation of leaders that are passionate about conservation of our oceans and are qualified to pursue career paths in the fast-emerging Blue Economy in South Africa.

Progress:
In 2018 and 2019 research cruises were undertaken in the Delagoa Ecoregion within the iSimangaliso Wetland Park, generating data at a total of five canyons (Leven, Diepgat, Wright, Jesser, and Island Rock) as well as at three sites distant from canyons along the shelf edge. Fish community surveys at and between these canyons in iSimangaliso were completed in 2018 aboard *RV Honkenii* using S-BRUVS, comprising 104 individual BRUV deployments. ROV surveys of the canyon head habitats and areas between canyons was undertaken aboard *RV Angra Pequena* in 2018 and 2019, with a total of 27 dives

achieved. These benthic surveys were complemented during the cruises by deploying nets to sample for fish larvae and plankton, and by collecting oceanographic measurements to gain an understanding of the processes and dynamics at and around the canyons. A full set of biological sampling and oceanographic measurements was achieved for three canyon heads and three areas between canyons. Full sets of phytoplankton, ichthyoplankton, and zooplankton surveys were done at these sites each year, which will allow investigation of inter-annual temporal variation as well as spatial distribution and processes.
Acoustic telemetry listing stations (with VR2W acoustic receivers and temperature recorders) to monitor the use of the canyons by tagged sharks, and connectivity between them and other areas, were deployed in iSimangaliso and Protea Banks in 2018, at the canyon heads (100 m) and inshore (15 m) adjacent to the three canyon heads at each location, and these were rolled over (and data collected) every six months during the project, with final retrievals of the deep listening stations achieved in the second half of 2020.
A multi-beam bathymetric canyon survey was done in 2018 in the Pondoland MPA using the *RV Angra Pequena* as a platform. A further five-day cruise aboard *RV Angra Pequena* to conduct boomer sub-bottom profiling of canyon heads between Protea Banks and Port St Johns was scheduled for December 2020 (delayed owing to COVID-19 restrictions earlier in the year). Unfortunately, extremely bad weather over the period precluded the full survey, but a pilot survey off Durban to test and calibrate equipment was achieved and will expedite collection of this data is now planned for the for first half of 2021.
The ROV team also monitored Jesser Canyon for coelacanths and twice managed to film coelacanth at about 110 m depth in this canyon, Individual 27 (Barbara) in 2018 and Individual 26 (Eric) in 2019. These coelacanth sightings, the canyon research conducted in iSimangaliso, and the acoustic telemetry work at Protea Banks MPA, were showcased in two documentaries as part of a series called "Our Oceans" created by WILDOCEANS in collaboration with Nelson Mandela University and SAIAB, and released in 2019.
During 2020, a key focus of the project has been processing samples, data curation and analysis, and write-up of the separate components of the project as student theses. Marine science capacity building is a strong aspect of this project and is achieved by a partnership with the WILDOCEANS Ocean Stewards programme, which provides an experiential journey for marine science students. Seven Ocean Stewards have been supported to collect data during the ACEP Canyon Connections research cruises and received postgraduate bursaries linked to the project. One Honours project and two MSc studies have been completed, while four MSc studies are underway and due to be submitted in 2021. The last of these postgraduate studies commenced in 2020 and is entitled "Modelling the ecological role of submarine canyon heads on the east coast of South Africa"; it is utilising data from all the other project components and will provide a synthesis output.

2020 Outputs:
Cawthra H. 2020. "How examples from paleo-record of sea-level, climate and environment can help to inform future trends." Oral Presentation. Coastal Hazards in Africa Symposium (online).
Cawthra H. 2020. "Marine geology in a South African context." Oral Presentation. Ocean Stewards Annual Science Session (online).
Cawthra H. 2020. "How the sea and submerged continental shelf of Mpondoland assisted human occupation for the last 300,000 years." Invited lecture: Friends of the South African Museum, Iziko Museum, Cape Town.
Mdluli N. 2020. "Do submarine canyons influence zooplankton assemblages? A case study from the east coast of South Africa." Oral Presentation. Conservation Symposium (online).
Nyawo M. 2020. "The effect of ecosystem and depth on the diversity and structure of benthic fish assemblages found in Wright Canyon, South Africa." Oral Presentation. Deep-Sea Biology Society (DSBS) Conference (online).
Rautenbach G. 2020. "The role submarine canyons play on upwelling." Poster Presentation. Nansen Tutu Centre 10th Anniversary Symposium.

News article: "'Our Oceans' set to make waves." Cape Times. 10 June 2020.

Completed postgraduate projects and theses:
Nobuhle Mpanza. 2019. Macro-zooplankton communities associated with submarine canyons off the east coast of South Africa. Project for Honours Degree at University of Western Cape.
Mpilonhle Nyawo. 2020. Do submarine canyons influence the structure and diversity of benthic fish?

Canyon Connections Student Projects

Modelling the ecological role of submarine canyon heads on the east coast of South Africa

Student (Degree): Abigail Rohde (MSc, UKZN) Supervisor: Prof. Ursula Scharler (UKZN)

The complex topographic features of submarine canyons enhance phenomena such as upwelling and cross-shelf transport, thereby resulting in higher productivity, diversity, and biomass at canyons (Fernandez-Arcaya *et al.*, 2017). However, canyon heads tend to support higher biomasses and productivity than their surrounding canyon areas (Hargrave *et al.*, 2004; De Leo *et al.*, 2010). Since food webs allow for identification and analysis of the general pattern of ecosystem structure and functioning, they are an important tool for investigating the ecological interactions within a food web (Hui, 2012). Moreover, because food webs have been commonly used for spatial and temporal comparisons of ecosystems, as well as inter-ecosystem comparisons (Baird and Ulanowicz, 1993; van Oevelen *et al.*, 2011), they are used to determine the ecological role of submarine canyon heads in South Africa.

The canyons included in this study are the Wright Canyon, Diepgat Canyon and Leven Canyon (South Africa). Networks (food webs) will be constructed for each canyon head and the adjacent non-canyon area for these three canyon systems. These networks will be compared with one another to determine differences or similarities in food web structure and function.

To construct networks, information on the standing stock and energy budget of each compartment is required (i.e., who eats whom, and at what rate?). The network compartments are selected by identifying and compartmentalising major species and functional groups. Information on phytoplankton and zooplankton stocks, ROV data, and CTD data from the ACEP Canyon Connections Project sampling trips in 2018 and 2019 will be used to construct the canyon networks. Physiological parameters such as consumption, respiration and egestion will be gathered from other literature and quantified for each compartment. The biological abundance and percent cover data will be converted into carbon biomasses and flows, and together with diet information, an adjacency matrix will be constructed to show interactions between compartments.

Next, the enaR package in the R software will be used to analyse various structure and function properties of the networks. Indices such as the Average Path Length (APL), the Finn Cycling Index (FCI), Detrivory:herbivory (D:H) Ratio, Mean Trophic Level (MTL) and Ascendency will be investigated. These indices are regarded as the most relevant network indicators (Fath et al., 2019), and so they have been chosen to compare the networks of the canyon heads and non-canyon areas with one another and to determine ecological significance.

The species list, densities of zooplankton and ichthyoplankton, and chlorophyll-a and nutrient concentrations from the ACEP Canyon Connections Project sampling trips have been received. A literature database has been compiled for zooplankton and ichthyoplankton to aid conversions to biomasses and carbon flows.

No workshops or conferences were attended in 2020 owing to the COVID-19 pandemic.

Upwelling over submarine canyons: an in situ and modelling approach

Student (Degree): Gustav Rautenbach (MSc, NMU) Supervisor: Prof. J. Hermes (SAEON, NMU), Dr T. Morris (SAWS), Dr I. Halo (CPUT), Dr J. Veitch (SAEON)

This thesis aims to build on current knowledge of the oceanographic processes (i.e., upwelling) that takes place within the iSimangaliso Wetland Park. Upwelling is an important oceanographic feature that brings nutrients from the deep sea onto the surface which enhances biological productivity, may act as a buffer to coral bleaching events, and can speed up recovery of corals after coral bleaching events. The iSimangaliso region is of particular importance as it hosts South Africa's only tropical coral reef systems which contribute millions of rand to the Gross Domestic Profit (GDP) through the diving and sport fishing industry.

The upwelling events were investigated at three of the submarine canyons (Diepgat, Leadsman and Leven Canyons) located along the continental shelf of the iSimangaliso Wetland Park using Underwater

Temperature Recorders (UTR's). The UTRs were deployed at the canyon heads and within the canyons from 1 May 2018 to 30 April 2019. The temperature signal from the UTRs indicates a total of six upwelling events over the deployment period. Sea-level anomalies from satellite altimetry and wind speed and direction measurements from the Mbazwana weather station, distributed by the South African Weather Services (SAWS) show that a cyclonic eddy and upwelling favourable alongshore wind stress alone can drive the upwelling events, but the combined forcing leads to a more intense upwelling event.
An idealised numerical model was configured using the Coastal and Regional Ocean COmmunity (CROCO) modelling system to further investigate the forcing mechanisms (mesoscale eddies and alongshore wind stress) and their concurrent influence on the Mixed Layer Depth (MLD). The MLD is significant as it provides insight into phytoplankton dynamics by controlling the available light and nutrients. The model results agree with the *in situ* results that cyclonic eddies and upwelling favourable alongshore wind stress are sufficient in their ability to drive upwelling over the submarine canyon, which results in a shallower MLD. Additionally, the combined forcing of the cyclonic eddy and upwelling favourable alongshore wind stress leads to a more intense upwelling event with the greatest shoaling of the MLD. Results further show that, during the passage of an anticyclonic event, strong downwelling takes place on the leading edge of the eddy that results in the deepening of the MLD, but as the eddy passes, upwelling takes place along the trailing edge, and the MLD shoals. The model results also show that the effects of Ekman veering cannot be neglected as it definitely plays a role in driving the upwelling events over the canyons. This is important for future studies to consider when investigating upwelling within the iSimangaliso Wetland Park.
During the course of this thesis, I took part in two research aboard the *RV Angra Pequena* where numerous Conductivity, Temperature and Depth (CTD) casts were undertaken, as well as horizontal and vertical phytoplankton tows and chlorophyll and nutrient extractions. Furthermore, I configured and simulated

a multilevel embedded idealised model using the server at the Cape Peninsula University of Technology (CPUT). I attended several conferences/events: WILDOCEANS Ocean Stewards Introduction Day, WILDOCEANS Ocean Stewards Science Session, NMU Master's Students' Symposium, and the Nansen-Tutu 10th Year Anniversary Symposium, at which I presented my Master's research orally or through posters. The thesis has been submitted at NMU and graduation is expected to take place on 28 April 2021. Publications are currently being worked on.

The geological evolution of the submarine canyons on the Mpondoland Continental Shelf, South Africa

Student (Degree): Hlanganani Shange (MSc, NMU) Supervisor: Dr Hayley Cawthra (CGS, NMU), Dr Nicolas Tonnelier (NMU)

Submarine canyons are geomorphologic features characterised by deep, narrow, incised valleys, often with a complex topography, that serve as major conduits for sediment transportation from the continental shelf to the adjacent basins. Canyons are classified into shelf-indenting and slope-confined features. Often shelf-indenting canyons have an obvious connection to the adjacent river system while slope-confined features do not. Models on canyon development combine the up- and downslope processes, based on cyclic processes of canyon cut and fill as shelf edge depocentres shift and bury areas of active canyon incision. Turbidity currents become important in downslope eroding paradigms. Understanding canyon systems may elucidate cyclic processes of sea-level change and tectonic instability of the continental margin. Submarine canyons studied from geoscience perspectives are undoubtedly important in marine biology, considering canyons as benthic habitats.

Mpondoland continental shelf (MCS) is part of a narrow (~8 km) South African eastern margin that is dissected by submarine canyons from northern KwaZulu-Natal to the southern Eastern Cape. These canyons were first described by Dingle (1981), Birch (1981) and Flemming (1981); however, it was only after the discovery of the coelacanth, *Latimeria chalumnae*, that a concerted effort was made to study these canyons from a point of view of complex biological habitat and the geological context thereof (e.g., Ramsay et al, 2006; Green, 2009). The last detailed investigation in MCS was Birch's (1981) studies.
The bathymetry of MCS from digitised South African Navy Hydrographic charts presented in Fisher et al. (2020) elucidated broad features, including palaeo-coastlines and incised canyons on the shelf edge. Canyon heads on the adjacent shelf are associated with on-land faults and fluvial drainage systems. While most river mouths in the area correspond with proportional canyon heads offshore, the Mtentu canyon does not.
For this study we used multibeam bathymetric data and boomer sub-bottom profiling, in addition to legacy data, to unravel the geological evolution of MCS and understand how structures in geosciences are connected to submarine canyons which are benthic habitats and important in marine biology.
Multibeam bathymetric data for MCS acquired as part of the ACEP Canyon Connections were processed using HYPACK. Processed bathymetric data have depths ranging from ~30 m to 400 m. Deep features (>120 m) are canyon heads that dissect the shelf. Palaeo-channels are visible from the sea bed connecting river mouths and adjacent canyon heads interpreted as associated with on-land faults. Legacy data from PASA have shown that sediments from the continent deposited offshore are shaped by bottom currents to produce contourite drifts on the adjacent deep basin. Automated Harvard Centroid Moment Tensor (CMT) Catalogue solutions have shown that seismic events located on lineament structures in this region are normal faults with an orientation symmetrical about the Egosa Fault basement high. Those located south of the basement high dip south, and those located north of the basement high dip north; this is interpreted as regional extension in a north-south direction. Available body waveforms from teleseismic stations are used in this study to model earthquakes and determine source parameters using the inversion method of Abers et al. (1998). The fieldwork was done in May–June 2019 to gain an understanding of the geology of the region and, more importantly, of the coastal geology of this region.
No research has been published yet, and my MSc is still in progress.

Zooplankton assemblages associated with submarine canyons off the north-east coast of South Africa

Student (Degree): Njabulo Mdluli (MSc, UKZN) Supervisor: Dr Jenny Huggett (DEFF), Dr Shael Harris (UniZulu), Dr Nicola Carrasco (UKZN)

Several submarine canyons incise the continental shelf of the northeast coast of South Africa. These environments have been observed to have enhanced primary productivity due to canyon-induced upwelling, downwelling, and vertical mixing caused by internal tides. Food availability and habitat complexity are some of the main drivers of elevated abundance, biomass and marine taxa diversity in canyon heads compared to shelf areas. Submarine canyons are also target areas for fisheries, which can be destructive to these environments. In this study, the submarine canyons are protected within the iSimangaliso MPA and are famous as the coelacanth's home in Southern Africa.
This project aims to investigate the influence of submarine canyons on zooplankton communities by comparing abundance, biomass, biovolume and taxa diversity between the canyons and adjacent non-canyon shelf areas. Zooplankton samples were collected on the heads of three submarine canyons, namely Leven, Diepgat, and Wright. Three replicates were collected from each canyon head and adjacent shelf (non-canyon) areas using a 200 µm mesh bongo net equipped with a Hydrobios flowmeter. A CTD was also deployed at each station to collect environmental variables which will be used to explore relationships with the zooplankton assemblagesWe hypothesised that submarine canyon heads would have higher zooplankton abundance, biomass and biovolume, and host a different zooplankton community compared to adjacent shelf areas.
Processing of the 2018 samples for biovolume, biomass and abundance has been completed. For the 2019 samples, biovolume and biomass data have been collected. Counting and identification for abundance data is to be completed in 2021. Preliminary findings from 2018 CTD data indicated differences in environmental conditions between the canyons and non-canyon areas, the most evident being lower temperatures at canyon heads, suggesting that there was cold water upwelling from deeper sections of the canyon towards the shelf. Higher abundance was only at non-canyon sites due to small copepods (<1 mm) occurring in large quantities on shelf areas. There was lower zooplankton biomass in 2019 compared to 2018. In 2018, higher biomass at canyon heads than adjacent shelves was recorded at Wright and Leven, but this was not the case in 2019. In general, there was a high diversity of zooplankton, dominated by copepods with an average of 37 taxa identified. *Paracalanus spp.* and *Oncaea spp.* were some of the most numerous copepods. Preliminary results were presented at the Conservation Symposium on the 3rd November 2020.

The spatial ecology of sharks around submarine canyons on the east coast of South Africa

Student (Degree): Shanice Ramanooj (MSc, UKZN) Supervisor: Dr Matt Dicken (KZNSB), Prof. Ursula Scharler (UKZN)

Protea Banks and Sodwana Bay are both locations that support diverse marine habitats and form part of an integral network of Marine Protected Areas in South Africa (MPAs). There are approximately 100 species of shark that occur along the coastline of southern Africa, with Protea Banks being a critical habitat for these sharks. Nonetheless, minimal research has been conducted on the submarine canyons existing in this marine environment. Similarly, the canyons in Sodwana Bay, where the coelacanth, *Latimeria chalumnae* was discovered, lack in-depth research. Submarine canyons are topographic features that incise the continental shelf. They experience unique circulation patterns resulting in high productivity in these localities and a subsequent increase in food supply, and thus serve as a feeding ground for apex predators.
The aim of this study was to determine whether the submarine canyons of Protea Banks and Sodwana Bay are hotspots for five shark species known to frequent those waters. The shark species include the ragged-tooth shark (*Carcharias taurus*), tiger shark (*Galeocerdo cuvier*), bull shark (*C. leucas*), blacktip shark (*C. limbatus*) and a ray, the giant guitarfish (*Rhynchobatus djiddensis*). All five species are included on the IUCN Red List; however, there is a scarcity of information about their behaviour and movement patterns. The main aim of this study is to determine whether these shark species spend more time at the canyon than at inshore sites. Acoustic telemetry was used to investigate the movement patterns of selected sharks at six canyon and six inshore habitats at Protea Banks and Sodwana Bay. This is an investigation into the connectivity between canyons along the east coast of South Africa. A further understanding of the shark movement and behavioural patterns will aid the efficient conservation of shark species, especially if taken into consideration in the planning of new MPAs.
An existing network of sharks tagged by scientists across the country is being monitored for this project. Data collected were viewed in ArcGIS Spatial Analyst (version 10.5.1) to determine the movement and residency patterns of sharks at inshore and canyon locations. The presence or absence of sharks was visualised using GGplots in R Studio (Version 1.3.1093) after which statistical analyses were conducted using R Commander (3.5.1). Of 29 tiger sharks tagged, a total of 23 were detected.
Detections were most prevalent in 2018. Of 61 ragged-tooth sharks tagged, twelve were detected over three years (2017–2020). The canyon sites of Protea Banks were often frequented between 2017 and 2018.
Two female blacktip sharks out of the seven tagged were detected over a period of four years (2014–2018). One female frequented the canyons at Protea Banks, while the other female made fewer visits to inshore sites.
Of the 47 tagged bull sharks, 20 were detected at the canyon and inshore sites. The inshore sites of Sodwana were often frequented by these sharks. Two giant guitarfish were detected at Sodwana with one displaying preference for the canyon habitats and the other for the inshore habitats. All five species of sharks have been observed to move between inshore and canyon habitats, with a few moving between Sodwana and Protea Banks.

WILDOCEANS™
OCEAN STEWARDS

The Ocean Stewards Program

A programme of the WILDTRUST™

Through its Ocean Stewards Initiative, WILDOCEANS aims to nurture a new generation of young minds that heed the ocean's call and pursue career paths focused on marine science and conservation, contributing to the fast-emerging Blue Economy in South Africa. Students participate in various experiential learning activities, including research cruises aboard *RV Angra Pequena* and ACEP's *RV Phakisa*. They also attend Science Communication Training and an annual Science Session where they are exposed to some of the most recent research and conservation programmes underway in South Africa. The program is funded by Grindrod Bank, the Blue Fund, and receives support from the Blue Action Fund through the WILDOCEANS Oceans Alive project in iSimangaliso MPA. The Ocean Stewards program is implemented in partnership with ACEP and makes use of the SAIAB Research Platform to provide the marine science students to access to offshore research activities and equipment.

Overview of the year

A new cadre of fifteen 2020 Ocean Stewards were welcomed to the Program at a virtual online event in May 2020. The disciplines represented by the new annual intake of Ocean Stewards has been broadened from the original focus on Marine Biology, to include Environmental Science, Geography, Zoology and Social Sciences. Five Ocean Stewards were supported in their MSc studies during the year, all working on projects with data collected by the ACEP Canyon Connections project and supervised by the project's co-investigators.

During October, sixteen Ocean Stewards spent a practical day aboard the research vessel *RV Angra Pequena*, in lieu of the usual 5-day offshore cruises which were not possible this year due to the coronavirus pandemic. The day's program commenced with a presentation on the various WILDOCEANS Projects, and the multiple types of equipment used onboard the vessel during the research cruises. These included hydrophones deployed by the WhaleTime project for acoustic monitoring and Baited Remote Underwater Videos (BRUVs) and Remotely Operated Vehicle (ROV) used for the ACEP Canyon Connections project, Shark and Ray Protection project and Oceans Alive iSimangaliso project, supported by the SAIAB research Platform. The students watched underwater BRUV and ROV collected on previous research cruises, providing insights into research at sea.

Ocean Steward Engagements

The three-day Ocean Stewards Science Session was hosted online for the first time and attended by thirty-six Ocean Stewards from the 15th – 17th September 2020. This annual event is instrumental in their journey as Ocean Stewards. It exposes them to current and relevant marine science and conservation topics and passionate people working in these industries, expanding their knowledge base, enlarging their networks, and guiding their career choices. This year we focused on four main themes International Year for Biodiversity (IYB), Conservation in the Future, Marine Protected Areas, and Youth Involvement and Engagement. We had thirty-six Ocean Stewards join us for the 3-day session and thirteen presenters from the relevant industries, NGOs, and government. Hosting this event online allowed us to invite regional and international presenters all top of their fields that the Ocean Stewards would not usually have exposure to at this event. The final day focuses on exposing the students to the research and other currently available opportunities in both the science and social realms Session held online via Zoom. The annual Science Communication Training Session was also held online and was attended by the sixteen Ocean Stewards. This session is designed to build up the student's ability and confidence in science communication, and includes training in communication basics, knowing your audience, alternative forms of presenting science, and pitching your presentation accordingly.

The Ocean Stewards had the opportunity to participate in various other workshops, symposiums, and events online. These included the Conservation Symposium, the Youth for Sharks 'Spark for Sharks' events, the Legal Workshop focused on engaging with EIAs which was hosted by attorney Kirsten Youens, the Earth Echo Youth Leadership Summit hosted in the United States of America (USA), the International Marine Conservation Conference (IMCC6), the Ocean Conservation National Oceanography Centre (NOC) Solstice Massive Open Online Course (MOOC), a 2-day learning workshop focused on South Africa's shark species (a collaboration with Sharklife), and online marine biodiversity workshop hosted by Prof. George Branch. This year's Ocean Stewards were also provided with water safety and swimming skills training, to boost their confidence in entering the ocean and participating on offshore activities.

Ocean Steward Achievements

Ocean Steward Sandile Ntuli was featured by the Sustainable Seas Trust (SST) as a Young TrailBlazer, while Jamila Janna Youth for MPA's produced and directed a film "Hluleka" featured on 50/50 on SABC, Andile Nkosi attended a 2-week biomimicry immersion program in Skukuza, Kruger National Park, Natalie dos Santos and Njabulo Mdluli won the Roving Reporters Youth for Sharks writing competition (their articles published in the Daily Maverick), Katie Biggar was a 2020 NEWF Pitch Finalist, Summer Newton won the award for best poster presentation at The Conservation Symposium online, Zodumo Khowa was selected as one of four BCC Youth Ambassadors from South Africa, and Merrisa Naidoo attended the EarthEcho International Youth Network Meet-up as the official Youth for Marine Protected Areas (Y4MPAs) spokesperson.

As we advance

We look forward to welcoming a new cohort of Ocean Stewards in 2021. The Ocean Stewards Program endeavors to open doors and unlock opportunities for a Fellowship that now has over 100 members across the Western Indian Ocean region and continues to grow. This Program aims to create a network of passionate, informed, and equipped individuals that have strong decision-making, communication, and policy development skills, and take up positions in the marine science, management, and conservation sector to support a sustainable blue economy.

CAPTOR

Connectivity And disPersal beTween prOtected aReas

PI: Prof. Sean Fennessy (ORI & UKZN)

Co-investigators: Dr Marjolaine Krug (CSIR), Dr Bruce Mann (ORI & UKZN), Dr Sandi Willows-Munro (UKZN), Fiona MacKay (ORI & UKZN), Dr Dave Pearton (ORI & UKZN), Prof. Johan Groeneveld (ORI & UKZN), Dr Gavin Gouws (SAIAB), Dr Peter Teske (UJ)

Collaborators: Prof. Tommy Bornman (SAEON), Ryan Palmer (SAIAB), Sean Porter (ORI), Mike Schleyer (ORI), Bernadine Everett (ORI), Mathieu Roualt (UCT), Paul Cowley (SAIAB), Kendyl Le Roux (ORI), Skhumbuso Maduna (ORI), Thor Eriksen (SAIAB), Siseko Benya (SAIAB)

Students (degree): Samantha Ockhuis (PhD, RU), Ashrenee Naidoo (PhD, UKZN), Jessica Gilmore (MSc, UKZN), Sonia Heyes (MSc, UCT), Guy Logan (MSc, UCT)

We aim to determine whether east coast MPAs form a connected network in terms of some of their key inhabitants, and whether they contribute to biological replenishment of surrounding areas at multiple spatial scales. We do this by examining the extent of connectivity of functionally important species in reef and soft-sediment habitats in and around these MPAs, and by developing biophysical models to test connectivity. Connectivity will also be established using novel genetic methods, and planktonic and microbenthic community studies which will ground-truth the biophysical models. The outcomes will be at levels of genetic and oceanographic resolution not attempted previously in the region. In the process we are: supporting previous ACEP programme investment in marine spatial planning research on the east coast; advancing human capacity by training postdoctoral fellows, postgraduate students and interns; increasing public awareness and understanding of science, and appreciation of the uniqueness of east coast marine ecosystems.

The project clearly aims to provide information in support of SDG Goal 14 - Life Below Water (i.e., to conserve and sustainably use the oceans, seas and marine resources for sustainable development). By establishing the extent of connectivity of functionally important South African east coast fauna between MPAs and surrounding areas, our project will determine whether these MPAs perform a service beyond that of just conserving their inhabitants.

Albeit that most sampling has been completed, laboratory processing of samples for several components was compromised by the COVID-19 lockdown, hence project outputs have been delayed.

The oceanographic component identified limitations in merged sea surface temperature (SST) products for the Agulhas Current and showed relative better performance of the REMSS MW-IR SST product in representing current variability off South Africa's east coast. Outputs from a high-resolution ocean model and data from surface drifters showed little seasonal variability in the surface circulation within the Natal Bight. Other analysis shows a hitherto undescribed, coherent, north-eastward flow between the 50 m and 200 m isobaths extending from Durban to Richards Bay, with implications for connectivity between southern and northern MPAs. The model also shows an intensifying decadal trend in this north-eastward current, together with a weakening of the Agulhas Current. Moored ADCP current meters loaned by SAEON (SMCRI) and SAIAB deployed at Red Sands and Rabbit Rock in the iSimangaliso MPA were used to track inshore currents to further inform the modelling. MSc student, Sonia Heyes, is continuing with this research.

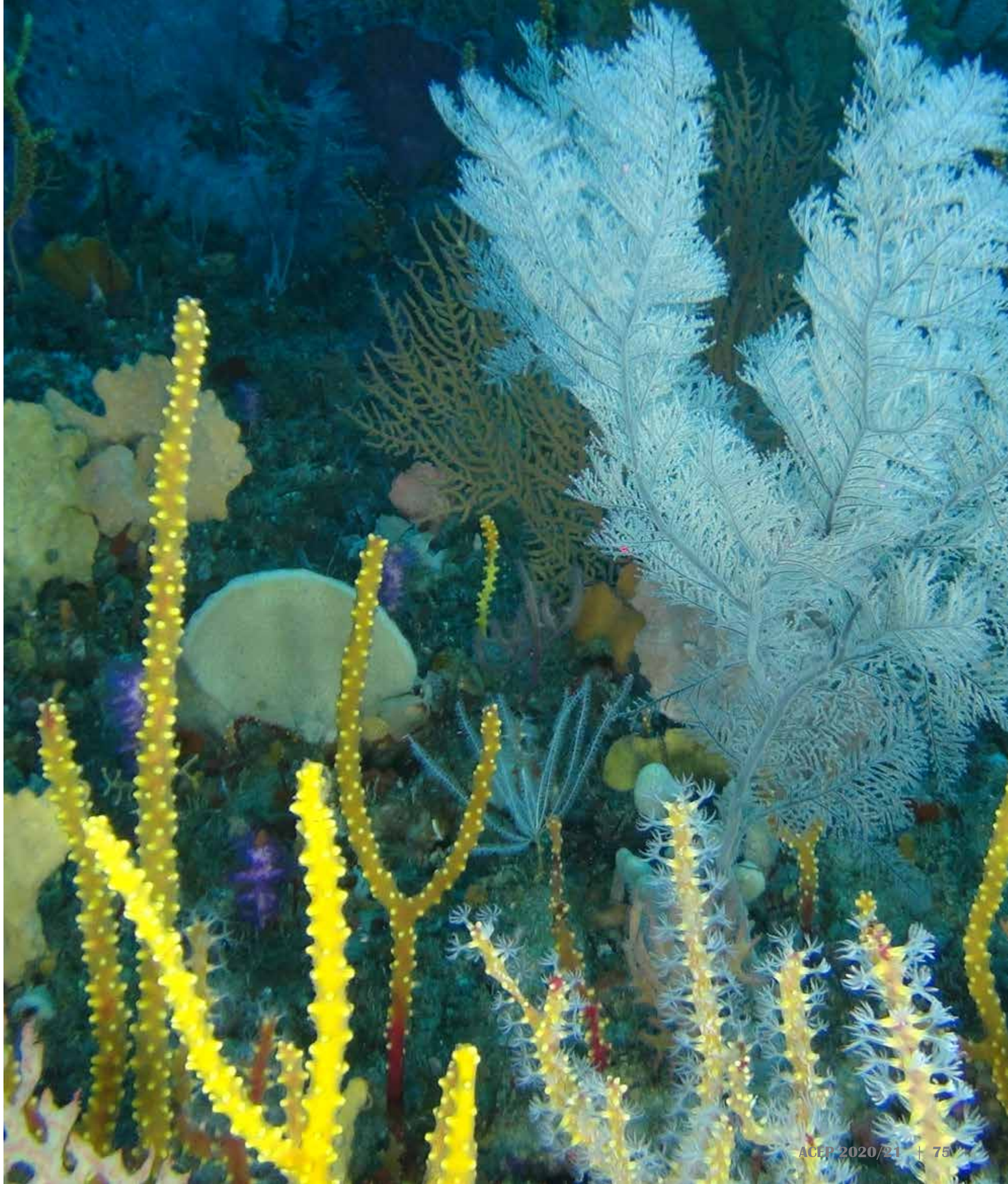
Processing and sequencing of the year-2 plankton samples (to inform inter- and intra-MPA zooplankton

comparisons) was delayed; this will now take place in 2021. Development of metabarcoding protocols for zooplankton has been completed, and two manuscripts describing the protocols have been submitted for publication in peer-reviewed journals. The PhD student, Ashrenee Govender, submitted her thesis for examination.

Provision of hard coral *Stylophora* RADSeq sequence data were delayed, and were obtained only late in 2020. Data quality was excellent with over 100 million reads, and 87% of the 149 hard coral samples covering all sites had greater than 10-fold coverage, which allows for detailed analysis of multiple loci. After passing the data through the Stacks genotype and SNP-calling pathway, almost 500,000 loci were identified with more than 61,000 variant sites. Analysis is ongoing, but there is clear differentiation between the two *Stylophora* clades previously identified and the population connectivity patterns are clear. Preliminary analysis of the populations using PCA and STRUCTURE shows clear evidence of ecological and current-driven population structure within and between MPAs along the coast. The soft coral *Sinularia* data were also obtained only late in 2020 and only preliminary analyses have been carried out, but it was determined that there are two *S. brassica* species present, with preliminary indications of structure within the IWP, though this needs to be explored further. An additional round of zooplankton sampling for the coral spawning and larval dispersal component was carried out in February 2020. Unfortunately, these samples and libraries could not be processed due to laboratory restrictions. MSc candidate Jessica Gilmore submitted her thesis at the end of 2020.

In the fish component, seven years of acoustic data have been collected from multiple receivers deployed in iSimangaliso, and MSc student Guy Logan's preliminary analyses data using basic dispersal and detection summary statistics as well as network plots indicate 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, together with greater movement within the iSimangaliso and the highest number of detecting stations. The acoustically-tagged *E. andersoni* continued to show high levels of residency in both iSimangaliso in the north and Pondoland in the south. PhD candidate Samantha Ockhuis showed that genetic diversity in *C. puniceus* lacked temporal structure in three fished sites and did not differ between 2012 and 2018, likely indicating high connectivity in this species due to high gene flow; the lack of changes also suggests that there has been little impact of fishing pressure over this period. Work to demonstrate the degree of parentage from MPAs to non-MPAs is ongoing.

For the macrobenthos, sorting existing samples for microscopy (taxonomy and enumeration) continued despite constrained access to labs, to discern the nature and abundance of communities in and between MPAs. Planned sampling within iSimangaliso could not take place. Final collection of metabarcoding samples (to complement traditional taxonomy) was undertaken early in 2020 along a depth gradient from two MPAs (iSimangaliso and uThukela), and also off Richards Bay. Various extraction techniques were trialled to best discern diversity, as an alternate to morpho taxonomy. Subsequently, whole-sediment samples were sent to Nature Metrics in the UK in late 2020 for extraction and sequencing in a collaborative venture. To support these results and to build a sorely-lacking local reference library, there has been a drive to barcode east coast macrobenthic species which will contribute to global species information (via BOLD and GENBANK) of these poorly known faunae. To expedite results and speed up information provision to CAPTOR, an ACEP-funded postdoc position at UJ has been secured.



Outputs:

Gilmore J. (Submitted). Population Connectivity of *Stylophora pistillata* and *Sinularia brassica* between Kwazulu-Natal Marine Protected Areas. MSc thesis. University of KwaZulu-Natal.

Govender A, Singh S, Groeneveld J, Pillay S, Willows-Munro S (Submitted). Marine zooplankton, mini-barcodes, and DNA metabarcoding: The case for taxon-specific primers. *Ecological Applications.*

Govender A. (Submitted). DNA metabarcoding of zooplankton enhances community-level analyses of connectivity in a marine pelagic environment. PhD thesis. University of KwaZulu-Natal.

Heyes, S. 2020. Impact of a Natal Pulse on the Surface Dispersion in the Natal Bight. Nansen-Tutu Centre 10th Anniversary Symposium, 10–12 March 2020. Cape Town, South Africa. Poster presentation.

Jing S. 2020. Evaluation of Satellite-Derived Sea Surface Temperature (SST) Using Ocean Glider Data in the Agulhas Current System. Ocean Science 2020, 16–21 February 2020. San Diego, USA. Oral presentation.

Krug M. 2020. Agulhas Current variability along South Africa's east coast. Nansen-Tutu summer school. Cape Town, 14–21 January 2020. Oral presentation.

Krug M. 2020. Agulhas Current variability along South Africa's east coast. *Ocean Science* 2020, 16–21 February 2020. San Diego, U.S.A. Oral presentation.

Kug M. 2020. Agulhas Current variability along South Africa's east coast. Nansen-Tutu Centre 10th Anniversary Symposium. 10–12 March 2020. Cape Town, South Africa.

Ockhuis S, Gouws G, Fennessy ST. 2020. A temporal comparison of genetic diversity in the slinger *Chrysoblephus puniceus* along the east coast of South Africa. South African Institute for Aquatic Biodiversity Student Symposium. NRF-SAIAB, Grahamstown, 4 December 2020. Oral presentation.

Singh S, Groeneveld J, Huggett J, Naidoo D, Cedras R and Willows-Munro S (Accepted) Rapid species identification through DNA metabarcoding of marine zooplankton in South Africa: How good is the reference library? *African Journal of Marine Science.*

Web page with regular project updates https://www.saambr.org.za/the-captor-project/; shared to Twitter and Facebook.

CAPTOR Student Projects

DNA metabarcoding of zooplankton enhances community-level analyses of connectivity in a marine pelagic environment

Student (Degree): Ashrenee Govender (PhD, UKZN) Supervisor: Dr Sandi Willows-Munro (UKZN), Prof. Johan Groeneveld (ORI & UKZN), Dr Sohana Singh (ORI)

Zooplankton are abundant and diverse marine organisms that form ecologically important communities in marine pelagic ecosystems. They are well-suited for biomonitoring of ecosystem health and changes in biodiversity because their community structure and biomass respond rapidly to environmental variation. Biomonitoring of zooplankton communities using traditional morphology-based species identification methods is labour intensive owing to their cryptic morphology, high diversity, and small body size. Fast-developing molecular techniques such as DNA metabarcoding (large-scale, high-throughput DNA sequencing of targeted gene regions to simultaneously identify multiple species present in samples) may provide higher resolution, accurate, faster, and more cost-effective biomonitoring tools.

The dispersal and connectivity among animal populations in the marine environment (a key objective of CAPTOR) relies on life history stages that drift in the zooplankton, including the larvae of crustaceans, fish, molluscs, echinoderms and sponges. The main objective of this study was to develop and test a novel DNA metabarcoding approach for biomonitoring marine zooplankton along the KwaZulu-Natal coast with which to rapidly sample and compare zooplankton at spatio-temporal scales, to monitor the effects of environmental and climate change.

The *RV Phakisa* and plankton tow nets were used to sample cross-shelf transects at three sites (uThukela, Durban and Aliwal) that differ in shelf width, seafloor substrate and benthic habitat structures. DNA extracted from bulk zooplankton were amplified using universal mini-barcode markers (COI) found in literature, together with taxon-specific mini-barcode markers designed and optimised to detect key decapod taxa such as lobsters, prawn, shrimp and crab. Community composition and connectivity network analysis was carried out to assess the clustering or dispersal of zooplankton communities associated with each transect.

All field and laboratory work for this project has been completed (2018–2019). Primers to amplify mini-barcodes for economically important zooplankton such as lobsters, crabs, shrimp and prawns have been designed, ordered, tested and published (see Govender et al., 2019). Artificially assembled zooplankton mock communities with known species composition and relative abundances were then used in an experimental setup to test detection rates and the accuracy of designed and published primers (Govender et al., in review). The DNA metabarcoding protocol was then used to assess connectivity among zooplankton communities over the narrow KwaZulu-Natal continental shelf (Govender et al. in prep). A strong benthic-pelagic coupling effect was inferred, based on the species composition of planktonic larvae and benthic adults occurring at the respective transects. I was accepted to present an oral paper at the IIOSC 2020 held in Goa (India); however, the conference was cancelled due to COVID-19. My PhD dissertation has been completed and submitted for examination.

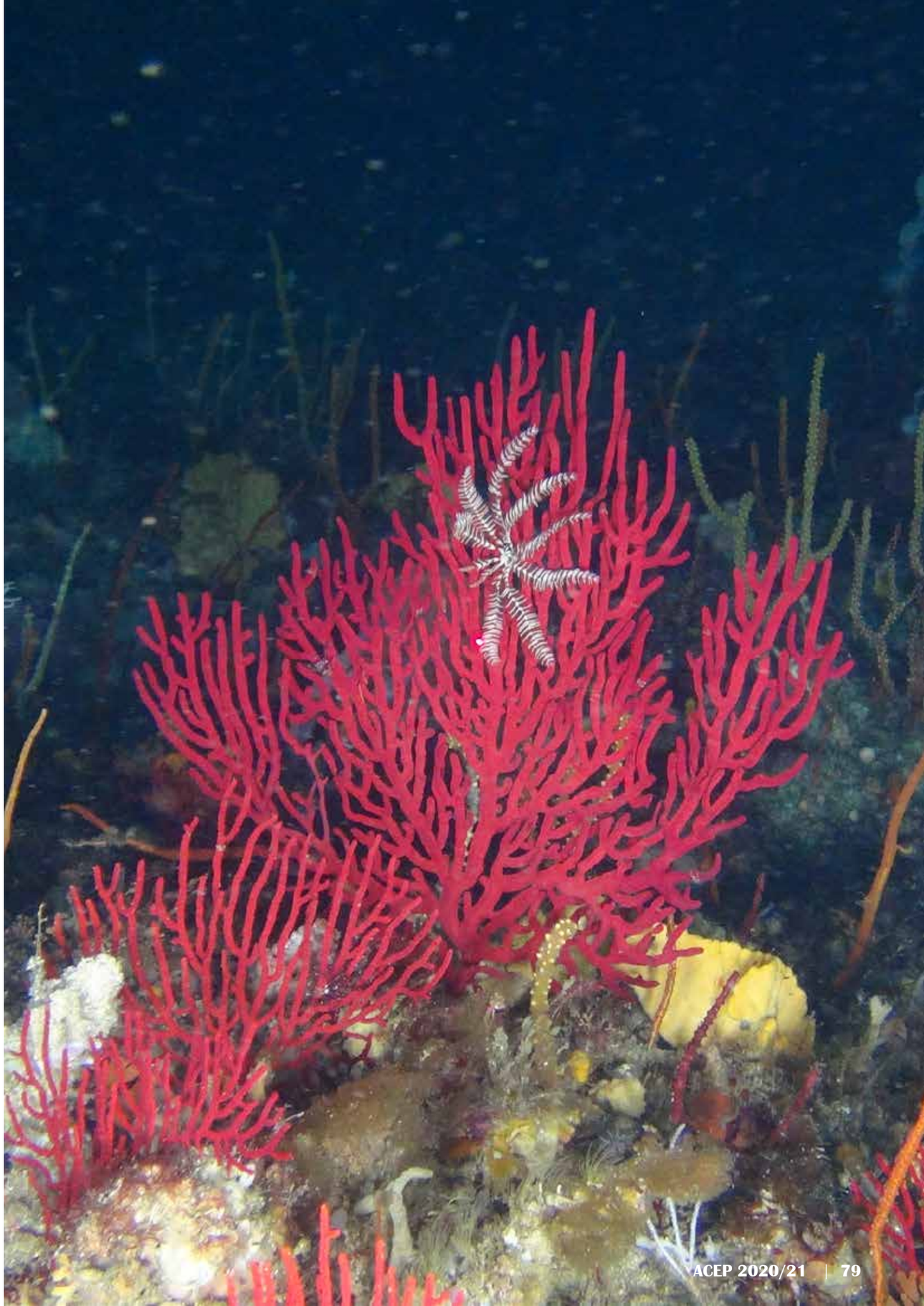
Publications:

Govender A, Groeneveld J, Singh S, Willows-Munro S. 2019. The design and testing of mini-barcode markers in marine lobsters. *PLOS One* 14(1): e0210492.

Govender A., Groeneveld J., Singh S., Pillay S. and Willows-Munro S. (In review) Marine zooplankton, mini-barcodes, and DNA metabarcoding: The case for taxon-specific primers. *Ecological Applications* (submitted in June 2020).

Govender A. (In review) DNA metabarcoding of zooplankton enhances community-level analyses of connectivity in a marine pelagic environment. PhD thesis, UKZN.

Govender A., Groeneveld J., Singh S., Pillay S. and Willows-Munro S. (In prep.) Connectivity of marine zooplankton communities in a dynamic ocean environment off eastern South Africa, inferred from DNA metabarcoding analysis.



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

Student (Degree): Guy Logan (MSc, UCT) Supervisor: 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 using acoustic telemetry: *Caranx ignobilis*, *Aprion virescens* and *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 iSimangaliso, making this study important for the effective management of these species. Using a matrix of 48 acoustic receivers (VR2Ws) from southern Mozambique to the Eastern Cape, acoustic telemetry data (detections) were 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 (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 standardised framework for categorising these species' movement patterns.

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 them 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 have 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 indicate 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 iSimangaliso and the highest number of detecting stations.

Population Connectivity of Corals in MPAs

Student (Degree): Jessica Gilmore (MSc, UKZN) Supervisor: Dr David Pearton (ORI), Dr Angus MacDonald (UKZN), Dr Gavin Gouws (SAIAB)

Marine Protected Areas (MPAs) are a critical tool for managing and protecting marine ecosystems. In the case of coral reefs, the role of MPAs includes reducing local stressors such as overfishing and pollution, and protecting source populations, in order to support resilience to larger global threats. One important criterion for MPA success is whether it provides sufficient protection for a variety of ecosystems while maintaining population connectivity. This study aimed to examine the population connectivity within and between east coast reefs (inside and outside MPAs) of two coral species, a hard coral (Scleratinia), *Stylophora pistillata*, and a soft coral (Alcyonacea), *Sinularia brassica*. These two corals are found throughout KZN waters and are prevalent on both subtidal and deeper reefs. The key aims for this project are: to understand the degree to which the two coral species are connected genetically between sampling locations; and to investigate if the level of connectivity is ecologically relevant and whether there is any evidence of environmental adaptation.

Corals were collected on SCUBA or, where necessary, by the ACEP Remote Operated Vehicle (ROV) in three MPAs (iSimangaliso Wetland Park, Aliwal Shoal and Pondoland) as well as representative reefs located in the "gaps". DNA was extracted and genetically identified using traditional markers such as COI and nuclear ITS. In addition, double-digest restriction site-associated DNA sequencing (dd-RADSeq) was performed in order to identify thousands of SNPs for population level analysis. A standard pipeline (STACKS) was used to assemble, "de-multiplex" and quality filter the data and to produce within-sample clusters, consensus base calls, and among-sample clusters. Exported data were subjected to downstream population genetic analyses. This included examination of diversity indices, differentiation among populations/localities, estimates of gene flow and migration, assignment tests and admixture analysis (for identification of sources and sinks, and reproductive contributions) in packages such as STACKS, Arlequin, GenAlEx, Adegenet in R and STRUCTURE. This research will provide an additional measure of the effectiveness of existing MPAs and further our understanding of their capacity to replenish one another, as well as their surrounding areas, and will provide data to help manage MPAs for enhanced resilience.

Traditional markers (COI and ITS) demonstrated that two non-mixing clades/species of *S. pistillata* found in South Africa are not reliably distinguishable on the basis of morphology. Different distribution shows clade 3 restricted to the tropical Delagoa bioregion within iSimangaliso, while clade 2 is found in both Delagoa and Natal bioregions all the way to Pondoland. Population genetics approaches further showed that there is a complex population structure of clade 2, potentially driven by a combination of currents, ecological selection and distance. A subset of *Stylophora* clade 2 samples was analysed using a RADSeq approach which clarified the structure suggested by traditional markers, and clearly identified three distinct populations across four reefs (Leadsman Shoal, Blood Reef, Aliwal Shoal and Aliwal Deep) spanning the Delagoa/Natal biogeographic break. These populations did not appear to be structured solely by geographic distance, with one population comprising samples from two sites (Blood Reef and Aliwal Deep) that were non-adjacent and at different depths (12–18 m vs >30 m), while a geographically adjacent population (Aliwal Shallow) at 12–18 m constituted a distinct population. This suggests that ecological selection might be involved in structuring the population over short distances for this coral.

In this study, the soft coral, *S. brassica*, was not found south of the iSimangaliso Wetland Park, despite it being recorded in the southern sites in previous surveys. Analyses of COI sequences revealed that there are potentially two clades and that there is a poleward decrease in genetic diversity. Neither of these clades showed any clear geographical or genetic population structure between the reef complexes, but additional studies using RADSeq will clarify the situation. The thesis titled "Population Connectivity of *Stylophora pistillata* and *Sinularia brassica* Between KwaZulu-Natal Marine Protected Areas" was submitted to the University of KwaZulu-Natal for examination.

Genetic connectivity of the slinger *Chrysoblephus puniceus* in Marine Protected Areas and unprotected areas along the east coast of South Africa

Student (Degree): Samantha Ockhuis (PhD, RU) Supervisor: Dr Paul Cowley (SAIAB); Dr Gavin Gouws (SAIAB); Dr Sean Fennessy (ORI)

The slinger, *Chrysoblephus puniceus*, is endemic to the south-eastern coast of Africa from southern Mozambique to Algoa Bay in the Eastern Cape and occurs within Marine Protected Areas (MPAs) (iSimangaliso Wetland Park, uThukela, Aliwal Shoal, Protea Banks and Pondoland) along the upper east coast of South Africa. Though MPAs have shown they enhance reef fish abundance and diversity, the extent of their effectiveness remains poorly understood. *C. puniceus* is relatively slow-growing, reaching maturity at the age of three years, and is a protogynous hermaphrodite, changing sex (from female to male) after the age of five years. Spawning is restricted to offshore reefs from southern Mozambique to northern KwaZulu-Natal, occurs in shoals and over down-current reefs, which initially led to speculation that it is likely that larvae are transported southward by the Agulhas Current. Tagging studies have revealed that this species is highly resident, with occasional long-distance northward movements by adults. The slinger is the main targeted species of the commercial linefishery in KwaZulu-Natal and southern Mozambique and is also important in the recreational fishery. Despite the commercial importance of *C. puniceus*, little is known about the relative importance of northern MPAs in KwaZulu-Natal in sustaining populations further south. A panmictic stock has been found for *C. puniceus* with high connectivity from southern Mozambique to the southern Transkei. This study aims to examine the genetic connectivity and gene flow of *C. puniceus* between MPAs and unprotected areas along the east coast of South Africa. Microsatellites and multi-locus Single Nucleotide Polymorphisms (SNPs) will be used to examine this, providing a better understanding of connectivity, whether there is spillover of adults into the surrounding areas and recruitment into the fishery, and we will better understand reproductive contributions, which can inform fisheries management.

Sampling and laboratory work has been concluded for all three data chapters. The temporal genetic diversity study found a lack of both temporal structure and of changes in genetic diversity between 2012 to 2018 in northern and southern KZN samples, which likely indicates high connectivity in *C. puniceus* due to high levels of gene flow maintaining diversity. This phenomenon was also demonstrated in a previous study on the slinger, suggesting that there has been no change in fishing impacts on diversity over this period, supporting the most recent (2017) fisheries stock assessment which suggested the stock has recovered somewhat, and is not over-exploited. After considerable delays owing to COVID-19, the Next-Generation sequencing results were received from the USA late in 2020, and I am currently analysing data for the fine-scale structure of populations and examining the sources and parentage of juvenile fish from MPA and non-MPA sites. The results of the temporal comparison of genetic diversity in slinger were presented at the NRF-SAIAB Student Symposium in December 2020.

Investigating the presence of the northward flow in the KwaZulu-Natal Bight and its impact on MPA connectivity

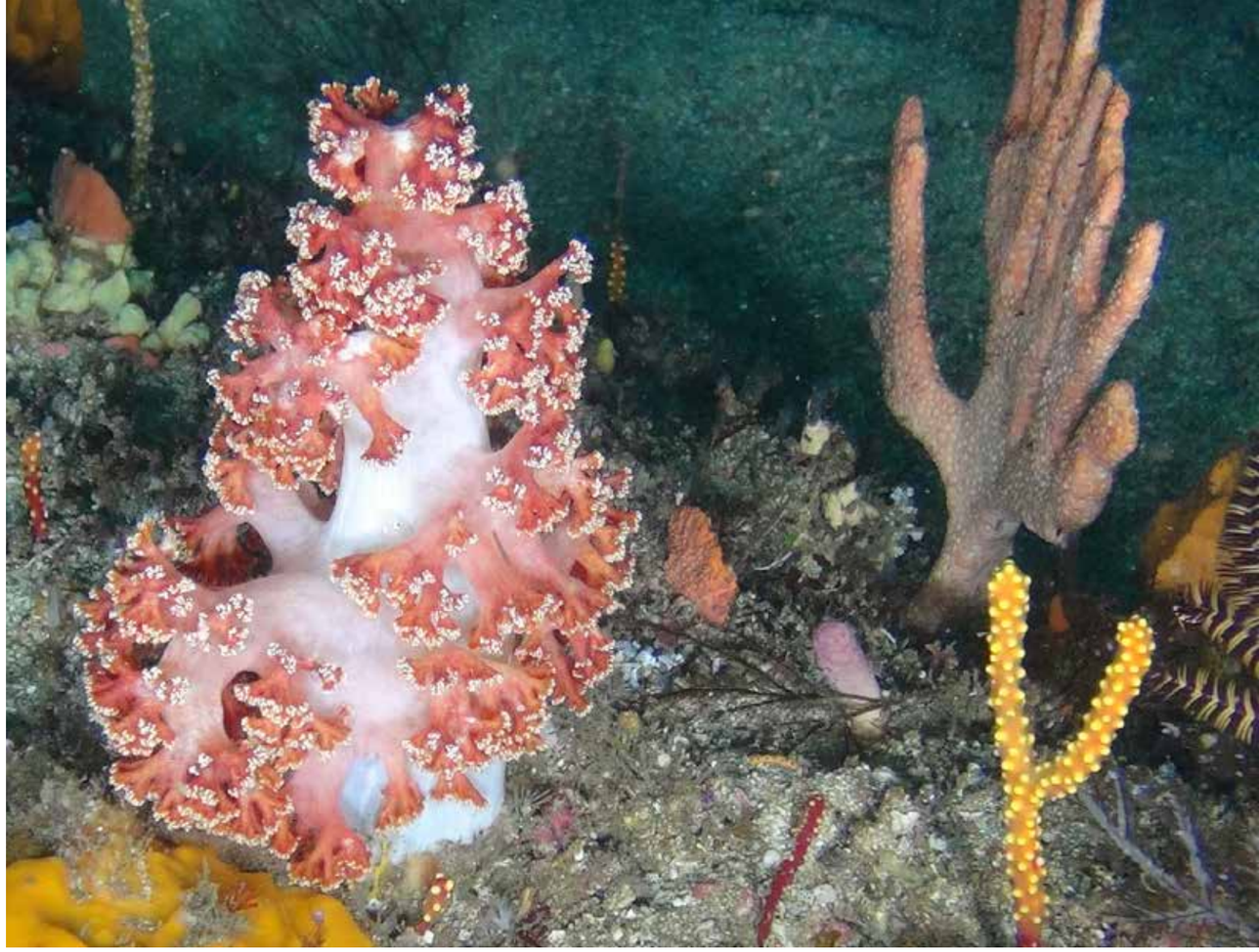
Student (Degree): Sonia Heyes (MSc, UCT) Supervisor: Dr Marjolaine Krug (DEFF), Prof. Mathieu Rouault (UCT), Prof. Pierrick Penven (IRD), Mr Michael Hart-Davis (DGFI-TUM)

The CAPTOR project aims at determining if the iSimangaliso MPA, the uThukela Banks MPA, the Aliwal Shoal MPA and the Protea Banks MPA form a network. All these MPAs are adjacent to the Agulhas Current, a strong current with a south-westward setting. Any flows in this region could affect the connectivity between these MPAs. In this study, we use outputs from a high-resolution ocean model to gain insight into a northward return flow within the KZN Bight, which is part of the uThukela Banks MPA and has the potential to increase the connectivity between the MPAs in this region. Its location, persistence and its drivers are investigated, and virtual particles will be released within this ocean model to determine their path with and without the presence of this return flow.

Increased connectivity between these MPAs has significant potential implications for larval retention and fish recruitment. It is important that we understand the circulation within these biologically important regions to be able to protect them and their inhabitants.

A high-resolution ocean model, drifter data from CAPTOR and previous projects, and ERA5 wind data were used. From these, the trajectories of the drifters, the mean surface circulations, spatial averages and Hovmoller plots, trend plots, and correlations between the wind and currents and between the Agulhas Current and shelf currents, are derived. So far, the results show the presence of a northward return flow in the mean surface circulation which stretches northward from Durban to Richards Bay. Drifters are also often caught in this northward flow, validating the model output. The correlations between currents and winds do not indicate direct correlations between the wind and the northward current. Meanders in the Agulhas Current's trajectory are also not strongly correlated with shelf currents, but this correlation may be stronger if a lag effect and non-linear relationships are considered.

The virtual particle tracking experiments still need to be completed. They will provide insight into the pathways of larvae and recruits, which are otherwise difficult to obtain owing to factors such as their small sizes. Further work in this region will improve our knowledge of the connectivity between these MPAs and the implications of that connectivity. The research is being used for my MSc at the University of Cape Town.



DEEP FORESTS

Geoff Spiby

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

PI: Dr Kerry Sink (SANBI)

Co-investigators: Dr Hayley Cawthra (CGS), Dr Lara Atkinson (SAEON), Dr Kerry Howell (Plymouth University), Dr Theminkosi Dlaza (WSU), Prof. Rosie Dorrington (Rhodes), Prof. Gary Williams (California Academy of Sciences), Dr Stephen Cairns (Smithsonian)

Collaborators: Dr Mark Rothman (DAFF), Dr Sven Kerwath (DAFF), Dr Denham Parker (DAFF), Dr Wayne Florence (iZiko), Dr Shirley Parker Nance (Rhodes), Dr Ant Bernard (SAIAB), Prof. Mandy Lombard (NMU), Mike Roberts (NMU), Ms Georgina Jones (SURG), Ms Carol Poole (SANBI), Dr Christoher Mah (Smithsonian)

Students (degree): Jock Currie (Postdoc, NMU), Talicia Pillay (PhD, NMU), Mari-Lise Franken (MSc, UCT), Loyiso Dunga (MSc, UCT), Sinothando Shibe (MSc, UKZN)

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 supports 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 important to fisheries (including kingklip, sole, south coast rock lobster, jacopever and hake), carbon sequestration, and other ecosystem services. The project is building research capacity and multidisciplinary teams, and extending this capacity into increasingly deeper water. New links and projects enable South African scientists and students to participate in much deeper surveys with new, international collaborations to survey seeps and seamounts beyond the shelf edge.
A key focus of the Deep Forests Project is to help the South African hake trawl fishery meet Marine Stewardship Council eco-certification standards in habitat management. 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 five-year period, with a potential loss of about 12,000 jobs. Vulnerable Marine Ecosystems (VMEs) are those sensitive or fragile ecosystem types that consist of animals (including slow growing, long-lived species) that create habitats, such as cold-water coral reefs comprising stony corals, black corals, sea fans and lace corals, dense sponge grounds and sea pen beds. These habitats can take a long time to recover from activities that damage the seabed, such as mining, trawling and anchoring.
This project contributes to the following Sustainable Development Goals (SDGs):
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 education initiatives are reaching children, students, skippers, industry, managers, and government officials.
Goal 5: Gender Equality – this project is led by women and supports six female postgraduate students.
Goal 12: Sustainable consumption and production – this project supports improved fisheries sustainability, and ecosystem-based management and education in this context. The research is helping South Africa to strengthen its scientific and technical capacity to move towards more sustainable

patterns of consumption and production. Results inform the Southern African Sustainable Seafood Initiative (SASSI) for improved consumer awareness.
Goal 14: Life in the Ocean – this project increases 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. A contribution to indicator 14.5 was made through the research and work to identify further priority areas for protected area expansion and to ensure that contributions of the 20 new MPAs declared in 2019 are reflected in new MPA management plans developed in 2020 and 2021.
Goal 17: Partnerships – this project spans the biodiversity knowledge chain from foundational research to improved management and depends on the efforts of a diverse team, multiple institutions, industry partnerships and international collaboration. This project exemplifies the multi-stakeholder partnerships that mobilise and share knowledge, expertise, technology and financial resources to support the achievement of the SDGs in a developing country
This project has made progress in discovering and mapping deep kelp, other seaweed and animal forests in South Africa while developing capacity, supporting students and engaging in new Ocean Literacy work. In order to support eco-certification of South Africa's hake trawl fishery, this project developed a working group to help identify and map potential VMEs; participated in an industry led VME Management working group and provided scientific advice and management recommendations to support effective management of VMEs. In 2020, new moves on rules were implemented and new data are being collected by the trawl industry to improve understanding of the distribution of potential VMEs. Identification guides with associated catch thresholds were developed for potential VME indicator groups and are displayed on trawl vessels with information in English, Afrikaans and isiXhosa. New research is underway to improve the scientific foundations for identifying and mapping potential VME indicator species. The project contributed to a skipper's handbook that explains and provides guidance on dealing with potential VMEs, and a short film is under development with planned social media activity in 2021 (#DiepRespek).
The Deep Forests project was not able to take students to sea in 2020 but provided dedicated Global Information Systems (GIS) and Statistical (R) training at Walter Sisulu University in 2019, and online training in 2020 and 2021. Students are making new species discoveries, taxonomic progress, mapping progress and advances for improved biodiversity assessment, all realised in a difficult year.
Outreach activities: This project was featured on international television on CNN Inside Africa, showcasing young scientists from this project and featured in the online SciFest Africa online with African storyteller Gcina Mhlope.

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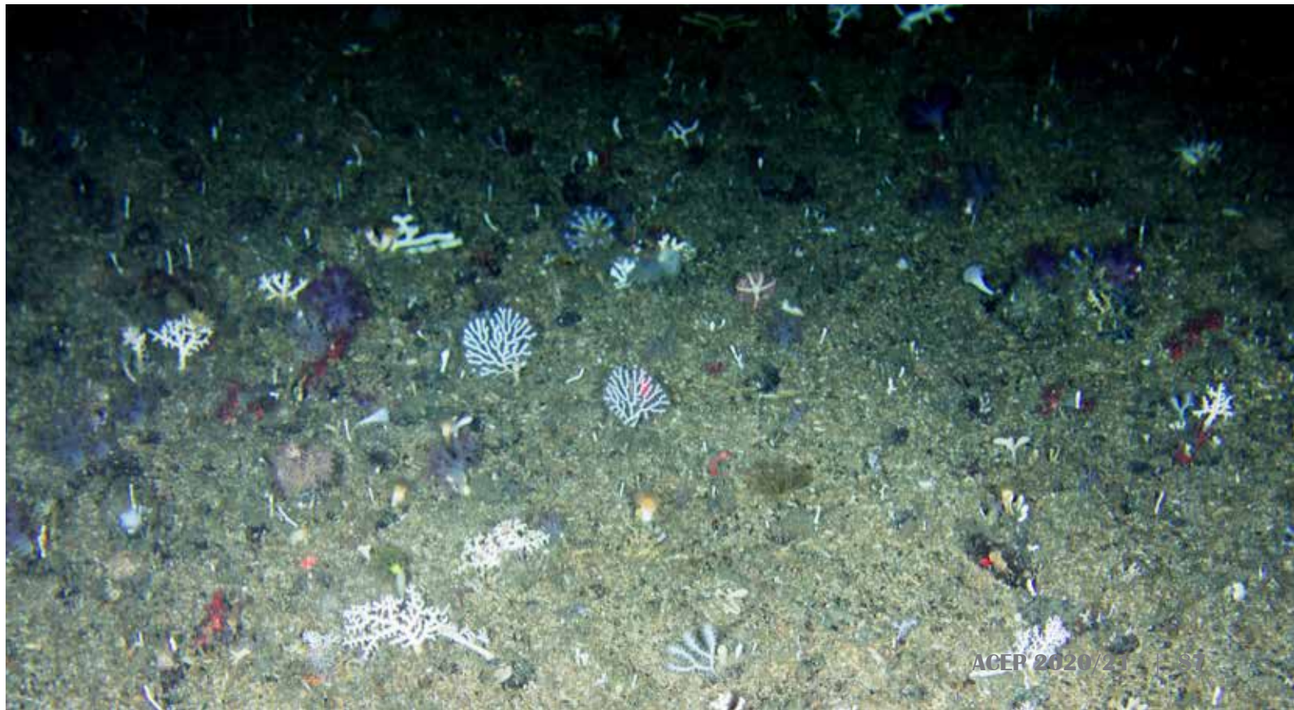
Graduations
Loyso Dunga (MSc) graduated with distinction.
Sinothando Shibe (Honours) graduated and registered for an MSc on this project.
Talicia Pillay (PhD) submitted her PhD thesis.



Deep Forests Student Projects

Mapping and assessing ecosystem threat status of South African kelp forests

Student (Degree): Loyiso Victor Dunga (MSc, UCT)
Supervisor: Prof. Kerry Sink (SANBI), Prof. John Bolton (UCT), Dr Mark Rothman (DEFF)

By providing ecosystem services, kelp forests play a significant ecological, social and economic role. South African kelp forests are no exception and are among the small, high-value ecosystems that offer multiple services to people. To maintain the benefits kelp forests provide, informed management is necessary, and understanding kelp forest distribution, ecosystem functioning, pressures, and ecosystem state are key requirements for effective management. Because kelp forests were not represented on the National Map of Ecosystems, they were excluded from two previous assessments, and do not appear in the South African National Biodiversity Assessment (NBA), which is a key tool for reporting on the status of ecosystems to guide policy, planning and decision making. This thesis addresses this omission by producing a map of the kelp forest ecosystem types and conducting the first assessment of their threatened status.
Remote Sensing (RS) and Geographic Information Systems (GIS) techniques were developed and applied to map South African kelp forests. Advanced high spatial and spectral resolution imagery, normalized difference vegetation index (NDVI) thresholds, supervised classification and an accuracy assessment were used to define and map three kelp forest ecosystem types: Namaqua, Cape and Agulhas kelp forests, using the National Map.
The NBA approach was aligned to the emerging International Union for Conservation of Nature Red List of Ecosystems (IUCN RLE) criteria and applied to assess the ecosystem threat status of all three types. To assess threat status, ecosystem extent and condition were considered by mapping ten pressures to determine degradation using a cumulative pressure mapping approach. Four categories of condition were recognised in alignment with the IUCN thresholds for degradation. The results of the assessment show sensitivity to the different assessment criteria, the scale of ecosystem delineation and assessment approaches. There is no reported reduction in distribution of any of the South African kelp forest ecosystem types, therefore, decline in extent under criterion (A) was assessed as Least Concern for all types. Results for criterion (B), which is related to geographic extent, were most sensitive to ecosystem delineation with results ranging between Least Concern and Endangered. For criterion (C), which is related to the extent of abiotic degradation, all types were assessed as Vulnerable, which a

national expert reference group considered a realistic result. Further research should focus on improving pressure data, ground-truthing the kelp forest ecosystem condition, assessing the disruption of biotic processes, and defining thresholds of a collapsed ecosystem.
Loyiso graduated with distinction in 2020 and has gone on to work as an emerging researcher supporting ecosystem assessment and research into understanding the use of marine species in ritual and medicine in South Africa. His research has contributed significantly to the advancement of ecosystem classification and assessment. He made inputs into the NBA through contributions to work on biodiversity benefits, ecosystem classification, pressures on marine biodiversity and ecosystem assessment. Loyiso is now applying his skills in the kelp farming industry.

Characterising and mapping of South African vulnerable marine ecosystem indicators

Student (Degree): Mari-Lise Franken (MSc, UCT) Supervisor: Dr Kerry Sink (SANBI), Dr Lara Atkinson (SAEON) and Dr Natasha Karenyi (UCT)

Vulnerable Marine Ecosystems (VMEs) are sensitive to demersal fishing impacts; they are highly vulnerable to disturbance and have a low recovery potential. The Food and Agricultural Organisation (FAO) uses five criteria to establish guidelines for managing deep-sea fisheries. However, efforts to designate VMEs in South Africa's waters have lagged because of inadequate data, lack of taxonomic expertise and mapping efforts challenging the effort to manage VMEs. Improved knowledge of potential VME indicators and their distribution is needed for spatial assessment and planning and to support fisheries eco-certification.
This research work increases our knowledge of the characteristics and distribution of South African VMEs to support fisheries management, fisheries eco-certification and current efforts in marine spatial assessment and planning. The research will be applied to advance South Africa's national marine ecosystem map, to identify Ecological and Biological Significant Areas (EBSAs) and to support Marine Protected Area (MPA) planning and management.
This study is systematically assessing the sensitivity of potential VME indicator taxa in South Africa and serves as a useful guideline for formalising the list of indicator taxa for monitoring and mapping of VMEs within national jurisdiction. The study has applied the Fisheries and Agriculture Organization (FAO) guidelines for identifying VMEs and draws on national bathymetric, geological and biodiversity datasets to map distribution. Underwater video footage collected from more than ten research surveys, spanning more than 300 sites is being reviewed to identify and map potential VMEs through direct evidence. This information has fed into the most recent update of South Africa's Coastal and Marine Spatial Biodiversity Plan which defines Critical Biodiversity Areas for Marine Spatial Planning. The study also uses high resolution multibeam data over the Cape Canyon area to predict potential distribution of cold-water corals using species distribution modelling.
In 2020, the relative sensitivity of potential VME indicator taxa were systematically assessed against five FAO criteria and produced a new map of potential VME locations. These include reef building corals, other deep-water stony corals, stylasterine lace corals, habitat forming sponges, bryozoans and sea pens. A total of 22 species were assessed with some species, such as an anemone and basket star, showing greater resilience and being less likely to meet VME criteria. Literature review and research work has supported the provision of new training, and identification materials and scientific information deliberated in the VME scientific and management working groups are feeding into management. Work completed on assessing sensitivity of potential VME indicator taxa was presented at the South African VME working group meeting (24/11/2020) and as a poster presentation was made at the annual UCT Research Day, for which the presenter was awarded 2nd place.

Sea pen (Cnidaria: Octocorallia: Pennatulacea) communities in unconsolidated habitats of the eastern margin of South Africa

Student (Degree): Sinothando Shibe (MSc, UKZN) Supervisor: Dr Kerry Sink (SANBI), Dr Nicola Carassco (UKZN)

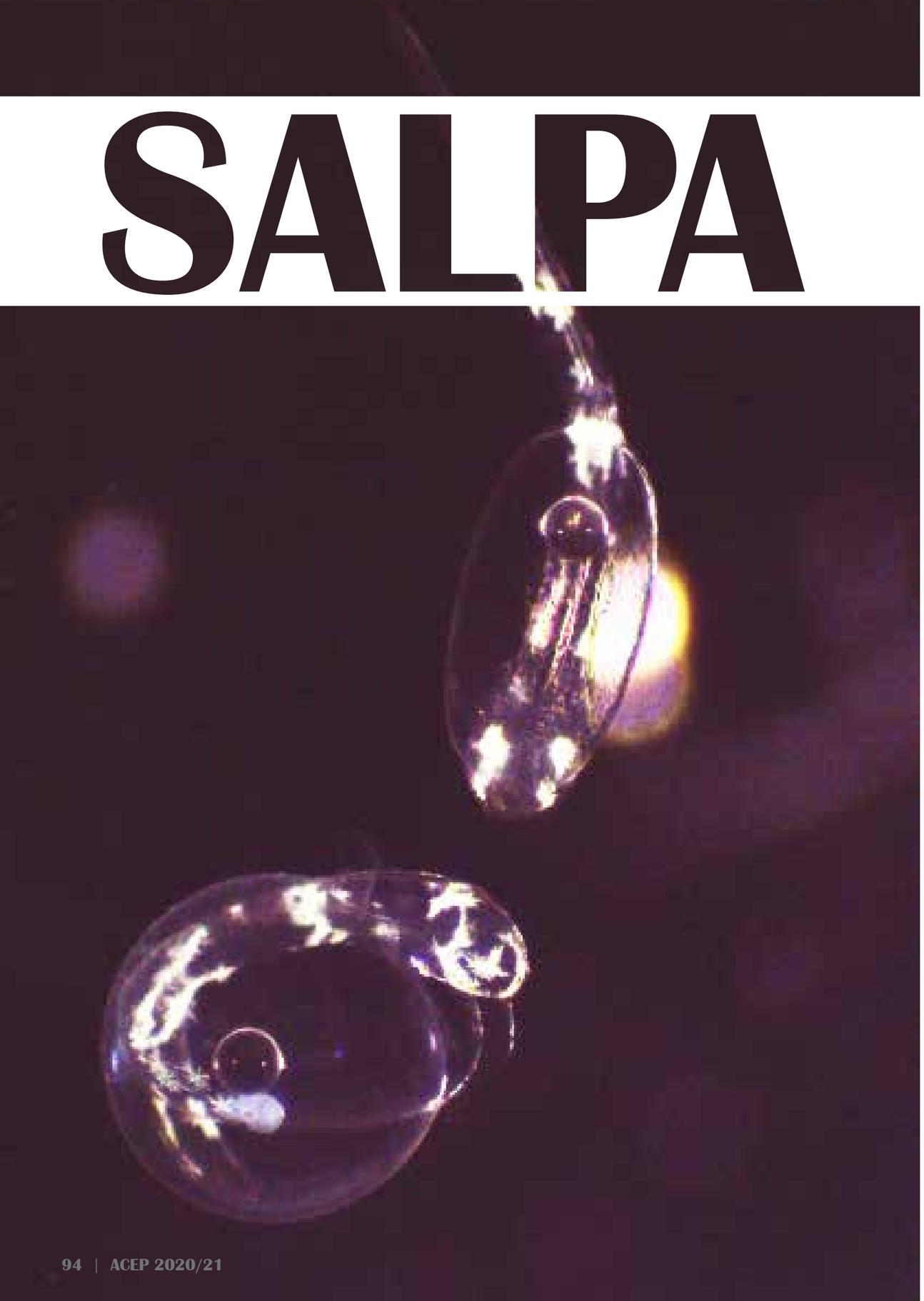
Sea pens perform important ecosystem functions, such as providing structural complexity to habitats, harbouring fish larvae, and cycling or retaining nutrients for benthic fauna. Studies have suggested that such aggregations may be biodiversity hotspots, may act as essential fish habitats, and may constitute potential Vulnerable Marine Ecosystems (VMEs). Despite the important roles that sea pens play in ecosystem functioning, they have received little research attention in South Africa compared to other orders. This project investigates (1) the occurrence of sea pens in canyon and non-canyon associated habitats and (2) whether the distance between a sea pen community and a canyon head has an influence on species richness and densities. The research is being carried out analysing ROV footage from KwaZulu-Natal and the Eastern Cape.
In 2020, we were unable to complete any field work owing to COVID-19 restrictions; therefore we extracted data collected in 2018 and 2019 from the ACEP Imida and ACEP Canyon Connections projects. Although the data has not been statistically analysed, a species catalogue was compiled to support the identification of sea pens in the long term and the dataset has been prepared for analysis in Primer once the full set of data is collected. Prof. Gary Williams from the California Academy of Science could not travel and no collections were feasible in 2020, but he compiled a PowerPoint presentation to help identify local species and to train project members in the classification and identification of sea pens. KZN has more sea pen species than the Eastern Cape, and initial findings suggest that canyon habitats in the north of KZN are more diverse and have greater densities compared to non-canyon habitats.
In 2020, I attended the Indian Ocean webinar series: "The role of youth in advancing the Indian Ocean Blue Economy", as well as "Climate Change and Our Oceans: Impacts and Solutions" conference, along with other webinars. I also attended a popular article training course and have prepared an article in both English and isiZulu that explains what sea pens are, what their role in the ecosystem is, and how we can ensure their long-term survival.

Benthic habitat mapping of the continental shelf of South Africa using marine geophysics and machine learning

Student (Degree): Talicia Pillay (PhD, NMU) Supervisor: Dr Hayley Cawthra (CGS, NMU), Prof. Amanda Lombard (NMU)

The project centres on using geophysical tools and benthic biology to create benthic habitat maps of South Africa's seafloor. Multibeam bathymetry, multispectral backscatter, and side scan sonar are used to map the seafloor in the Table Bay and Cape St. Francis areas. The benthic biology of the study areas was classified using video logs, grab samples and photo logs. These two datasets were combined using machine learning techniques to create comprehensive habitat maps of these areas.
The main aim of the project was to create a predictive tool to convert backscattered sonar waves into maps showing benthic habitat environments, based on the geological substrate. There were two main objectives: firstly, I sought to conduct high-resolution marine geophysical surveys, ground truth the geophysical data with video logs and camera footage from the seafloor, and process the side scan sonar mosaics, bathymetric and backscatter data collected. Secondly, I set out to create algorithms to classify benthic biota based on seafloor characteristics and to use these results to help improve the benthic habitat map of the next National Biodiversity Assessment. In addition, we sought to provide baseline data for long-term monitoring (for example, monitoring the response of biota to cumulative human impacts) in order to contribute to marine spatial planning and assessment.
Side scan sonar, multibeam bathymetry and backscatter data the Table Bay area were collected and processed in 2017; multibeam bathymetry, backscatter and ROV surveys along the Cape Saint Francis area was completed the first half of 2019, and processed by the end of 2019. A paper describing the machine learning methods used to map the study areas was published in *Marine Geology* in 2020. A second paper, "Integration of machine learning using geophysical techniques and sediment sampling to refine substrate description in the Western Cape, South Africa", and third paper "Benthic habitat mapping from a machine learning perspective on the Cape St Francis inner shelf, Eastern Cape, South Africa" are currently under review. The work from this PhD was presented at GEOHAB in 2018 (Santa Barbara, United States of America) and 2019 (St. Petersburg, Russia), with an abstract submitted in 2020 (conference cancelled due to COVID-19). This PhD was submitted for assessment with a proposed graduation date in April 2021.

SALPA



Fisheries induced evolution on fish physiology

PI: Prof. Warren Potts (RU)

Co-investigators: Dr Amber-Robyn Childs (RU)

Collaborators: Dr Nicola James (SAIAB), Dr Anthony Bernard (SAIAB)

Students (degree): Cuen Muller (PhD, RU), Pule Mpopetsi (PhD, RU), Lauren Bailey (PhD, RU), Michael Skeeles (MSc, RU), Bontle Mateboge (MSc, RU), Xolani Nabani (BSc hons, RU), Nonhle Mlotshwa (BSc hons, RU), Mihle Gayisa (BSc hons)

Although several studies have found evidence for fisheries-induced evolution on the life history and behavioural traits of fishes, none have found any evidence for the selection of physiological traits. However, recent research by this research team found clear evidence of fisheries selection on the metabolic rate of an exploited South African linefish. As metabolic rate is closely linked to resilience, this finding suggests that exploited populations may be less resilient to the impacts of climate change. This has enormous implications for our understanding of how fishes will react to the impacts of climate change and how Marine Protected Areas can be used as a tool for adapting to the impacts of these changes.
To explore these implications, a team of young and motivated researchers are conducting a multidisciplinary project that aims to better understand the effects of selectivity by passive fisheries on the physiological traits of fishes, how this impacts their resilience and how this knowledge can used to adapt to the impacts of climate change. In particular we will establish whether the selection operates at the level of phenotype and the genotype as this will have major implications for how we plan to use marine protected areas to adapt to the impacts of climate change. The project comprises three subprojects, ecophysiology, acoustic telemetry and Baited Remote Underwater Video, is laboratory and field-based and makes use of the Small Coastal Craft, ATAP and the BRUVs from the Mar-RIP platforms. It uses contemporary research techniques, many of which have never been used in South Africa.
This project aligns with seven of the Sustainable Development Goals. As it aims to improve our understanding of fishes and looks to predict change and offer options for adaptation, it aligns directly with the “Life below water” goal. Similarly, the findings will have implications for the way that we adapt to climate change and therefore aligns with the “Climate action” goal. As the study species and many of the other resident reef fish species are critical to commercial linefishers and to the new small-scale fishery that is being developed, the findings of this study can contribute to maintaining the fishery and reducing poverty (“No poverty” goal) and hunger (“Zero hunger” goal). In addition, if implemented, the recommendations from this study will likely improve the resilience of the linefish resource and promote the goal of “Responsible consumption and production”. This project has a considerable gender equality drive, with the project leadership team and student gender ratio pegged at 50:50, thus supporting the “Gender equality” goal.
Finally, since this research is a global first and we are at the cutting edge of examining the impacts of exploitation on the resilience of fishes to climate change, and are using a complimentary broad range of research methods there is no doubt that students participating in this project will not only receive quality education (“Quality education” goal), but will likely emerge as world leaders in this field of research. The outcomes of the project which will provide us with an understanding of how exploitation influences the physiology of fishes and their resilience to the impacts of climate change, will not only be of global scientific interest, but will also be very relevant to the development of policy, legislation and ultimately our adaptation strategies to minimise the impact of climate change on society.

We made several advances towards achieving this aim of this project during 2020. We have continued comparing the physiological traits of Red Roman (our primary candidate species) and have continued to find physiological differences between exploited and unexploited populations. Unfortunately, due to the COVID restrictions, we were unable to collect additional species for further physiological experiments. The two BSc honours students that would have conducted these experiments were required to work on existing datasets which contributed to the other objectives of the project. We have just completed a comparison of the physiology of the larvae of adults from exploited and unexploited populations when subjected to a stressor. This research was extremely challenging and the PhD student (Cuen Muller) must be commended for his progress here. The results, although preliminary, suggest that larvae from parents in protected populations were physiologically fitter when exposed to low pH conditions than those from parents in unexploited populations. This information is a world first and demonstrates that fisheries-induced selection operates at the level of genotype. This has massive implications for how we respond to the impacts of climate change and suggests that the promulgation of Marine Protected Areas will confer resilience to coastal fish populations well beyond their boundaries. This is a HUGE deal and provides us with some real hope for adaptation plans. We continued examining how physiological fitness influences the activity, feeding and movement patterns of Red Roman. We completed the laboratory and field experiments, analyses and thesis writing. We have two manuscripts from this in the final phase of writing. We found that physiological fitness does determine the response of individuals to environmental stressors in the wild. We found clear evidence that the high performance physiological phenotypes were more active during thermal extremes. We are also in the final stages of collecting fish behaviour information (using baited underwater remote video methods) during and outside of intensive upwelling events from several exploited and unexploited areas. This will assist us in understanding the response of individuals to environmental stressors in the wild. Wed also made excellent progress on improving our understanding on the effect of physiological fitness on the response of individuals and populations to environmental stressors in the wild. Using laboratory validated acoustic accelerometry data from 2019, a BSc honours student examined how exploitation impacted the response of fish populations to extreme upwelling events and marine cold spells (MCS). We found that exploited and unexploited populations responded differently, with exploited populations reducing their activity and unexploited increasing their activity in response to an upwelling event. During the marine cold spell, fish from the exploited population increased their activity, while those from the unexploited population decreased their activity. These findings demonstrate that the physiological advantage of fish in unexploited populations has a measurable impact on their behavioural response to upwelling events. Since these events are expected to increase in frequency and intensity, this demonstrates that fish in or from MPA's will likely be fitter in future ocean conditions. In terms of our Baited Remote Underwater Video experiments, we were unable to complete our fieldwork which would allow us to compare the feeding behaviour of exploited and unexploited populations (at different temperatures) in the wild. This will be done early in 2021 and the MSc student involved in this project is expected to complete her thesis in April. However, we did use archival videos to compare the feeding behaviour of another resident species, the frans madam (*Boopsoidea inornata*) as part of another BSc honours project and found that behaviour was different between the exploited and unexploited environments at extreme temperatures.

Outreach activities:
We have been extremely active on social media in 2020. Our contributions via Instagram and Facebook can be seen at https://www.instagram.com/safer_lab/ and https://www.facebook.com/SAFisheriesEcologyResearchLab, respectively.
Outputs: (include peer-reviewed papers, popular articles, public engagement (including conferences), students graduated)

Peer-reviewed manuscripts

Michael R. Skeeles, Alexander C. Winkler, Murray I. Duncan, Nicola C. James, Kerry-Ann van der Walt, Warren M. Potts (2020) The use of internal heart rate loggers in determining cardiac breakpoints of fish. Journal of Thermal Biology. DOI: https://doi.org/10.1016/j.jtherbio.2020.102524

Muller C, Childs A-R, Duncan MI, Skeeles MR, James NC, van der Walt K-A, Winkler AC, Potts WM (2020) Implantation, orientation and validation of a commercially produced heart-rate logger for use in a perciform teleost fish. Conserv Physiol8(01): coaa035; doi:10.1093/conphys/coaa035

Potts WM, Attwood C, Cowley PD, Childs A-R, Winkler AC, Duncan MI, Murray T, Mann B (In press). Editorial: Towards a resilient South African linefishery in the Anthropocene. Africa Journal of Marine Science 42(3):

Potts WM, Attwood CG, Cowley PD (2020) Linefish resilience in the Anthropocene. Africa Journal of Marine Science 42(3): iii. DOI: 10.2989/1814232X.2020.1835099

Murray I Duncan, Nicola C James, Warren M Potts, Amanda E Bates (2020) Different drivers, common mechanism; the distribution of a reef fish is restricted by local-scale oxygen and temperature constraints on aerobic metabolism, Conservation Physiology, Volume 8, Issue 1, 2020, coaa090, https://doi.org/10.1093/conphys/coaa090

Muller C, Childs A-R, James N, Potts WM (2020) Effects of Experimental Ocean Acidification on the Larval Morphology and Metabolism of a Temperate Sparid, *Chrysoblephus laticeps*. Oceans 2: 26–40.

Conferences

Potts WM (2020) Effective governance of recreational fisheries – recommendations from research and experience. Keynote presentation. Gulf and Caribbean Fisheries Institute 73rd annual conference.

Students graduated: Michael Skeeles (MSc), Xolani Nabani (BSc honours), Nonhle Mlotshwa (BSc honours)

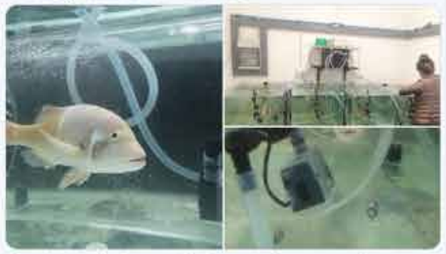
SALPA Student Project

Investigating the associated effects of exploitation and climate stress on the resilience of the resident sparid *Chrysoblephus laticeps* through respirometry and morphometry

Student: Cuen Muller Degree: PhD, RU Supervisor: Prof. Warren Potts (DIFS, RU), Dr Nikki James (SAIAB), Dr Amber Childs (DIFS, RU)

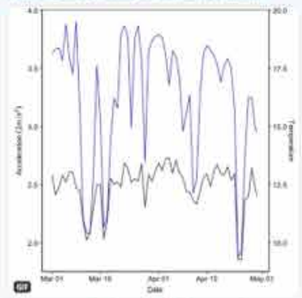
Exploitation has clear impacts on the demography of a population which is most evident to changes in size structure and recruitment as a response to a selective pressure. Less evident are the long-term changes in nondescript characters such as physiology. Most fisheries exploit some sort of trait from the population; most obvious being selection of the largest individuals, imposing an evolutionary trajectory known as fisheries-induced evolution. Line fishing is believed to exploit the most aggressive, boldest individuals leaving more timid fish remaining to contribute to subsequent generations. Aggression and boldness in fish has been linked to increased metabolic rates relating to individuals who have higher rates of growth. This selective pressure may therefore be reducing physiological trait distributions within a population or, otherwise put, the physiological diversity necessary to cope with an onslaught of stressors. Red roman, *C. laticeps*, are exploited throughout much of their range and are shown to be highly resident to localised areas from shortly after recruitment. Their high rates of residency mean populations in exploited areas are likely to suffer from fishing pressure and potentially reflect this in their physiological diversity. This project will explore the relationship between exploitation and climate change by examining survival, growth and metabolism on offspring from two populations of red roman experiencing disparate levels of exploitation. Developing larvae will be reared in contrasting pH conditions, based on predicted future values attributed to ocean acidification, where their resilience to this stressor will be assessed.
To date, offspring from both exploited (Noordhoek, Port Elizabeth) and protected (Tsitsikamma Marine National Reserve) populations have been successfully reared up to flexion stage under control (pCO_2 = 400 µatm, pH = 8.03) and treatment conditions (pCO_2 = 1600 µatm, pH = 7.63). Oxygen consumption and morphometric measurements have been carried out on these larvae at key developmental periods which include yolk-sac, preflexion and flexion stages. Findings suggest that the earliest stages (yolk-sac and preflexion) are tolerant to high pCO_2 but by the onset of flexion, along with the co-occurring development of the gills as a major site of ionic regulation, treatment larvae expend far greater energy by significantly increasing metabolic rates. In a natural setting these elevated energetic rates may not be sustained when food is limited and mortality rates may therefore be greater under predicted future Ocean Acidification conditions.

SAFER LAB @SAFER_Lab · Dec 5, 2019
Final adjustments in the @AERP_ecophys lab for PhD student Lauren Bailey who is aiming to link physiology and behavior! @ACEP_ZA
#physiology #ecophysiology #respirometry



3 10

You Retweeted
Michael Skeeles @FishSciSkeeles · Aug 20, 2019
Avg daily temp in blue and acceleration in black over 3 months from one of our VEMAP tagged red roman sea bream. Temp drives activity? Yes! Note the large dips in temp (upwelling event) where acc is significantly reduced..
@SAFER_Lab @ACEP_ZA @ATAP_ZA @OceanTracking @vemcoteam



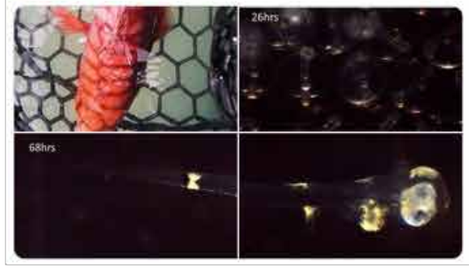
SAFER LAB @SAFER_Lab · Nov 16, 2019
PhD students Cuen Muller and Lauren Bailey, along with their skipper and team of anglers enjoyed a successful fishing trip collecting one of South Africa's endemic sparids, the roman seabream, for their upcoming physiology experiments @ACEP_ZA @AERP_ecophys

4 11

You Retweeted
Michael Skeeles @FishSciSkeeles · Feb 18, 2019
Look what we've just been up to with some of @vemcoteam's tags... The full #scicomm story to follow soon! Now we patiently await for some exciting data. Big thanks to team @ACEP_ZA, @ATAP_ZA and @SAFER_Lab for all the help and laughs in the field 🙌🐟 #MarineScienceInSouthAfrica

10 21

You Retweeted
Cuen Muller
@CuenMuller
Following the successful field spawning trip twitter.com/SAFER_Lab/stat...
Developing roman seabream larvae are going strong, developing well and undergoing respirometry trials with @LoligoSystems and support of @ACEP_ZA, @AERP_ecophys and @SANParks..
@SAFER_Lab



You Retweeted
Michael Skeeles @FishSciSkeeles · Oct 24, 2018
We've got a swimmer! 💯
Finally nearing the end of lab experiments. Some very interesting data on the horizon which I'm excited to get stuck into! @SAFER_Lab @ACEP_ZA @vemcoteam

6 23

You Retweeted
Acoustic Tracking Array Platform @ATAP_ZA · Jan 13
A total of 118 fish were tagged, including a new species - the red Roman. This was work done by @FishSciSkeeles of the @SAFER_Lab in the no-take Tsitsikamma National Park MPA + an open area near Port Elizabeth.

#TeamFish #accelerometry

Pic c/o: @FishSciSkeeles

Warren Potts and 4 others
1 3 11

SAFER LAB
@SAFER_Lab
@CuenMuller started the year running on his recent trip to the Tsitsikama MPA. The team successfully caught, induced, stripped and spawned Roman seabream, an endemic sparid! The embryos are currently developing in the lab! Thanks @SANParks @KyleSmith00 for your tireless support!

You and 7 others
10:47 AM · Jan 20, 2020 · Twitter for Android
View Tweet activity
5 Retweets 13 Likes

You Retweeted
Acoustic Tracking Array Platform @ATAP_ZA · Jan 13
We provided additional receivers for a number of @ACEP_ZA projects:
1. Fisheries-induced evolution on fish physiology (@SAFER_Lab)
2. Canyons connections (@WILDOCEANSSA and @KznSharks)
3. Connectivity and dispersal between protected areas (@saambr)

Michael Skeeles and Jade Quinton Maggs
1 2 6

You Retweeted
Michael Skeeles @FishSciSkeeles · May 27, 2019
What an exciting Sunday kicking off the receiver retrieval for my thesis. Talk about a bucket full of gold! A quick glimpse at some data and I couldn't be happier.. Very fortunate to be part of such a great team! @SAFER_Lab @ACEP_ZA @OceanTracking @RhodesResearch @vemcoteam

8 27

SAFER LAB @SAFER_Lab · Nov 25, 2019
Amazing work from Cuen in the @AERP_ecophys lab!

> **Cuen Muller** @CuenMuller · Nov 25, 2019
> Day After Hatch = zero
>
> Red roman hatching 31 hrs after fertilization, ready for eco-physiology experiments
> #physiology #fish_larvae
> @SAFER_Lab @AERP_ecophys

3 3

SAFER LAB

SAFERLAB

SAFER LAB @SAFER_Lab · Nov 21, 2019
Happy birthday @NRF_SAIAB! 50 years of excellence! Looking forward to the next 50 years of collaboration and ground breaking research @Rhodes_Uni @RhodesResearch @AERP_ecophys @ATAP_ZA @ACEP_ZA

1 6

You Retweeted
Michael Skeeles @FishSciSkeeles · Mar 13, 2019
Piecing together some very interesting findings from swimming these resident reef dwelling Red Roman with @vemcoteam's V13AP tags in a custom built swim tunnel! Very excited to hopefully share these results soon in the form of a paper or two. #fisheries #fisheryecology #southafrica

1 10

SAFER LAB
195 Tweets

Edit profile

SAFER LAB
@SAFER_Lab
The Southern African Fisheries Ecology Research Lab is a working group under Prof. @wpotts18 @Rhodes_Uni Department of Ichthyology and Fisheries Science
Grahamstown, South Africa safisheriesecologyresearchlab.com
Joined March 2018
278 Following **191** Followers

ACEP PLATFORMS

COASTAL CRAFT

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 Port Elizabeth. 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.

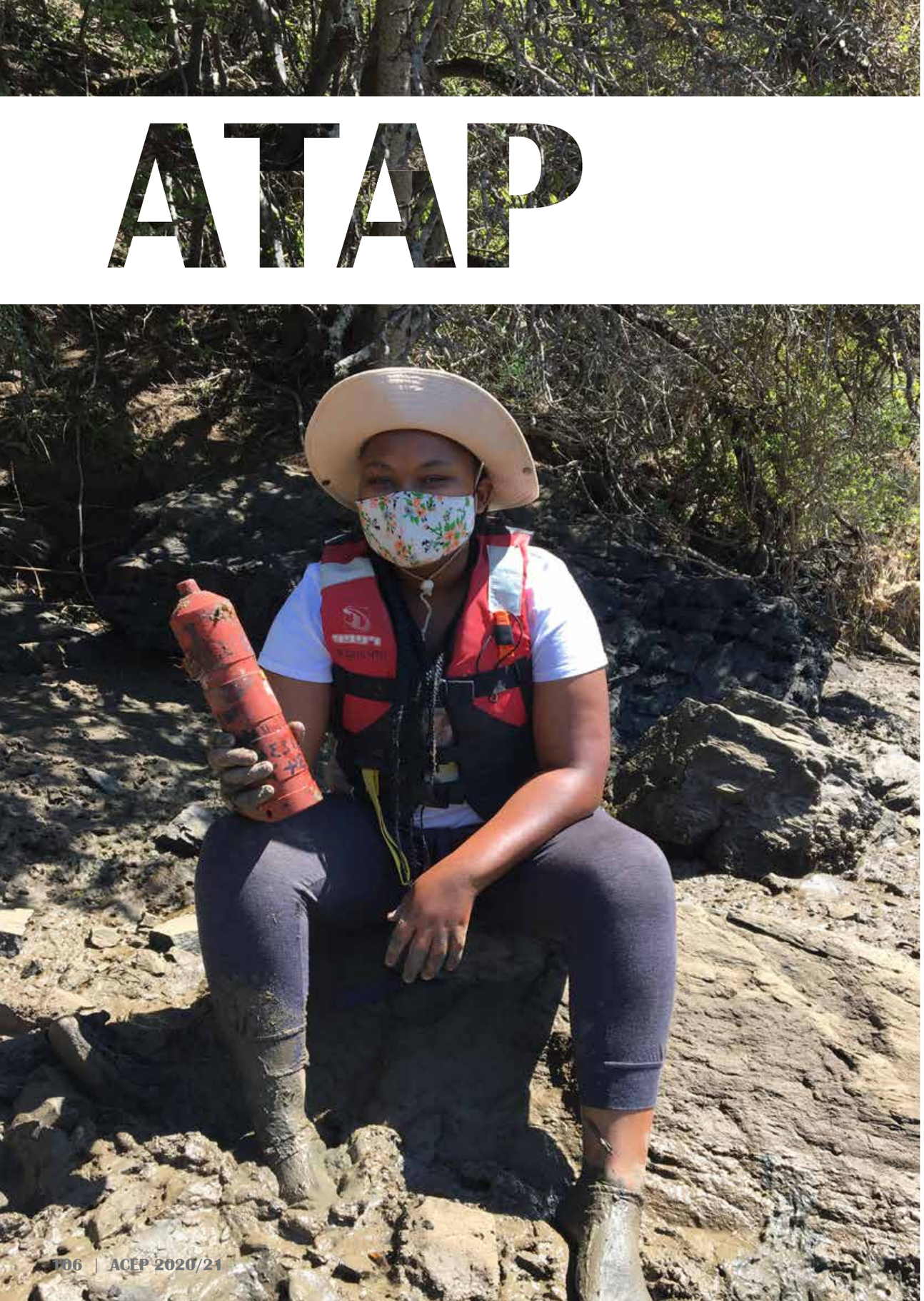
RV Phakisa, a 15 m LegacyCat aluminium catamaran hull boat, was built in 2016, and is based in KwaZulu-Natal, operating from Durban and Richards Bay harbours. This larger, highly manoeuvrable vessel with jet propulsion and a hydraulic A-frame and winch has proved exceptionally capable for ROV work, BRUV 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 will operate from East London, Port Elizabeth, Port St Francis or Mossel Bay depending on project needs. With similar capabilities as *RV Phakisa*, *RV Observer* provides exceptional research capacity to the Eastern Cape.

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.

Marine Remote Imagery Platform

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 300m depth and is fitted with a 12 megapixel still camera, a high definition video camera and a 5 function manipulator arm for collected specimen samples. The platform offers a broad variety of stereo-video camera systems including tethered (HD video cameras; depth rating of 350m; n=10) and untethered (HD video cameras; depth rating of 1000m; n=4) baited remote stereo-video systems (stereo-BRUVs) and pelagic stereo-BRUVs (4K video cameras; depth rating of 380m; 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 8.5m 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 has been involved in four ACEP Open-Call projects and completed stereo-BRUVs sampling linked to the ACEP SALPA project. The MARIP research vessel provided support to the ATAP by assisting in the rollover of acoustic receivers. In addition to the open call projects, the MARIP supports numerous national and international research projects. These include (1) Tsitsikamma marine protected area (MPA) long-term monitoring, (2) Assessment of MPA effectiveness in South Africa, (3) South African reef ecosystem condition, (4) Assessment of the subtidal ecosystems of the iSimangaliso Wetland Park, (5) Development of deep water baited camera systems, (6) Testing the effectiveness of the environmental DNA for surveying subtidal reef fish assemblages, (7) Investigating essential habitats for threatened sharks in South Africa, (8) Assessment of elasmobranchs in the Western Indian Ocean, (9) Advancing pelagic stereo-BRUVs method and investigating pelagic fish assemblages in Seychelles-Maldives seamounts, (10) Monitoring reef fish populations in Tofu, Mozambique marine reserve, (11) Assessment of the mesophotic ecosystems in Comoros, (12) Assessment of the mesophotic ecosystems of Vamizi Island in Northern Mozambique for the Ocean-Vivo WILDOCEANS project. Recent development have seen MARIP equipment utilised in freshwater ecosystems in the Cederburg and Lake Malawi.
National institutions using the MARIP include Rhodes University, Nelson Mandela University, University of KwaZulu Natal, South African National Biodiversity Institute, Oceanographic Research Institute, Elwandle and Egagasini nodes of the South African Environmental Observation Network, Ezemvelo KZN Wildlife, WildOceans, Department of Agriculture, Forestry and Fisheries, and SAIAB.
International institutions using the MARIP include the Australian Institute of Marine Science (Perth, Australia), Wildlife Conservation Society (Antananarivo, Magagascar), Marine Megafauna Foundation (Inhambane, Mozambique), University of Lurio (Pemba, Mozambique), NEKTON, Coastal Oceans Research Development – Indian Ocean (Mombassa, Kenya), University of Comoros (Mvouni, Comoros), Comoros Fisheries Department, Oxford University (Oxford, United Kingdom), University of Miami.



ATAP

Acoustic Tracking Array Platform

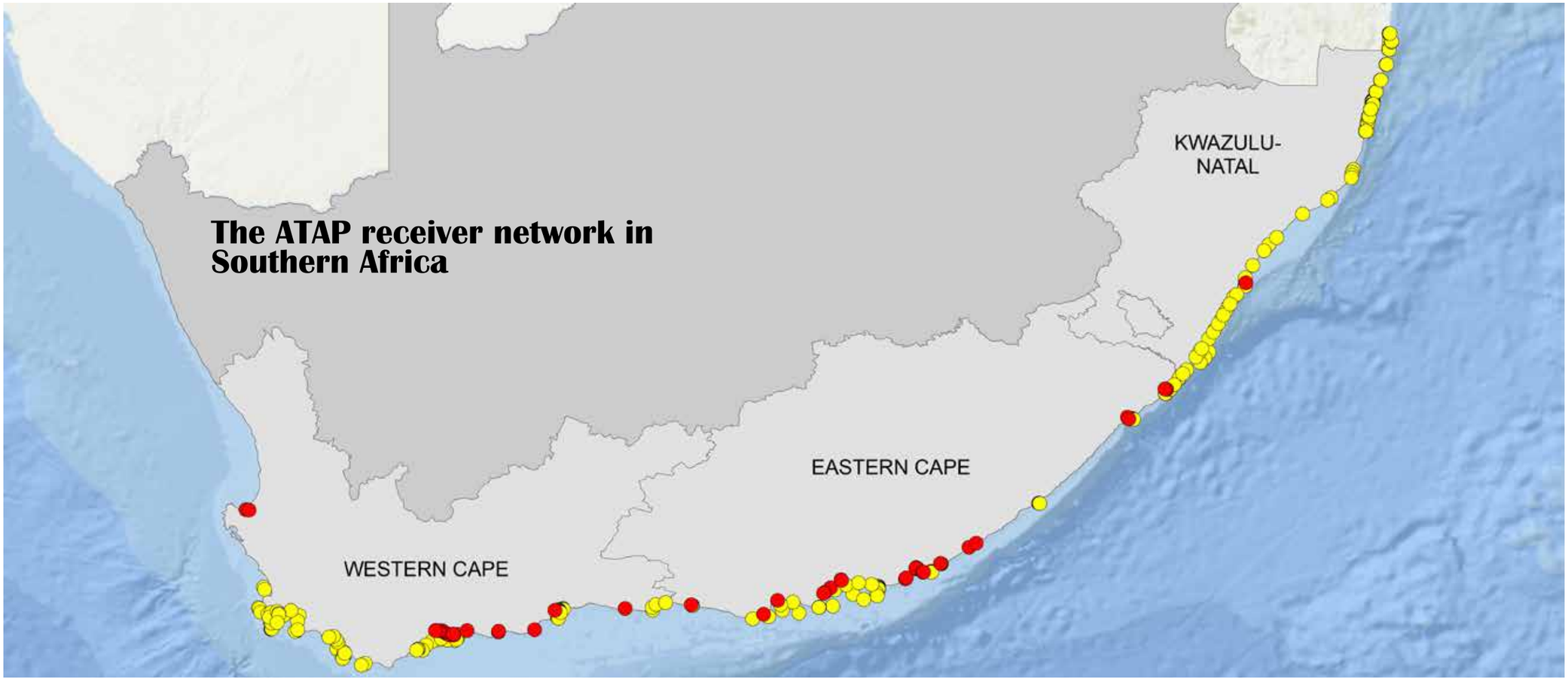
South Africa's Acoustic Tracking Array Platform, hosted by the South African Institute for Aquatic Biodiversity (NRF-SAIAB), is an infrastructure platform consisting of a receiver network spanning approximately 2 200 km of the southern African coastline with receivers deployed between False Bay (Cape Town) and Ponta do Ouro on the Mozambique border, as well as 21 estuaries throughout the region.
The ATAP, with the financial support from the African Coelacanth Ecosystem Programme (ACEP) and Save Our Seas Foundation (SOSF) to maintain the nation-wide receiver network, provides a backbone of acoustic telemetry hardware to facilitate the large-scale, long-term monitoring of acoustically-tagged marine animals. Currently the ATAP provides support to no less than 58 individuals (including 12 post-graduate students) from 27 different organizations. The design of the current large-scale array continues to allow researchers to address a number of key questions pertaining to animal movement. These include i) estuarine-marine and inter-estuary connectivity, ii) bay-scale movements, iii) movements in relation to MPA boundaries, iv) large-scale annual migrations, v) transboundary movements, and vi) a host of ecological aspects.
ATAP provided support to three ACEP projects funded between 2018 and 2020 by deploying additional receivers in each study site to increase the available listening power. Two ACEP-funded projects conducted work within marine protected areas (MPAs). The first involved investigating connectivity between MPAs in KwaZulu-Natal, where researchers from the Oceanographic Research Institute tagged catface rockcod *Epinephelus andersoni* in the Pondoland and St Lucia MPAs. The fish have been tagged with three-year lifespan transmitters therefore this project is still ongoing. To date, just over 7 000 detections have been recorded. The other MPA project is a collaborative effort between the South African Fisheries Ecology Research Laboratory (SAFER lab) of Rhodes University, ATAP and the Ocean Tracking Network, and saw red Roman *Chrysoblephus laticeps* being tagged in the Tsitsikamma National Park MPA. This project aimed to answer questions associated with fisheries-induced evolution on fish physiology, with the aim of assessing the influence fishing pressure has on the behaviour and activity of this species at different temperatures. Overall, almost one and a half million detections have been recorded for red Roman, the second-most for any ATAP-monitored species (after dusky kob *Argyrosomus japonicus*). A third ACEP-funded project, dubbed the 'Canyons Connections' project, aimed to assess the ecological role of submarine canyons on the east coast of South Africa, particularly in relation to the movements of sharks between the nearshore and these offshore canyons. To date, 19 758 detections on seven shark species have been recorded on six acoustic receivers positioned over canyons on the KZN coast.
Infrastructure and data management support is being provided 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 and MPA connectivity by selected species. To date, over 30 animals of seven different species have been tagged, with significant tagging effort planned for 2021. ATAP also supports a number of collaborative projects with international partnerships, including the OCEARCH white shark project and telemetry projects in False Bay (Dr Alison Kock), Gansbaai (Alison Towner) and Mossel Bay (Dr Enrico Gennari).
Besides the ACEP-funded projects, ATAP supports other projects within several southern African MPAs. These include an ongoing project in the De Hoop Marine Protected Area, which aims to evaluate the efficacy of the De Hoop Marine Protected Area for endemic and threatened shark species, including puffadder shyshark (*Haploblepharus edwardsii*), dark shyshark (*H. pictus*), leopard catshark (*Poroderma pantherinum*), pyjama catshark (*P. africanum*) and smooth hammerhead shark (*Sphyrna zygaena*). Another

MPA-related project is investigating the movement behaviour of giant trevally *Caranx ignobilis* in the Mtentu Estuary (part of the Pondoland MPA) and their connectivity with surrounding areas, including their known spawning aggregation site in Mozambique. SAIAB's research on estuarine-associated fishery species has also expanded its objectives by deploying six receivers in the De Hoop MPA to assess connectivity between the MPA and the neighbouring Breede Estuary. This project is starting to reveal some interesting movements, for example, two white steenbras tagged in De Hoop MPA were recorded moving approximately 500 km east, being detected on receivers deployed in St Francis Bay. This is in keeping with behaviour observed by Bennett (2012), where steenbras conventionally tagged in the De Hoop MPA (using plastic dart tags), while moving an average distance of only 33.5 km, moved a maximum distance of 620 km to Algoa Bay.

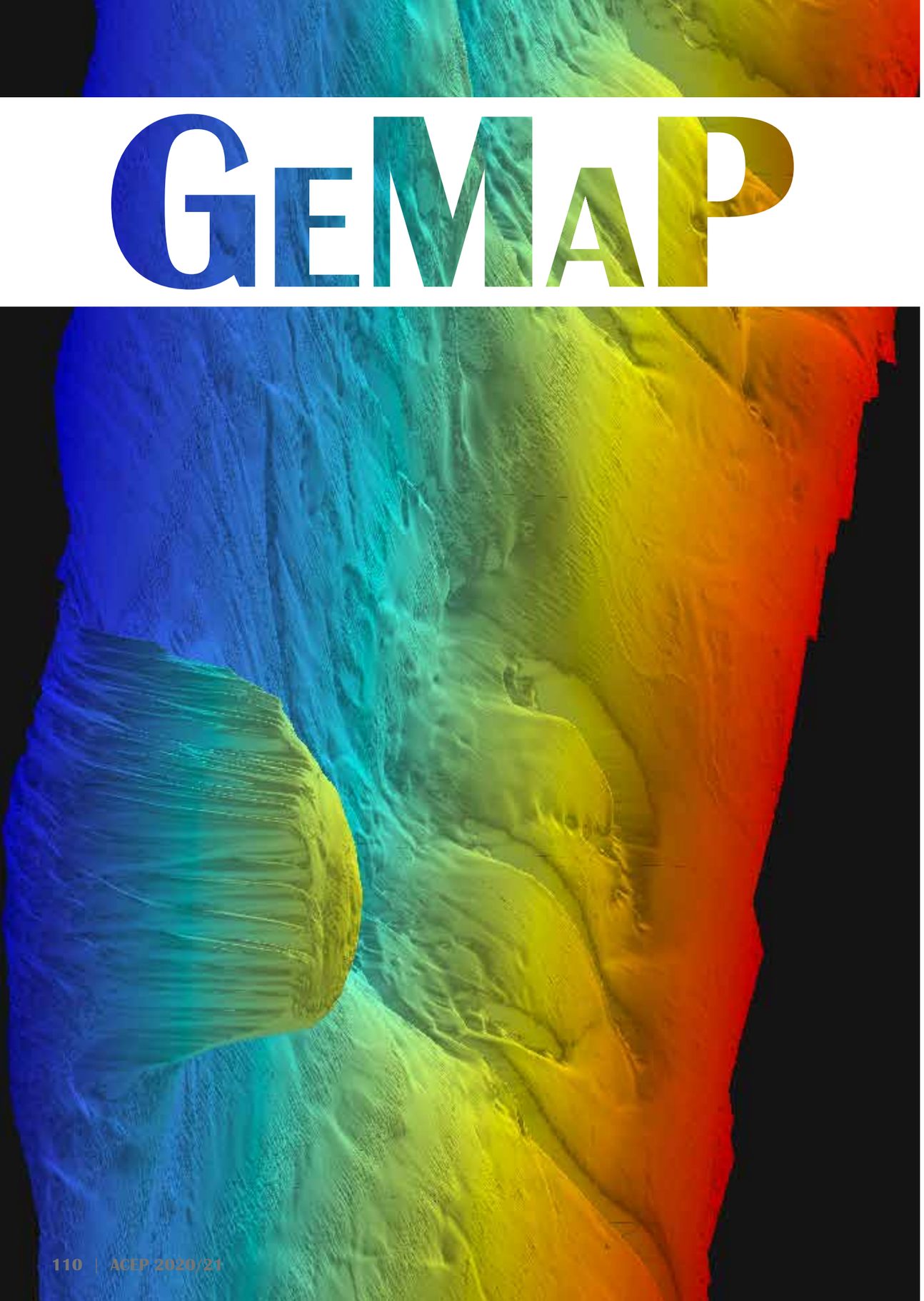
Other noteworthy projects include a study initiated in 2016 by SAIAB in the Breede Estuary aimed at understanding the movement patterns of large adult dusky kob throughout their South African distribution. The findings to date suggest these large fish are far more range restricted than previously believed, which has major implications for their management. This species is currently managed as a single well-mixed stock; therefore, this information has the potential to significantly improve the management of this threatened species in South Africa. Telemetry research at the border of South Africa and Mozambique has also achieved great successes and on a recent fieldtrip the research team tagged the 100th animal at this study site in the Partial Marine Reserve at Ponta do Ouro. This study aims to evaluate trans-boundary movements and interactions between a number of top predators (sharks and reef fish). Flagship species which have been tagged with long-life transmitters include bull sharks *Carcharhinus leucas*, tiger sharks *Galeocerdo cuvier* and giant trevally *C. ignobilis*.

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 in available, information on the movement behaviour for almost all rays is largely unknown. Collaborative research over the last five years have seen 92 animals from four species, namely duckbill rays *Aetomylaeus bovinus* (n = 25), blue stingrays *Dasyatis chrysonota* (n = 27), diamond rays *Gymnura natalensis* (n = 34) and eagle rays *Myliobatis aquila* (n = 6), equipped with long-life acoustic transmitters. Dr Chantel Elston, who is currently a postdoctoral fellow at SAIAB, is busy analysing the ray data collected over the last five years and these results should be published over the next two years.

Besides its primary role of supporting scientific research, the ATAP also engages with the public in many different ways, including via social media, which, due to the global pandemic, became increasingly used in 2020. The ATAP continues to have a strong online presence, with a steady increase in the number of followers across all social media platforms. Our Facebook page (ATAP – Tracking fish movements) currently has 1640 follows, our Twitter account (@ATAP_ZA) has 938 followers and our Instagram page (@atap_za) has 438 followers. While social media accounts seem trivial, it is one of the quickest means of disseminating information and gaining support for various tagging projects. The majority of the interactions across the platforms is positive, with members of the public, particularly the angling community, enjoying and engaging with posts where examples of movements of various species is provided. We aim to increase our reach in 2021.



The ATAP receiver network in Southern Africa



Geophysics and Mapping Platform (GeMaP)

The Geophysics and Mapping Platform comprises a Teledyne Reson SeaBat 7101 extended range multibeam echosounder (MBES), Teledyne Reson top-side data acquisition computer, Supermicro processing computer and 2021 HYPACK Max software suit including HYSWEEP. A Navsight Apogee inertial navigation system from SBG is used for all motion and position corrections. The motion and position data are post-processed using SBG Qinertia software. Sound velocity profiles are captured using a Teledyne Digi-bar S SVP. All data backed up on a Redundant Array of Independent Disks, an external harddrive archive, and the in the "Cloud". The complete MBES system has been mobilised on CC uKwabelana for extensive testing out of Durban in 2020 ahead of high-impact bathymetric surveys in 2021.

The GeMaP supported data collection for the ACEP "Canyon Connections" project. These data are currently being processed and interpreted by the Geophysics and Remote Sensing Unit of the Council for Geoscience and Mr Hlanganani Shange, an MSc student at Nelson Mandela University. This research documents the geological evolution and sedimentary context of submarine canyons on the Pondoland continental shelf. The preliminary bathymetric chart was crucial in visualising the seafloor morphology to allow efficient planning of sub-bottom survey transects within the region. The sub-bottom survey will be completed in 2021 and provide vertical context describing the stratigraphic evolution over time.

During the platfroms 2020 testing phase, the GeMaP has collected over 20 km^2 of nearshore bathymetry data (-10 -- -50 m) which has been integrated into "Multi-Benth", a multi-disciplinary project which seeks to classify nearshore habitat, describe nearshore geomorphology and processes, and provide the basis for wave climate modelling to assess coastal vulnerability to coastal hazards (coastal erosion, loss of infrastructure). The goal is to contribute meaningfully to several SDG's (Life below water, Sustainable cities and communities, Life on land) using one core data set. This research is in collaboration with the Oceanographic Research Institute, University of Sterling, University of Kwazulu Natal Coastal Engineering and the eThekwini Costal Engineering Department.

Through various interactions GeMaP is associated with support to several institutes, including: Oceanographic Research Institute, Council for Geoscience, South African National Biodiversity Institute, University of KwaZulu Natal, Nelson Mandela University, Wildlands Conservation Trust: Wild Oceans, University of Stirling, University of Zululand, and eThekwini Municipality. This support is in the form of practical and technical assistance for existing projects, and in planning of future projects. Outreach and engagement activities planned for 2020 were postponed due to Covid-19 restrictions; these will be re-visited once practicable.

GeMaP
sounding the depths

Conclusion & way forward

ACEP performed well in the 2020–21 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 2018–20 ACEP Open Call is supporting four multi-disciplinary projects, is fully subscribed and highly active (60 researchers and 25 students); 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 (96 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. The next phase will continue to offer the four key platforms: Open Call, Marine Platforms, *Phuhlisa*, and Science Awareness (Outreach). 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. 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.

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 60 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)
- › 120 submerged base stations between Cape Town and Ponta do Ouro
- National ATAP database

GeMaP - Geophysics and Mapping Platform
- Multibeam sonar

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

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

During the period 2018–2021, 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 and WSU
- Summer School
- WildOceans Ocean Stewards

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
- 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 Siseko Benya
- Prof. Paul Cowley
- Mr Ryan Palmer
- Mr Koos Smith
- Mr Matt Parkinson
- Dr Errol Wiles
- Dr Anthony Bernard
- Dr Taryn Murray
- Mr Thor Eriksen
- Ms Roxanne Juby

ACEP *Phuhlisa* Team
- Mr Garth van Heerden
- Mr Ferdy Jacobs
- 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 Environment Forestry and Fisheries
- Dr Kim Prochazka
- Mr Ashley Naidoo
- Mr Marcel van der Berg

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

ACEP Statistics

Phuhilsa **2020**

100
students supported

nineteen
supervisors

ACEP funded
113
students
in total in 2020
95% black

4
open call projects
2018-2020

225
peer-reviewed publications

ACEP PUBLICATIONS

New ACEP Publications from 2020

ACEP has produced total of 190 peer reviewed papers before 2020. These publications specifically acknowledge ACEP and include publications that only benefitted from ACEP funding.

Adams LA, Maneveldt GW, Green A, Kerenyi N, Parker D, Samaai T, Kerwath S. 2020. Rhodolith bed discovered off South African coast. *Diversity* **2020,** 12, 125.

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ACRONYMNS &ABBREVIATIONS

AAPG	American Association of Petroleum Geologists
AASA	Aquaculture Association of South Africa
ACEP	African Coelacanth Ecosystem Programme
ADCP	Acoustic Doppler Current Profiler
APL	Average Path Length
ATAP	Acoustic Tracking Array Platform
BO2A	Benthic Annelid Amphipod Index
BRUV	Baited Remote Underwater Video
BUS	Benguela Upwelling System
CECs	Contaminants of emerging Concern
CGS	Council for Geoscience
CMT	Centroid Moment Tensor
CPUT	Cape Peninsula University of Technology
CROCO	Coastal and Regional Ocean COmmunity
CSIR	Council for Scientific and Industrial Research
CTD	Conductivity, Temperature and Depth
D:H	Detrivory:herbivory ratio
DEFF	Department of Environment, Forestry & Fisheries
DMRE	Department of Mineral Resources and Energy
DSI	Department of Science & Innovation
DWS	Department of Water and Sanitation
EBSAs	Ecological and Biological Significant Areas
EcoQs	ecological quality status
EDX	Energy Dispersive X-Ray
enaR	ecosystem network analysis R
ENMs	Engineered Nanomaterials
FAO	Food and Agricultural Organisation
FCU	Finn Cycling Index
GDP	Gross Domestic Product
GIS	Geographic Information Systems
GPS	Global Positioning System
HDI	Historically Disadvantaged Universities
IMTA	Integrated Multi-Trophic Aquaculture
IRD	Institut de Recherche pour le Développement
ITS	Internal transcribed spacer
IUCN	International Union for Conservation of Nature
JMLP	Joint Marine Lab Programme
KDD	Kelp Derived Detritus
KZN	KwaZulu-Natal
KZNSB	KwaZulu-Natal Sharks Board
MCS	Mpondoland Continental Shelf
MIRAI	Macro Invertebrate Response Assessment Index
MLD	Mixed Layer Depth
MPA	Marine Protected Area
MTL	Mean Trophic Level
NBA	National Biodiversity Assessment
NDSI	Normalised Difference Salinity Index
NMR	Nuclear Magnetic Resonance
NMU	Nelson Mandela University
NRF	National Research Foundation
ORI	Oceanographic Research Institute
PAH	Polycyclic Aromatic Hydrocarbon
PetroSA	Petroleum Agency of South Africa
POM	Particulate Organic Matter
ROV	Remotely Operated Vehicle
RS	Remote Sensing
SAEON	South African Environment Observation Network
SAIAB	South African Institute of Aquatic Biodiversity
SAMSS	South African Marine Science Symposium
SANBI	South African National Biodiversity Institute
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 & Coastal Research Infrastructure
SNP	single-nucleotide polymorphism
SPE	Solid-phase extraction chromatography
SST	Sea Surface Temperature
SURG	Southern Underwater Research Group
TSS	Total Suspended Solids
UCT	University of Cape Town
UJ	University of Johannesburg
UKZN	University of KwaZulu-Natal
UFH	University of Fort Hare
UTR	Underwater Temperature Recorder
UWC	University of the Western Cape
UNIZUL	University of Zululand
VME	Vulnerable Marine Ecosystem
WRC	Water Research Commission
WSU	Walter Sisulu University
XRD	X-ray Diffraction

South African Institute for Aquatic Biodiversity
Somerset Street, Private Bag 1015, Makhanda, 6140
Eastern Cape, South Africa
www.saiab.ac.za, email: saiab@saiab.ac.za
Tel: +27 46 603 5800

Report design and layout by Rosanne Palmer


ACEP