

REPORT



**AFRICAN COELACANTH
ECOSYSTEM PROGRAMME**

PROJECT OVERVIEWS 2022/23

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

Key contributing partners include:

National Research Foundation - Human and Infrastructure Capacity Development Programme (NRF-HICD)

South African Environmental Observation Network (SAEON)

Department of Forestry, Fisheries & Environment (DFFE)

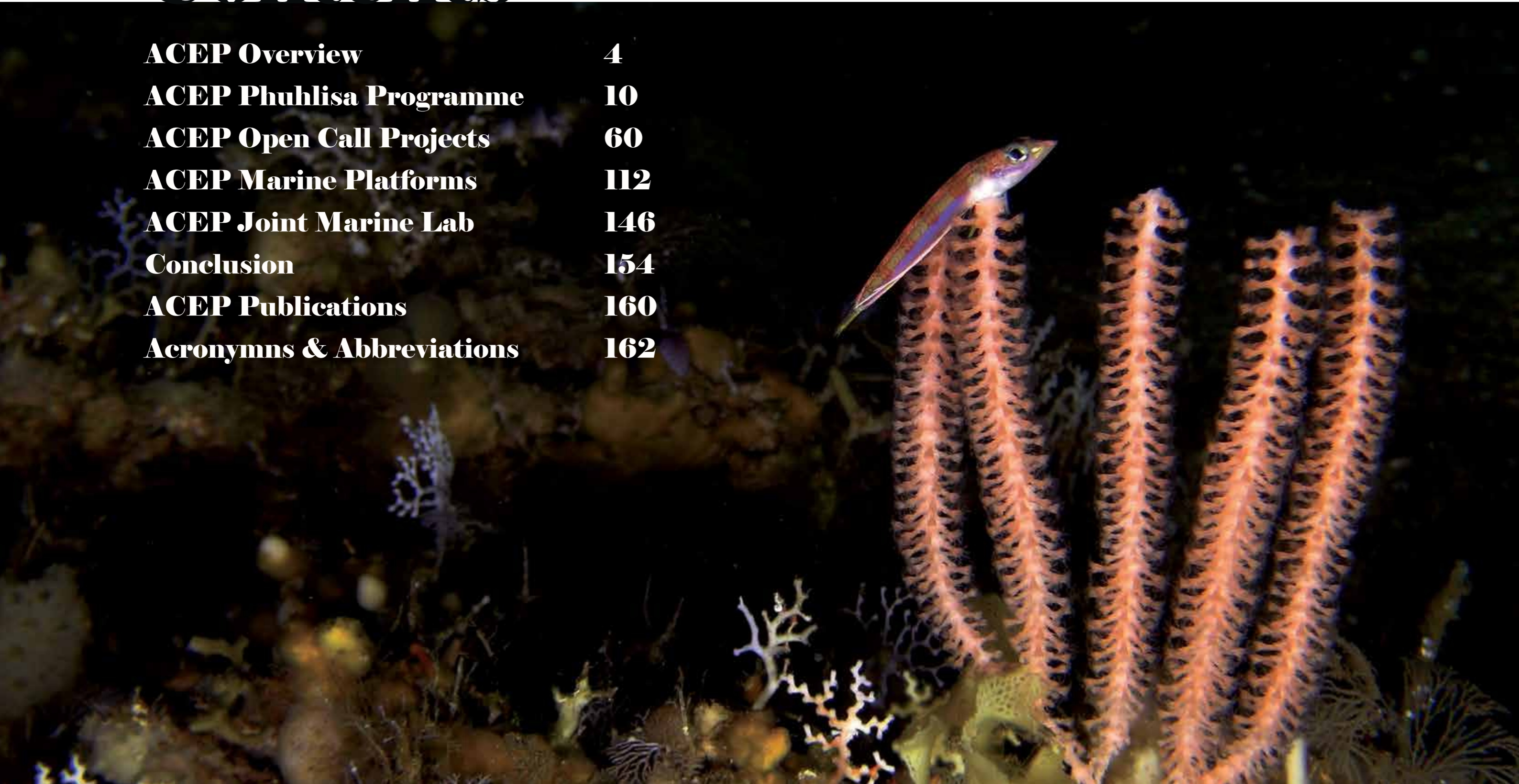
National Research Foundation - Knowledge Fields Development (NRF-KFD)

Shallow Marine & Coastal Research Infrastructure (SMCRI)



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ACEP Overview

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

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

The overarching aim of the ACEP is to drive sustainable development in the Blue Economy to better the lives of all South Africans.

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). The DSI Decadal plan specifically speaks to the development of capacity at 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 orientated around providing scientific input around decision making and innovation within the Blue Economy.

ACEP Joint Marine Laboratories Programme: This aims to build research capacity at HDIs through the establishment and support of specialized laboratories at the partner universities. The laboratories were all selected to answer key challenges faced by South Africans. Currently laboratories have been set up and are operational at the University of Fort Hare (UFH), the University of the Western Cape (UWC), while laboratories at the University of Zululand (UNIZUL) and Walter Sisulu University (WSU) are being set up.

University of the Western Cape – Pollution: Micro-plastics laboratory (Dr Anusha Rajkaran)

University of Zululand – Pollution: Marine and estuarine ecotoxicology (Dr Ntuthuko Masikane)

University of Fort Hare – Innovation: Bio-discovery (Prof. Graeme Bradley)

Walter Sisulu University – Livelihoods: Rural Livelihood and Food Security (Dr Tembinkosi Steven Dlaza)

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

Marine Remote Imagery Platform – MARIP (SAIAB)

Acoustic Tracking Array Platform – ATAP (SAIAB)

Coastal Craft Platform (SAIAB)

Geophysics and Mapping Platform- GeMaP (SAIAB)

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

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

ACEP Phuhlisa Programme

At the beginning of 2016, the DSI requested the ACEP Phuhlisa Programme extend support from University of Fort Hare and Walter Sisulu University to include the University of Zululand and University of the Western Cape. Subsequent to this expansion, the programme now supports 19 supervisors and 64 postgraduate students, and has resulted in marine science developing rapidly at the universities. This is testament to how a directed instrument, such as the ACEP Phuhlisa Programme, can drive transformation. The programme has numerous research disciplines, including marine biology, estuarine ecology, marine geology, marine microbiology, and marine biochemistry.

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

ACEP Open Call Research

The 2022/23 year has seen ACEP support four Open Call research projects. The new projects have a strong focus on management of the marine environment and Climate change. The four projects being supported for 2021-2023 are:

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

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

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

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

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

Research output from this and previous ACEP open calls continues to grow, reflecting the

high standard of the research being achieved. Nineteen new peer-reviewed articles were published in 2022, 68% of which were first authored by researchers from designated groups. Many more publications are expected to come from this and previous phases of the programme.

ACEP Joint Marine Laboratories Programme

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

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

ACEP Marine Platform Provision

A key facet of ACEP is the provision of research infrastructure to the NSI. Not only does the platform provide infrastructure, but skilled instrument technicians and instrument scientists who are capable of providing both technical, scientific and academic support. High 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*. Furthermore, with investment from SMCRI, the platform is expanding its reach into the deep-sea.

Marine Remote Imagery Platform – The MARIP hosts the ROV, the Stereo-Baited Remote Underwater Video (SBRUV) systems, a benthic drop-camera (dropCAM) for photographing benthic macro-fauna assemblages, and a deep-water BRUV Lander capable of operating to 1500 m. The ROV team conducted expedition field trips to East London, Algoa Bay and Sodwana Bay supporting the ACEP Deep Forests and Agulhas Bank Connections Projects, as well as the Rhodes University Marine Natural Products Programme. The platform is managed by Dr Anthony Bernard, who also supervises postgraduate students and trains them in the use of the equipment and associated analysis software. Dr Bernard also represents MARIP on several national, regional and international working groups, including the Marine Ecosystem Committee, the National Marine Biodiversity Working Group, the GOOS EcoBio panel and is co-chair on the SCOR CoNCENSUS working group.

Acoustic Tracking Array Platform – ATAP expanded its reach significantly and now has 16 major coastal sites and 22 estuarine sites, comprising 148 listening stations, between Cape Point and Ponta do Ouro. ATAP's manager, Dr Taryn Murray serves as a member of the international OTN Data Management Committee. Tracking marine animals and in particular fish is pivotal in the understanding of key line fish stocks and the impact of climate change on South Africa's fisheries. ATAP now also includes the largest array of underwater temperature recorders deeper than 10m. This data feeds directly into SAEONs National Temperature Database.

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

the SAEON Sentinel Site and the SAIAB ATAP, GeMaP, and MARIP which are serviced on a regular basis by the Coastal Craft.

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

Geophysics and Mapping Platform – The platform provides a new dimension for marine science in South Africa. The platform comprises a RESON SeaBat 7101 multibeam echosounder and mini sound velocity profiler, a Teledyne Digibar S sound velocity profiler, RESON SeaBat 7101 control and data acquisition PC, a Full HYPACK license and dongle for data acquisition and processing, SBG Apogee Inertial Navigation System, and a high-powered processing PC. The platform is well subscribed by the 2021–23 ACEP Open Call and is supporting Marine Spatial Planning on the uThukela Bank. The ability to map the sea floor provides the base layer for all planning. This information will be used in decision making around economic activities such as oil & gas development, fisheries and mining.



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



The Phuhlisa programme, a strategic DSI transformation initiative, in line with the national imperative of equity and redress, directly builds capacity in Marine Science at Historically Disadvantaged Institutions (HDIs) accelerating transformation of the marine science research community. This is the only programme of its kind in the marine landscape in South Africa and as such critical to the transformation of this sector. 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.

Collaboration between SAIAB and four HDIs (Universities of Fort Hare, Zululand, the Western Cape, and Walter Sisulu) has resulted in a managed programme through which research platform support is provided by SAIAB to enhance research capability at these universities. The SAIAB Transformation Manager, Mr Garth van Heerden, and his office provide the professional support needed to drive the programme and ensure that high-quality research is maintained.

ACEP call further supports Phuhlisa through funding with one third of the funding ring-fenced to support marine science researchers and their students at HDIs. The programme capacitates 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.

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 HDIs. Since its inception in 2012, 383 students have graduated under ACEP Phuhlisa Programme. The expansion of support to include 4 HDIs was hugely advantageous, not only through the increased reach, but in the diversity of topics that can now be researched. The UWC focuses on biodiversity and conservation, UFH focuses a lot of research on GIS, geology and genomics. WSU focus is on rocky shores with most of the research is conducted within the nature reserves of the eastern part of Eastern Cape. UniZulu researchers continue to focus on ecotoxicology and they have benefited from capital equipment grants for research equipment in the form a digestion microwave, AA spectrometer, multi-parameter probe, a river vessel, etc. UniZulu Department of Zoology is well staffed with well rated and experienced aquatic researchers- a strength to build on. Phuhlisa is currently supporting 19 Supervisors at 4 HDIs supervising 64 postgraduate students

Access to research 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 order to address the articulation gap between students coming from a disadvantaged background, the Phuhlisa programme facilitates custom training courses to help students catch up on writing, presentation, and other research skills. Students and their researchers are provided opportunities for academic and professional development including supervisory, scientific, and life skills courses like swimming and driving lessons, skipper's and diving lessons, as well as first-aid training. This year this included Capillary Electrophoresis Fragment Training (for population genetics) at SAIAB on 25 – 28th July 2023 and Stereo BRUV Training for WSU researchers and students 31st January 2022.

Critical to the success of the programme is that we follow an HBU researcher-centered approach. We believe that this is where the greatest potential lies for capacity building. Passion and research excellence are imperative but, if South African marine science is to thrive, we must ensure that we have a representative scientific cohort. This requires dedicated and strategic transformation initiatives such as the Phuhlisa programme.



I started as a Phuhlisa supported student myself, doing Honours in 2014. I know the extent of assistance one gets from the Team Phuhlisa. Support from workshops and training to help with writing, logistics support from transportation to accommodation to the most scenic Nature Reserves in the WildCoast and funding for my Honours research. I actually met the Marine World for the first time through the Honours programme. Since then I have become a supervisor, I have also been contributing to the departmental growth and success. - Zinzisa Nokwali (WSU)

UNIZULU-NRF-SAIAB Summer School 1st – 2nd September 2022.

The summer school was developed and piloted in 2021 by staff from both SAIAB and UNIZUL Zoology Department. In 2022, the 2nd UNIZUL-NRF-SAIAB welcomed a new partner, MILE (Municipal Institute of Learning), which is eThekweni's Knowledge Hub. This summer school, which ran for two days (1-2 September), provided a unique opportunity (i.e., out-of-classroom learning experience) and this year, our postgraduate students (honours to MSc level) were introduced to marine geology, seafloor mapping and the technical side of marine research. On the first day of the summer school, the presentation by the Programme Manager at MILE (Dr. Collin Pillay) provided students with a unique insight on how government (particularly at a local or municipal level) can collaborate with, and/or absorb research knowledge in answering socioecological challenges.

This was followed by an open discussion that was mainly led by the students who raised various issues including employment opportunities, skills development (including soft and hard skills) and the importance of integrating related disciplines to increase the marketability of students in seeking employment. Students were then introduced to Marine Geology by Dr Errol Wiles from SAIAB. His lecture mainly focused on how Marine Geology can be integrated into Marine Biology, and how the integration of these two disciplines can provide a more holistic understanding of the marine ocean environment thus providing a better context of how marine organisms may cope in the marine environment.

The second day of the summer school was dedicated to the technical side of marine sciences. The importance of technical support and/or staff in marine sciences (including research assistants, general laboratory assistants, marine technicians, and skippers) is often overlooked, yet very little research can be conducted without this support. Mr. Thor Eriksen, SAIAB's Marine Technician, lectured students on various sampling equipment (e.g., nets, grabs, ACDP, CTD) and techniques based on research objectives, highlighting the importance of a good research study design. This lecture was then followed by a practical session where students completed an exercise on study design before they boarded a research vessel for a demonstration on how some of the instruments are deployed and/or used in marine research. The enthusiastic feedback from students was very encouraging and the organisers from NRF-SAIAB, MILE and UNIZUL Zoology Department were commended by students for their contribution to the success of the summer school.

NRF-SAIAB and Diplomics Collaborate for Skills Development 20th – 24th February 2023.

SAIAB (in collaboration with Diplomics), hosted a training workshop aimed at upskilling researchers interested in entering into the field of molecular biology or those that wish to refresh previously obtained skills. The 5-day training workshop began from Monday (February 20, 2023) until its successful conclusion on Friday (February 24, 2023) at the Aquatic Genomics Research Platform laboratory at SAIAB. The participating researchers were exposed to theoretical and experiential learning in the field of molecular biology and the methods associated with it.

Molecular biology is a branch of study that seeks to study and understand the composition, structure and interactions of cellular molecules. Through this study, researchers also get to understand how the molecules that determine cells determine the behaviour of living things. This was no different for the researchers that participated in this training workshop as they got to explore different methods associated with this study.

The workshop had an attendance of 10 diverse researchers from various institutions across the country, these institutions are SAIAB, UNIZUL, UFH and NUM. The workshop was facilitated by SAIAB's Instrument Scientist, Dr Gwyneth Matcher, who introduced or re-introduced the participants to theory and practical learning to this field with the focus on a

different aspect daily. The daily sessions began with theoretical learning in the morning to understand the basic concepts and the lesson would move to the lab for practical learning.

The different methods covered in DNA extraction (manual and kit-based method), Polymerase Chain Reaction (PCR), Agarose gel electrophoresis, Purifying PCR products for sequencing, Cycle sequencing (preparing samples for Sanger sequencing) and the Purification of cycle sequencing products. All these methods are set to ensure that the researchers get the most accurate results and findings.

The Southern African Marine Science Symposium (SAMSS) in Durban was well attended by 6 Phuhlisa supervisors and 44 Phuhlisa students from 4 HDIs.

Oral Presentations by Phuhlisa delegates:

Godfrey Padare; Paul Cowley; Taryn Murray; J Du Plessis; Stephen Lamberth; Lukhanyiso Vumazonke- Movement Patterns of Spotted Grunter In Relation To An Existing Estuarine Protected Area

Bantony Ziko; Paul Cowley; Taryn Murray; John Filmlater- Linking Movement- Patterns and Reproductive Biology to Assess Habitat Connectivity in Spotted Grunter *Pomadasys commersonnii*.

Sinoxolo Fiki; Motebang Nakin; Thembinkosi Dlaza- Mapping The Mangrove Snail, *Cerithidea decollata*, Distribution In Selected Wild Coast Estuaries.

Aseeqah Davids; Robin Leslie; Mark Gibbons Spatial and Ontogenetic Changes In $\Delta 15n$ and



$\Delta^{13}C$ Isotopic Signatures of Two Species of South African Dogfish.
 Sazi Fortune Nzama; Leon Vivier; Ann De Fortier- The Use of Biotic Indices to Assess the Effect of Fish-Farming In Richards Bay Harbour.
 Buyani Mazeka; Leon Vivier; An De Fortier; Hendrick Mzimela- Nematodes as Indicators of Sediment Metal Contamination: do we need to Work at Genus Level?
 Olwethu Ndabankulu; Steven Thembinkosi Dlaza- Does Protection Status, Seasons and Habitats Affect the Metal Contents in *Saccostrea cucullata* Oyster.
 Emmanuel Akanbi; Henry Njom; Graeme Bradley; Niall Vine- Isolation and Identification of Potential Probiotics From The Digestive Tract of The Short-Spined Sea Urchin (*Tripneustes gratilla*).
 Culumanco Sibotoboto; Thembinkosi Steven Dlaza; Dumisani Horatius Kali- Site and Habitat Effects On The Size and Protein Content of *Ecklonia radiata* Kelp Along The South African East Coast.
 Thembinkosi Dlaza; Dumisani Kali- Fishing Gives Insight into Socio-Ecological Linkages along the Wild Coast.

Poster Presentations by Phuhlisa Delegates

Nokubonga Mbandzi; Motebang Dominic Nakin; Adebola Oyedeji. Assessment of Heavy Metals in Macroalgae-Limpet Species and Biomagnification of These Metals along South-East Coast, South Africa.
 Sbusiso Cyril Mkhabela; HMM Mzimela; NF Masikane- Bioaccumulation of Microplastics in *Perna perna* and *Saccostrea cucullata* along the North Coast of Kwazulu-Natal.
 Olwethu Maqalekana; T.S Dlaza; H.D Kali- Brown Mussel Harvesting and Seeding at Dwesa Cwebe
 Viwe PAYA; M.D.V Nakin; O.A Oyedeji; G.M Saibu; Mervin Meyer- Cytotoxic Potential of Selected Mollusc Shell Species Against Cancer and Non-Cancerous Cells In The Wild Coast.
 Faith Masilive Mshiywa; Graeme Bradley- Cytotoxicity Profile of Red Algae Species Found Along the Coastline of the Eastern Cape Province.
 Aamirah Botha; Anusha Rajkaran- Distribution and Abundance of Microplastics in an Urban Estuary.
 Sethu Mngqotho; Thembinkosi Steven Dlaza- Effect of Protection on the Biochemical and Amino Acid Composition of *Cymbula oculus* and *Scutellasta longicosta*.
 Abigail Onomu; Matthew Slater; Niall Vine- Feeding Traits and Bioremediation Ability of The Sea Cucumber *Neostichopus grammatus* Fed Potential Aquaculture Wastes.
 Siyasanga Zoko; Motebang Nakin- Heavy Metal Concentration in Water of The Eastern Cape Coast.
 Mthokozisi Xulu; Sibusiso Mkhabela; Ntuthuko Masikane- Sensitivity of *Grandierella bonnieroides* to an Organic Contaminant SDS and Photoperiod Effect On Amphipod Survival.
 Alizwa Mdludlu; Thembinkosi Steven Dlaza- Stable Isotope Connectivity In Seaweeds and Invertebrates At Dwesa-Cwebe MPA Along The South African Wild Coast
 Masivuye Bulube; Niall Vine- The Effect of the Anesthetic Clove Oil and Ms-222 on the Sedation and Recovery of *Pseudodiaptomus hessei*.
 Bongile Langa Mngqushu; Niall Vine- The Effect of Water-Off Events on the Survival, Growth and Health of Farmed Abalone (*Haliotis midae*).
 Ziyanda Mzozo; Sanet Hugo; Niall Vine- Effect of Temperature on the Development and Settlement of the Abalone Larvae *Haliotis midae*: Considerations for Ranching and Stock Enhancement.
 Errol Wiles; Ntuthuko Masikane; Hendrick Mabutho Mduduzi Mzimela Mzimela- Estuarine Benthic Ecology and Pollution: Geospatial Context Provided By Cost-Efficient Sonar Techniques.

Aldi Nel; Niall Gordon Vine- The Effect of Photoperiod on the Diel Metabolic Rhythm of the Calanoid Copepod *Pseudodiaptomus hessei* under Culture Conditions.
 Omega Ndongeni; Thembinkosi Steven Dlaza; Motebang Vincent Nakin- Variation In $\delta^{13}C$ and $\delta^{15}N$ Isotope Signatures of Different Tissues in *Perna perna*.



Training to use the Illumina MiSeq at SAIAB

A selection of updates from Phuhlisa supervisors

Prof. Ken Liu - UFH Geology Department

Students supervised: Salmina Mokoetele (PhD), Mthulisi Mpofu (PhD), Ayabulela Pezisa (MSc), Lutho Best (MSc), Sithembele Zangqa (MSc), Afika Nyamambi (MSc).

During 2022, we continued our research projects on the geology and hydrodynamic environments along the coastal areas of Eastern Cape and Western Cape provinces. A number of postgraduate students finalised their research projects and graduated.

Dr Ntuthuko Masikane - UNIZUL Zoology Department

Students supervised: Ms Lungelo Nsibandane (MSc), Mr Murendeni Mavhungu (MSc), Mr Blessing Xulu (MSc), Ms Mbali Mthethwa (BSc Honours)

The ACEP Phuhlisa programme has been significant in the Marine Sciences at UNIZUL. Without the assistance of the programme, key support for postgraduate students would have been impossible. For example, the research of Ms Lungelo Nsibandane, who has completed her MSc with distinction, was able to show that contaminants of emerging concern are not efficiently removed by wastewater treatment works but are distributed in freshwater and estuarine ecosystems. She has presented her work at an international conference (UNESCO-IWRA).

Mr Mavhungu has also completed his study on the development of a biofloculant using a microorganism sourced from fish gut. Ms Mthethwa's research focused on the benthic macrofauna of a coastal lake that has been neglected for at least three decades and showed the importance of revisiting these important ecosystems. She is now continuing with her Master's degree in oceanography. Mr Xulu is in the final stages of his MSc, in which he is developing a chronic toxicity test using an amphipod crustacean. None of the work conducted by this team would have been successful without the logistical and bursary support of ACEP Phuhlisa.

Mr Horatius Kali - WSU Department of Biological & Environmental Sciences

Students supervised: Nelisiwe Hambile

The financial assistance we receive from Phuhlisa is immeasurable. The student finished the project in record time and graduated in May this year, thanks to the support from Phuhlisa. In addition, the vehicle we have on loan from SAIAB has made field trips possible, thanks to Garth van Heerden and Dr Angus Paterson. Currently Marine Science in our department is growing in leaps and bounds, to the extent that nine students (up from the two last year) are currently enrolled for Honours this year. From this point, there will be no turning back. I can proudly claim that the progress we have made in Marine Science in our University would never have been possible without the support from SAIAB/Phuhlisa.

Prof. Mark John Gibbons - UWC Department of Biodiversity and Conservation Biology

Students supervised: Ms Y Parker (MSc 2022- graduated), Ms C Chateau (MSc 2023- working on corrections), Mr P Sithuba (MSc 2023- thesis under examination), Mr A Rawoot (MSc in progress), Ms E Maphuti (MSc in progress)

Phuhlisa has made a very important contribution to developing capacity in Marine Sciences at UWC; less so for myself, but certainly for students and some of my younger colleagues. Apart from providing resources for staff who do not otherwise have access to funds for research, it has allowed us to run with projects that we would not otherwise have been able to because it has provided funding to support research expenses in areas outside the scope of other grants. This has allowed us to collaborate with experts that would otherwise have been impossible, for example, Lyle Vorsatz, Brandon Beukes, and Aseeqah Davids were

all co-supervised by Dr Carl van der Lingen from DFFE because their research expenses for stable isotope analyses were provided by Phuhlisa. Phuhlisa opens doors for staff to expand their skill base through collaboration, and it should allow students to develop networks of their own, accordingly.

Prof. Gavin W. Maneveldt - UWC Department of Biodiversity and Conservation Biology

Students supervised: Ms Lauryn J. Bull (Hons), Ms Nicole Okkers (MSc)

My research encompasses three thematic areas: 1) Coralline Algal Taxonomy and Systematics; 2) Marine Ecology and Conservation Biology; and 3) Integrated Aquaculture. The two students who were funded in 2022 participated in the latter two thematic areas (Marine Ecology and Conservation Biology; Integrated Aquaculture), respectively. These projects are still ongoing. Students participating in my primary research area (Coralline Algal Taxonomy and Systematics) were supported by Phuhlisa in previous years, notably the PhD studies of Courtney Puckree-Padua. Were it not for the Phuhlisa funding, the projects offered in 2022 would have been impossible to support.

Prof. Anusha Rajkaran - UWC Department of Biodiversity and Conservation Biology

Students supervised: Ayanda Zide (MSc), Kylene-Leigh Brown (MSc), Kezia Dreyer (MSc), Aamirah Botha (MSc)

Phuhlisa funding has safeguarded long-term monitoring studies (Ayanda Zide) and allowed for the development of new studies, such as the valuation of carbon stocks and associated threats at the Berg River Estuary, understanding the pollution status and indicators in mangrove-dominated estuaries of the Eastern Cape, investigating the distribution and abundance of microplastics and heavy metals in the water, sediment, and the sand prawn (*Kraussillichrius kraussi*) in the Zandvlei Estuary.

The funding has supported and enabled sampling and student training. Most significantly, the DSI/NRF-SAIAB Joint Marine Lab has led to the development of the UWC Microplastic and Coastal Research Laboratory. The main purchase was a LUMOS II compact standalone FT-IR imaging microscope which is a scientific instrument used to analyse the chemical composition of materials, such as microplastics, using Fourier-transform infrared (FT-IR) spectroscopy. The LUMOS II microscope uses a technique called imaging spectroscopy, which collects spectral data from multiple points across a sample of either sediment, water or animals. It is a high-resolution imaging system that allows visualisation of the sample at the microscopic level. <https://www.uwc.ac.za/study/research-and-innovation/news-and-events/science-uwc-lab-to-help-understand-microplastics-for-better-ecosystem>

Kylene Brown successfully submitted a thesis entitled, "Diversity and abundance of epiphytic diatoms and macrofauna associated with *Zostera capensis* in the lower reaches of the Swartkops Estuary", where the main aim was to identify the food resources (epiphytic diatoms and macrofauna) available to *Rhabdosargus holubi* in the seagrass habitat of the Swartkops. The study showed that the seagrass habitat in the lower reaches of the Swartkops Estuary provides food resources for *R. holubi*, with the composition rather than the relative abundance of these indicating nursery suitability. Epiphytic diatom and macrofauna food resources were available during all seasons (with considerable variation in the abundance of individual taxa), showing seasonal consistency in resource availability. The presence of epiphytic diatoms and macrofauna in all seasons shows that this is a reliable food resource for *R. holubi* as well as for other juveniles.

Ayanda Zide successfully submitted a thesis entitled, "Understanding mangrove dynamics in range edge populations in South Africa", with the aim of assessing the genetic connectivity of two mangrove species, namely *Bruguiera gymnorhiza* and *Rhizophora mucronata*, to assess

the sediment and porewater characteristics of three mangrove estuaries in the Eastern Cape, using long-term monitoring data and to assess the population performance of *Avicennia marina* populations at the range edge. This study presented evidence that the range-edge populations require conservation priority, not only because of their location, but also for their performance and genetic diversity. It is necessary for more effort and implementation of strategies to protect, especially, the smaller mangrove forests. However, the larger mangrove forests also require safeguarding as they could act as source populations of propagules for the smaller forests. All other studies are ongoing, and have enabled us to measure pollutants and microplastics in estuaries in the Eastern and Western Cape.

Dr Thembinkosi Steven Dlaza - WSU Biological & Environmental Sciences Department

Students supervised: Ncokola Zizipho Mateyisi (MSc graduated), Unathi Mankonkwanan (MSc graduated), Olwethu Ndabankulu (MSc graduated), Culumanco Sobotoboto (MSc graduated), Alizwa Mdludlu (MSc graduated), Olwethu Maqalekana (MSc), Hlumela Nkwelo (MSc), Lihle Majiyezi (MSc), Monde Ndamase (MSc), Naledi Nkohla (PhD)

The ACEP Phuhlisa programme has been vital in providing the running costs to support the sampling field trips for all the students. The Isuzu 4x4 bakkie from SAIAB has been invaluable in transporting the research equipment and students to the field. The students also managed to attend the SAMSS conference where they presented their research findings thanks to the support of the Phuhlisa programme.

The Phuhlisa programme has assisted in supervisor development through field training on using the MARIP. Supervisor training was also received through logistic support to participate in developing the South African Masters in Ocean Sciences. Through the Phuhlisa programme, funding to enhance marine science capacity within the institution was secured to buy research equipment via the Joint Marine Laboratories call.

Mr Olwethu Duna - WSU Department of Biological & Environmental Sciences

Students supervised: Zizipho Msingubala (Hons)

The financial assistance received from Phuhlisa is greatly appreciated and plays a huge role in enabling the students to conduct their research. Not only was the student assisted financially for field trips, but also with equipment, such as the vehicle we have on loan from SAIAB, thanks to Mr Garth van Heerden and Dr Angus Paterson. The student has submitted her Honours thesis for examination. Owing to issues of accreditation last year, we did not have Honours students in the Zoology department, which we corrected and, this year, we have nine, providing evidence that Marine Science in our department is growing.

Zinzisa Nokwali - WSU Biological & Environmental Sciences Department

Students supervised: Hlumela Nkwelo (Hons graduated 2020), Zamabhisi Majingo (Hons Graduated 2022), Zizipho Msingubala (Hons to graduate 2023), Summaya Mukuya Dube (Hons Graduated 2023), Akho Sunduza (Hons), Avela Madikizela (Hons), Nomfuneko Rangayi (Hons).

I started as a Phuhlisa supported student myself, doing Honours in 2014. I know the extent of assistance one gets from the Team Phuhlisa. Support from workshops and training to help with writing, logistics support from transportation to accommodation to the most scenic Nature Reserves in the WildCoast and funding for my Honours research. I actually met the Marine World for the first time through the Honours programme. Since then, my department has been gaining a lot of momentum on enrolling Honours students through the great support of ACEAP/Phuhlisa. We have been benefiting positively including increased number of outputs (graduates) from the department over the past 10 years. Since I have become a supervisor, I have also been contributing to the departmental growth and success.



Murendeni Mavhungu and Blessing Xulu grab sampling for macrofauna



A selection of Phuhlisa student reports

Macrozoobenthic community structure of Mzingazi Lake, Richards Bay

Student name: Mbali Phindile Mthethwa **Degree and university:** BSc (Hons), UNIZUL **Supervisor and affiliation:** Dr NF Masikane (UNIZUL)

Mzingazi Lake is the largest of the four freshwater coastal lakes located in Mhlathuze catchment of Zululand. It is the main source of water for Richards Bay's industries and surrounding residential areas (e.g., Meerense and Mandlazini Agri-village). It is in close proximity to the Richards Bay Harbour, yet there is limited information on the macroinvertebrates of the lake. Existing literature available is two decades old and since then, there has been significant development in the surrounding areas. The aim of this study was to conduct a baseline survey on the macrozoobenthic community of the Mzingazi Lake and identify the drivers of the community structure.

Progress: Data were collected in winter from five randomly selected sites in the southern basin. An Orion star was used to measure physico-chemical parameters of the water column of the sites. Sediment samples for faunal and physico-chemical analyses were collected using a Van-Veen grab and preserved, pending analysis. Laboratory analysis of benthos involved using dissecting and compound microscopes to identify specimens to the finest taxonomic resolution possible. Loss of ignition and granulometry were used to analyse sediment physico-chemical parameters. No major variations of the physical environment were observed between sites. The abundance of dominant taxa and assemblage patterns observed in the present study differ from those observed by previous studies. According to the multivariate analyses, the physical environment was homogenous, yet the species assemblages showed heterogeneity. Important factors driving the benthos community structure of Mzingazi Lake could not be determined. The inability to identify specific factors driving this community structure in the present study suggests the presence of unmeasured variables that warrant further investigation. Expanding the time frame and scope of research to include additional ecological factors will contribute to a more comprehensive understanding of the macrozoobenthic community dynamics in Mzingazi Lake.

The project was completed in November 2022, and officially awarded in 21 April 2023.



The effect of the anaesthetics, clove oil and MS-222, on the sedation, recovery, survival, population growth and fecundity of the calanoid copepod, *Pseudodiaptomus hessei* (Copepoda: Calanoida) under culture conditions

Student name: Masivuye Bulube **Degree and university:** MSc, UFH **Supervisor and affiliation:** Prof. Niall Vine (UFH)

Project description: Compared to current live food organisms used in aquaculture, the calanoid copepod, *P. hessei*, is smaller and has superior nutritional value. However, owing to their fast and erratic movements, manipulating and counting this species for research purposes is difficult. It is therefore necessary to sedate them so that they are easier to manipulate.

Adult *P. hessei* was exposed to clove oil and tricaine Methanesulfonate (MS-222) to determine their effect on survival, fecundity, and population density. The copepods were exposed to clove oil at 100, 150 and 200 $\mu\text{L/L}$, and to MS-222 at 300, 600, 900, 1200 and 1500 mg/L. All three concentrations of clove oil anaesthetised the copepods; however, copepods exposed to 300 mg/L of MS-222 were not fully anaesthetised.

The 150 $\mu\text{L/L}$ and the 1200 mg/L concentrations were used in the second experiment to test whether these anaesthetics have an effect on population growth and fecundity.

The results showed that the anaesthetic concentrations used had no effect on either copepod population growth or fecundity.

Progress: All field work has been completed.

Preliminary results: the goodness-of-fit tests were used for sedation time analysis instead of a chi-square test of independence because the observations were not independent since the same individuals were observed at different times, thus violating assumptions of test of independence. Instead of an ANOVA, a Kruskal-Wallis non-parametric test was used. The Kruskal-Wallis test, a non-parametric statistical test, was used to compare survival among different concentrations of anaesthetics.

Instead of using a Tukey's HSD post-hoc test to identify pairwise differences at a significance level of $p < 0.05$, a Dunn's test with a Holm correction was used. Copepod intrinsic growth did not meet the requirements of normality and therefore were compared using a Shapiro-Wilk test.

The egg sac size data were found to follow a normal distribution and were analysed using a one-way ANOVA. In cases of significant differences ($p < 0.05$), Tukey's multiple comparisons test was applied to identify specific differences between treatments.

Statistical analysis was performed using SPSS version 26, and results are presented as mean \pm standard error.

I attended the statistics workshop held from 12–16 July 2021, and the SAMSS on the 24th of June 2022.

The Department of Entomology and Zoology: Aquaculture had a zoom discussion for *Aquaculture Africa Magazine* (AAM) on 22 July 2021. The project was completed, and I graduated on the 19 May 2023.

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

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

The project seeks 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 been and can be employed for shoreline protection. Studying the soil and rock types along the coastline, their properties and ability to support engineering structures, and the geographical features and structures along the coastline may help understand the past events and background of the coastline and solve – or avoid – environmental geological concerns, particularly coastline environmental concerns. The consequences of turning a blind eye to them affects not only those residing in coastal regions, but by the entire country, as well as trading partners because coastline activities play an important role in economic growth and wealth generation. Good maintenance of the coastlines affects offshore mineral and energy resources, marine transportation (including ports and shipping), ship- and boat-building, coastal tourism and recreation, coastal real estate, research and development (oceanographic research institutions), coastal construction, restoration, maintenance and repair activities (restoration of wetlands, the building of waste treatment plants, and the dredging of harbours); without such maintenance, none of these activities can be successfully implemented.

Progress: The research proposal was written up, and presented in the Department of Geology, UFH, and was approved by the Science Faculty and Senate High Degree Committee in 2019. However the student was advised to revise the topic and make changes which started the project anew in 2021. The thesis was completed and sent out for external examination. The feedback from one external examiner has been received, and feedback from the other is awaited. Samples collected from different stations along the coastline of Port Elizabeth/Gqeberha were analysed in the UFH Geology Laboratory for mineral compositions by the scanning electron microscope (SEM) and Energy Dispersive X-Ray (EDX) for grain-shape, size and surface texture studies. Sedimentary structures and grain size parameters were used for hydrodynamic analysis.

The bivariate plot of standard deviation and skewness showed that the skewness is almost symmetrical, according to the skewness table, as skewness values ranged from 0.10 to – 0.10 phi. The same plot also showed that sediments were well sorted, as was expected, because the standard deviation and mean bivariate plot showed that the sediments were predominantly fine grained. The linear discriminate functions showed that sediments were deposited in the shallow marine environment by turbidity currents.

The sediments have a zircon-tourmaline-rutile index, indicating extremely harsh conditions. The grains of these heavy minerals are all etched in different ways, which indicates harsh conditions and reworking, as well as lengthy transportation from the source to the deposition areas. The sands comprise quartz, plus some heavy minerals such as hematite, magnetite, ilmenite and tourmaline. Grain surface textures like the V-shaped percussion marks, etch pits, and upturn steps reflect the physical and chemical erosion and precipitation history of the sands.

SAMSS 2022 was attended.





An investigation into the effect of dietary protein and fishmeal replacement in juvenile yellowtail, *Seriola lalandi* (Pisces: Carangidae) in a recirculating aquaculture system

Student name: Apelele Manjingolo **Degree and university:** MSc, UFH **Supervisor and affiliation:** Prof. Niall Vine (UFH)

The yellowtail kingfish, *Seriola lalandi*, is a carnivorous species which requires high levels (>40%) of protein in its diet, a significant portion of which comes from fishmeal. Fishmeal is usually the main ingredient in the diet formula for carnivorous fish because of its high protein content, good digestibility and balanced essential amino acid profile. The use of fishmeal in diet formulations has decreased because of high prices and short supply and aquaculturists have little alternative but to reduce the amount used or replace it with alternative suitable protein sources. This study aimed to contribute to the optimisation of protein requirements and fishmeal replacement in the diet of juvenile yellowtail in a Recirculating Aquaculture System (RAS). This study was conducted at the marine finfish farm, Kingfish Enterprises (Pty) Ltd, in the East London Industrial Development Zone (ELIDZ) in a purpose-designed RAS.

Progress: The first experiment investigated the effect of dietary protein levels on survival, growth, food conversion ratio (FCR) and health of juvenile yellowtail in a RAS. Four iso-caloric diets containing different dietary protein levels (38%, 44%, 50% and 56%) were formulated. Each diet was fed to three RAS tanks holding juvenile yellowtail (30 fish per tank) for 49 days.

Dietary protein levels did not influence survival of juvenile yellowtail. Specific growth rate (SGR) ($p=0.003$) was greater in fish fed 56% protein compared to fish fed 38% protein but there were no differences between the 56%, 50% and 44% protein diets. There were no differences in protein efficiency ratio (PER) between the four diets. The FCR decreased with increasing protein level with fish being fed the 56% protein yielding the lowest FCR (1.26) compared to fish fed 38% protein (1.76) ($p=0.003$); however, there was no difference between the 44%, 50% and 56% protein levels. The hepatocytes of fish fed high dietary lipid content (diet with 38% and 44% protein) showed large lipid vacuole zones in the cytoplasm ($p<0.001$). Body protein, ash, moisture, and lipid were not affected by different dietary protein levels. In terms of producing a diet with best growth at the lowest cost, a 44% protein diet is considered optimal for juvenile yellowtail in a RAS.

The second experiment investigated the effect of partial and full replacement of fishmeal with a mixture of alternative protein sources (chicken meal, blood meal, and soybean meal in equal proportions) that are more sustainable and less costly. Four experimental diets were formulated to be iso-nitrogenous (44% protein) and iso-caloric (19.50 Mg/Kg) as follows: 1) a control diet with fishmeal as the only protein source (which was the same formulation as the 44% diet used in the first experiment); 2) control diet in which 33% of fishmeal was replaced with the protein mixture; 3) control diet in which 67% of fishmeal was replaced with the protein mixture, and 4) control diet in which 100% of fishmeal was replaced with the protein mixture.

Different fishmeal levels in the diets did not have an effect on the survival of juvenile yellowtail. Specific growth rate (SGR) was greater for fish fed 67% and 100% fishmeal ($p=0.017$) compared to fish fed 0% fishmeal. There were, however, no differences in SGR

between fish fed 33%, 67%, and 100% fishmeal. The condition factor (CF) was significantly affected by the interaction between dietary treatment and time, with average values lower at the end of the experiment compared to the start. On day 28 ($p=0.02$) and 49 ($p=0.01$), the CF of fish fed 67% and 100% fishmeal diet differed significantly from those fed the 0% fishmeal diet, but those fed 33%, 67%, and 100% fishmeal diets did not differ from each other.

The feed conversion ratio (FCR) was significantly affected by fishmeal replacement; fish on fishmeal-containing diets showing lower FCRs than those on fishmeal-free diets ($p=0.001$). Fish fed diets containing 67% and 100% fishmeal had a lower PER (0.026) than fish fed 0% fishmeal. There were, however, no differences in PER between fish fed 33%, 67%, and 100% fishmeal. The Hepatosomatic index (HSI) was not affected by levels of fishmeal replacement in the diet. Body protein, ash, moisture, and lipids were not affected by partial or full replacement of fishmeal.

The results indicate that full replacement of fishmeal (0% diet) had the worst SGR, FCR, and PER. The remaining three diets were statistically similar, which suggests that a diet with 33% fishmeal produces as good growth, FCR and PER as 67% and 100% fishmeal diets. However, as there were also similarities in SGR and PER for the 0% and 33% fishmeal diets, it is recommended that future studies focus on the region between 33-67% to find the optimal break point for the various growth indicators.

This study has provided foundation for the formulation of yellowtail kingfish diet which is suitable for use in a RAS. The project is complete and the degree was conferred on the 19 May 2023. I attended and presented orally at the following conferences: the SAMSS conference held in Durban from 20–25 June 2022, and the AASA conference held at the University of Stellenbosch from 11–15 July 2022. I am currently writing a manuscript from my MSc thesis.



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

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

Isotopes are atoms with an equal number of protons and electrons, but a different number of neutrons. Typically, these isotopes are referred to as ratios that are articulated in the delta notation. The International Periodic Table of Elements and Isotopes (IPTEI) was generated and launched in 2011 by the International Union of Pure and Applied Chemistry (IUPAC) in order to provide knowledge about the existence and importance of isotopes of chemical elements. Isotopes are formally described as ZAE, where E is the element abbreviation, A is the atomic mass and Z is the atomic number equivalent to that of protons.

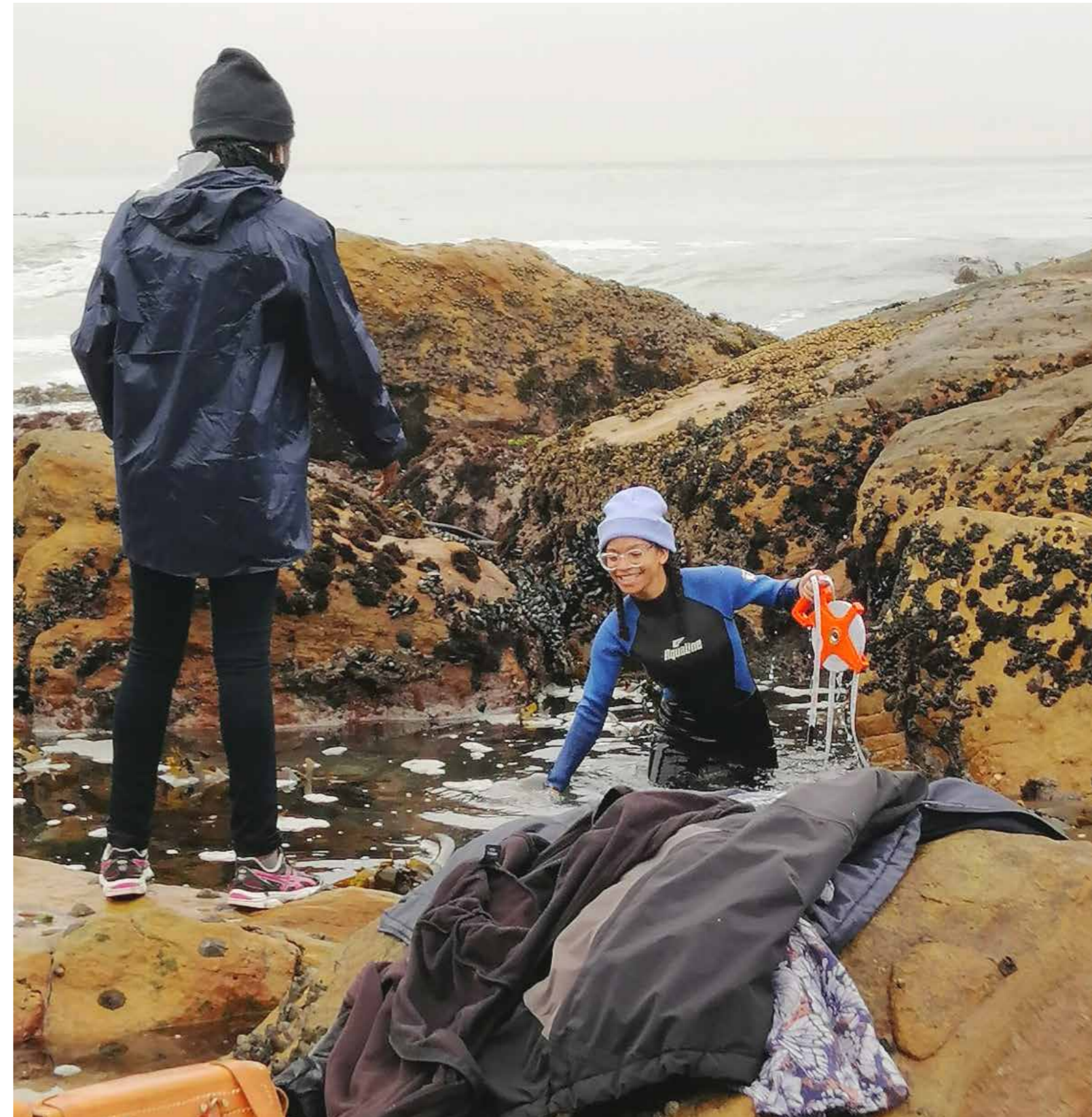
Inorganic carbon, nitrogen and phosphorus are the main elements required by seaweeds for photosynthesis and growth. During photosynthesis, nitrogen is required for photosynthetic pigment generation, while during growth, nitrate is necessary to generate the proteins necessary for active/fast growth rates. 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 because carbon plays a significant role in seaweed photosynthesis and growth in the generation of carbohydrates.

The research question was how seasonal changes influence the isotope signatures of different seaweed and invertebrate species at the Dwesa MPA rocky shore. It was predicted that if the feeding mode and seasonal difference influence seaweeds and invertebrate isotopes, then the species would display different signatures during different seasons. The null hypothesis assumed that the feeding mode and seasonal difference would not influence the isotope signature of species at Dwesa MPA rocky shores, while the alternate hypothesis stated that the feeding mode and seasonal difference would influence the isotope signature of species at Dwesa MPA rocky shores.

The aim of this project was to determine the degree of seasonal trophic relationships among the rocky shore seaweed and invertebrate species of different feeding modes in Dwesa MPA. The main objective of was to quantify and compare the seasonal variations in nitrogen ($\delta^{15}\text{N}$) and carbon ($\delta^{13}\text{C}$) isotope ratios of different algal and invertebrate species across two habitats.

Progress: The summer season field sampling and collection at five sites, Mnyameni, Silaka Nature Reserve (Port St John's), Mthatha mouth, Coffee Bay, and Qolora was done at the beginning of October 2020. By the end of October 2020, sample preparation had been completed in the laboratory. The interesting part to date are observations of the difference in rock formation, the growth of vegetation and how *Gelidium pristoides* is laid out on various substrates from rock to oysters and barnacles in the sites. Because the machines for analysis of stable isotopes at the Ithemba laboratories were broken, few changes were made to results of the dissertation.

Departmental presentations served to report on progress. Seminars from RAVAC and the research office were attended, as well as a writing workshop conducted at WSU. I was fortunate to attend the SAMMS 2022 and have the opportunity to go to SEAmester 2022. The project has been completed and graduation took place on 9 May 2023.





Sethu Mngqotho doing the biochemical analysis of mussels and oyster

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

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

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

There has been growing concern about the increasing population and industrial developments along the coasts. In South Africa, approximately 30% of the population lives along the coastline and 63 licensed pipelines discharge about 800 000 m³ of effluent into South African waters on a daily basis.

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

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

The aim of this study is to determine the levels of selected organic and inorganic pollutants in the water and sediment of Thukela beach, Mvoti Estuary and Sheffield Beach; to

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

Progress: Sediments, water and mussel samples were collected from Thukela Beach, Mvoti Estuary, and Sheffield Beach during high and low flows. Metals and PAHs have been analysed in water, sediment and tissues of brown mussels. The three biomarkers were also analysed in the mantle tissues of mussels from three systems. Sheffield Beach is known for its pristine environment; surprisingly, the concentrations observed in this study ranged along those recorded in Mvoti Estuary and Thukela Beach. I presented a poster of my metal concentration and acetylcholinesterase activity results at the South African Marine Science Symposium (SAMSS 2022). At present, I am editing the first draft of my MSc dissertation and expect to graduate in May 2024.

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

Student name: Lungelo Nsibande **Degree and university:** MSc **Supervisor and affiliation:** Dr NF Masikane (UNIZUL), Mr HMM Mzimela (UNIZUL) and Dr M Thwala (CSIR)

Rivers, estuaries and oceans are exposed to a cocktail of pollutants, including contaminants of emerging concern (CECs). This study aimed to examine the extent of contamination and/or pollution of selected CECs in the uMhlathuze and uThukela River estuaries, following the source-to-sea approach. Microplastics, organic pollutants, engineered nanomaterials (ENMs) and metals were analysed in surface water samples, and the accumulation of metals and biomarker response (acetylcholinesterase enzyme) were examined in the mud crabs, *Chiromantes eulimene*. A student's t-test was performed to compare seasonal microplastic abundance.

One-way ANOVA was used to determine the significant difference in microplastic abundance between sites, and compare total metal concentration in *C. eulimene*. Principal component analysis (PCA) was used to explore the relationship between the total concentrations of metal in water samples and crabs. A variety of pharmaceuticals and lifestyle drugs (58 compounds), pesticides (27 compounds), microplastics (fibres and films), and inorganic metals (Al, Cr, Cu, Fe, Mn, Ni, Pb, Si, Ti, and Zn) were detected in both river systems. Additionally, bioaccumulation of metals was detected in *Chiromantes eulimene*. Overall, for both river systems, the highest detection frequency and concentration of CECs were downstream of WWTP's effluent discharge points, indicating that WWTP effluent is a notable point source of CECs in water resources, whereas industrial and agricultural activities in the respective catchments were potentially diffuse sources of the contaminants.



Progress Project completed, Graduation date April 2023. The results were presented at local and international conferences and workshops. A manuscript was submitted to the journal for publication.

Conference presentations

- Nsibande LR, Masikane N, Thwala M, Mzimela HMM. 2019. "Exposure assessment of organics in the uMhlathuze and uThukela River-Estuary, KwaZulu-Natal". Second Africa Conference in Health Effects of Endocrine Disruptors: Sustainable Approaches to Healthy African Communities approaching at a rapid pace. Future Africa on the University of Pretoria's Hatfield Campus, Pretoria. Poster presentation.
- Nsibande LR, Masikane N, Thwala M, Mzimela HMM. 2021. "Exposure assessment of microplastic contamination in surface waters of uMhlathuze and uThukela River Estuary, KwaZulu-Natal". The opportunities of crisis: resilience and change in the 21st Century Symposium. Theme: Public health. Faculty of Science, Agriculture and Engineering Virtual Symposium. University of Zululand main campus. Oral presentation.

Publications

- Occurrence of contaminants of emerging concern in the uMhlathuze and uThukela river systems, KwaZulu Natal, South Africa. Status: submitted.

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

Student name: S'khumbuzo Lungisani Ndwandwe **Degree and university:** MSc, UNIZUL
Supervisor and affiliation: Mrs SN Mpanza, Mr HMM Mzimela (UNIZUL)

The southern areas of the Richard Bay Estuary were designated as a sanctuary ecosystem and as a nursery ground and shelter for aquatic species. However, the area has recently been associated with high metal contamination emanating from industrial and urban activities. Many studies have been conducted on metal contamination, but since there is no specific bioindicator to monitor the health status of the estuary, it was necessary to investigate the feasibility of using *Neosarmatium africanum* as a bioindicator.

The crab was subjected to various tests to investigate changes at different levels of organisation from the individual (evaluating metal bioaccumulation in different tissues), physiology (monitoring the osmolality changes of *N. africanum* exposed to metal solution), biochemical processes (investigating the changes in Acetylcholinesterase (AChE) in *N. africanum* exposed to metal solutions). To be good bioindicator, *N. africanum* must be able to bioaccumulate metals in different tissues, and for the metals to have a significant effect on osmoregulation and AChE activity. The bioindicator will provide a better insight into bioavailability and the effect of particular contaminants on aquatic organisms in KZN estuaries. This study will be regarded as baseline information for future monitoring in the Mhlathuze catchment and elsewhere.

Progress: *N. africanum*, water, and sediment samples were seasonally collected from the Mhlathuze Estuary and analysed for concentrations of heavy metals in different tissues. Some crabs were exposed to different metal concentrations to measure the changes in physiology and biochemical processes. Both field work and experiments have been completed.

Changes in biomarkers were recorded, and the mixture of heavy metals was observed to have more effect than an individual metal. Higher concentrations of heavy metals were measured in different tissues, particularly in the carapace and pincers. We can conclude that *N. africanum* can be used as bioindicator of metal contamination in the KZN estuaries.

With the help of the Phuhliisa programme, I attended several workshops and a conference, namely, the Literature Review Workshop at SAIAB, the SAMSS symposium at Durban, the MILES workshop at Durban, and the SEAmester and R course workshop. A paper is in progress, and the project is in its final states.

The optimization of culture technology for *Ulva lancinulata*: implications for aquaculture

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

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

nutritional profile of *Ulva* in different nutrient/effluent conditions.

Progress: Four cultivation experiments were conducted, testing the effects of stocking densities, volume exchange rates, fertilisation concentrations and methods of nutrient administration on the growth, TAN uptake rates, pigmentation, and nutritional quality (micro- and macro-nutrient content, including protein, ash, fat, moisture and carbohydrates) of *Ulva lancinulata*. All data from these experiments were collected and statistically analysed and have been written up for the completion of the thesis. Thus far I have completed writing most of my chapters. I am currently in the process of finalising my discussion chapter for editorial review by my supervisors.

From January 2022–September 2023 the proximate nutritional content of all cultivated samples was analysed. The results indicated that increased flow rates result in *Ulva* that has 3% more protein, 5% less carbohydrate and 0.85% more lipids. Increased fertilization concentrations resulted in *Ulva* with 2% more protein, 4% less carbohydrate and 0.98% higher lipid contents. *U. lancinulata* cultivated under drip fertilization (compared to pulse fertilization) had 4% more protein, 1-2% less carbohydrate, and 0.1% higher lipid content. Results indicated that flow rates, fertilization conditions and methods of fertilization can have a significant impact on the macro-nutrient content of *Ulva*. This work was presented at the 33rd Congress of the Phycological Society of Southern Africa .





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

Student name: Nicole Okkers **Degree and university:** MSc, UWC **Supervisor and affiliation:** Prof. GW Maneveldt (UWC), Prof. DR Beukes (UWC), Dr B Macey (DFFE)

Aquaculture, and notably integrated multitrophic aquaculture (fish, seaweeds and invertebrates), has the potential to contribute significantly towards several key national priorities. Such priorities include rural development, increase in gross domestic product (GDP), job creation, food security, environmental sustainability, and poverty alleviation. Sustainable production within the aquaculture industry is negatively affected by disease, which prevents growth of the aquaculture sector. This reduction in growth can amount to as much as 40% of 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. Within this sector, disease outcomes are common, often caused by microbial pathogens, which may have expensive and devastating consequences for aquaculture activities. Expensive antibiotics are used as treatment, increasing the risk of outbreaks of antimicrobial resistant bacteria as well as environmental contamination.

The literature shows that *Ulva* species produce natural products that display antimicrobial activity. Importantly, natural *Ulva* products have shown resistance against pathogenic infection. The aim of this study was to determine if *U lacinulata* extracts, grown in integrated systems, produce antimicrobial activity and to identify the specific compounds responsible for the activity.

Prepared organic and aqueous extracts were tested against nine marine fish and invertebrate pathogenic micro-organisms using disk diffusion antimicrobial bioassays and Minimum Inhibitory Concentration (MIC) tests. It is hoped that this project will generate new and relevant information regarding potential biosecurity implications for South African commercial integrated aquaculture systems, as well as bioremediation benefits.

Progress: I presented my Honours project findings at the 32nd and my some of my Masters' findings at the 33rd Congress of the Phycological Society of Southern Africa (PSSA) in January 2020 and January 2023, respectively.

My Honours project served as a preliminary investigation, the results of which formed 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, *Ulva 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. During the second year, I spent time developing the methodology to complete the MIC tests. This proved a challenging task, as there were administrative issues in the lab as well as many failed trial and error attempts. Additionally, the Nuclear Magnetic Resonance (NMR) analyses of the extracts (that displayed activity with the disk diffusion method) showed some very interesting compounds that are responsible for the activity displayed. The NMR analyses showed that the ethanolic and dichloromethane-methanol extracts were the most active, confirming the potential of *Ulva lacunculata* as a source of natural antibiotics.

In my third year I completed the MIC trials and presented those results.



Assembly and Annotation of the Nuclear Genome of *G. pristoides* obtained from the Kenton-On-Sea region in South Africa

Student name: Sitha Emmanuel Ntlokwana **Degree and university:** PhD, UFH **Supervisor and affiliation:** Prof. Graeme Bradley (UFH)

The nuclear, mitochondrial, and plastid DNA constitute the three types of genomes which play interconnected roles in an organism. Genome sequencing enables researchers to understand the regulation and expression of the various genes and the proteins they encode, and it allows researchers to extract and analyse genes of interest for a variety of studies, including molecular, biotechnological, bioinformatics, and conservation and evolutionary studies.

A few genomic studies of *Rhodophytes* have been conducted, particularly in South Africa where ocean economy has been identified as an essential sector that needs to be developed to sustain economic development. The mitochondrial and plastid genome sequences of *Gelidium pristoides* have recently been sequenced and annotated by the Marine Natural Products Research Group at the University of Fort Hare, and are currently the only annotated South African *Rhodophyta* genome sequences available.

This study is a continuation of that study, and will focus on the sequencing and annotation of the *G. pristoides* nuclear genome. The sequencing and annotation of the nuclear genome will complete the genome sequencing study for *G. pristoides* and will serve as a foundation for future research projects, including genome comparison studies, gene regulation studies and identification, expression and characterisation of novel enzymes that may have medical or industrial applications. Therefore this study will generate new knowledge within the Ocean Economy Programme and provide essential information for the Marine Biotechnology and Medical Industry.

Progress: The proposal was presented to and accepted by the Faculty of Science and Agriculture, and the ethical clearance certificate was applied for and approved by the Inter-Faculty Ethics Committee (IFREC). The pre-sampling of *G. pristoides* from Kenton-on-Sea has been completed. Currently I am optimising the extraction of DNA and RNA from *G. pristoides* for genome sequencing. I attended a training workshop (Introduction to Molecular Biology) hosted by SAIAB and a Manuscript write-up workshop that was hosted by the Faculty of Science and Agriculture (UFH).



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

Student name: Ziyanda Mzozo **Degree and university:** PhD, UFH **Supervisor and affiliation:** Prof. Niall Vine (UFH)

The South African government has driven the Blue Ocean Economy to combat poverty by creating job opportunities through the Operation Phakisa project. An abalone (*Haliotis midae*) stock enhancement project has the potential to rehabilitate and enhance the natural stock and secure sustainable harvests which will significantly contribute to the social development, revenue, and long-term sustainability of rural communities along the coastal line 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 rate and early survival which varies between 2% to 10% per seeding. Seeding abalone larvae requires understanding factors that are important in increasing settlement and early survival. The study aimed to better understand the factors which enhance settlement and early survival of *H. midae* larvae.

Investigation involves determining the effect of temperature on the development and settlement of abalone larvae (*H. midae*) for abalone hatchery management and stock enhancement. To identify hatchery-reared larvae that have been released into the sea, the optimum dose for staining the abalone larval shell while not affecting settlement and survival is important. The optimal chemical cue is determined using potassium chloride for enhancement of larval settlement and metamorphosis. Lastly, I will assess the short-term success of seeding abalone larvae, *H. midae*, in the ocean. This information will provide a platform for potential commercial sea seeding of the species and could also be used in land-based farming hatcheries to enhance abalone settlement.

Progress: Data are in the process of being analysed. To date findings have shown that 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 outside the seeding area. Staining larvae with calcein (50 mg/L) for 48 hours produces a bright, long-lasting marker on the shell of juveniles, making it easier to identify marked *H. midae* among wild abalone. Higher settlement occurred with larvae exposed to 10 mM potassium chloride and diatom (swimming) for 24 hours. I plan to submit by the end of 2023.

Publications:

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

Mzozo ZB, Hugo S, & Niall GV. (in press). The use of chemical and biological cues in enhancing the larval settlement of abalone (*Haliotis midae*): Implication for hatcheries and ocean ranching. *Journal of the World Aquaculture Society*.

Mzozo ZB, and Niall GV. 2023. Staining of larval abalone (*Haliotis midae*) shells using two epifluorescent dyes. *Journal of Applied Aquaculture* (with the reviewers).

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

Student name: Faith Masilive Mshiywa **Degree and university:** PhD, UFH **Supervisor and affiliation:** Prof. Graeme Bradley (UFH)

Cancer is the second leading cause of death worldwide, with breast cancer being the second most common cancer (approximately 2 million new cases diagnosed worldwide in 2018). Substantial progress has been made in recent years concerning prevention and treatment options for cancer. However, anti-cancer drugs involved in chemotherapy are cytotoxic to healthy cells and cause immunotoxicity. New anti-cancer drugs, with no or low side effects on the immune system, are essential for the pharmaceutical industry. As a result, natural compounds from macro-algae have become a substance of great importance for cancer therapy.

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 the development of anti-cancer drugs that have few or no side effects.

Progress: Phytochemicals (total phenols, flavonoids, flavanols tannins, terpenoids, alkaloids, proanthocyanidins, alkaloids and saponins) were screened for in the methanolic red algae extracts which were found to be highly cytotoxic to Human Triple-Negative Mammary Carcinoma (HCC70) breast cancer cell lines used in this study. These extracts' radical scavenging activities were determined, including the ferric reducing antioxidant power, the ABTS (2,2'-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid)) inhibition activity, and the nitric oxide and the hydrogen peroxide scavenging activity assay.

The HCC70 toxic red algae extracts were fractionated using solid-phase extraction chromatography (SPE), and the fractions obtained were tested for cytotoxicity with the resazurin assay. The dominant phytochemicals/antioxidants yielded from *Gelidium amansii* were total phenols, tannins and saponins. *G. pristoides*, on the other hand, yielded 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 H₂O₂ scavenging activity. *G. amansii* showed a higher cytotoxicity activity than *G. pristoides*. Its IC₅₀ was the lowest of all the species, which yielded a positive result for cytotoxicity. The compounds responsible for this activity may be either tannins, saponins or total phenols. The single point cytotoxicity results of *G. amansii* fractions revealed high cytotoxicity from fractions 4 (80% MeOH fraction), 1 (20% MeOH fraction) and 5 (100% MeOH fraction), respectively. All fractions, except fraction 5, of *G. pristoides* were non-toxic. The HCC70 cell inhibition percentages of the *G. amansii* fractions were 85.6%, 54.4% and 48%, while *G. pristoides*' was 63.2%. Fractions were tested

for cytotoxicity and analysed using ultra performance liquid chromatography (UPLC) in order to detect the compounds responsible for cytotoxicity. Western blot assays have also been conducted to determine the apoptosis pathway in which cell death is caused by the red algae compounds from this study. A poster was presented at the 17th SAMSS in 2022.



Reservoir rock properties and shale gas potential of the Ecca Group in the Southern Karoo Basin: A case study of the newly drilled boreholes (KWV-1 and KZF-1)

Student name: Lutho Best **Degree and university:** PhD, UFH **Supervisor and affiliation:** Prof. Ken Liu (UFH)

The study investigates the reservoir rock properties and shale gas potential of the Ecca Group, Karoo Supergroup in the Southern Karoo Basin through evaluation of newly drilled boreholes (KWV-1 and KZF-1) to determine the petrological properties, depositional environments and diagenetic alterations by analysing the stratigraphic successions of the Ecca Group sediments of the well logs. Various integrated methods are used to address the maturation of organic matter in the southern Karoo Basin and to analyse the potential of shale gas in the study areas. The PhD research project titled, "Reservoir rock property and hydrocarbon potential in the southern Karoo Basin in South Africa", not only has scientific importance, but also economic significance. The southern Karoo Basin of South Africa holds a large volume of black shales which occur in the Prince Albert, White Hill and Collingham Formations where shale gas could be hosted. Like black shales in the USA and China, shale gas had been found worldwide in many countries. Through detailed geological research, we hope shale gas could also be found in the southern Karoo Basin from the Western Cape to Eastern Cape provinces which have a lithological background and geological environment similar to that of the USA and China. The study involves the collection of rock samples and geological data, and the measurement of borehole cores in the Council for Geoscience in Pretoria. The methods of the study comprise laboratory analysis work, including microscope petrology, XRF, XRD, SEM and EDX analyses of rock and mineral samples, and a review of previous reports and publications.

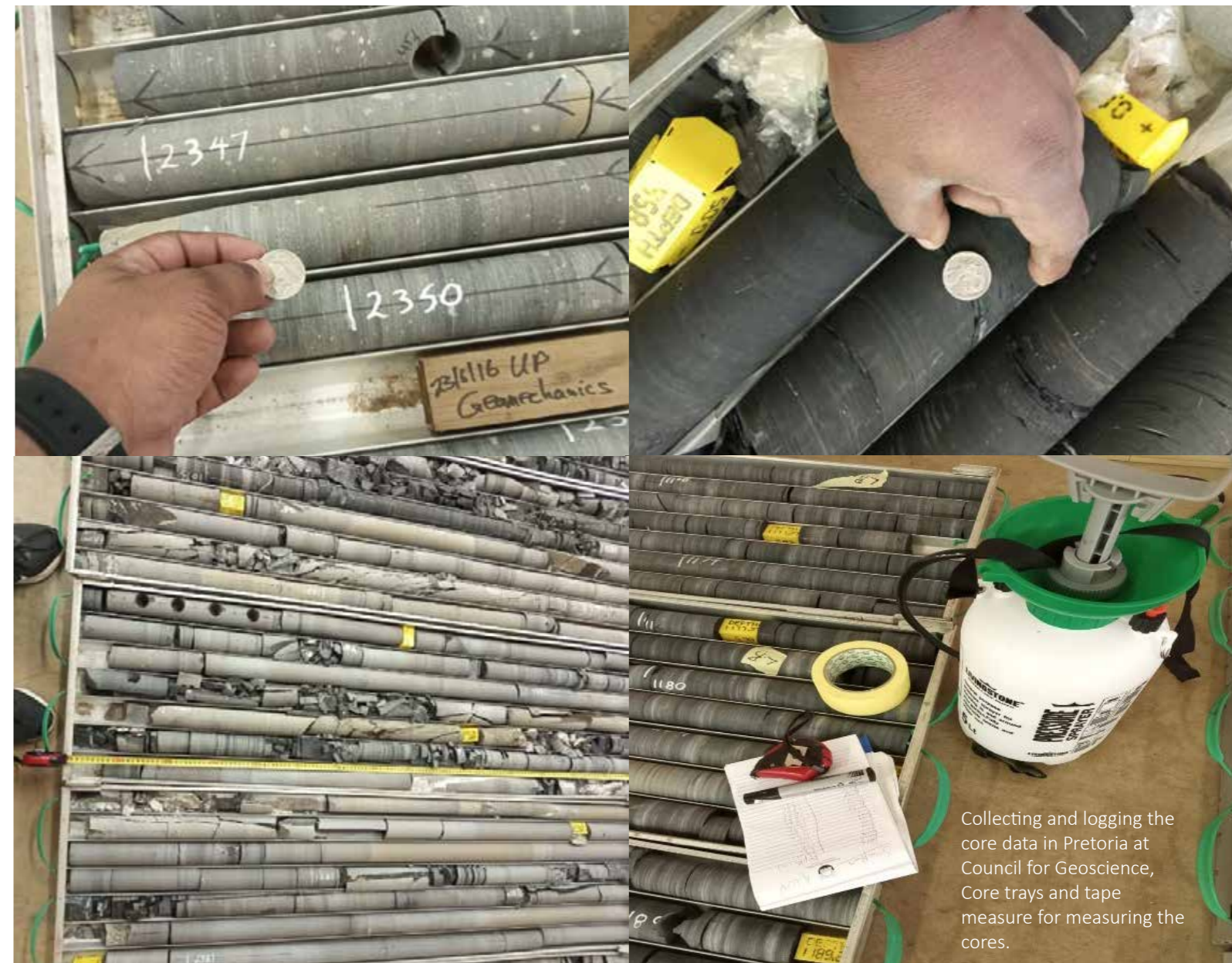
Thin sections will be prepared and analysed using a petrographic light microscope. Authigenic and detrital minerals are identified by their optical properties under cross and plane polarised light. Petrological textures of identified minerals are studied in order to discover the mineral composition and rock types. The smooth samples are mounted on a 26 mm x 46 mm glass microscope slide using Struers specific resin mixed with Struers specific-40 curing agent in the ratio 5:2 by weight. They are left for 48 hours before being microscopically examined, the minerals observed and recorded, and the pictures taken. This work will be carried out done in August to September 2023.

Mineral compositions of the shales, mudstones and sandstones will be determined by XRD, while major and trace element geochemistry will be determined by XRF. Both XRD and XRF will be sent to the South African laboratory responsible for XRD and XRF analysis. In this study, a number of trace elements of the geochemistry of the sandstones and shales will be used to determine the provenance and tectonic setting of the Main Karoo Basin. This work will be carried out from October to December 2023.

Total organic carbon (TOC) content is determined first, to screen the samples before they are sent to different laboratories for vitrinite reflectance (Ro) and Rock-Eval analyses. Outcrop samples of shale presumed to be rich in organic matter are collected from the Ecca Group and borehole logs, and tested for TOC content. Outcrop samples of shale are weighed into clean crucibles and demineralised by adding 10% hydrochloric acid and distilled water to halt the reaction. The acid is then removed using a filtration apparatus fitted to a glass microfibre filter. The samples are dried in an oven at about 50 °C for 24 hours. The dried samples are weighed and placed in the muffle furnace at a temperature of

650 °C, then removed, cooled down and re-weighed to determine their TOC. The samples will be sent to CGS or Mintek, and the work will be done between January and May 2023.

Progress: The proposal for this project was written and presented in the Department of Geology at UFH in February 2023, and has been approved by the Higher Degree Committee of the Faculty of Science and Senate Higher Degree Committee. The literature review, which will become a chapter of the PhD dissertation, was carried out between April to December 2022. May 2023 – a field trip to the Council for Geoscience in Pretoria to collect the data and samples in the research area. The stratigraphy was done between May and June 2023. Forty (40) samples were collected in the field trip and will be analysed and sent out for geochemical analysis.



Collecting and logging the core data in Pretoria at Council for Geoscience, Core trays and tape measure for measuring the cores.



Isolation, identification, screening and efficacy of potential probiotics from wild and cultured short-spine urchin *Tripneustes gratilla* for urchin aquaculture

Student name: Olufemi Emmanuel Akanbi **Degree and university:** PhD, UFH **Supervisor and affiliation:** Prof. Niall Vine (UFH)

The short-spined urchin, *Tripneustes gratilla*, is a fast-growing, shallow water echinoid, occurring throughout the waters of the tropical Indo-Pacific. The species produces large gonads with excellent market acceptance and is one of the most commercially important sea urchin species in countries such as Japan. High demand has led to overfishing of natural populations, prompting many countries, including South Africa, to explore the possibility of sea urchin aquaculture. With the increasing intensification and commercialisation of aquaculture production, mass mortality during the larval stages (usually associated to the presence of opportunistic pathogens) is a major problem in the aquaculture industry. With increasing demand for environment-friendly aquaculture, the use of alternatives such as probiotics is now widely accepted. The aim of the study is to isolate, identify, screen, and test the efficacy of potential probiotics from the short-spine urchin, *T. gratilla*, that could be used as potential probiotics in urchin aquaculture. This study will serve as a guideline for isolating and screening potential probiotics candidates for aquaculture applications.

Progress: Chapter 2, titled "16S rDNA-based metagenomics analysis of the digestive tract associated microbiota of the collector sea urchin, *Tripneustes gratilla*: Insight into the identification of candidate probiotics" has been completed and will be submitted to the journal, *Applied and Environmental Microbiology*, before the end of September. Chapter 3, titled "Isolation, screening, and identification of potential probiotics from the digestive tract of the collector sea urchin, *Tripneustes gratilla*" has been completed. Chapter 4, titled "Qualitative and quantitative screening of protease and amylase production from candidate probiotic bacteria isolated from the digestive tract of the collector sea urchin (*Tripneustes gratilla*)" has been completed. Experiments for the final *in vivo* chapter of this study was completed at KingFish Enterprises and the chapter titled "Assessing the effects of probiotics on sea urchin (*Tripneustes gratilla*) larvae: a promising approach for enhanced growth and survival" is being written up. Data for this chapter are being analysed and the chapter should be finished before the end of October. The final thesis write-up is being drafted and should be submitted to external examiners before the end of the year. Results from this study were presented as oral presentations at the Southern African Marine Science Symposium (20–24 June 2022) as well as the Aquaculture Society of Southern Africa Conference (11–14 July 2022).

Macrofaunal communities associated with *Ecklonia radiata* holdfast along the southeast coast of South Africa

Student name: Nkohla Naledi **Degree and university:** PhD, WSU **Supervisor and affiliation:** Dr Dlaza (WSU)

The current work comes at a time when both marine botanists and zoologists in South Africa are experiencing challenges in their fields in the face of climate change which seems to be modifying the marine environment. A recent range expansion of the historically west



coast-restricted brown algae (*Ecklonia maxima*) towards the east coast provides glimpses of the modification of the marine environment. This is of concern to both marine botanists and zoologists, since the colonisation of new areas by species is known to alter the native communities, alter the biodiversity indices, change the predator-prey relationships and could lead to local extinction of native species due to enhanced competition for resources.

To be able to anticipate such changes, there is need for baseline data, especially for areas susceptible to colonisation by *E. maxima*, for example, the primary substrate currently dominated by *E. radiata*. Although much work has been done on *E. maxima*, *Macrocystis pyrifera* and *Laminaria pallida* on the west coast, the *E. radiata* on the east coast has been neglected. Lack of data on this kelp makes them poorly considered in conservation planning due to the undermined ecosystem services it provides. The present study is part of a bigger project that seeks to unravel the ecological and economic importance of the *E. radiata*, as the habitat, food source, and a dispersing medium. The specific questions we attempt to answer in this PhD work are: What are the invertebrate communities linked to this kelp? How do the kelp holdfast-associated invertebrate assemblages vary spatially and temporally? Are there any specialist kelp-dwelling invertebrate species? What are the important factors affecting the kelp-invertebrates' ecological association? To answer these questions, *E. radiata* holdfast was collected from four sites across the southeast coast of South Africa. Invertebrates making up the macrofaunal community associated with kelp holdfast were identified and compared across sites and how they vary seasonally in different habitat types (rock pool vs. gully). The physical factors known to affect the kelp-invertebrate association in other studies were also investigated to identify the most important drivers of kelp-associated macrofaunal assemblages, with the intention of generalising the results. Special attention was paid to polychaete assemblages, since the group is currently under taxonomic revision.

The data generated by this research will assist the conservation planners to expand the marine protected areas network towards the sites most prone to environmental changes. The findings will also elevate the general understanding of the ecology of invertebrate communities associated with *E. radiata* holdfast. Such information will give the conservation planners reasons to see the need to protect kelp and its habitats, since these species are not only ecologically important, but also provide the food items (fish prey) to locally and commercially important rock fishes. These results can be generalised and used as an exemplary guide to similar coastal systems containing kelp. Finally, our findings will contribute to the current taxonomic revision of polychaetes of South Africa. We will describe the diversity of polychaetes associated with *E. radiata* holdfast and compare the patterns of variation seasonally in rock pool and gully habitat types. Described species will be deposited in zoo-banks, and specimens will be kept in museums.

Progress: The data for comparing spatial variation in kelp holdfast-dwelling macrofaunal communities has been sorted and analysed. The communities varied spatially; Nqabarha (the western-most site) was more species-rich than other sites, but Xhorha (the eastern-most site) contained a high number of rare species, although it was generally the least specious site. There was generally a higher community abundance in gullies than in rock pools. However, rock pools were generally more species rich than gullies. The species abundance and richness were high, between 5-100 ml holdfast volume, but decreased in holdfasts greater than 100 ml. These patterns were at least retained in all sites. When polychaetes were pulled out and analysed separately, the pattern was similar. Nqabarha will be used as a laboratory to test our hypotheses. The project will require seasonal comparison of holdfast-associated community structure under controlled conditions in Nqabarha for the validation of results. The experiment will continue for the winter-spring-

summer season. Thus, the expected final submission of the whole thesis is early 2024.

In 2023, I attended the Global Change Conference hosted by the University of Free State where I presented a paper: "Physical factors affecting the trophic composition of macrofauna associated with kelp holdfast". At the International Polychaete Conference 13 hosted by Stellenbosch University, the paper I presented was titled, "Polychaete distribution in *Ecklonia radiata* holdfast along the southeast coast of South Africa". I attended a Polychaete identification workshop (Stellenbosch University). The paper, "Polychaete distribution in *Ecklonia radiata* holdfast along the southeast coast" (Submission ID 231166070) has been submitted to the *African Journal of Marine Sciences* and is currently under review.

Effects of estuarine type on the biochemical, isotopic and heavy metal content of selected mollusc species along the Eastern Cape coast

Student name: Sethu Mnqotho **Degree and university:** PhD, WSU **Supervisor and affiliation:** Prof. MDV Nakin and Dr TS Dlaza (WSU)

Organisms within coastal marine habitats receive organic food materials from several sources: rivers, estuarine, and marine sources; as a result the composition may differ both temporarily and spatially. Estuaries are among the most productive systems in the world. They have numerous photosynthetic primary producers and act as carbon sinks. The connection between the river, estuary and the ocean is very important as it influences the productivity, nutrient transport, and nutrient utilisation between these habitats along a continuum. The dynamics of such primary productivity, carbon and heavy metal accumulation directly depends on the type of estuary. As such, the connectivity between the ocean and estuaries (i.e., estuarine type) is likely to play an important part in the availability and uptake of both biological and geochemical compounds by coastal marine organisms.

Although it has been over five decades since the pioneering works on the topic, the understanding of the concept and process of outwelling is still in its infancy. It is clear that there is a trade-off between the estuarine channel and the adjacent coastal marine habitats. There is evidence of signatures of estuarine and/or terrestrially sourced sediments and organic matter up to 6 km and 25 km across and along the shore, respectively, from the mouths of the estuaries investigated. What is still not clear, however, is how these signatures affect biota in these adjacent marine habitats. Secondly, how do different types of estuaries affect the dynamics of this trade-off and, subsequently the marine coastal biota? To answer these questions, the thesis adopted a multi-faceted and interdisciplinary approach to investigate how the type of an estuary and its connectivity affect marine sessile filter feeders. Biochemical, stable isotope and ecotoxicology techniques will be combined to investigate the effects of the connectivity between estuaries and the ocean on the marine invertebrates.

Progress: All the samples were collected successfully in 2022, and all have been processed and prepared for further analysis. The analysis for the biochemical composition, water stable isotopes (D and O¹⁸) has been completed and the data are currently being analysed. Samples for the $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ as well as the heavy metals, will be sent for analysis externally. Some of the preliminary findings were presented at the 5th Global Climate Change (GCC), conference in Bloemfontein in 2023.



Geological and geophysical investigation of the Algoa Basin, Eastern Cape Province of South Africa: implications for hydrocarbon resources

Student name: Caku Nomveliso **Degree and university:** PhD, UFH **Supervisor and affiliation:** Prof. K Liu (UFH)

The study evaluates the hydrocarbon potential of source-reservoirs in the Offshore Algoa Basin by examining offshore legacy data from the Petroleum Agency, South Africa (PASA). The Offshore Algoa Basin is a synsedimentary structure of transitional tectonism that sits on the south-eastern continental shelf margin. The Algoa Basin forms part of the Great Outeniqua Basin, which hosts oil-producing fields, and the recent substantial oil and gas discoveries made in the south off-coast region.

As part of the Outeniqua System, the offshore Algoa Basin is also considered a hydrocarbon-bearing basin. The Basin's tectonic history, chronostratigraphy, provenance, and structural developments are similar to the South African Coastal Offshore Cretaceous Basin that hosts oil-producing fields.

The study focuses on petrographic, petrophysical 2-D seismic analysis to assess the potential source-reservoirs of the offshore Algoa Basin. These aspects are used as the study's research methods to examine the implications thereof on the hydrocarbon resources within the basin.

Progress: The proposal writing and presentation, and the literature review have been completed, as has the research design (methodology). Significant progress has been made in the completion of C and Petrographic Evaluation, and rock samples have been sent for Stable Isotope Analysis at the University of Cape Town Laboratory. The expected results will be used for specific clay analysis of the potential source-reservoirs. The findings will add a novel component to the study's interpretive analysis.

The evaluations determined mineralogical and geochemical variation using thin-section and SEM-XRD analyses, which enabled inferences of developmental modifications and their impact on the potential source-quality reservoirs.

Quartz-rich sandstone facies, subarkosic and lithic, graywackes, mudrock facies, carbonate-rich bioturbated, and glauconite-rich facies were identified. These facies consist mainly of monocrystalline and polycrystalline detrital quartz, perthitic K-feldspar, matrix, and clay cement. Glauconization, feldspar dissolution, silica precipitation, calcite cement, and Fe-rich oxides with chlorite overgrowth characterise authigenesis.

The assemblage shows low-rate, shallow-depth, open-marine, anoxic deposition with burial diagenesis at increasing temperatures. Prevalent stable smectite indicates a burial zone with a temperature of $>8\text{ }^{\circ}\text{C}$. Elemental phases reflect diagenetic fluid reactions from hydrothermal, pore water, and seawater circulation. Shales, the potential source rocks, are relatively brittle and more likely to yield gas than oil. The abundance of clay reduces both porosity and permeability, reducing the potential of the reservoirs. The proportion of detrital and authigenic mineral assemblages indicates the immature argillaceous nature of the studied sediments. Immature deposits have a low-to-poor potential for hydrocarbon potential.

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

Student name: Mthulisi Mpofo **Degree and university:** PhD, UFH **Supervisor and affiliation:** Prof. K Liu (UFH)

Presently, one of the most pressing issues in South Africa is the availability and quality of groundwater as a natural resource critical for human and industry development. Based on the best estimates of current water withdrawals and supply, South Africa is overexploiting its groundwater resources at a national level, meaning that 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 too costly to tap.

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

This PhD research project started in 2020 with the main aim of investigating the quantity and quality of groundwater, the pollution and salt water intrusion in Port Alfred, on the Eastern Cape coast. 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 where seawater mixes with the freshwater zone, and the effects of groundwater flow with rock porosity.

Different techniques will be applied in the study area for a better characterisation of saltwater intrusion and a detailed knowledge of aquifer geometry by integrating geological, geochemical and geophysical data. This investigation 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.

Progress: The candidate completed his data collection in 2022. He is currently processing his laboratory and geophysical results; upon completion he will write up his thesis. Estimated submission date: December 2023. In 2023 the candidate presented his geochemical and geophysical results at two international conferences (GeoCongress and Global Change Conference).



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SALPA

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

PI: Prof. Warren Potts (RU) **Co-investigators and affiliations:** Prof. Amber Childs (RU) **Collaborators and affiliations:** Dr Romina Henriques (UP), Dr Cuen Muller (RU), Dr Matthew Farthing (RU), Prof. Clive Truemann (University of Southampton) **Students (degree):** Lauren Bailey (PhD), Xolani Nabani (MSc), Nonhle Mlotswa (MSc), Bradley Van Heerden (MSc), Caitlin Allison (MSc).

This project will advance knowledge in the field of global change and ocean science by examining the synergistic effects of anthropogenic climate change and overexploitation on our coastal fish resources by assessing how fisheries selectively affect the physiology of fishes and how this, in turn, alters the resilience of fishes to climate change stressors. It will also advance our understanding of the potential role of marine protected areas (MPAs) in maintaining the resilience of fishes to climate change impacts.

The outcomes of this project will contribute to several sustainable development goals, including reducing poverty, zero hunger, world class education, and life underwater. It will place South Africa firmly at the forefront of this area of research. At a local level, this project will give critical insight into

the efficacy of South Africa's MPA network and attempt to popularise the idea of MPAs to groups that generally oppose them (e.g., recreational anglers).

Capacity development is central to the advancement of knowledge in our society and will be a central theme of this project as postgraduate students will be the lead researchers, supported by their respective supervisors, on each of the experimental projects. The project will incorporate at least five honours, five MSc students, one PhD student and a post-doctoral Fellow over the three years.

In terms of implementation, the findings from this study may have major implications for the way that we (the global community) view MPAs in adaptation planning for the impacts of climate change. The project will also provide information on the efficacy of the South African MPAs for promoting the resilience of its resident fishes as well as identify gaps in the current MPA network which can be incorporated into future MPA planning. Thus, the results of this study have the potential to significantly influence national and global legislation and policy. As MPAs will only promote resilience if there is compliance with fisheries regulations (i.e., no exploitation), the implementation of a pro-environmental approach will not only assist with general conservation goals, but will also play a role in further maintaining the climate resilience of fish populations.

Fish resources are critical for the economies of coastal communities worldwide. This study is likely to have very real and positive economic impacts via its contribution to sustainable management. The knowledge from this project could be used to enhance and maintain the resilience of fish populations to the impacts of climate change and may be critical for the livelihoods of coastal communities. By improving the resilience of fish populations and reducing the impact of climate change, we can potentially, with good management, maintain current fisheries practices in the short-term. This will allow us more time to develop alternative livelihoods, insurance policies, early warning systems, and initiate changes in fishing operations, which will be critical for the long-term sustainability of community livelihoods.

Progress: All of the milestones as stated in the original proposal have been achieved this year. Our PhD student, Lauren Bailey, completed her work on the relationship between the physiology and behaviour of fishes. She found that there was a clear link between the two and that high performance phenotypes were also the boldest and most likely to be captured by hook and line. This has major implications for our understanding of the impacts of angling on the behaviour and physiology of fish populations. She also published a review paper that used a metadata analysis to examine the link between the physiology and behaviour of fishes.

Our one MSc student, Cailin Allison, examined the long-term impacts of ocean acidification on the physiological response of juvenile red roman to a range of thermal conditions. Adults from a MPA were spawned, and the eggs were subjected to acidified ocean conditions for six months. She found that fish that were kept in acidified conditions showed improved physiological performance at thermal extremes. This was attributed to rapid natural selection during the early life stages and the high individual variability associated with individuals from an MPA. These findings suggest that offspring from fish from MPAs have the potential to adapt to the extreme conditions expected at the end of the century.

Xolani Nabani, another MSc student, compared the thermal physiology of adult red roman populations from comparable exploited and unexploited areas. Like similar previous studies, he found further evidence to support our hypothesis that MPAs hold physiologically fitter fish, and that exploitation removes these fish. He was awarded a distinction.



Nonhle Mlotshwa was also awarded a distinction for her MSc research. She compared the activity of exploited and unexploited populations of red roman in the wild using acoustic telemetry techniques. She found that fish from unexploited populations were significantly more active at thermal extremes. Not only did this finding align with those of previous studies in different sites, but it also provided further evidence to show that MPAs retain high performance fishes and that exploitation removes fish that are active at thermal extremes.

The collection and sequencing of the genetic material from fish with known physiological performance phenotypes heralds an extremely exciting component of this project, and we cannot wait for the whole genome mapping (which will happen in 2023) to gain an understanding of how hook-and-line fishing influences the genetic and evolution of fish populations. However, we have struggled to extract sufficient DNA from larval specimens (marine larvae are incredibly small), which makes the link between high physiological performance and genetics more difficult. We are trying some alternative techniques and strategies to fulfil this objective.

Our human dimension research included a detailed examination of the attitudes and perceptions of recreational anglers to MPAs. We examined the public comments by recreational anglers on the promulgation of the last round of MPAs and gained an understanding of the key areas for intervention. This information has been used to identify attitudes that we would like to change, and we are busy designing interventions in the hope of influencing these attitudes. This behavioural component will be rolled out in 2023.

Outputs:

Peer-reviewed papers:

Bailey LA, Childs A-R, James NC, Winkler AC, Potts WM. (2022). Links between behaviour and metabolic physiology in fishes in the Anthropocene. *Reviews in Fish Biology and Fisheries* 32 (2): 555–579

Muller C, Lett C, Porri F, Patrick P, Bailey D, Denis H, Barrier N, Potts WM. (2023). Coastal connectivity of an abundant inshore fish species: model-data comparison along the southern coast of South Africa. *Marine Ecology Progress Series*, DOI: <https://doi.org/10.3354/meps14272>

Conference presentations:

Kerry Sink, Shakirah Rylands, Judy Mann-Lang, Megan van der Bank, Matthew Farthing, Warren Potts. (2022). From Hindsight to Foresight: Analysis of Stakeholder Comments on the Operation Phakisa Marine Protected Areas. 17th South African Marine Science Symposium Durban, 20–24 June 2022.

Warren Potts, Amber Robyn Childs, Cuen Muller, Lauren Bailey, Murray Duncan, Alexander Winkler, Kerry-Anne Van der Walt, Michael Skeeles, Bernard Erasmus, Carla Edworthy, Nicola James. (2022). Preliminary Analysis of Environmental and Ecological Data for Future-Proofing our Coastal Fishery Species. 17th South African Marine Science Symposium Durban, 20–24 June 2022

Matthew Farthing, Warren Potts, Amber Childs, Judy Mann-Lang. (2022). The Role of Fishing Guides in Promoting Pro-Environmental Fishing Behaviours in the Recreational Angling Community. 17th South African Marine Science Symposium Durban, 20–24 June 2022

Amber-Robyn Childs, Michael Skeeles, Nonhle Mlotshwa, Alexander Winkler, Duncan Murray, Cuen Muller, Kyle Smith, Warren Potts. Impact of Exploitation on Resident Reef Fish Activity in a Thermally Variable Environment. 17th South African Marine Science Symposium Durban, 20–24 June 2022

Nonhle Mlotshwa, Warren Potts, Amber Robyn Childs, Cuen Muller, Micheal Skeeles,

Murray Duncan, Alexander Winkler. Impact of Exploitation on the Activity of a Coastal Fish during Intense Cold Temperature Extremes. 17th South African Marine Science Symposium Durban, 20–24 June 2022

Poster presentations:

Xolani Nabani, Amber Childs, Lauren Bailey, Warren Potts. Comparison of the Metabolic Physiology of Exploited and Unexploited Populations of Red Roman Fish. 17th South African Marine Science Symposium Durban, 20–24 June 2022

Cuen Muller, Warren Potts, Amber-Robyn Childs, Nicola James. Impact of Ocean Acidification on the Metabolic Performance of Early-Stage Larval Red Roman (*Chrysolephus laticeps*). 17th South African Marine Science Symposium Durban, 20–24 June 2022

Public lectures:

Amber Childs (2022). Insights into the movement behaviour of coastal fishes. Kenton Homeowners Association Estuary Care AGM, 22 Dec 2022



Warren Potts (2022) Management of coastal fish species and the role of MPAs in a changing climate. RASSPL International prizegiving, Dec 2022

Warren Potts (2022) Management of coastal fish species in a changing climate. RASSPL National prizegiving, January 2023

Students graduated:

Lauren Bailey (PhD)
Caitlin Allison (MSc)

Nonhle Mlotshwa (MSc) with distinction
Xolani Nabani (MSc) with distinction

SALPA Student Project

The link between aerobic scope and behaviour in predicting the survival of linefish, *Chrysoblephus laticeps*, under climate change

Student name: Dr Lauren Bailey Rossi **Degree and university:** PhD, RU **Supervisor and affiliation:** Prof. Warren Potts (RU), Prof. Amber Childs (RU), Prof. Nicola James (SAIAB)

Warming sea surface temperatures and ocean acidity, attributed to anthropogenic CO₂ emissions, have decreased aerobic performance in fish species with limited thermal tolerance or acid-base regulation ability. Behavioural plasticity is the primary mechanism allowing species to adapt to climate change by remaining within their thermal envelope.

Fishing-induced mortality is thought to aggravate marine environmental stressors by reducing the genetic potential and selecting for particular phenotypes, such as a broad aerobic scope or bold personality traits deemed to have high fitness potential. Although the causal link between physiological phenotypes and behavioural phenotypes is not known, an understanding of climate variability and exploitation of the novel link between behavioural plasticity and aerobic scope phenotypes is critical to predict linefish survival. To assess the vulnerability of an important linefish species, *Chrysoblephus laticeps*, this study is the first to examine how hierarchical behavioural plasticity varies with aerobic scope under changing temperatures in a fished population.

Respirometry was used to measure energy expenditure under variable temperatures to categorise high and low performance aerobic scope phenotypes, which was related to behavioural types (bold vs. timid) through a series of hierarchical behavioural tests. To determine different physiological responses among behaviour types, the plasticity of behavioural responses under temperature variability was assessed. Individuals with a broad aerobic scope were identified as the physiologically fittest individuals with the greatest resilience to thermal variability. Such individuals also had the energetic capacity for adaptive behavioural plasticity to changing temperatures. Individual variation in physiological and behavioural phenotype did determine competitive access to food resources in a climate variability scenario. Social dominance was predicted by aerobic scope, where bold high performers occupied upper dominance ranks across thermal contexts.

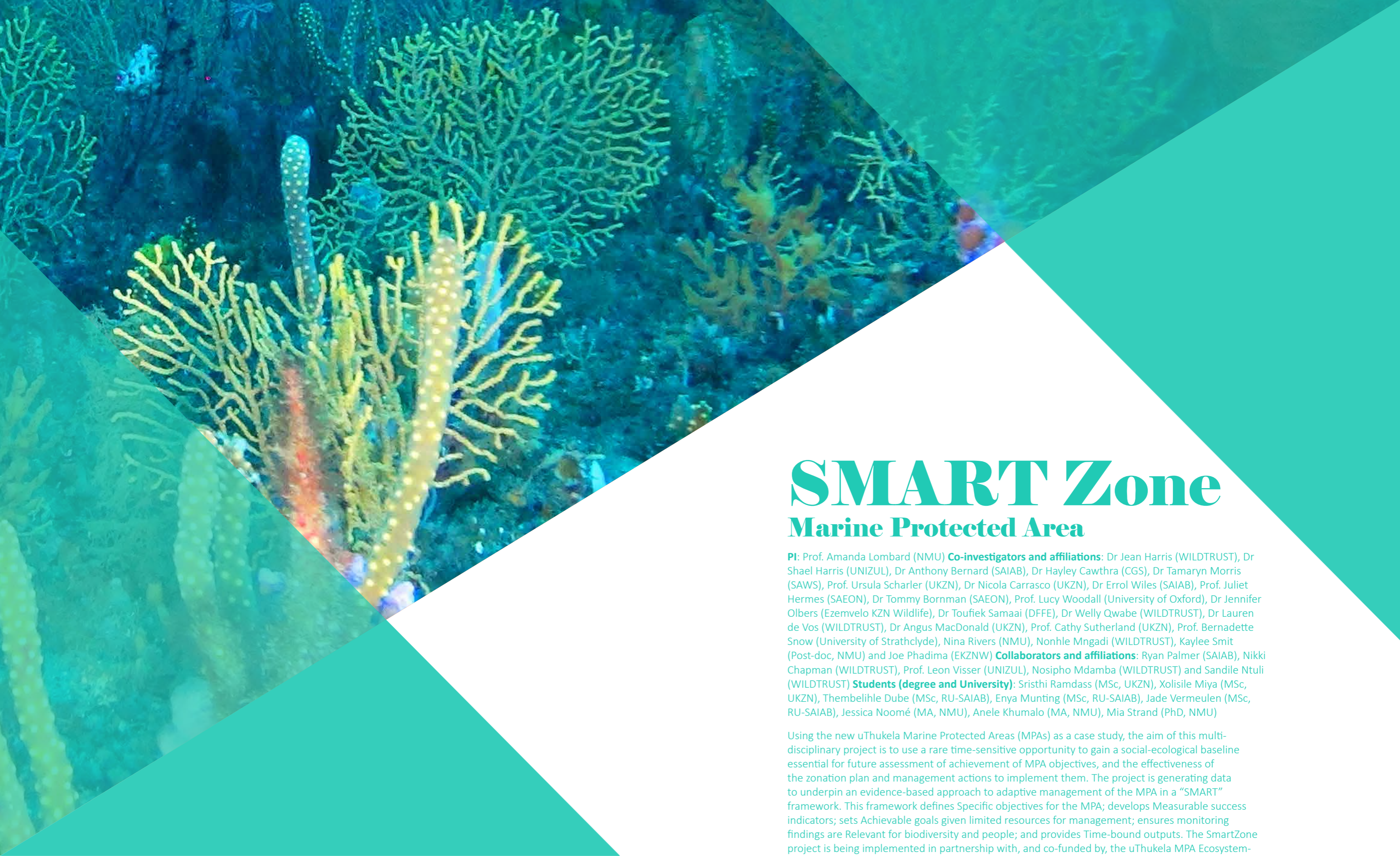
These findings emphasise the importance of the spatial protection of the fittest individuals with the aerobic capacity to respond to climate variability through behavioural plasticity. For the sustainable management of fished stocks, the offspring of these protected individuals can move into nearby fished areas and preserve the phenotypic diversity needed for social groups to respond to climate change. All research has been completed and I graduated in April 2023. I am currently writing a manuscript for publication in *Conservation Physiology*.

on how metabolic physiology can determine the adaptive capacity of marine life to climate change.

Conferences: This work has been presented at the [Southern African Marine Science Symposium, Durban, South Africa \(2022\)](#), the [World Aquaculture and Fisheries Conference in Japan \(2022\)](#) and the [South African Marine Linefish Symposium \(2019\)](#).

Publications: Bailey LA, Childs AR, James NC, Duncan MI, Winkler A, Potts WM. (in review 2020–2021). Links between behaviour and metabolic physiology in fishes in the Anthropocene. Reviews in *Fisheries and Fish Biology*.






SMART Zone

Marine Protected Area

PI: Prof. Amanda Lombard (NMU) **Co-investigators and affiliations:** Dr Jean Harris (WILDTRUST), Dr Shael Harris (UNIZUL), Dr Anthony Bernard (SAIAB), Dr Hayley Cawthra (CGS), Dr Tamaryn Morris (SAWS), Prof. Ursula Scharler (UKZN), Dr Nicola Carrasco (UKZN), Dr Errol Wiles (SAIAB), Prof. Juliet Hermes (SAEON), Dr Tommy Bornman (SAEON), Prof. Lucy Woodall (University of Oxford), Dr Jennifer Olbers (Ezemvelo KZN Wildlife), Dr Toufiek Samaai (DFFE), Dr Welly Qwabe (WILDTRUST), Dr Lauren de Vos (WILDTRUST), Dr Angus MacDonald (UKZN), Prof. Cathy Sutherland (UKZN), Prof. Bernadette Snow (University of Strathclyde), Nina Rivers (NMU), Nonhle Mngadi (WILDTRUST), Kaylee Smit (Post-doc, NMU) and Joe Phadima (EKZNW) **Collaborators and affiliations:** Ryan Palmer (SAIAB), Nikki Chapman (WILDTRUST), Prof. Leon Visser (UNIZUL), Nosipho Mdamba (WILDTRUST) and Sandile Ntuli (WILDTRUST) **Students (degree and University):** Srithi Ramdass (MSc, UKZN), Xolisile Miya (MSc, UKZN), Thembelihle Dube (MSc, RU-SAIAB), Enya Munting (MSc, RU-SAIAB), Jade Vermeulen (MSc, RU-SAIAB), Jessica Noomé (MA, NMU), Anele Khumalo (MA, NMU), Mia Strand (PhD, NMU)

Using the new uThukela Marine Protected Areas (MPAs) as a case study, the aim of this multi-disciplinary project is to use a rare time-sensitive opportunity to gain a social-ecological baseline essential for future assessment of achievement of MPA objectives, and the effectiveness of the zonation plan and management actions to implement them. The project is generating data to underpin an evidence-based approach to adaptive management of the MPA in a “SMART” framework. This framework defines Specific objectives for the MPA; develops Measurable success indicators; sets Achievable goals given limited resources for management; ensures monitoring findings are Relevant for biodiversity and people; and provides Time-bound outputs. The SmartZone project is being implemented in partnership with, and co-funded by, the uThukela MPA Ecosystem-



based Adaptation project (2022-2027) that is funded by the Blue Action Fund.

Focussing on the upper mesophotic zone (40-70m), the project team is surveying geology, benthic biodiversity, ichthyoplankton and mero-zooplankton, and fish of soft-coral and sponge-dominated reefs. The upper mesophotic reefs are targeted not only because they are priority ecosystems in the National Biodiversity Assessment (2018), but also because they lie in the only depth zone that spans all MPA management regimes and are prime reefs for line-fishing. This work will allow assessment of the zonation plan for balanced representation of reef types across management zones and outside the MPA so that analysis of future long-term monitoring results is not flawed by a priori differences due to zone boundary selection.

The MPA boundary and zonation plan are products of stakeholder consultation, notably mining, oil/gas and fishing, that modified initial proposals mainly for conservation objectives. Our balanced sampling design has initiated an “in situ experiment” that in time will allow investigation of effects of different management regimes on reef ecosystem structure and tests the value of no-take areas for fisheries support and ecosystem resilience. Notably, we are also viewing this study through a social-ecological systems lens. By active stakeholder engagement and socio-economic research parallel to ecological studies, measurable indicators will be developed for multiple objectives across different interests.

The need to understand the economic, ecological, and social benefits of MPAs is relevant in terms of South Africa’s drive for an “oceans (or blue) economy”. Demonstrating the role of MPAs as ecosystem restoration and fish recovery mechanisms, and critical climate change inhibition and mitigation assets, and local economic stimulators, is important.

This deep but luxuriant grove of black corals and sea fans at Carpenter reef is earmarked for full protection in the proposed uThukela MPA.

Progress: A focus in this second year of the project has been processing plankton and eDNA sampling conducted in 2021 using the WILDTRUST’s research vessel *RV Angra Pequena*, by the two UKZN ecology students. A follow-up cruise is planned for 2023. Sristhi Ramdass is working on her MSc degree, looking at larval fish assemblages associated with mesophotic reefs in the uThukela Banks MPA, while Xolisile Miya is conducting an eDNA evaluation of fisheries diversity. The eDNA sampling is coupled spatially with reef fish community surveys conducted using baited underwater video (SBRUVs) surveys led by SAIAB, and reef benthic biodiversity surveys (detecting cryptic and non-carnivorous fish) using SAIAB’s remotely operated vehicle (ROV) surveys that are being led by NEKTON and WILDTRUST. In addition, good progress was made with multibeam bathymetry data collection for the 14 mesophotic reef complexes (sites) was made using ACEP’s *RV uKwabelana* to guide the selection of ROV and BRUV stations (3 per reef complex). Prior to the first ROV cruise in November 2022 the multibeam data collected was processed by GeMAP (SAIAB) and this provided a base layer for operations. Previous ROV dive stations for each known reef complex were added as an additional layer to support prioritisation of dive locations. Ten (10) ROV dives were conducted over four days in 2022. Unfortunately, COVID infections aboard and poor sea conditions limited the operational window. Operations were conducted on 19-20th May and 24-25th May. In addition stereo video cameras were calibrated in a local pool, to provide vertical imagery for parallel processing with the normal ROV footage. A follow-up survey to complete the ROV dive stations is planned for the first half of 2023.

A BRUV survey was conducted across the reef sites in June 2022 and achieved deployment of 130 stereo-BRUVs at 11 of the reef complex sites. These stereo-BRUVs samples collected to date have all been processed and will contribute to the MSc degrees for three students (Thembehle Dube, Enya Munting and Jade Vermeulen) that commence their studies in 2023. The 2022 fish surveys provide a baseline against which further surveys will be compared. A follow-up survey is planned for 2023. In addition to these ecological surveys, the impacts of the MPAs on the offshore boat-based commercial and recreational line-fishery are also being assessed from a social perspective. Surveys to determine perceptions of these line fishers regarding the ecological and social impacts of MPAs and their management have been initiated to support adaptive management of the entire social-ecological system in future. A series of workshops is planned with these stakeholders in 2024 to demonstrate the outcomes of the social-ecological surveys



and facilitate discussion on MPAs. Important social studies and engagements have been underway in year 2 of the project with the coastal communities and small-scale fishers at the uThukela MPA. Fieldwork for these studies was undertaken by 2 MSC students: Jessica Noomé is conducting arts-based participatory research for inclusive MPA management at uThukela banks and Anele Khumalo is investigating the socio-cultural and economic context of Iwangu in the uThukela MPA and its supplementary livelihood options. In addition, Mia Strand has focussed some of her PhD work on arts-based participatory research for more equitable ocean governance in South Africa amongst communities that live adjacent to the uThukela MPA.

Outreach activities: Science awareness for, and communication to, the youth and members of the public through social media and promotion of online science sessions/webinars has been a key activity using social platforms established by the WILDTRUST for MPAs (www.impact.co.za and [OceaniMPActSA](https://twitter.com/OceaniMPActSA) on Twitter). Furthermore, the ACEP SmartZone project and the associated uThukela MPA EbA project were featured at the 3-day in-person Oceans Stewards Science session in September 2023, attended both the new intake of 12 new 2022 Ocean Stewards as well as Ocean Stewards who joined the Fellowship over the past 7 years (now including over 130 net-worked Ocean Stewards).

SMART Zone Student Projects

Understanding socio-environmental relations of uThukela Marine Protected Area: A political ecology approach

Student: Cameron Msimelelo Gqaleni **Degree and university:** MSc, UKZN **Supervisors:** Prof. Catherine Sutherland (UKZN), Prof. Bernadette Snow (Scottish Association for Marine Sciences)

Marine and coastal environments are regarded as one of the most fruitful and productive ecosystems around the world. The ability to enjoy natural resources has a significant impact on people's life and their well-being. Marine environments are a significant part of people's daily lives, however, marine environments are still the most heavily degraded environments, hence the need for Marine Protected Areas (MPAs). Increasing development and population growth along the coast has led to an increase of activities in the oceans, putting huge pressure on the marine space. This pressure has led to concern for the sustainable management and governance of marine spaces, and MPAs have been universally declared as a potential solution. MPAs are part of a coastline or ocean that is protected specifically for the benefit of present and future generations, and nature.

Uncertainties and conflicts arise on why MPAs were developed and how they are managed. The IUCN notes that the goal of MPAs, is to conserve the biological diversity and productivity (including ecological life support systems) of the oceans. However, for this goal to be achieved, MPAs depend on the support of local fishing communities, environmental stakeholders, education, and government officials. Also, the story of coastal community exclusion is not one that is often told in the 'success' story of South African MPAs. In South Africa, coastal communities have been "conserving" resources for a long time through customary systems of governance. The focus on legislation and conservation results in social issues associated with MPAs being largely overlooked. This study then tries to fill the gap between affected parties (MPA users), decision makers, and the social environmental issues that arise because of MPAs. The research focusses on two communities (Nyembe and eNqutshini) around uThukela MPA to understand socio-environmental relations using a political ecology approach.

It has long been claimed that a better understanding of human or social dimensions of environmental issues will improve conservation. The social sciences are one important means through which researchers and practitioners can attain that better understanding. However, a lack of awareness of the scope and uncertainty about the purpose of the conservation social sciences hinders the conservation community's effective engagement with the human dimensions. Also, managing MPAs is about managing human behaviours, yet, decision making process have traditionally focused on ecological aspects, treating social as secondary.

Generally, communities around MPAs rely heavily on marine living resources for their livelihood and their access is limited due to permits. People living along the coast normally argue that they do not have permits for harvesting and lack awareness about government's decision making. This study investigates the socio-ecological relationships of two vulnerable communities that live adjacent to or in and around uThukela MPA using political ecology approach; the two communities are Nyembe and eNqutshini.

The quest for understanding socio- environmental relations of uThukela MPA at Nyembe and eNqutshini was inspired by the basis of political ecology of participatory conservation. This research, therefore investigated the power relations and social inclusion and participation of different stakeholders in the establishment and proclamation of the uThukela MPA, identified and mapped the socio-environmental relationships of the uThukela MPA in relation to the vulnerable communities living adjacent to it. More specifically the research objectives were to investigate the involvement and participation of stakeholders living adjacent to and/or using the ocean in the establishment of the uThukela MPA, to investigate public perceptions, awareness and attitudes towards the uThukela MPA of vulnerable communities living adjacent to the MPA, to investigate the significance of the marine environment in supporting the livelihoods and way of life of the communities and to investigate the costs and benefits of the implementation of climate smart agricultural projects and an environmental training hub as part of supporting the sustainability of the uThukela MPA.

Progress: To achieve the aims and objectives of this study mixed methods are being employed. Mixed methods approach involves both collecting and analysing quantitative and qualitative data. Elements of both quantitative research and qualitative research are combined in answering the research question. However, this form of research is more than simply collecting both quantitative and qualitative data; it indicates that data will be integrated, related, or mixed at some stages of this research process. The methods for data collection in this research so far include focus groups with small-scale fisheries in both communities conducted on the 27-29 of September 2022, and household surveys using questionnaires also in both communities conducted on the 27-28 of September 2022 with the help of YES interns. These data collection tools were used to understand, identified and map the socio-environmental relationships of these two communities to the uThukela MPA. These were also used to investigate public perceptions, awareness and attitudes towards the uThukela MPA. The analysis and presentation of data collected using questionnaires at Nyembe and eNqutshini is still ongoing. Data from the questionnaires has been systematically coded, captured, cleaned and currently being analysed using the Statistical Package for Social Sciences (SPSS) version 28.0. Semi-structured interviews will be conducted with stakeholders (Department of Forestry, Fisheries, and the Environment and Ezemvelo KZN Wildlife) to investigate power relations, social inclusion and participation of different stakeholders in the establishment and proclamation of the uThukela MPA.

Investigating the socio-cultural and economic context of Nqutshini in the uThukela Marine Protected Area, Kwa-Zulu Natal (KZN), and its supplementary livelihood options

Anele Rebecca Khumalo **Degree and university** MA, NMU **Supervisors and affiliation:** Dr Nina Rivers (NMU), Prof. Bernadette Snow (Scottish Association for Marine Science), Ms Mia Strand (NMU), and Prof. Catherine Sutherland (UKZN)

Coastal communities around the uThukela MPA are knowledge holders, and experts in their own right, of Indigenous and Local Knowledge Systems and practices. For successful and sustainable blue economy initiatives in Africa, it is vital to encourage the inclusivity of local coastal communities. They measure success in terms of the balance between ecological, social, and economic aspects.

In order to achieve sustainability, MPA management planning needs to consider and



implement ways that do not pose risks and difficulties to already marginalized communities. Their environmental benefits and losses also need to be taken into consideration, including how this could influence social risk and difficulties experienced by communities that impact and are impacted by MPAs. Members of communities attach their feelings and sense of belonging to the ocean and further attach tangible and intangible wellness from engaging with others and participating in certain activities in that particular place.

Understanding what people appreciate and value about their environment and why they appreciate a particular area can lead to a better understanding of possible conflicts that may arise in the context of proposed developments and can help to mitigate these conflicts if addressed early in the development process. This particularly applies to the intangible benefits that come from marine environments and ecosystems, such as cultural identity, aesthetic appreciation, personal and community competencies, learning, and empowerment. Social considerations, rather than physical or ecological elements, dictate the success (or failure) of MPAs.

Extremely little recognition has been given to indigenous and local knowledge systems (I&LKS), and this knowledge is rarely included in MPA management. It can be argued that local communities should not be denied access to their local environment that they have relied on for many years in terms of not only livelihoods but also as part of their identities. Local communities deserve to keep such freedom, which can be achieved by involving them in the co-management of the new uThukela MPA. Therefore, this study aims to better understand the social, cultural, and economic context of Nqutshini within the uThukela MPA and their supplementary livelihood options to contribute to a more evidence-based, just, and adaptive MPA management process.

Building the foundation for efficient monitoring of mesophotic fishes to support management of the uThukela Banks Marine Protected Area

Thembelihle Dube **Degree and University:** MSc, RU **Supervisors:** Dr Anthony Bernard (SAIAB), Dr Lauren De Vos (SOS)

Anthropogenic activities such as pollution, human-induced climate change, and overexploitation pose threats to marine biodiversity and the essential services provided to humans. Therefore MPAs have been implemented to mitigate anthropogenic impacts and protect marine biodiversity, ecosystems, and fisheries resources. MPAs are spatially demarcated areas zoned to restrict and control human activity and promote sustainable ecosystem management. While growing literature shows that MPAs play an important role in marine conservation, many MPAs lack suitable ecological long-term monitoring (LTM) programmes required to measure their effectiveness. For a LTM programme to be effective, it must be able to detect changes in the environment and ecosystem structure between different management zones and be cost-effective to ensure their variability in the long-term. Ecological research and monitoring are essential management requirements as they quantify the ecological response to the management measures and allow for adaptive management.

Progress: The uThukela Banks MPA is a newly established (2019) MPA in the KwaZulu-Natal province and to date there has been only limited research and monitoring. Therefore, this study aims to build the foundation for efficient monitoring of mesophotic fishes to support the management of the newly established uThukela Banks MPA. The objectives of the study are to: 1) determine how environmental variables (depth, relief, and benthic habitat)

influence the structure of demersal fish assemblages and fish diversity; 2) provide a baseline assessment of the spatial variability in fish assemblage structure and diversity among the different management zones of the uThukela Banks MPA.

The third objective is to identify key areas for long-term ecological research and an optimal sampling programme to monitor change in the fish assemblages through time. To achieve this, data on the diversity, abundance, and size structure of the mesophotic (40-190 m depth) benthic and demersal fish were collected from key reef sites within the different management zones of the uThukela Banks MPA using baited remote underwater stereo-video systems (stereo-BRUVs) in June 2022. Video Footage was analysed and processed using the EventMeasure software package (www.SeaGIS.com.au).

Results obtained from this study will be used to obtain baseline assemblage structure, conduct spatial comparisons and then design an LTM programme to allow MPA management to report on the status of fishes. Preliminary results showed considerable variation in habitat structure and fish assemblages among the different zones of the MPA. As such, a comprehensive LTM programme would need to ensure adequate sampling within all zones and over the appropriate environmental gradients, however, this might not be cost-effective or realistic in the long-term. Writing of the thesis is ongoing.

Arts-based participatory research for inclusive marine protected areas management: uThukela Banks

Jessica Noomé **Degree and University:** MA, NMU **Supervisors and Affiliation:** Ms Mia Strand (NMU), Dr Nina Rivers (One Ocean Hub), Prof. Bernadette Snow (Scottish Association for Marine Science)

Traditional and Local Knowledge Systems (TLKS) are often excluded from area-based ocean management and current management of MPAs in South Africa. This means that the knowledge and viewpoint of TLKS are overlooked, further marginalising affected communities, which is why it is crucial to identify TLKS and ensure that this knowledge informs MPA management. Adjacent local communities should be consulted to identify areas and practices that are important to them, such as places with traditional or ancestral value. Without considering the priorities and interests of local communities, MPA management may fail in their objectives of sustainable and inclusive approaches.

This shows the value of collaborative research because it allows all stakeholders to share their values and knowledge. This study, therefore, aims to identify how TLKS can be better understood and integrated with MPA management in South Africa, utilising arts-based participatory research approaches that have been found to effectively communicate different ways of knowing the world without extracting knowledge. The research works closely with community members of iWangu and Nqutshini local communities adjacent to uThukela MPA to explore how their TLKS can better be recognised in the management of the MPA.

Progress: Draft Literature Review (draft 2) and Methodology (draft 1) chapters have been developed. Fieldwork is set to commence on 3 October 2023 after receiving approval from the iNduna of Nqutshini and iWangu communities on 8 September 2023.



Larval fish assemblages associated with mesophotic reefs in the uThukela Banks MPA

Sristhi Ramdass **Degree and university:** MSc, UKZN **Supervisor and affiliation:** Dr Nicola Carrasco (UKZN), Prof. Nadine Strydom (NMU)

When considering the function and design of MPAs, it is important to take into account the larval stages of fishes that are part of the pelagic communities because the recruitment success of fishes within the MPAs can be better comprehended with an understanding of the fish larval stages that reside within them. Fish larvae are important as their density can be used in fisheries to estimate the relative size of fish populations/stocks within the area. Patterns in larval fishes' distribution also have the potential to highlight possible hatchery and nursery areas within the MPA.

This project aims to gather baseline information on the species composition, diversity and density of larval fish in the newly established uThukela MPA and to identify any notable patterns in species composition or density that may be used to inform management.

Progress: Plankton sampling was completed between Durban and Richards Bay aboard the *RV Agra Pequena* from 7–16 June 2021 at 12 of the 14 planned reef sites across the different MPA zones. Triplicate plankton tows were carried out at each site using a plankton net (500 μm mesh, 2.5 m long, 57 cm mouth diameter) equipped with a General Oceanics Model 2030R propeller-driven flowmeter, to measure sample volumes. Three stations were sampled at each of the reef sites, with triplicate samples taken from each station, resulting in a total of 111 samples for 2021. The net was deployed from the side of the boat, lowered to the seafloor, and then towed obliquely up through the water column for approximately 10–20 minutes, at an average speed of 2 $\text{m}\cdot\text{s}^{-1}$. The samples were collected between the 60 m and 80 m depth contour. Preparations for the upcoming cruise (25 July 2023 – 8 August 2023) are in place to sample the same areas sampled in 2021. Processing of the 2021 samples is currently underway, but no preliminary results are available yet.

Smartzone Tugela Banks eDNA evaluation of fisheries diversity

Xolisile Miya **Degree and university:** MSc, UKZN **Supervisor and affiliation:** Dr Nicola Carrasco (UKZN), Prof. Nadine Strydom (NMU)

MPAs have been established in order to protect marine resources, and part of the benefit provided by protected living resources is that they may provide a demographic surplus to neighbouring 'harvested' populations. Many of SA's MPAs have been established with this in mind in order to protect habitats that are productive, diverse and unique.

eDNA surveys of marine biota are a non-invasive approach to estimating the abundance of target species in inaccessible and dynamic environments. All marine organisms release DNA into their habitats in various forms (faecal matter, mucus, sloughed tissue and blood) and this provides us an opportunity to detect them. Thus, marine habitats that are traditionally difficult to access may be sampled and their diversity assessed using this highly sensitive approach without the use of remote vehicles, divers or submersibles. We have targeted reefs within the MPAs and outside of the MPAs in order to measure whether there are differences between these habitats.

Progress: Xolisile has completed her research proposal and the literature review for her MSc study which will be a product of this research. The first round of sampling is complete and the samples have been processed. eDNA has been extracted from all sampled depths



and the molecular markers chosen for this study have been amplified in all samples. Xolisile has targeted 16S ribosomal DNA and the cytochrome oxidase I region from the mitochondrion as amplicons that have extensive databases available for comparison with. The final set of samples will be/ were collected in June/July 2023 and these two data-sets may be compared between sampling trips.

Arts-based participatory research for more equitable ocean governance in South Africa

Mia Strand **Degree and university:** PhD, NMU **Supervisor and affiliation:** Dr Nina Rivers (NMU), Prof. Bernadette Snow (University of Strathclyde)

Traditional, Indigenous and local knowledge is important for how we use and care for our oceans and coasts. These knowledge systems inform how people interact with, care for and understand the environment around them. When we speak of traditional, Indigenous and local knowledge, we refer to knowledge of communities that identify with a specific area, identify as the first known inhabitants of an area, sometimes with specific cultural identities, or people living in and around a specific place. In the context of communities near the uThukela marine protected area in KwaZulu-Natal province, this can for example refer to members of the eMacambini traditional communities' knowledge, and anyone from youth to fishers, traditional healers, bait collectors and recreational ocean users like surfers, scuba divers and recreational fishers. Despite the importance of these knowledge systems, these are often excluded from how the ocean is used and managed, and this lack of recognition of realities and priorities of local communities can lead to ocean governance approaches that are limited in their scope, inclusivity and reach. The continued exclusion of traditional, Indigenous and local knowledge in ocean management is often attributed to challenges in collecting and then integrating this knowledge into ocean management. It is however not impossible, and this project has therefore been exploring the usefulness of arts-based participatory research methods in identifying more inclusive and equitable ocean management approaches.

Working with 24 local community members from Mandeni Local Municipality as co-researchers, the research process involved using photographs and recorded stories to identify and document people's personal relationship with the ocean, specific areas of cultural value and what the ocean means to them. The final photostories culminated in an exhibition and a multi-stakeholder workshop at eMacambini Traditional Authority Council in March 2023. Bringing together the co-researchers with relevant traditional authority members, national, provincial and local government representatives, non-governmental organisations and conservation authorities, the workshop aimed to identify opportunities to ensure that the priorities, interests and knowledges of co-researchers are included in the uThukela MPA management. A short video about the project can be found at <https://www.youtube.com/watch?v=m0g8dWyfTEA>, whilst a virtual exhibition of the final photostories can be found at https://www.youtube.com/watch?v=fKcg2lOe_2k.

Progress: Following successful work in Algoa Bay, the arts-based participatory research was conducted with Hwebede, Mangeza and Mhlabulo co-researchers from Mandeni Local Municipality between May 2022 and April 2023. This included seeking permission to do research with the eMacambini Traditional Authority Council and initial scoping workshops to co-develop the objectives of the research. Then, once the final 24 co-researchers were enrolled in the research, shaping workshops and training in photography and storytelling took place, before co-researchers ventured to sites of importance to them to take their photographs and record their stories. Once all the photostories had been finalised, the

team got together to analyse the emerging stories and priorities and used participatory community mapping to spatially delineate these on a map when possible. Finally, the photostories were exhibited in March 2023, followed by a multi-stakeholder workshop with relevant coastal managers and government representatives to explore how these stories can inform management of the uThukela MPA in the future. The student completed and submitted her PhD thesis in August 2023.

Marine Protected Areas for Fish and Fishers: Investigating the multidimensional effects of KwaZulu-Natal's Marine Protected Area Network on the commercial linefishing sector

Enya Munting **Degree and university:** MSc, SAIAB **Supervisor and affiliation:** Dr Ant Bernard (SAIAB)

Marine Protected Areas (MPAs) in South Africa are typically gazetted with stated objectives. Recovery of fisheries resources and sustainability is the third most stated objective and is gazetted for all KwaZulu-Natal (KZN) MPAs. Another common objective among these is maintaining cultural heritage. My master's project looks at providing a baseline from which to measure the impacts of the MPA network in KZN on the commercial linefishing sector – one of the oldest fishing sectors in the country. I measured these impacts from an ecological and social perspective for a holistic understanding. To measure ecological effectiveness, I used Baited Remote Underwater Stereo-Video (stereo-BRUVs) footage to compare fish populations inside and outside five MPAs, focusing on species found on mesophotic reefs which are important to the commercial linefishing sector. Indicators of ecological success in conservation projects are no longer enough: in the Anthropocene, we must consider humans as part of the systems we are trying to manage. MPAs are a case in point: compliance plays a disproportionate role in determining their effectiveness, and the perceptions of communities living adjacent to MPAs are strongly linked to their willingness to support and abide by such conservation initiatives. Therefore, the perceptions of commercial linefishers regarding the ecological and social impacts of MPAs and their management were gathered by means of open-ended, face-to-face interviews. Initial results indicate that most MPAs are ecologically effective with no-take areas containing more and bigger linefish species. However, the sustainability and overall effectiveness of the MPA network is compromised by insufficient and ineffective law enforcement. The future management of MPAs in KZN would benefit from greater stakeholder inclusion and better adaptive management planning.

Progress: I have collected data for both the social and ecological components of my project. I have collected and transcribed (verbatim) 22 interviews from the commercial linefishers in KZN. I have started analysing these data but have not finished, as I needed to contribute to the processing of BRUVs videos first. With the MARIP team, we collected 131 BRUVs videos both inside and outside the uThukela MPA at different management zones. This data was processed for statistical analyses and this week (26 September) we should start with our statistical analysis. For my project, the data from uThukela MPA will be supplemented with existing data from other MPAs in KZN. The rest of this year will be spent focussing on finalising the ecological chapter of my thesis, and I have applied for a 1 year extension for 2024. During this time I intend to finalise the social component and to integrate the findings from two types of knowledge that I have sought out for my final discussion chapter. I intend to submit my final draft of my thesis by the end of June 2024 and to spend the rest of the year on publishing my results.



Deep Connections

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

This project aims to build knowledge of genetic, oceanographic, ecological and socio-cultural connectivity for improved spatial biodiversity assessment, planning and management. This is being achieved by piloting novel approaches across the biodiversity value chain. Deep Connections includes a focus on the iconic coelacanth and the first dedicated South African coelacanth research expeditions since the 2005 ROV expedition that led to the acquisition of the ACEP ROV. The project is making the science easily accessible through theatre, children’s stories, a new aquarium exhibit and social learning to recognise and foster emotional connections to the ocean while increasing socio-cultural exchange and advancing research on human dimensions of MPAs.

This project contributes to nine Sustainable Development Goals. The greatest contribution is to the “Life below water” goal in terms of supporting the maintenance of marine biodiversity at the

genetic, species and ecosystem level. The genomic work on sea breams to support linefish assessments and management, and the MPA network expansion contribute to the “Zero hunger” goal in terms of long-term food security and fisheries sustainability. In alignment with the “No poverty” goal, the project is working with the Mbazwana Creative Arts Theatre Company to develop empathetheatre skills and pilot a programme to boost the local economy by diversifying marine-inspired crafts.

The project contributes to “Quality education” through postgraduate students, training, work experience, mentorship, and new ocean literacy curriculum content to support inclusive and equitable learning opportunities to reach children, students, MPA staff, communities and decision-makers. The project supports transformation through opportunities to previously disadvantaged postgraduate students and researchers, and is providing mentorship, targeted training, new teaching material, essentially contributing to the “Reduced inequalities” goal. This female-led team with three women PhD students, contributes to the “Gender equality” goal.

The social science and engagement component of the project contributes to the “Sustainable cities and communities” goal in the plans to address current gaps in spatial planning and in addressing current challenges affecting the expansion and management of the diversified benefits from MPAs. Through the co-production, mobilisation and sharing of knowledge, expertise, and technology across the multitude of local and international partnerships, this project aligns with the “Partnerships” goal.

The emotional connection to the ocean component of the project contributes to the “Good health and well-being” goal. The collection and research on deep-water sponges may contribute to drug discovery and access and benefit sharing.

Progress: The project held two successful field expeditions in 2022, conducted 82 ROV dives, discovered six new coelacanth individuals and was able to detect coelacanth DNA using an environmental DNA approach. Coelacanth No. 2 (triton) was seen 22 years after this individual was discovered in 2000, and the sightings database is contributing to a mark-recapture study (noting that coelacanths are individually marked by their natural spot patterns) that will help estimate the South African population size to inform a revised assessment and management plan for this Critically Endangered fish species.

Project work was showcased at the South African Marine Science Symposium, sharing lessons on stakeholder engagement in the context of MPA development and management, oceanographic processes affecting MPAs and the evaluation of the current MPA network. Key lessons for other countries were shared in a 2023 publication that details South Africa’s journey in MPA expansion. Some progress was made in surfacing stakeholder issues at Aliwal Shoal with Kira Erwin, Kerry Sink and Bruce Mann supporting a multi-disciplinary approach and a deep engagement with local fishers to resolve concerns about the MPA design and zonation. The government has made commitments to adjust the MPA zonation in that area to address concerns with proposed changes published for comment in a recent Government Gazette.

A coelacanth puppet was constructed by the Empatheatre team with participation from local basket weavers adjacent to the iSimangaliso MPA. The *Umkhosi Wenala* play was completed and held several showings in Mbazwana and beyond. This innovative new play is shifting perspectives and supporting an emerging new vision for the collaboration of coastal communities, knowledge-holders, rights-holders and stakeholders in spatial planning and management in the coastal and marine environment of South Africa. As such, the production is creating a more participatory decision-making space for rural youth

in KwaZulu-Natal and was among the arts-based research approaches showcased at the United Nations Decade. Similarly the *Indlela Yokuphila (The Soul’s Journey)* animation which includes collaboration from the PI of the Deep Connections project was launched (and can be seen on YouTube) and is demonstrating the interface and power of collaboration between indigenous and scientific knowledge to support inclusive ocean decision-making.

Project team members worked together with the Coastwise Project to advance the identification and mapping of Culturally Significant Areas with a publication under a development and a short film, showcased at the Marine Spatial Planning workshop.



Outputs:

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- McQuaid KA, Bridges AE, Howell KL, Gandra TB, de Souza V, Currie JC, Hogg OT, Pearman TR, Bell JB, Atkinson LJ, Baum D, Bonetti J, Carranza A, Defeo O, Furey T, Gasalla MA, Golding N, Hampton SL, Horta S, Jones DOB, Lombard AT, Manca E, Marin Y, Martin S, Mortensen P, Passadore C, Piechaud N, Sink KJ and Yool A. 2023. Broad-scale benthic habitat classification of the South Atlantic. *Progress in Oceanography*. <https://doi.org/10.1016/j.pocean.2023.103016>
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Conference presentations

- Adams L, Karenyi N, Parker D and Sink K. Between Light and Dark: Mesophotic Reef Communities and their Environmental Drivers in the Amathole Region. Oral presentation. South African Marine Science Symposium. Durban, July 2022.
- Currie J, Murillo F, Sink K, Fairweather T and Atkinson A. Mapping seabed assemblages from South Africa's demersal trawl surveys for improved management. Oral presentation. South African Marine Science Symposium. Durban, July 2022.
- Dunga L, Sink K, Bolton J, Rothman M, Lück-Vogel M, Blamey L, Desmet P. An ecosystem map and assessment of the threat status of South African Kelp Forests. Oral presentation. South African Marine Science Symposium. Durban, July 2022.
- Erwin K and Sink K. Deep connections, deep hurts and deep possibilities: a case study on participation in an MPA. Oral presentation. South African Marine Science Symposium. Durban, July 2022.
- Franken M, Sink K, Karenyi N, Atkinson L and Howell K. DeepForests: progress in the identification, scoring and mapping of VMEs in South Africa. Oral presentation. South African Marine Science Symposium. Durban, July 2022.
- Kirkman S, Mann B, Sink K, Adams R, Livingstone T, Mann-Lang J, Pfaff M, Samaai T, van der Bank M, Williams L, Branch G. Ecological effectiveness of South Africa's MPAs. Oral presentation. South African Marine Science Symposium. Durban, July 2022.
- McQuaid K, Bridges A, Howell K, Sink K, Lombard A, Borges T, Gandra R, Currie J, de Souza V, Hogg OT, Pearman TR, Bell J, Atkinson L, Baum D, Bonetti J, Carranza A, Defeo O, Gasalla MA, Golding N, Hampton S, Horta S. Tools to support marine conservation. Oral presentation. South African Marine Science Symposium. Durban, July 2022.
- Mtetandaba A, Smith ME, Van Niekerk L and Sink K. The use of satellite imagery for mapping coastal river plumes in the Marine Realm. Poster presentation. Oral presentation. South African Marine Science Symposium. Durban, July 2022.
- Oliver J, Sink K, Teske P, Mariani S and Matcher G. Using cutting-edge molecular tools to detect and monitor priority marine fishes classification of environmental variables: a predictive tool to support. Oral presentation. South African Marine Science Symposium. Durban, July 2022.
- Perschke M, Harris L, Sink K, Lombard A. Effects ecological infrastructure as a framework for including ecosystem services in systematic conservation planning. Oral presentation. South African Marine Science Symposium. Durban, July 2022.
- Sejeng C, Sink K, Halo I, Ansorge I and Braby L. Incorporating and connecting multi-scale oceanographic features in marine spatial planning and management. Oral presentation. South African Marine Science Symposium. Durban, July 2022.
- Shibe S, Sink K, Atkinson L and Carrasco N. Patterns and Drivers of Epifaunal Assemblages In Unconsolidated Outer Shelf Sediments of The Amathole Region. Oral presentation. South African Marine Science Symposium. Durban, July 2022.
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- Skein L, Sink K, Majiedt P, Van der Bank M, Shannon L. Integrated Ecosystem Assessment To Support Ecosystem-Based Management In South Africa. Oral presentation. South African Marine Science Symposium. Durban, July 2022.
- Von der Meden S, Patrick P, Van der Heever G, Wozniak D, Porri F, Atkinson L, Filander Z, Majiedt P, Levin L and Sink K. Quantifying complex biogenic habitat provided by *Thouarella Spp.* (octocorallia), and the incidence of associate taxa C. Oral presentation. South African Marine Science Symposium. Durban, July 2022.



Deep Connections Student Projects

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

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

The Amathole region includes two marine protected areas (MPAs) (Amathole MPA and Amathole Offshore MPA) within distinct areas bordered with an overarching goal: to protect and conserve marine biodiversity. This region remains one of the most diverse yet under-sampled areas on the eastern margin of South Africa. With the majority of MPAs promulgated between 1964 and 1994, the Amathole Offshore MPA is unique in that it was expanded by proclamation in May 2019 with the aim of extending protection from the coast to the shelf and slope. The current study makes use of hydrographic and biological data to evaluate the physical oceanographic features influencing the Amathole MPAs and surrounding waters. The CTD data collected during the ACEP cruise are being used to evaluate the dynamics and variability associated with the above-mentioned physical oceanographic features.

Progress: From 11–27 February, I had an opportunity to collect oceanographic data on the One Ocean Hub Capacity Development Cruise in collaboration with the African Coelacanth Ecosystem Programme (ACEP) onboard the *RV Observer*. The aim of this cruise was for emerging researchers to work together to develop multi-disciplinary skills while surveying the MPAs within the Amathole region, drawing from South Africa's insights into the deep-sea challenges and enablers (Sink et al., 2021). This potentially enhanced our knowledge and provided a better perspective of the existing limited offshore research and sampling opportunities within the Amathole region. In addition, key gaps in hydrographic and biologically relevant data in deep water were addressed, thus improving our understanding and management of sensitive offshore ecosystems. The focus of the cruise plan was to sample inside and outside the Amathole MPA and the Amathole Offshore MPA to understand physical oceanographic and biological data within this warm temperate ecoregion of southern Africa. To achieve this, hydrographic and benthic data were collected using various instruments such as the CTD (to visualise vertical structure of temperature, salinity, pH, oxygen etc.), landers (to collect biological or physical data near or at the sea floor), a cone dredge (to collect sediment samples that will be used for habitat classification) and ROV (to collect targeted specimens that will be used for DNA barcoding and metabarcoding). The focus of the study is on analysing CTD data and possibly validating this data with available model outputs. Satellite data (MODIS Aqua Level 3) will also be analysed to evaluate the chlorophyll variability in the region during the duration of the cruise. Other workshops attended include the Ocean Dynamics Workshop, University of Cape Town, South Africa; the Southern African Marine Science Symposium (SAMSS), East London, Oral Presentation; Western Boundary Current Conference Skidaway Institute of Oceanography, United States of America, Poster Presentation). The project is still in progress.

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

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

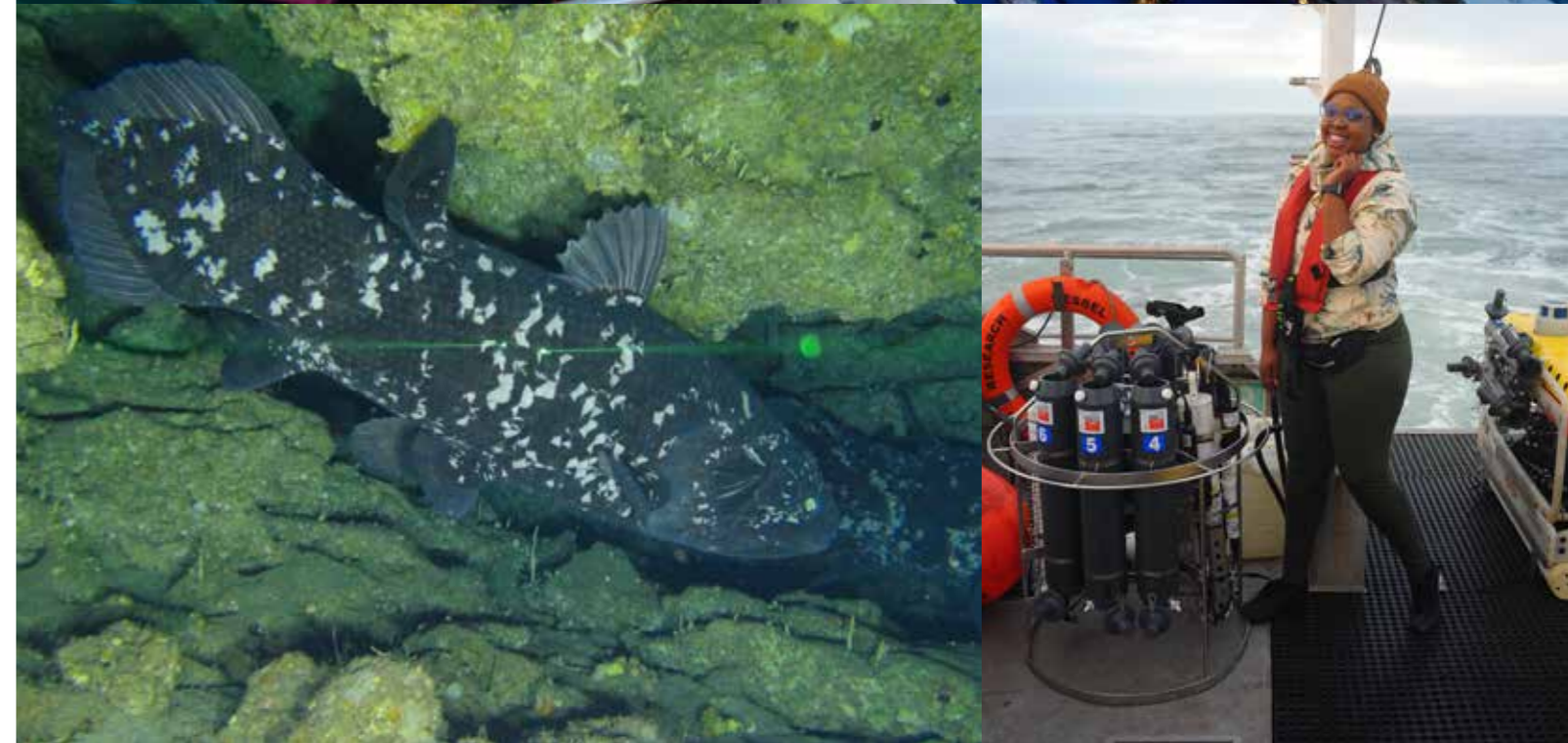
Novel, rapid, but cost-effective methods are urgently needed to better assess and monitor marine biodiversity, with next-generation sequencing approaches showing great promise. In South Africa, the generation of such data and the skills required to analyse them remain limited in marine biodiversity assessment, monitoring and resource management. This project will employ two recently developed molecular methods, environmental DNA (eDNA) metabarcoding and population genomics, in detecting and monitoring priority South African fishes.

The eDNA contained in water and in sponges (which are natural eDNA samplers) will be used to assess the presence of coelacanth (*Latimeria chalumnae*) and key sea bream species (family Sparidae) along South Africa's eastern coastline, using species-specific markers. Additionally, a population genomic approach will be employed to investigate population connectivity of two sea breams about which too little information exists for effective assessment and management, namely *Polysteganus undulosus* (seventy-four sea bream) and *P. lineopunctatus* (trawl soldier). Potential impacts of this project are comprehensive information on distributions and population connectivity of the study species that can significantly improve the knowledge, fisheries assessments, and their management. Collectively, the findings will inform spatial planning and MPA design in South Africa, while the focus on the coelacanth will provide a unique opportunity to pave a new way for the non-invasive monitoring of this iconic species, potentially having a local and international impact. This research will also be applied in updating South Africa's coelacanth management plan.

Progress: During this reporting period I developed first-time sea experience, which allowed me to gain hands-on experience with ROV research and targeted water and sponge collection, and I also had the opportunity to test different sampling techniques. Subsequently, 54 water samples, including a set collected inside coelacanth caves, and 56 sponge samples were successfully collected for eDNA metabarcoding in the iSimangaliso and uThukela MPAs and at uMzambe where coelacanths were found in 2019.

Genomic DNA has been extracted from all samples collected to date. Polymerase chain reaction (PCR) amplification and purification of all water samples have been done for the universal 16S fish primer set, and for the developed *Latimeria chalumnae* primer set. Progress has been made in building South Africa's marine fish barcode reference library by preparing 40 fish barcodes (DNA extraction, PCR amplification and purification) for sequencing of the expected fish species that occurs in the main project sampling area. For the population genomics component, genomic DNA has been extracted from 129 fin clip samples, spanning seventy-four, *P. undulosus*, Scotsman, *P. praeorbitalis* and Blueskin, *P. lineopunctatus*.

I presented my PhD project at the South African Marine Science Symposium 2022, the 2022 NRF-SAIAB Student Symposium, the Rhodes University, and the DIFS seminars. I also attended the SeaMap barcoding workshop in Cape Town, where I was able to network and gain solutions to common challenges surrounding genetic methods. I have attended an NGS metabarcoding data analysis workshop that will aid me in analysing my dataset.



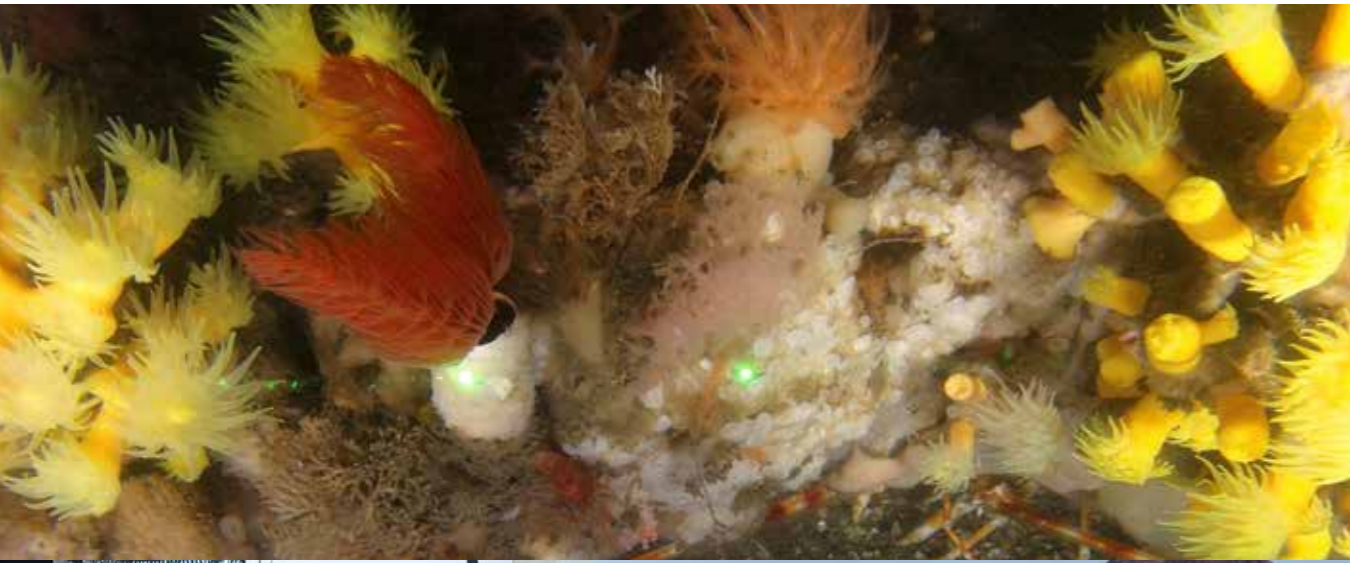


Agulhas Bank Connections

PI: Dr Natasha Karenzi (UCT) **Co-investigators and affiliations:** Ms Nikiwe Solomon (UCT), Prof. Kerry Sink (SANBI, NMU), Dr Emma Rocke (UCT), Ms Nancy Job (SANBI), Dr Stephen Lamberth (DFFE), Dr Lara van Niekerk (CSIR), Dr Jock Currie (SANBI) **Collaborators and affiliations:** Dr Lara Atkinson (SAEON), Dr Marie Smith (CSIR), Dr Lisl Lain (CSIR) **Students (degree and university):** Shakirah Rylands (MSc, UCT), Yi-Ting Ho (MSc, UCT), Humeshni Pillay (MSc, UCT), Tyla Cloete (MSocSci, UCT), Silke Brandt (PhD, UCT), Mystecia Kanengoni (PhD, UCT), Matthew Farthing (Post-doctoral Fellow, NMU)

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

The ABC project aligns with seven Sustainable Development Goals, with the greatest contribution to goal 14, “Life Below Water”, in terms of supporting the maintenance of marine biodiversity at the genetic, species and ecosystem levels. This woman-led project has “Gender Equality” and “Reduced



Inequalities” at its core, as evidenced in the diversity of women co-investigators (5), collaborators (3) and students (6) on this project. The work to support the management of sole, hake and kob species makes a contribution to sustainable fisheries to support food and job security (“Zero Hunger”). The social science and engagement components will integrate human communities along the river in the project leading to more sustainable communities (“Sustainable Cities and Communities”). The project exemplifies the multi-stakeholder partnerships enshrined in Goal 17 “Partnerships for the Goals”.

Progress: The science-to-policy pipeline has been a particular focus of the ABC project in 2022. In response to a common public misconception, the Agulhas Bank Connections and Deep Connections project scientists have been involved in research and policy initiatives to highlight that freshwater flowing into the sea is not wasted but rather provides multiple benefits to people. Adequate freshwater and sediment inputs play a key role in the functioning and health of marine and coastal ecosystems, ensuring productive fisheries. In South Africa, reduced river inputs have a significant impact on coastal and marine ecosystems around the entire South African coastline. Recognising the importance of freshwater input in marine ecosystems, 12 scientists from five key organisations (CSIR, SANBI, DFFE, ORI, UCT) developed a policy brief to highlight the key role fresh water plays in the marine environment. The provision of fresh water to the marine environment is a wicked problem that straddles a range of sectorial mandates (i.e., water, fisheries, coastal management, biodiversity protection, waste management). It is thus critical that it be recognised as a shared mandate between the Department of Water and Sanitation and the Department of Environment, Forestry and Fishery, with existing ministerial-level structures such as the MINTEC Working Groups dealing with Biodiversity Oceans and Coast and Inland Fisheries ideally placed to facilitate such shared mandates.

Socio-ecological research carried out by Tyla Cloete (MSc) highlighted the need for improved management practices of the Breede River catchment to counteract the observed flow reduction and decreased water quality. For this research, multiple stakeholders were interviewed, and water quality was tested. Humeshni Pillay (MSc) has focused on developing a remote-sensing tool to potentially monitor the river plume inputs from the Breede, Duiwenhoks, Goukou and Gouritz rivers into the adjacent marine environment. The tool prototype utilises satellite data to quantify the total suspended sediments and chlorophyll *a* in the surface water of the river plume using a machine-learning algorithm. *In-situ* data from two seasons (June and September 2022) have been utilised to set the parameters of the synthetic dataset used to train the machine-learning algorithm and to verify the outputs of the prototype. The prototype will be completed in 2023.

The infauna, epifauna and microbe diversity of the Agulhas Muddy Mid-shelf is currently being explored by Silke Brandt (PhD), to determine whether there are mud-characterising species and to better understand the functioning of these mud ecosystems. Two field trips to Mossel Bay and Algoa Bay prioritised grab and ROV sampling respectively, to complete the mud microbial and infauna sampling and to investigate Algoa Bay as a potential mud site. These field trips also supported the research of Yi-Ting Ho (MSc) on the connectivity of sea cucumber, *Hemiodon insolens*, populations across the Agulhas Bank and Benguela. She sequenced the 16S and CO1 genes of various colour morphs and found that these were not separate species, but that there was some genetic structure across the species distribution. The impact of inshore trawling on the habitat structure of mud ecosystems is also being investigated by Shakirah Rylands (MSc). She has developed a method of scoring various aspects of habitat structure and is testing these for consistency across various sites.

ABC post-doctoral Fellow, Matthew Farthing, developed a draft kob conservation strategy during a workshop with expert stakeholders in August 2022. Kob are estuarine-dependant species, making them reliant on freshwater flows and riverine inputs in the marine system. They are also sought-after linefish species which is putting pressure on their stocks. The goals of the conservation strategy include the reduction of fishing pressure to sustainable levels, identification of critical habitats for priority conservation actions, and securing the necessary policy and management commitments to ensure long-term recovery of regional kob populations. Matthew also revised the regional red-listing assessments for the dusky, silver and squaretail kob, currently in draft form. Further funding applications are being prepared to roll out the actions recommended in the conservation strategy.

The initial workshop on understanding land-sea connectivity was attended by various co-investigators, students and collaborators on the ABC project, representing social scientists, marine ecologists, estuarine ecologists, and hydrologists. It very quickly became apparent that we did not have a good understanding of one another's fields of research or paradigms. As a team, we will endeavour to engage more closely in the various fields to develop better understanding of our socio-ecological systems and integrate trans-disciplinarity into future projects.

Outreach activities: The ABC team participated in the annual beach clean-up in September 2022 in False Bay and Algoa Bay.

Outputs:

Humeshni, Shakirah, Silke and Yi-Ting presented either posters or oral presentations at the South African Marine Sciences Symposium held in Durban in June 2022. In addition, Humeshni and Silke presented posters at the International Statistical Ecology Conference in June 2022 in Cape Town.

A policy brief entitled "Fresh water flowing into the sea is not wasted" was produced for distribution to government stakeholders.

The draft kob conservation strategy and draft revised red-listing assessments for three kob species has been produced and will be finalised in 2023.



Agulhas Bank Connections Student Projects

Monitoring river plumes in the Agulhas Bank using machine learning on remotely-sensed data

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

River plumes play a major role in connecting the land and sea, providing essential nutrients, sediment and organic matter for marine ecosystem functioning and habitat structuring. However, with the onset of climate change and anthropogenic activities, river flow has drastically changed over the past decades, resulting in out-of-phase riverine inputs and changes in nutrients, sediment and organic matter concentrations. Monitoring changes in riverine outflow could assist efforts to mitigate the effects of these changes.

This project aims to develop an inexpensive tool for monitoring riverine input into the marine ecosystem by utilising satellite data to quantify the phytoplankton biomass and sediment output from river plumes to the Agulhas Bank. A synthetic dataset comprising remote sensing reflectance of surface water constituents was parameterised using *in-situ* data collected off the Breede, Duiwenhoks, Goukou, Gouritz rivers on the South African south coast. *In-situ* data consisted of chlorophyll concentrations, total suspended sediments, and coloured dissolved organic material and non-algal particles. With this dataset, a machine-learning algorithm was trained to capture the complexities within the spectrum of reflectance recorded from satellite overpasses off the rivers.

The results will show how well our ocean colour product for river plumes performs on the Agulhas Bank rivers. Further investigations using flow rates and seasonality with the best performing satellite algorithm will be used to assess long-term changes in river plume outputs in the Agulhas Bank region.

Progress: Water samples were collected from river plumes off the Breede, Duiwenhoks, Goukou and Gouritz rivers in June and September for *in-situ* measurements, and fluorometric, gravimetric and spectrophotometric analysis were completed.

Reflectance and ocean colour product data over the sampling stations were extracted from satellite images. The *in-situ* data were used to parameterise the synthetic dataset to capture June and October season reflectance spectra. The deep-learning model was trained, using this dataset, to create our river plume algorithm. The reflectances collected from satellite extractions for each site were input into the trained algorithm.

The *in-situ* data can then be compared to the model outputs to evaluate the performance of the synthetic dataset and its ability to predict the phytoplankton and sediment concentrations in the river plume. I have plotted the first results comparing the potential algorithms, including our algorithm, to the *in-situ* results and produced the first phytoplankton and sediment concentration maps based on our river plume algorithm model and the currently available satellite algorithms of the four Agulhas Bank rivers.

I have also completed the introduction and methods chapters of my thesis. I presented posters at my first national (SAMSS in Durban) and international (International Statistical Ecology Conference 2022 in Cape Town) conferences.



IUCN conservation Strategy for threatened sciaenids (“kobs”) in South Africa

Student: Dr Matthew William Farthing **Degree and university:** Post-doc, NMU **Supervisor and affiliation:** Prof. Kerry Sink (SANBI)

The post-doctoral Fellowship aims to support, coordinate and execute the research objectives of Work Package 5 of the Agulhas Bank Connections project. It contributes to the effective conservation of three threatened sciaenids (dusky kob, silver kob and square-tail kob) in South Africa as part of a broader, multi-disciplinary investigation of land-sea connectivity. This work aims to produce three, updated, regional IUCN species assessments and support the development of an integrated IUCN conservation strategy for the three kob species in South Africa under the guidance of SANBI’s threatened species programme. Additionally, the Fellow will collaborate with the NRF-funded CareZone project headed by Dr Amber Childs at Rhodes University on a research project pertinent to the effective conservation of sciaenids to further support the development of the integrated conservation strategy and to bolster our understanding of sciaenids in South Africa.

Progress: To date, several milestones have been achieved. Firstly, three regional Red List assessment documents were updated to synthesise a status review for the three main kob species in South Africa. Using these as the basis for the conservation strategy, a workshop held on 4 August 2022 was attended by 17 expert stakeholders and yielded a significant amount of information for the strategy.

This was followed by a prioritisation workshop held on 21 August 2022 to refine the information gathered for inclusion in the strategy. The workshop report detailed the strategic workshopping process and was followed by the first draft of the conservation strategy document which was sent to all 17 workshop participants for comments. All comments have been received, and the strategy document is currently under revision for finalisation in early 2023. The updated regional Red List assessments for the three main kob species have been drafted for review by the relevant Red List authority before publication in early 2023. Following this, two additional proposal meetings were held with stakeholders and conservation actors. We have outlined two research/funding proposals for submission in 2023. The first is for a large, multi-disciplinary research project to address the critical knowledge gaps identified during the strategic planning meetings. The second is a funding proposal to execute some of the priority actions required for kob conservation in South Africa, such as a pro-environmental, community-based social marketing and outreach campaigns to highlight the plight of kob in South Africa and improve the behaviour of important resource users. These proposals will be drafted in early 2023 for submission before their relevant call dates in March 2023. I attended the 17th South African Marine Science Symposium in Durban (20–24 June 2022) and the 12th Western Indian Ocean Marine Science Association Scientific Symposium (10–15 October 2022) and used the opportunity to engage with important stakeholders from academia, conservation and government in the aforementioned strategic conservation initiative. Discussions included potential collaborative work on strategic objectives, additional input on strategy, and the structure of future proposals mentioned before.



Impacts and indicators of inshore demersal trawling on soft sediment habitats of the Agulhas Bank

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

Bottom trawl-induced alteration of benthic habitats is hypothesized to be partially responsible for restructuring demersal fish communities on the inshore south coast of South Africa, following the onset of the industry in the early 1900s. However, trawling effects are limited across inshore habitats in South Africa, and we have little knowledge of the extent to which benthic invertebrate communities are impacted by bottom trawling.

To address these knowledge gaps, we aim to:

- 1) investigate potential trawl-induced alterations to unconsolidated benthic habitats across spatial gradients of trawling intensity, and
- 2) assess and test potential indicators of trawling disturbance using visual imagery collected by ROV.

As a first step, a comparison was made between trawled and untrawled areas in Cape St Francis Bay in terms of the physical habitat structure (e.g., sediment characteristics and seafloor rugosity), habitat structure created by biota (e.g., biogenic 3-D complexity, bioturbation and mobile invertebrate tracks), and the invertebrate assemblages.

Potential indicators of trawl disturbance were then applied to two further areas off Algoa Bay to test the consistency of indicators. Outputs of this research will contribute to understanding inshore trawling as an anthropogenic pressure for future inclusion in biodiversity assessments.

Progress: January–December 2022: I completed processing and annotating all images and processing all sediment samples for my thesis. After completing the analysis for the first of two data chapters, I produced the first draft of this chapter. There were some conflicting results, so I have refined my analyses for the first data chapter and submitted a second draft. Potential bioindicators, for example diversity and abundance of bryozoans, were identified in this first chapter for application in my second data chapter.

I have started analysing data and writing up my second data chapter. Since this second chapter relied on the results from the first data chapter, it was slightly delayed and required some revision of its aims and objectives. I submitted a draft of my introductory chapter in early 2022 which I will revise when I have completed my data chapters.

In May, I participated in the Centre for Statistics in Ecology, Environment and Conservation (SEEC) Symposium with preliminary results of my first data chapter and ranked in the top four students for a recorded oral presentation. I also won first prize for my first-ever poster presentation at the UCT Department of Biological Science's annual Student Research Day. I attended my first conference, the Southern African Marine Science Symposium (SAMSS) in Durban in June where I made an oral presentation titled, "Investigating bottom trawling impacts on the complexity of inshore soft sediment habitats of South Africa".

During 2022, I was responsible for hosting the Marine Chatteries which is a platform through which students can share their research, practise conference presentations, hold discussions on marine topics and brainstorm creative ideas for poster/oral presentations.





Characterising and assessing the biodiversity and ecological status of South African marine muds

Student: Silke Brandt **Degree and university:** PhD, UCT **Supervisor and affiliation:** Dr Natasha Karenyi (UCT), Dr Emma Rocke (UCT)

Marine mud ecosystems are soft sediment habitats where the majority of sediment is composed of silt and clay (particle size smaller than 63 μm). These fine sediment ecosystems have characteristic ecological traits and drivers which support unique biodiversity and many are under acute risks of collapse, with consequences for habitats of species, genetic diversity, ecosystem services, sustainable development and human well-being.

The IUCN Global Ecosystem Typology is a hierarchical classification system that, in its upper levels, defines ecosystems by their convergent ecological functions and, in its lower levels, distinguishes ecosystems with contrasting assemblages of species engaged in those functions. This report describes the three upper levels of the hierarchy, which provide a framework for understanding and comparing the key ecological traits of functionally different ecosystems and their drivers. An understanding of these traits and drivers is essential to support ecosystem management. However, various fishing pressures are concentrated on South African marine muds, and the riverine input which supports near-shore mud deposits is experiencing reductions in flow; consequently, subtidal marine mud ecosystems are one of the most threatened ecosystems in South Africa, yet the current MPA network does not sufficiently cover marine muds at the suggested biodiversity target of 10%.

The west and east coasts of South Africa have extensive, well-studied mud belts which are strongly dependent on riverine input, whereas deeper shelf mud sediment may be authigenic in origin. However, south coast mud belts and mud pockets around bays are not well studied. On the Agulhas Bank of the south coast, the Agulhas muddy mid-shelf is considered to be Critically Endangered owing to fishing pressure and freshwater flow reduction. Observations from recent visual surveys suggest that the extent of the mud habitats may be receding or changing (K Sink, pers.comm.), but this has yet to be investigated or confirmed as baseline sediment data are scarce. Neither the invertebrate nor the microbial communities of the south coast muds on the Agulhas Bank have been quantified and their environmental drivers have not yet been explored. More research is required to address concerns regarding fishing pressure and the effect on biodiversity of decreased flow. Sediment composition needs to be compared over time to determine whether there has been a loss in mud ecosystems.

Understanding biodiversity patterns and natural environmental drivers is critical to building a strong theoretical foundation on which to base conservation and management decisions. This is significant at several levels of biodiversity, including genetic, taxonomic, and functional diversity, and across different faunal groups, including, microbes, meiofauna, infauna, and epifauna.

Progress: I have completed two field trips to Mossel Bay and one field trip to Algoa Bay. I will be joining two cruises in May and June 2023 to sample more areas. A field trip is also planned for the east coast which will happen later in the year. To support my research, I attended a marine genomics barcoding workshop at SAMSS 2022, and an eDNA modelling workshop at ISEC 2022. I have completed the first draft of my PhD proposal and have begun my lab work to process the samples I have collected.



Contest Waters: An ethnography of eco-logics of the human-Breede River relationships in the Western Cape, South Africa

Student Name: Tyla Cloete **Degree and university:** MSc, UCT **Supervisor:** Dr Nikiwe Solomon (UCT)

This study investigated the different ways the Breede River has been managed and imagined in water governance in the Western Cape Province, South Africa. I conducted three months of field work in Swellendam in the Western Cape Province from March to June 2022. The relevance of this study is to possibly inform river management policies in the Breede River catchment. The project also aims to contribute to environmental discourse by exploring environmentally and socially just approaches to water resource management with a particular focus on the Breede River. The data collected for this study will be used for my dissertation.

Progress: The field work, using both quantitative and qualitative research methods, was completed in June 2022. For data analysis, the transcribed interviews and conversations were coded and analysed in tandem with field notes, water samples and my observations that were collected during the fieldwork process.

The main findings showcased a deterioration in the water quality and availability of fresh water in the Breede River which, in turn, supports an urgent need to rethink the current management practices of the Breede River catchment. In February 2023, I presented the findings of my research project at the annual ABC project meeting. The final dissertation will be submitted in May 2023.

Population genetics of the endemic red-chested sea cucumber, *Hemiocnus insolens*, using gene regions 16S and COI

Student name: Yi-Ting Ho **Degree and university:** MSc, UCT **Supervisor and affiliation:** Dr Emma L. Rocke (UCT), Dr Natasha Karenzi (UCT)

By describing the population genetics of *Hemiocnus insolens*, a species that presents itself in three colour variations (red, yellow, and white), the project aims to elucidate whether these species are a single species or cryptic species as they occur along most of the southern African coastline. The information gathered provides further an understanding of population genetics, dispersal and phylogeographic breaks that may influence systems along the coastline of southern Africa.

Progress: My field work was completed in Algoa Bay and Mossel Bay by June 2022. All outstanding specimens were processed and the data successfully analysed, with the results suggesting that colour variations of species could be cryptic species when phylogeography is considered. Additionally, there appear to be differences between colour variations. I attended the SAMSS (Southern African Marine Sciences Symposium) 2022 and presented a poster with preliminary data and findings to discuss where the project was leading, and what information had been gathered. I have submitted my Masters for examination and expect to graduate in December 2023. I am currently working on a publication from this project.



ACEP

Marine Platforms





ATAP

Acoustic Tracking Array Platform

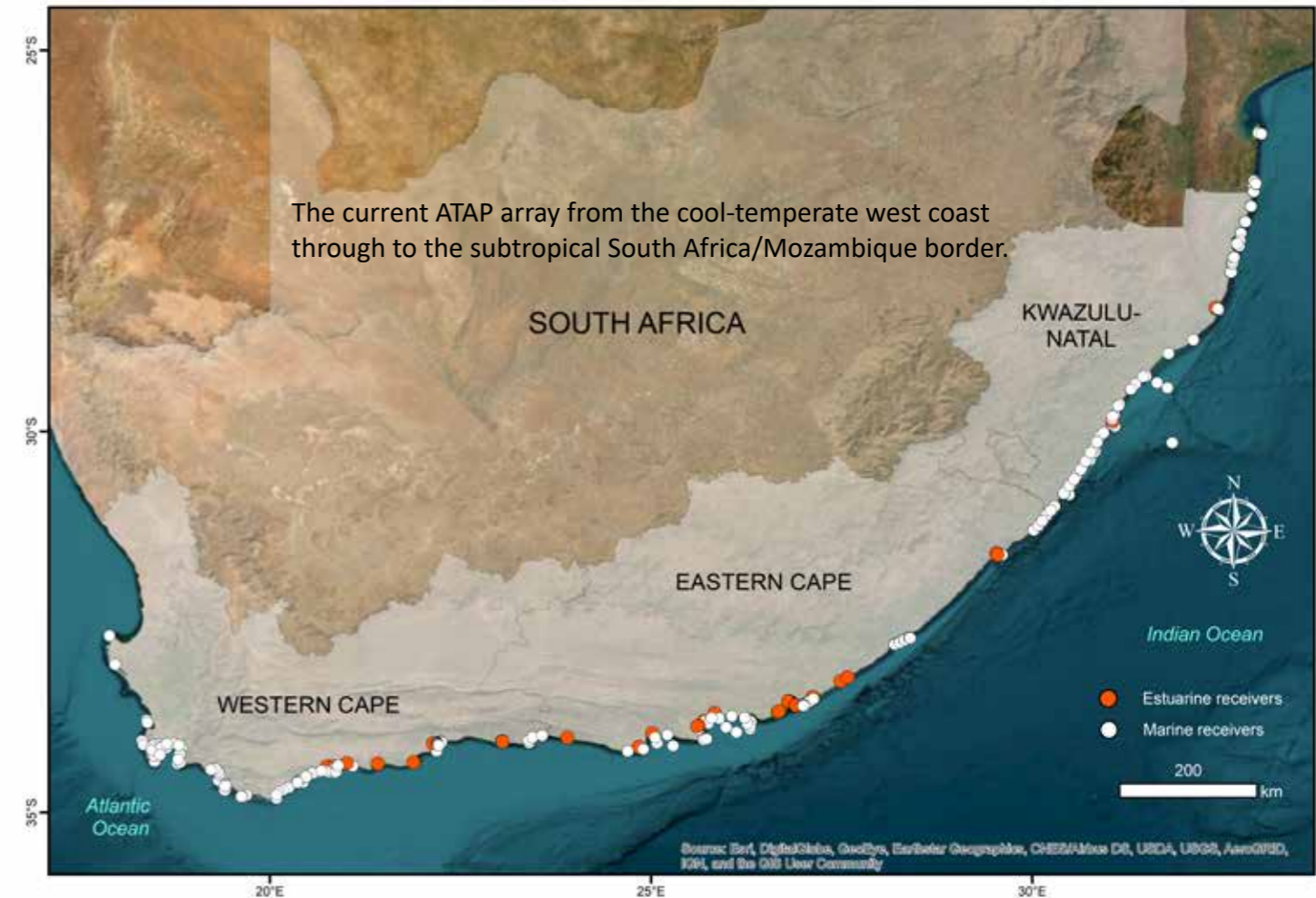
Acoustic telemetry is arguably the most popular tool currently used by researchers globally to determine the movements of aquatic animals. The popularity of this tool has led to the development of largescale networks across the globe, including South Africa's ATAP. The ATAP is an established research infrastructure comprising a nationwide network of acoustic receivers (currently 250+) covering ~2200 km of the South African coastline, from False Bay along the cool-temperate west coast, to the South Africa/Mozambique border along the subtropical east coast. This platform is collaborative in nature, whereby researchers using acoustic telemetry to study the movements and migrations of aquatic animals, tag and release animals. The receiver network then records the signals the released tags, allowing researchers to piece together the movements of individual animals, which together can provide information on the species in general; these data are freely available to the tag owners. This information is crucial not only for learning more about the movements of study species, but should be incorporated into management plans, ultimately having a positive impact on current fishery laws and policy. Movement data can shed light on biologically or ecologically significant areas for certain species, allowing the incorporation of these areas into spatial management planning, ultimately protecting a suite of species occupying these areas. Through this, the data collected by the platform have a positive, but indirect, impact on the health and wellbeing of impoverished people living along the coast, whereby increased protection of important fishery species results in an increase in numbers, leading to better fishing opportunities, etc. This will also have a positive impact on commerce and the economy through the sale of caught fish.

This year marked a decade of the ATAP, highlighting it as an example of successful ocean stewardship for Africa. The importance of this research platform was highlighted in a scientific manuscript published in the high impact journal *Frontiers in Marine Science* in May 2022, entitled “A decade of South Africa’s Acoustic Tracking Array Platform: An example of a successful ocean stewardship programme”. To date, this paper has been viewed more than 1 800 times, 58% more views than all *Frontiers* articles, and has been downloaded more than 180 times.

ACEP projects served: Infrastructure and data management support was provided to one ACEP-funded project managed by the Southern African Fisheries and Ecology Research Lab (<https://www.safisheriesecologyresearchlab.com/>) and Rhodes University, which saw 40 red Roman *Chrysoblephus laticeps* acoustically tagged at two sites along the southern coastline of South Africa – St Francis Bay, an exploited site, and the Goukamma Nature Reserve, a protected site. This research project follows on and compliments the research conducted on the same species in the Tsitsikamma National Park, a protected site, and Cape Recife, an exploited site.

Institutions using the ATAP: Currently the ATAP provides support to no less than 58 individuals from 27 different organizations. Projects include work on a suite of Carcharhinid shark species including grey reef *Carcharhinus amblyrhynchos*, bronze whaler *C. brachyurus*, spinner *C. brevipinna*, bull *C. leucas*, blacktip *C. limbatus* and dusky *C. obscurus* (Oceanographic Research Institute, NRF-SAIAB), recreationally-targeted species such as leervis *Lichia amia* and giant kingfish *Caranx ignobilis* (NRF-SAIAB), Endangered estuary-dependent fishery species such as dusky kob *Argyrosomus japonicus* and white steenbras *Lithognathus lithognathus* (NRF-SAIAB), endemic reef fish such as black musselcracker *Cymatoceps nasutus* and red Roman *Chrysoblephus laticeps* (NRF-SAIAB, Oceanographic Research Institute, Rhodes University), migratory ray species such as diamond *Gymnura natalensis* and duckbill rays *Aetomylaeus bovinus* (NRF-SAIAB, Oceans Research Institute, Oceanographic Research Institute) and several turtle species (green, hawksbill, loggerhead) (NRF-SAIAB, uShaka Marine World, Bayworld).

Any other projects serviced using the platform: The ATAP continues to provide infrastructure and data management support to multiple different projects, including those of a collaborative nature and loaner projects (i.e. acoustic receivers on loan) (see ATAP Platform Projects for more). The ATAP has largely collected the movements of teleost and elasmobranch species; however, some work gaining traction in South Africa is the release of rehabilitated turtles by the large aquariums in the country, including Two Oceans Aquarium in Cape Town, Bayworld Centre for Research and Education (BCRE) in Gqeberha, East London Museum in East London, and uShaka Marine World in Durban. To date, 19 individuals from three species (green, hawksbill and loggerhead) have been externally tagged with long-life acoustic transmitters and released back into the wild. These have all been juveniles, but as more tags become available and the project gains momentum, larger individuals will be tagged, including some who have significant injuries, e.g. missing fins due to tiger shark predation, to assess how the movement of these individuals may or may not be affected. In keeping with projects with Two Oceans Aquarium, the Aquarium houses large raggedtooth sharks *Carcharias taurus* in its large predator display. However, these sharks often become too big for their enclosure and as such, a release programme was initiated in 2004. To date, more than 30 sharks have been acoustically tagged and released from the Aquarium back into the wild, and the ATAP has been collecting long-term movement data in the form of acoustic detections of these sharks on its nationwide receiver network over the past 10 years. There has been very little research done on sharks’ post-release from an aquarium, but the principal reason for this study is to determine



whether the long-term movements of raggedtooth sharks post-release ultimately revert back to those of their wild counterparts.

Student supervised by platform personnel: In 2022, the ATAP team was either directly involved in supervising, or was providing data to, a number of postgraduate students, including one honours (BSc Hons) student, four masters (MSc and MTech) students and seven doctoral (PhD) students.

BSc Honours:

Elihle Mankuntsu (RU): Assessing the daily presence of two important estuary-associated fishery species in the Mzimvubu Estuary, Eastern Cape

Masters Science:

Vuyolwethu Mxo (RU) Coastal movements and estuarine use of sub-adult and adult leervis, *Lichia amia*: results from long-term acoustic tracking

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

Thembehlele Ndlovu (RU) Investigating the environmental influence on fish presence and abundance in a permanently open warm temperate estuary, South Africa

MTech:

Kevin Spiby (CPUT) Movements of captive-released raggedtooth sharks (*Carcharias taurus*) along the South African coastline

PhD:

Dinah Mukhari (RU) Movement behaviour and migration of catadromous fish species, *Anguilla mossambica* and *Pseudomyxus capensis* in the Kowie Estuary, South Africa

Bantony Ziko (RU) Movement behaviour of the striped mullet (*Chelon tricuspis*) in a modified warm temperate estuary

Alison Towner (RU) Spatiotemporal ecology and potential displacement of white shark in southern Africa. Submitted.

Ralph Watson (RU) Co-occurrence of sympatric *Poroderma* species: population composition, trophic ecology and movement behaviour of the endemic *Poroderma africanum* and *P. pantherinum* in Mossel Bay, South Africa. Submitted.

Toby Rogers (UCT) Movement behaviour of bronze whaler sharks *Carcharhinus brachyurus* along the South African coastline using a multi-method approach.

Melissa Pollard (NMU) Shallow-water seascape connectivity: micro-habitat utilization by a common estuarine-associated fish species in the estuary-ocean ecotone

Samantha Ockhuis (RU) Genetic connectivity of the slinger *Chrysoblephus puniceus* among Marine Protected Areas and unprotected areas along the east coast of South Africa

Outreach activities: The ATAP is dedicated to education, outreach and awareness through various platforms (e.g. social media, public talks, conferences, etc.) to ensure that it is as transparent and impactful as possible. This is particularly important when it comes to changes in existing management strategies e.g. reductions in size and bag limits, or declaring MPAs in popular fishing areas, while having a positive impact on fishery resources, can negatively impact people. As such, the ATAP has always made an effort to actively engage with the public via numerous avenues, positively impacting on public participation. The ATAP, together with NRF-SAIAB's Marine Remote Imagery Platform (MARIP), also ran the ever-popular Summer School in December 2022, which was attended by 10 enthusiastic undergraduate and postgraduate students. This provides an opportunity for the students to get some hands-on experience, and potentially take their studies further with NRF-SAIAB projects.



ATAP Platform Projects

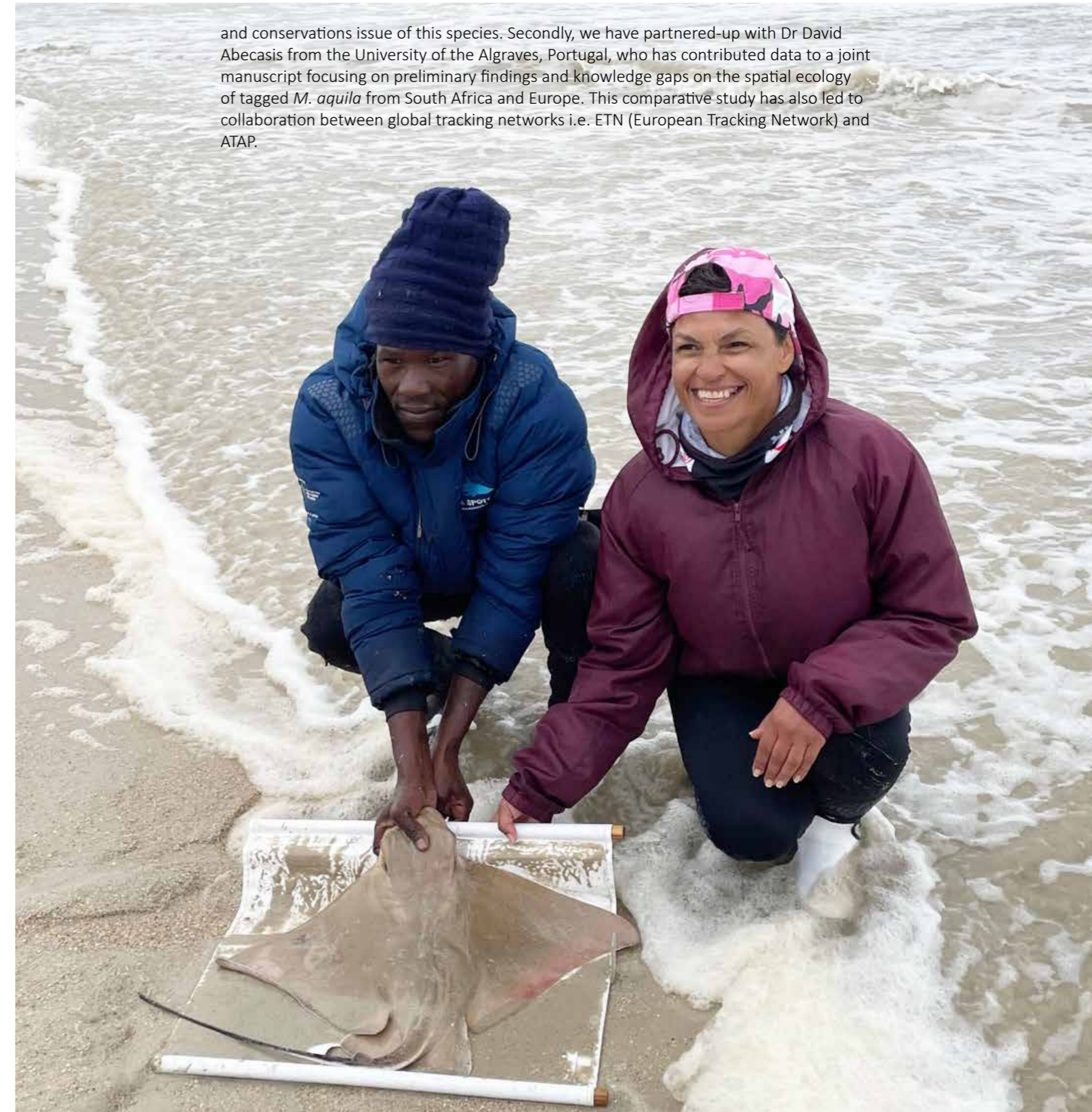
Understanding the movement behaviour and coastal connectivity of the critically endangered eagle ray *Myliobatis aquila* along the south and east coast of southern Africa

PI: Dr Edward Butler (SAERI) **Co-investigators and affiliations:** Dr Rhett Bennett (Wildlife Conservation Society, Western Indian Ocean Shark and Ray Conservation Program), Prof. Warren Potts (DIFS), Prof. Amber-Robyn Childs (DIFS), Dr Alex Winkler (DIFS) **Collaborators and affiliations:** Kyle Smith (SANParks), Dr Dave van Beuningen (Wildlife Conservation Society, Western Indian Ocean Shark and Ray Conservation Program)

The common eagle ray *Myliobatis aquila* is a coastal batoid species distributed across much of the East Atlantic and parts of the south-west Indian Ocean. It is also commonly present in the Mediterranean Sea. The taxonomic status of the species is unclear, with several authors suggesting that *M. aquila* may present a species complex with separate species in different parts of its distribution (e.g. European/North Atlantic and southern African). *Myliobatis aquila* has recently been classified as Critically Endangered by the International Union for Conservation of Nature (IUCN) Red List of Threatened Species. As a result, the conservation and management of this species has never before been such a pressing issue. Effective conservation and species management, however, requires knowledge of the socio-ecological system within which it occurs; yet aspects of the species' life history, ecology and biology, and socio-economics are poorly understood. Spatial management has become an increasingly popular and effective tool in supporting sustainable populations, with information on the spatial ecology of species critical for the development of conservation strategies. The aim of this study was to improve our understanding of the movement ecology, spatial connectivity and scale of coastal movements of the critically endangered *M. aquila*, to inform its conservation and management.

To monitor the spatial movement patterns of *M. aquila*, an acoustic receiver array (5 inshore, 3 offshore) was set up in the inshore coastal region between the Fish and Kowie rivers, Eastern Cape, South Africa. Thirteen *M. aquila* (3 males, 485 – 520 mm disc width (DW); 10 females, 520 – 825 mm DW) were tagged with two-year lifespan acoustic transmitters. Preliminary data revealed some exciting and relevant information on the residency and coastal connectivity of the species. All but one tagged *M. aquila* were resident to the array throughout the nine-month monitoring period (between January and September 2022). One individual exhibited increased levels of coastal connectivity and was recorded 100 km away in the coastal embayment of Algoa Bay. Home range analysis confirmed high levels of residency with all fish exhibiting core areas within the acoustic array; however, individual variability was also observed, as expected, with some fish exhibiting restricted core use of the array, while others exhibited a more dispersed home range. Despite variation among tagged fish, the core home ranges demonstrated high levels of residency, and support of spatial conservation initiatives of this Critically Endangered species.

Outputs: This small ATAP/SOSF transmitter grant has led to significant collaborative initiatives. Firstly, a Save Our Seas Keystone Grant-funded project with an extended team (now including Reel Science Co., Two Oceans Aquarium, University of Pretoria, SAAMBR and SAIAB) is now allowing us to expand the project to address several pressing research



and conservations issue of this species. Secondly, we have partnered-up with Dr David Abecasis from the University of the Algraves, Portugal, who has contributed data to a joint manuscript focusing on preliminary findings and knowledge gaps on the spatial ecology of tagged *M. aquila* from South Africa and Europe. This comparative study has also led to collaboration between global tracking networks i.e. ETN (European Tracking Network) and ATAP.

Investigating the spatial ecology of chondrichthyans in False Bay and Algoa Bay, South Africa

PI: Dr Alison Kock (SANParks, SAIAB) **Co-investigators and affiliations:** Toby Rogers (SS, UCT), Sarah Waries (SS, UCT), Dr Taryn Murray (SAIAB), Dr Nathalie Viljoen (Two Oceans Aquarium Foundation), Dr Judy Mann-Lang (TOAF), Dr Chantel Elston (SAIAB) **Collaborators and affiliations:** Gregg Oelofse (City of Cape Town [CoCT]), Joint Xingshe (CoCT), Dr Michelle Soekoe (Reel Science Co.), Luca Mendes (TOAF) **Students (degree and University):** Students have joined tagging trips from various institutes to date but will only be formally allocated a project upon maturation (ca. 1 Year) of telemetry data.

Sharks, rays, skates, and chimeras, collectively known as chondrichthyans, play an important ecological role in the ecosystems they inhabit, with many species regulating prey species abundance and behaviour. However, through anthropogenic activities such as targeted and industrial fishing and habitat modification, as well as reduced prey availability, more than 25% of the world's chondrichthyans are threatened with extinction. Only a few studies have investigated aspects of the demography, movement patterns and trophic ecology of chondrichthyans in the coastal waters of South Africa – information that is crucial for not only the quantification of their ecological role, but also for the development of appropriate conservation and management measures. Therefore, assessment of movement has been identified as a research priority for many coastal shark and ray species. Acoustic telemetry, whereby an acoustic transmitter that emits a unique signal is surgically placed into an animal and whose movements (via the unique signal) are recorded by acoustic receivers positioned in the sea, can provide insights into habitat and resource usage, behaviour, and population dynamics for tagged species. This allows for the identification of critical habitats for feeding, breeding and nursery grounds. Additionally, movement data can be used to investigate level of protection afforded to a specific species by the current MPA network in South Africa. Therefore, this study aims to use acoustic telemetry to gain a better understanding of the bay-scale and greater coastal movements of eagle rays, lesser guitarfish, short-tail stingrays and spotted gully sharks in False Bay, Western Cape and Algoa Bay, Eastern Cape.

Outputs: To date 20 individuals have been tagged with internal acoustic transmitters; 10 common eagle rays, 5 spotted gully sharks, and 5 lesser guitarfish. During fieldwork, we have hosted a multitude of students and staff from UCT, CPUT, Stellenbosch, SS, TOAT and CoCT, to name a few, for capacity building and transformation. Participants were exposed to training in angling survey design, data collection, entry and analysis, fish handling and dart tagging, fish veterinary techniques, internal tagging and genetic sampling. Several reports have been compiled for the City of Cape Town during biodiversity monitoring surveys in the Helderberg MPA as well as a conservation and funding report for Rheinmetall Denel who share the access rights to sections of the HMPA. As data mature, we will start to be able to produce preliminary findings to funders and the public, secure students to manage species-specific elements of the project and present findings at domestic and international conferences.





Investigating site fidelity and habitat use of endemic blue stingrays *Dasyatis chrysonota* in the Knysna Estuary, a potentially important breeding aggregation site

PI: Dr Chantel Elston **Co-investigators and affiliations:** Kyle Smith (SANParks), Dr Amber-Robyn Childs (RU), Dr Taryn Murray (SAIAB)

Understanding which habitats are important to species, and the reasons why they are important, are vital to the management and conservation of biodiversity. Unfortunately, given a lack of historical research effort, these insights remain largely undiscovered for rays, an ecologically important ocean faunal group. Specifically, the blue stingray *Dasyatis chrysonota* is a stingray species endemic to southern Africa that keeps our sandy ocean ecosystems healthy.

The only known aggregation of this species has anecdotally been noted to seasonally occur in the Knysna Estuary, and it is hypothesized this aggregation may be for reproductive purposes (pupping and/or mating). The extent to which stingrays use estuaries in South Africa is unknown, and more specifically, the purpose and characterisation of this aggregation in Knysna Estuary is unknown. This information could have significant conservation and management implications for this declining Near Threatened species, specifically through providing evidence-based recommendations for spatial protection. A relatively high density array of 15 acoustic receivers was deployed in October 2022, and is currently being used to monitor the movements of 15 acoustically tagged blue stingrays both in and outside the Knysna Estuary to determine if and why this may be an important habitat for them. Annual direct observations are also currently being undertaken to characterise the aggregation with metrics such as number of individuals, sex and size-classes of individuals, and the behaviour of individuals. This project was initiated in October 2022 and will run for three years. The information gathered will help to ensure that this population of stingrays in the Knysna Estuary remains healthy, which in turn will keep the estuary itself healthy – an important area for recreational and subsistence fishing.

Outputs: This project will result in 1 – 2 peer-reviewed papers and will be presented at one scientific conference and one public symposium (the Plett Ocean Festival).



MARIP

Marine Remote Imagery Platform

In underwater environments, responsible research on the status, structure and functioning of ecosystems and living resources is challenging, and limited by access to suitable technologies. This research is nevertheless essential to support sustainable utilisation and effective management of important ecosystem services. The Marine Remote Imagery Platform (MARIP) addresses this challenge by providing researchers from South Africa, and the broader region, access to advanced underwater imaging equipment that can be used to conduct exploratory and quantitative surveys of benthic, demersal and pelagic marine biota from the shallow subtidal down to a depth of 1500 m.

Infrastructure provided by MARIP includes an ROV, multi-imaging drop cameras, and a broad variety of stereo-video camera systems, including tethered and untethered stereo-BRUVs, pelagic stereo-BRUVs and a diver-operated stereo-video system. These are ideally suited to be operated off NRF-SAIAB's coastal crafts, which enable research up to 40 NM off South Africa's coastline.

The platform includes an extensive suite of computing systems for processing the imagery data, a large-scale imagery management facility dedicated to managing and sharing data, along with a team of video analysts trained to facilitate annotation and data analysis. The MARIP is the largest platform of its kind in southern Africa and provides our scientists unprecedented access to research opportunities to empower research that advances knowledge generation and promotes sustainable management practices.

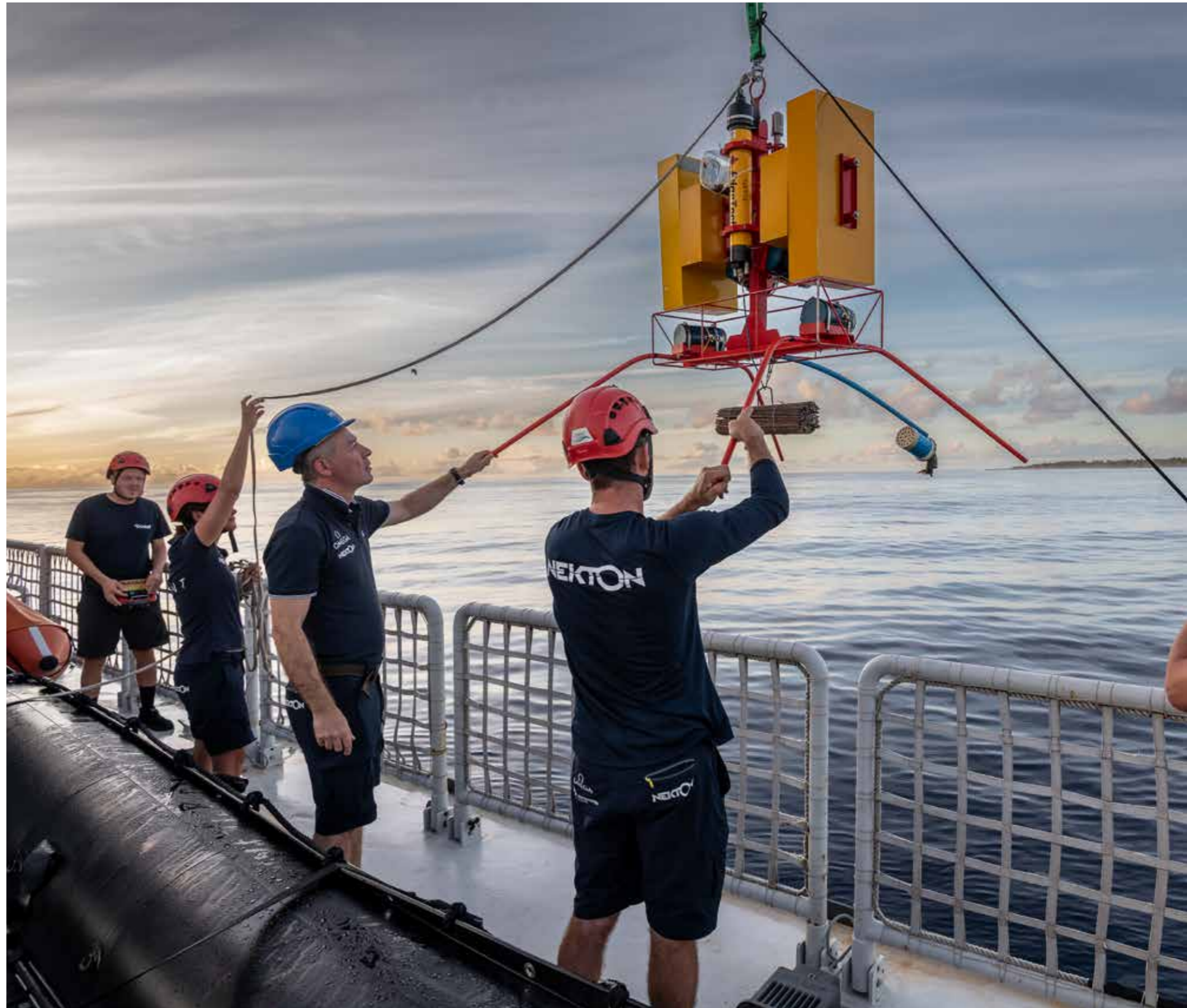
Context and Impact: In 2022, the MARIP supported research activities carried out by all four of the supported ACEP projects: the MARIP ROV conducted ecosystem mapping surveys and specimen collections for the Deep Connections, Agulhas Bank Connections and SMART Zone project. A baseline demersal fish assessment was carried out for the SMART Zone project with the stereo-BRUVs, while existing stereo-BRUVs datasets were provided to the SALPA project to determine if there are differences in foraging behaviours when exposed to natural physiological stressors.

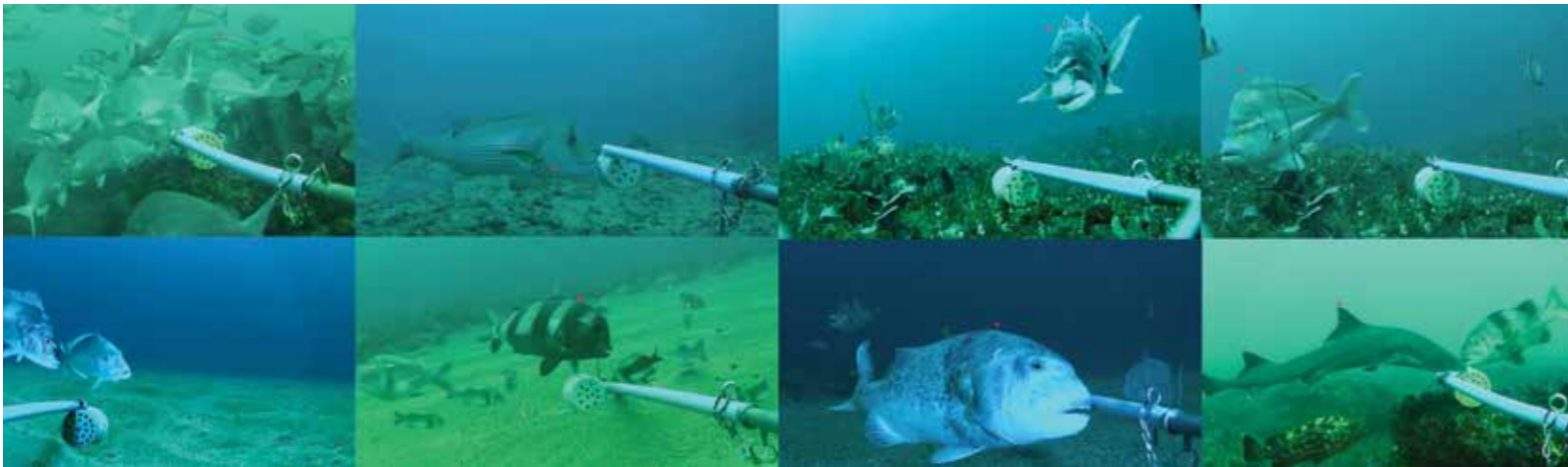
MARIP is extensively used by NRF-SAIAB scientists within two broad applied disciplines, methodologies and environmental management:

Methodological research aims to better understand the costs and benefits of different research methods and undertake optimisation to improve their effectiveness.

Environmental management research carried out by NRF-SAIAB with MARIP infrastructure, focusses on advancing our understanding of the structure, functioning and distribution of marine communities and ecosystems, the effects of anthropogenic pressures and climate change, and how current management measures are mitigating these pressures.

MARIP provides research support to numerous independent South African and International research projects on an annual basis. The extent of the support varies, based on the specific project's needs from basic training and equipment provision, to full logistical and research support to address research questions. MARIP also provides access to existing datasets, video analysts to assist with processing of imagery samples, and long-term support to securely manage imagery samples. In South Africa, MARIP has provided research support to the WILDOCEANS Programme on numerous of their marine projects that aim to support and improve the management of Marine Protected Areas and of elasmobranchs. Regionally, MARIP provided video annotation and data management support to the Wildlife Conservation Society's project, which will improve the Conservation Status of Sharks and Rays in the Southwest Indian Ocean. Similarly, MARIP provided infrastructure, expertise and training to the Namibian Nature Foundation to enable assessments of sharks and rays in the Namibian Islands MPA. Lastly, MARIP provided extensive support to the NEKTON Foundation and the Maldivian Marine Research Institute for a research project that aims to support MPA promulgation by implementing the first systematic survey and sampling of the Maldives from the surface to 1000 metre depths.





MARIP Platform Projects

The structure and function of ichthyofaunal communities within the Port of Ngqura and the benthos, habitats, structures and environmental drivers which shape them

PI: Prof Tony Booth (RU) **Co-investigators and affiliations:** Dr Matt Dicken (KZN Sharks Board) **Collaborators and affiliations:** Dr Anthony Bernard (SAIAB) **Students (degree and University):** Vivienne Dames (PhD, RU)

The deep waters within the Port of Ngqura were developed through extensive dredging of the mouth of the small and ephemeral Coegha River. Construction was completed in April 2006, and the port became operational at the end of 2009. The Port Ngqura Fish Biomonitoring programme, integrated into this project, is the second largest ORI Cooperative Fish Tagging Programme in South Africa. A fish tagging project started by Dr Dicken within the Port of Ngqura has been in place since 2009 and continues to date. Angler catches from a small team of experienced fishermen have been recorded on standardized datasheets between September 2006 and September 2007 and from December 2011 to present to monitor the health of the Port environment. The biomonitoring programme has tagged 7 507 specimens with a 9.3% recapture rate. A total biodiversity assessment has recorded 16 821 specimens across 70 species.

The second component of this project is to use stereo-baited remote underwater video systems (stereo-BRUVs) to assess the full fish community, and community changes over the course of one year. This sampling technique also allows for measures of habitat complexity and benthic cover along different micro-habitats within the Port. To date 160 successful stereo-BRUV deployments from September 2023 to present have produced incredible insight into the marine environment established within Port Ngqura. An additional 23 species have been identified, not recorded in the long-term biomonitoring programme. Footage has shown a strong community of euryhaline estuarine species, associated to the ephemeral Coegha river inlet and small sandy beach. Along the Eastern and Western breakwalls, spanning 2.6 and 1.5 km respectively, communities change to temperate reef associated fish with a strong tropical presence in summer months. Along these breakwalls exist numerous small reefs ranging from 6 to 12m in depth. Preliminary observations

show that these reefs are fully established with sponges, ascidians and algae. It is here that healthy populations of dageraad (*Chrysoblephus cristiceps*), yellowbelly groupers (*Epinephelus marginatus*) and red romans (*Chrysoblephus laticeps*) are resident in both summer and winter months. The stereo-BRUV sampling has also shown great shark and ray diversity and abundance, particularly in summer months. During summer months aggregations of adult raggedtooth sharks (*Carcharias taurus*), juvenile dusky sharks (*Carcharhinus obscurus*), adult smoothhounds (*Mustelus mustelus*), and adult and juvenile diamond rays (*Gymnura natalensis*) are captured in almost all deployments.

Ports are often recognised as having negative impacts on the marine environment. The diversity and abundance of fish recorded to date in this study clearly indicates the remarkable health of the environment within a man-made seascape and the importance of Port Ngqura as a habitat for both juvenile and adult fish.

Outputs: To date this project has hosted two workshops to anglers, one on fish identification and the second on correct handling, tagging and data management. As part of public engagement, we have worked with the Transnet Ngqura environmental office to provide insight to their management and health of their marine habitat. This includes articles written for the Port Newsletters and posters which have been placed in common workspaces providing information on species found within the Port.



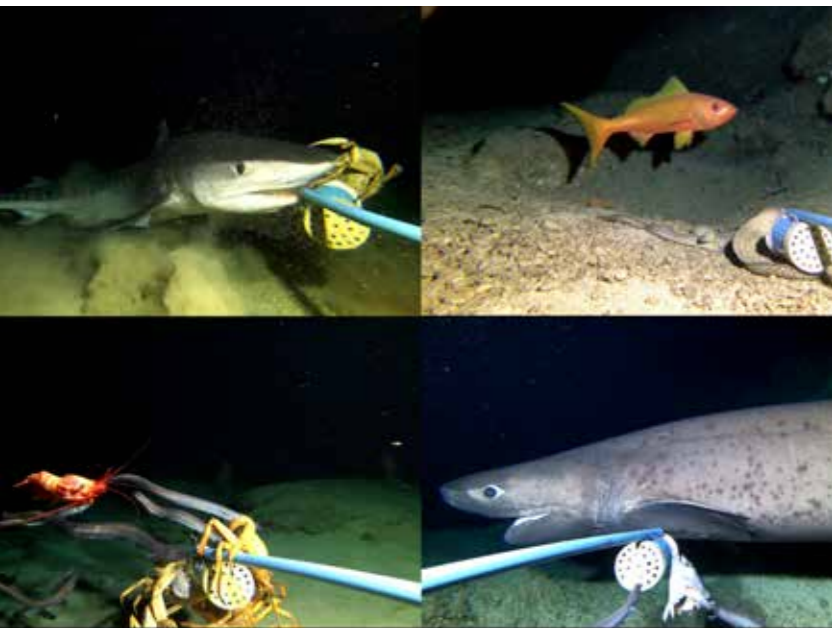
Namibia's Rays and Sharks (NaRaS)

PI: Dr. Ruth H. Leeney **Co-investigators and affiliations:** Hayley Brand (Namibia Nature Foundation), Dr. Margit Wilhelm (University of Namibia) **Collaborators and affiliations:** Dr. Anthony Bernard (SAIAB) **Students (degree and University):** Adolf Mabuta Simataa (MSc, University of Namibia)

There has been remarkably little research done on chondrichthyans (sharks, skates, rays and chimaeras) in Namibian waters to date. The NaRaS project aims to collect baseline data on these species, and in particular to document the diversity and distribution of sharks, skates and rays in the Namibian Islands Marine Protected Area (NIMPA).

As part of this work and in collaboration with SAIAB, stereo baited remote underwater video systems (stereo-BRUVs) have been used for the first time in Namibian waters. Despite challenging visibility in many parts of Namibia's coastal zone, it has been shown that stereo-BRUVs can be successfully used to document marine biodiversity. The data resulting from these stereo-BRUVs surveys is highly novel and has revealed diverse habitats and species within the coastal waters of the NIMPA. Thus far, the chondrichthyan species documented include sevengill cowsharks (*Notorynchus cepedianus*), dark shysharks (*Haploblepharus pictus*) and biscuit skates (*Raja straeleni*). A wide diversity of benthic habitats and fish fauna have also been documented, including muddy bottoms populated by sea pens; kelp forests and rocky reefs. The method appears to have excellent potential as a useful long-term monitoring strategy for the MPA.

Outputs: Thus far we have published two blog posts on the stereo-BRUVs work, by an intern who worked with the team last year: https://namibianaturefoundation.wordpress.com/2022/08/17/what-lies-beneath-the-surface-of-namibias-only-marine-protected-area/?preview_id=304&preview_nonce=e8aa9d7195&preview=true and more recently, by our MSc student: <https://westafricacetaceans.blogspot.com/2023/04/an-interview-with-mabuta-simataa.html>. We hope to produce a scientific publication on the chondrichthyan biodiversity in the NIMPA by early 2024.







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

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

RV Observer, a 15m LegacyCat aluminium hull boat, was built in 2019 and commissioned in early 2020, is based in Port Elizabeth. She has been operating from East London, Port Elizabeth, and Mossel

Bay during the past year. With similar capabilities as *RV Phakisa*, *RV Observer* provides exceptional research capacity to the Eastern Cape. She has proven to be particularly effective for ROV and benthic grab, allowing work to 300m depth.

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

Highlights for the Coastal Craft during 2022/3 include

- 3-week ROV expedition to East London for ACEP/OOH Capacity Building project.
- 3-week ROV work in Sodwana Bay for ACEP Deep Connections Project.
- 10- day expedition in Algoa Bay for ACEP Agulhas Bank Connections Project.
- 3-week ROV and benthic grab work in Mossel Bay for ACEP Agulhas Bank Project.
- Multi-beam surveys off Durban and uThukela Bank for ACEP SmartZone MPA project.
- Multi-beam surveys off Algoa Bay and St Francis for SAIAB/SAEON Seascapes Project.
- uMzumbi coelacanth trip for ACEP Deep connections Project.



Coastal Craft Platform Projects

Automated Penguin Monitoring Systems (APMS) at various African Penguin colonies

PI: Dr Alistair McInnes **Co-investigators and affiliations:** Eleanor Weideman (BirdLife South Africa), Dr Katta Ludunia (SANCCOB), Pierre Retief (BirdLife South Africa), **Collaborators and affiliations:** Dr Tegan Carpenter-Kling, Zamokhule Lazola (SANCCOB), Prof. Lorien Pichegru (NMU), Prof. Pierre Pistorius (NMU) **Students (degree and University):** Eleanor Weideman to start PhD in 2024.

The project includes the deployments of Automated Penguin Monitoring Systems (APMS) at various African Penguin colonies, including Bird Island (Algoa Bay), to passively monitor the performance of penguins (i.e. by measuring their body condition before and after foraging trips) in an effort to understand the influence of various factors on the availability of their specialised prey, anchovy and sardine. The installation of the APMS on Bird Island, Algoa Bay in 2022 with the incredible help of the crew of the *RV Observer*, has allowed us to monitor these birds in real-time via transmission of this data through cellular phone networks. The APMSs are currently being calibrated for penguin movement error and will also be calibrated to ecological conditions providing many opportunities for student research projects. The APMSs will also be used to monitor any interventions by DFFE to restrict purse-seine fishing around the last remaining large colonies including Bird Island.

Outputs: <https://www.birdlife.org.za/november-2022-newsletter/> (article: Automated monitoring at Bird Island)



Ecology and long-term monitoring of zooplankton in KZN

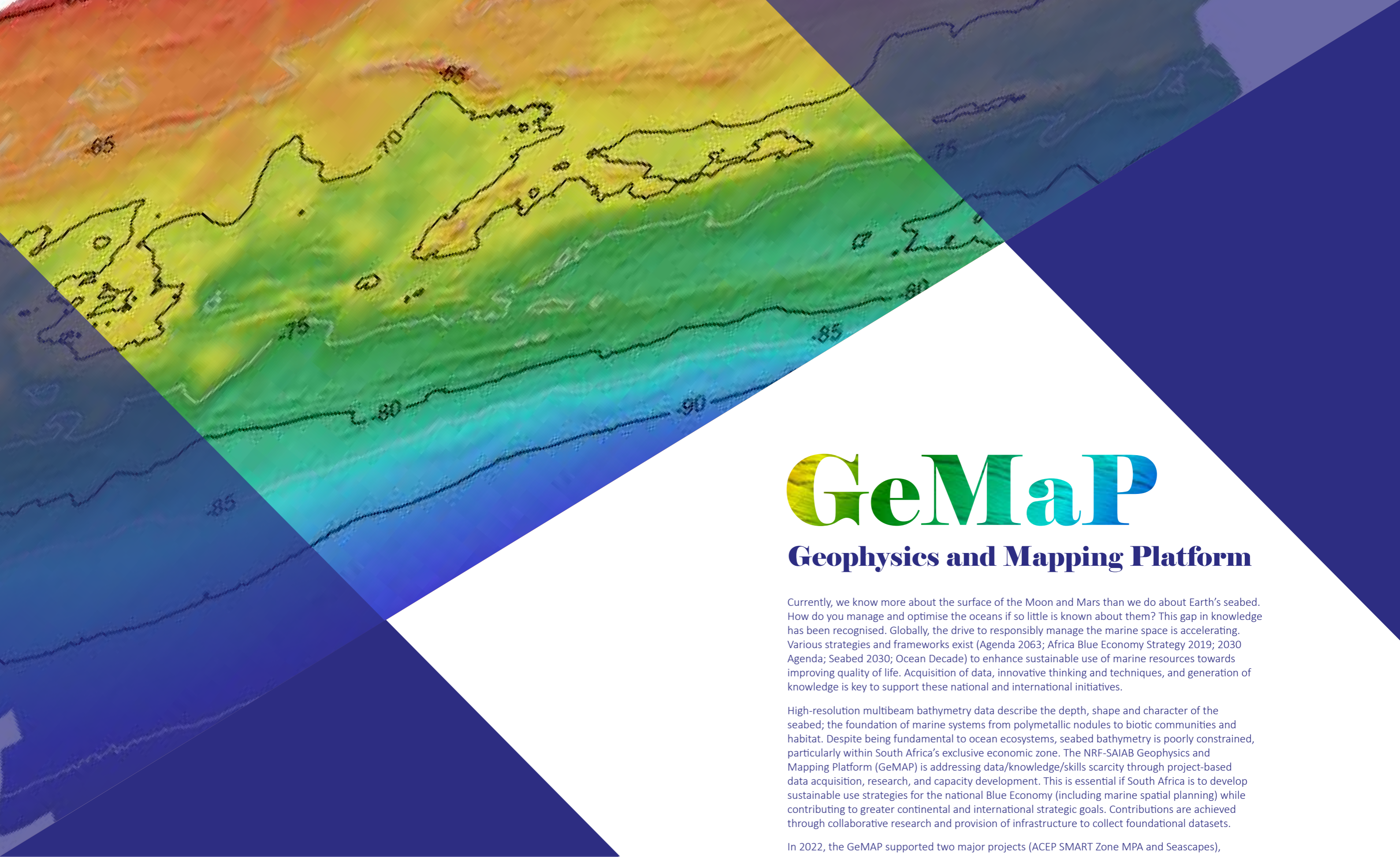
PI: Prof Johan Groeneveld (ORI) **Co-investigators and affiliations:** Dr Ashrenee Govender (ORI), Prof. Sandi Willows-Munro (UKZN), Dr Jenny Huggett (DFFE), **Collaborators and affiliations:** Thor Eriksen (SAIAB), Dr Riaan Cedras (UWC) **Students (degree and University):** Aadam Ravoot (MSc, UWC), Pariksha Govender (MSc, UKZN)

Zooplankton form ecologically important multispecies communities in marine pelagic ecosystems. They are well-suited to biomonitoring of ecosystem health because their abundance and community composition respond rapidly to environmental change. Traditional microscopy to determine zooplankton species composition is labor-intensive because they have high diversity, small body size and cryptic morphology. Molecular methods such as DNA barcoding (sequencing of individual specimens) and metabarcoding (simultaneous identification of multiple species present in samples) rely on barcode reference databases (barcode sequences matched with taxonomic species) which allow for fast, accurate and high-resolution identification of species in plankton tow net samples. Metabarcoding in combination with reference databases enables cost-effective biomonitoring which can be used to study the effects of climate change on marine pelagic ecosystems.

The project aimed to: improve the DNA barcoding reference database for zooplankton from South Africa; refine metabarcoding protocols for use in KZN shelf areas; apply metabarcoding in ecological studies; and support a cross-shelf monitoring line near Durban, the so-called Durban line. The availability of the *RV Phakisa* (SAIAB) to collect zooplankton samples across spatial and temporal scales is a key input, without which the project is not feasible. The vessel's continued availability is required for continued sampling of the long-term monitoring line, which forms part of the activities of the Natal Bight Sentinel Site platform, in collaboration with the Shallow Marine and Coastal Research Infrastructure (SMCRI) initiative led by SAIAB/SAEON.

During the period between April 2022 and March 2023, we undertook 3 cross-shelf (from the 20 m to the 200 m depth isobath) sampling trips on the *RV Phakisa* from Durban. Sampling trips were in May and September 2022 and March 2023. Apart from routine sampling of the Durban line, experimental work was conducted to study the effects of day/night sampling, net type, and tow duration on metabarcoding results. Experimental tows to search for lobster phyllosomas were also undertaken. Zooplankton samples have been processed at the ORI genetics laboratory, sequenced and data have been stored and analysed. Key achievements of the past year include: the support of two MSc projects, on the use of integrative molecular/morphology methods to grow the DNA barcode reference database for zooplankton from South African waters; accumulation of samples and molecular data on zooplankton biodiversity along the Durban line; and the publication of 4 scientific articles in the peer-reviewed literature. Over the past two years, the research focus has progressed from refining metabarcoding protocols to using metabarcoding in ecological studies, as reflected in the outputs shown below.

Outputs: Govender A, Singh S, Groeneveld J, Pillay S, Willows-Munro, S (2022) Experimental validation of taxon-specific mini-barcode primers for metabarcoding of zooplankton. *Ecological Applications* 32(1) e02469.
Huggett JA, Groeneveld JC, Singh SP, Willows-Munro S, Govender A, Cedras R, Deyzel SHP (2022) Metabarcoding of zooplankton to derive indicators of pelagic ecosystem status. *South African Journal of Science* 118(11/12), Art. # 12977. Govender A, Singh S, Groeneveld J, Pillay S, Willows-Munro S (2022). Metabarcoding analysis of marine zooplankton confirms the ecological role of a sheltered bight along an exposed continental shelf. *Molecular Ecology*, 00, 1–13.
Govender A, Groeneveld JC, Singh SP, Willows-Munro S (2022). Metabarcoding of zooplankton confirms southwards dispersal of decapod crustacean species in the western Indian Ocean. *African Journal of Marine Science* 44(3): 279-289.



GeMaP

Geophysics and Mapping Platform

Currently, we know more about the surface of the Moon and Mars than we do about Earth's seabed. How do you manage and optimise the oceans if so little is known about them? This gap in knowledge has been recognised. Globally, the drive to responsibly manage the marine space is accelerating. Various strategies and frameworks exist (Agenda 2063; Africa Blue Economy Strategy 2019; 2030 Agenda; Seabed 2030; Ocean Decade) to enhance sustainable use of marine resources towards improving quality of life. Acquisition of data, innovative thinking and techniques, and generation of knowledge is key to support these national and international initiatives.

High-resolution multibeam bathymetry data describe the depth, shape and character of the seabed; the foundation of marine systems from polymetallic nodules to biotic communities and habitat. Despite being fundamental to ocean ecosystems, seabed bathymetry is poorly constrained, particularly within South Africa's exclusive economic zone. The NRF-SAIAB Geophysics and Mapping Platform (GeMAP) is addressing data/knowledge/skills scarcity through project-based data acquisition, research, and capacity development. This is essential if South Africa is to develop sustainable use strategies for the national Blue Economy (including marine spatial planning) while contributing to greater continental and international strategic goals. Contributions are achieved through collaborative research and provision of infrastructure to collect foundational datasets.

In 2022, the GeMAP supported two major projects (ACEP SMART Zone MPA and Seascapes),



alongside short-term projects. The ACEP SMART Zone MPA project aims to generate a baseline to facilitate future assessments of MPA management zone effectiveness, and to achieve MPA management objectives.

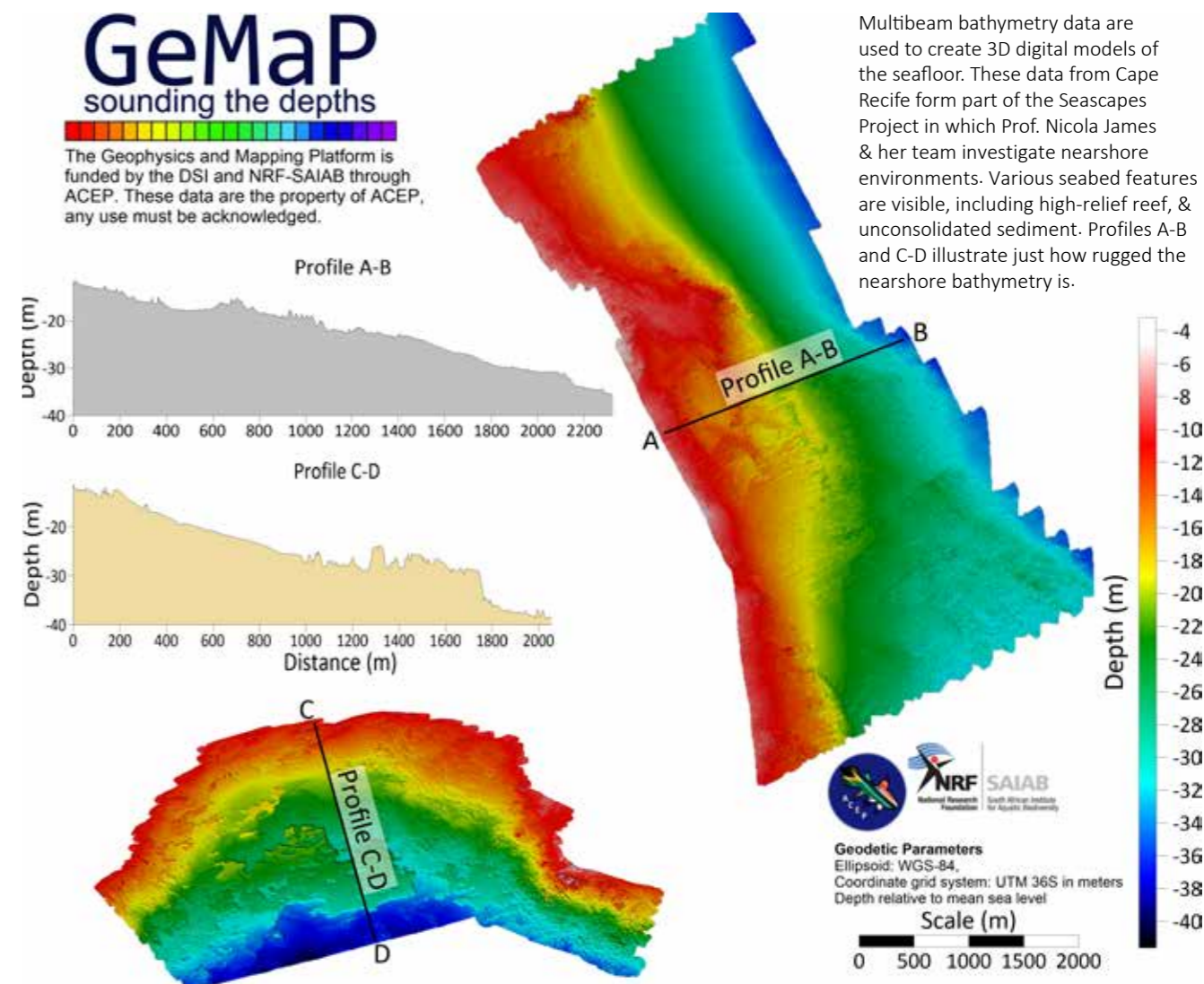
Six hydrographic surveys were completed for ACEP SMART Zone MPA located at sites within the uThukela MPA, which covered strategic biological areas of interest between 40 and 100 m depth, hitherto poorly constrained by high-resolution multibeam bathymetry data. Approximately 100 km² of data were collected using the ACEP's *RV ukwabelana*. Data contributed directly to a PhD project, led by Mr Thamsanqa Wanda, aimed at defining the seabed character at selected sites between Durban and Richards Bay. Drawing on skills from within NRF-SAIAB, NMU and the CGS, this research will classify geological habitat and discuss how this translates into biological and management aspects of the Blue Economy. In addition, the data were used to plan biological sampling efforts, including ROV and BRUV deployment sites.

The Seascapes project aims to i) map and model seascape spatial structure; ii) study the impact of climate change in seascapes, and iii) assess connectivity of fish within nursery seascapes and between shallow nursery seascapes and deeper adult habitat.

GeMAP was mobilised on SMCRI's *RV Observer* in the third quarter of 2022 when depths of 30 to 10 metres were targeted during surveys, and over 45 km² of new data were collected. The Seascapes project represented the first use of GeMAP's multibeam echosounder on *RV Observer*. The vessel proved to be an excellent survey platform and holds great potential for future work in the region. This is exciting as Algoa Bay has a long track record of biological research and marine spatial planning efforts which can now be coupled with multibeam bathymetry data in the region.

Data collected by GeMAP in Cape St Francis Bay has been shared with stakeholders from the local community, who are investigating the significant erosion of sediment from local beaches which has impacted coastal properties and tourism with knock-on implications for the local economy. Interested parties are looking to develop solutions which mitigate coastal erosion and reverse the negative impacts experienced to date.

Furthermore, GeMAP acquired data for the University of KwaZulu-Natal and the University of Zululand. These surveys took no longer than a day at sea to obtain the necessary bathymetry data, illustrating the rapidity with which data can be provided to focused projects. These projects are anticipated to contribute towards understanding anthropogenic impacts on biodiversity and ecosystem health. Both topics are integral to the Blue Economy and the sustainable use of marine resources. Negative impacts on biodiversity and ecosystem health would have dire implications for users, particularly in fisheries (subsistence and recreational) and on tourism. Furthermore, in-house training of marine technicians, summer schools in KwaZulu-Natal and exposure of students to the GeMAP is building capacity and familiarity with multibeam bathymetry data.



Multibeam bathymetry data are used to create 3D digital models of the seafloor. These data from Cape Recife form part of the Seascapes Project in which Prof. Nicola James & her team investigate nearshore environments. Various seabed features are visible, including high-relief reef, & unconsolidated sediment. Profiles A-B and C-D illustrate just how rugged the nearshore bathymetry is.

Joint Marine Laboratory





Unveiling of the UFH signage by (from left) Dr Gilbert Siko (DSI), Dr Clifford Nxomani (DCEO: NRF), Prof Sakhele Buhlungu (UFH Vice-Chancellor), Dr Angus Paterson (NRF-SAIAB Managing Director) & Prof Graeme Bradley (UFH: JML PI)

Joint Marine Laboratory Taking excellence to the people

Investing in research and science infrastructure is crucial for advancing marine science. This includes research vessels, laboratories, and technology to better understand and manage the marine environment. South Africa also places a great importance on development of skilled workforce in marine science and conservation. This includes training researchers, technicians to effectively manage and protect marine resources. The next phase of the Phuhlisa programme involves the development of the DSI/NRF-SAIAB Joint Marine Laboratories Programme (JMLP) at the HDI campuses. This aims to build research capacity at HDIs through the establishment and support of specialized laboratories at the partner universities. The laboratories were all selected to answer key challenges faced by South Africans. Currently laboratories have been set up and are operational at the University of Fort Hare (UFH), the University of the Western Cape (UWC), while Laboratories at the University of Zululand (UZ) and Walter Sisulu University (WSU) are being set up.

University of the Western Cape – Pollution: Micro-plastics laboratory (Dr Anusha Rajkaran)
 University of Zululand – Pollution: Marine and estuarine ecotoxicology (Dr Ntuthuko Masikane)
 University of Fort Hare – Innovation: Bio-discovery (Prof. Graeme Bradley)
 Walter Sisulu University – Livelihoods: Rural Livelihood and Food Security (Dr Tembinkosi Steven Dlaza)

All JML PIs have been added as SAIAB honorary research associates: Prof. Graeme Bradley, Dr. Ntombekaya Nqumla, Dr Niall Vine, Dr. Ntuthuko Masikane, Mr. Mduzi Mzimela, Prof. Anusha Rajkaran, and Dr Tembinkosi Dlaza.

Marine and Estuarine Ecotoxicology Laboratory (UNIZUL)

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

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

We are currently investigating the ecology of soft sediments in Algoa Bay and Cape St Francis Bay. We will also be investigating the sediment health of the two bays, looking at the pollution of metals, selected organic compounds and microplastics. We are developing a research programme for coastal lakes in KZN that will kick-start next year. We are hoping to collaborate with UKZN and KZN Wildlife on this project.

Micro-plastics laboratory (UWC)

Like many coastal nations, South Africa faces serious issues related to marine pollution, including plastic waste. Reducing plastic pollution and addressing other forms of marine pollution are critical priorities. The presence and movement of man-made particles, such as plastics, in aquatic systems threatens the health and integrity of the environment and is considered a global risk. Emanating from rivers and estuaries to the ocean are the main pathways for plastics to reach our oceans. The occurrence of microplastics in the oceans is a growing research theme globally, however in South Africa this theme is still in its infancy but is gathering momentum.

Since 2015 the baseline information on microplastics is growing steadily. Recent publications have attempted to estimate microplastics levels in the sediment and water column of four mangrove estuaries. However, in a country of over 300 estuaries this leaves a large number of systems where little to no data exists. Reports of microplastic (≤ 5 mm in length) ingestion by aquatic organisms are increasing with a particular interest in fish. A further risk associated with microplastics are organisms that attached and live on the plastic particles itself. Very little is known about this “plasticsphere” that may exist in the marine environments of South Africa. These may increase the risk of invasion of alien species, impact the health of aquatic organisms and may very likely transfer into humans. Therefore, the key objectives of this laboratory will be to establish the most comprehensive dataset on microplastics in the estuaries of South Africa, establish microplastics levels in key estuarine and marine species and to establish the components of the plasticsphere in different estuarine groupings (estuarine type, levels of development and particular threats).

This laboratory has the potential to contribute towards the following Sustainable Development Goals SDG 3 (Good health and well-being), 6 (Clean water and Sanitation), 13 (Climate Action), 14 (Life below water) and 15 (Life on land).

The rate at which we consume microplastics and the associated plasticsphere is becoming more and more relevant, a focus on species related to the South African diet will be a focus for this laboratory. The connectivity between rivers, storm water infrastructure, estuaries and the marine environment results in the movement of plastics from the land to the sea. This laboratory will identify the main sinks and sources of microplastics and provide recommendations for the improved management of plastics in aquatic habitats. The

Laboratory will also contribute to societal outcomes of the UN Decade of Ocean Science for Sustainable Development specifically “A Clean Ocean”. The laboratory currently hosts one registered PhD, one registered MSc and one PhD who will register next year using the lab. The majority of students are female (coloured).

Bio-economy and Biodiscovery Laboratory (UFH)

Many chronic non-communicable diseases have increased mainly because of a change in diet and increased sedentary lifestyle. These diseases include cardiovascular diseases, cancers, respiratory diseases and diabetes mellitus which together have been reported to be the number one cause of human mortality, accounting for 40 million deaths per year, equivalent to 70% of all deaths globally.

The challenges of developing effective new treatments for cancer has resulted in the search of new drugs from natural sources, which have included marine macro and microalgae and other marine organisms. Marine organisms are proposed to be a major source for new drugs, due to the huge biodiversity found in marine ecosystems, and hence have become a main focus in cancer research. Many metabolites isolated from marine algae have been shown to possess bioactive effects and exhibit antidiabetic effects. Marine algae have been discovered to contain diverse secondary metabolites and as such, many marine products have been traditionally used for the treatment of diabetes throughout the world. Antioxidant compounds play a vital role in scavenging free radicals and controlling oxidative stress related diseases such as diabetes.

Marine algae have been reported to be one of the underexploited plant resources. Furthermore, marine algae are a rich source of structurally diverse bioactive compounds that have great pharmaceutical and biomedical potential. Although the biologically active compounds for the natural source of drugs from marine algae are unknown, they are still used widely for the treatment of various diseases because of their effectiveness, very low cost, and very little side effects in clinical trials.

Macro algae can survive in highly competitive marine environments because of the unique and complex metabolic pathways that they have developed and they accumulate high levels of minerals from seawater. Red algae are therefore speculated to have the high levels of stress proteins and secondary metabolites, which fluctuate seasonally and therefore pose as a promising source of potential new anticancer or antidiabetic drugs.

Current projects: The Bio-Economy Marine Discovery Lab is exploring the medicinal properties of red algae species along the Eastern Cape coastline. The main focus is identifying bioactive compounds from the various red algae species with anti-cancer or anti-diabetic properties. In conjunction with this research, we are also researching the biodiversity of the red algae along the Eastern Cape coastline.

An additional project being undertaken to support the above, is the sequencing of the genomes of a specific red algae species found in abundance along the Eastern Cape Coastline. The staff and students who were trained were Dr Ntombekhaya Nqumla (Technician responsible for system), Dr Elizabeth Aladejana (Backup technician responsible for system), Ms Faith Mshiywa (Phuhlisa PhD student), Mr Sitha Ntlokwana (Phuhlisa PhD student), Dr Thuthuzelwa Stempa (Post-doctoral fellow and potential user), Emmanuel Aladejana Sitha (Doctoral student and potential user), and Ntlokwana Aldi Nel (Post-doctoral fellow and potential user). The training included the information in the fundamentals of HPLC, Fundamentals of Empower QuickStart Setting up the system, acquiring data, processing data, and extracting data from 3D channels (PDA/QDa), reporting and collecting fractions. A scouting run was performed on a provided sample after which a focus gradient was developed together with a fraction collection method.

The Bio-economy and Bio-discovery laboratory was launched on the 10th March 2022 and attended by 32 delegates including Prof. Sakhela Buhlungu (UFH VC), Prof. Renuka Vithal (DVC-T&L), Dr Nthabi Taole-Mjimba (DVC-Research, Partnerships and Innovation),

Dr Clifford Nxomani (NRF, Deputy CEO), Dr Kurt van der Heyden (NRF, Director of Strategic Science Support and Analysis), Dr Gilbert Siko (DSI- Science platforms), Ms Fhumulani Ramukhwatho (DSI, Deputy Director: Marine and Palaeosciences) and Prof. Graeme Bradley (Dean Faculty Science and Agriculture).

Fort Hare Aquaculture Research Unit (FHARU): The South African Aquaculture sector is a growing industry both in terms of commercial enterprises and food security initiatives. Unfortunately, the training and mentoring of young, black researchers (and potential future farm management) has been slow. This has resulted in the commercial sector being grossly under transformed and desperately requiring redress. This skills shortage and accompanying transformation challenges in the marine sector are recognised in the DST’s Marine Research Plan (2014-2019) which states that “Dedicated programmes that enhance marine research at HBU’s and drive transformation are required”.

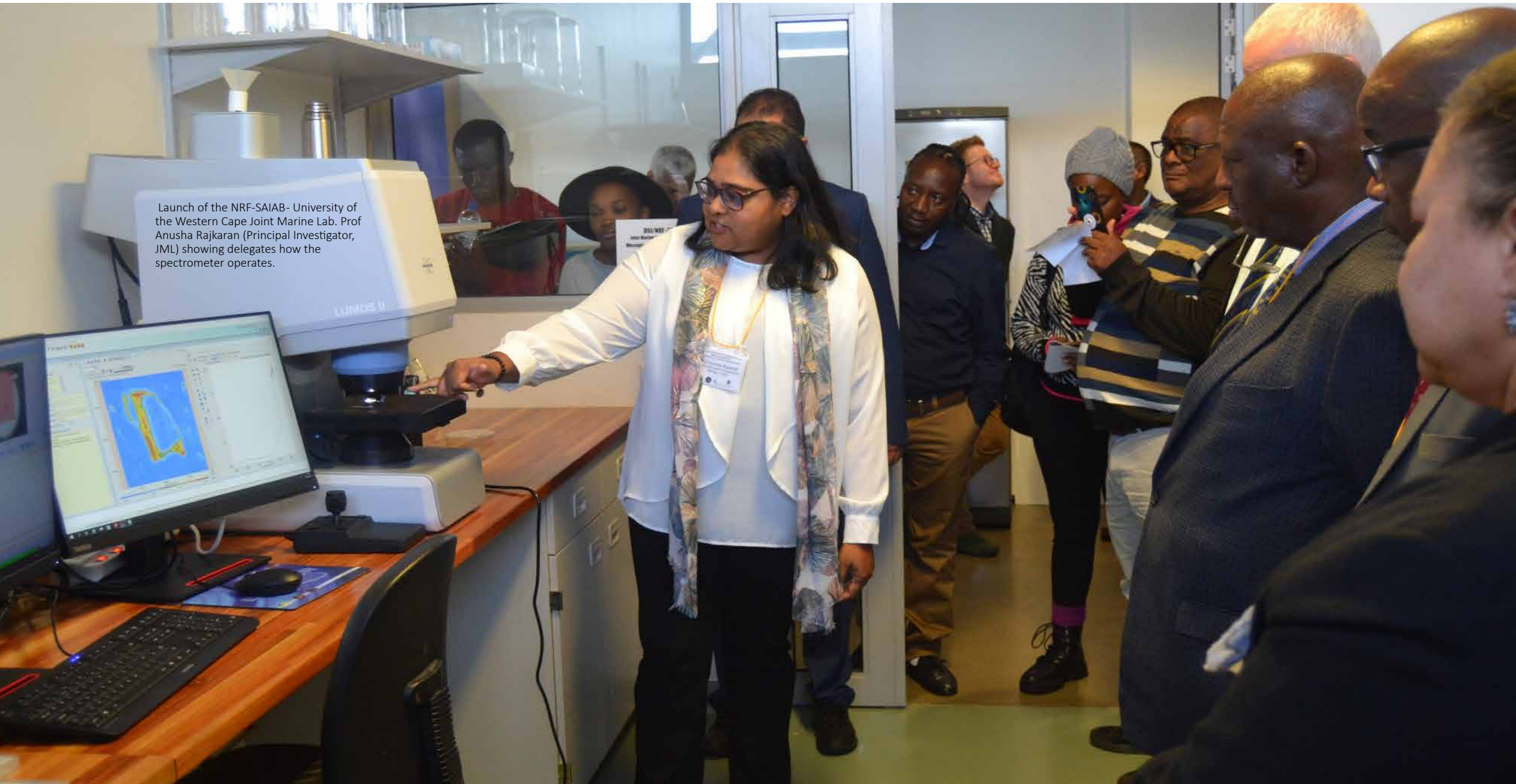
The Marine and Antarctic Research Strategy (2016) also acknowledges that employment and food security are intricately linked to fisheries and aquaculture and makes mention that research in these “marine technologies” are currently unfocussed and un-coordinated and therefore require specific attention.

The commercial aquaculture farm, Kingfish Enterprises (KE) is situated in the East London Industrial Development Zone (ELIDZ) and primarily focus on producing yellowtail kingfish and dusky kob but are also investigating a variety of other marine species such as, pacific oyster, sea urchins and abalone. The objective of the Fort Hare Aquaculture Research Unit (FHARU) is to conduct research which is driven by the local aquaculture industry. Currently, all research conducted by Prof Vine’s research group not only creates student and publication outputs but also makes the research both relevant and applicable to industry. Students will also be exposed to working on a commercial farm which enhances their exposure and adds to their acquired skill set.

Recent (2018 onwards) and current post-graduate research projects include:
Assessing the potential of a local candidate live-food organism (a calanoid copepod) for feeding to farmed marine finfish larvae;
Optimisation of the nutritional requirements for culturing the collector sea urchin (*Tripneustes gratilla*);
Optimising the transport requirements of larval abalone for stock-enhancement programmes;
The optimisation of protein and energy levels in the diet of juvenile yellowtail kingfish (*Seriola lalandi*);
Probiotic development for the collector sea urchin (*T. gratilla*);
Understanding the effect of culture-induced stress on abalone physiology, growth and health;
The co-culture of abalone and sea-cucumbers; and
Improving the settlement success of abalone larvae with the aim of replenishing the natural stocks.

Coastal livelihood & Ecology Laboratory (WSU)

Plans to build the research station has been moved to Lwandile near Mngazana. WSU has also revamped their research laboratories on Campus in Mthatha which now needs to be furnished with small lab apparatus The group will also receive field equipment including a 4x4 vehicle, and estuary boat, and multi-parameter probe, all critical to their research.



Launch of the NRF-SAIAB- University of the Western Cape Joint Marine Lab. Prof Anusha Rajkaran (Principal Investigator, JML) showing delegates how the spectrometer operates.

Conclusion

ACEP performed well in the 2022-23 year and continues to deliver effectively on the NRF and DSI mandate. The programme has actively driven transformation and is a key tool in the DSI's drive to ensure research is both relevant and performed by all South Africans. The 2021-23 ACEP Open Call is supporting four multi-disciplinary projects, is fully subscribed and highly active; the Marine Platforms are well utilised by the Open Call projects, Phuhlisa Projects, and partner platforms, and are growing in scope and activity. The Phuhlisa Programme reached 64 students, and the Science Awareness platform reached learners, undergraduate students, and the public.

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

ACEP Phuhlisa

Objective: Redressing the imbalances in the demographic structure of marine science through a dedicated ring-fenced programme at HDIs. The Phuhlisa Programme doubled in size in 2015 with UWC and UniZulu joining the programme, and has continued to grow year on year. The period 2017-2022 has been a consolidation period and the programme has been limited to supporting up to 20 researchers and up to 100 students (currently 19 supervisors and 64 students). The next three years will see the programme extending its support in terms of access to infrastructure to the participating institutions. The role that NRF-HICD plays in this programme is pivotal to its success, as ACEP Phuhlisa provides running costs and technical and academic input, while HICD provides bursaries. Support at the universities is being increased through the development and investment in laboratories at these universities (Joint Marine Laboratories).

ACEP Open Call

Objective: Open, competitive access to marine research infrastructure, technical support, bursaries and running costs to support the development of the Blue Economy. The current Open Call is supporting four multi-disciplinary, multi-institutional projects, two in the Eastern Cape and two in KwaZulu-Natal, involving 69 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 to support national research priorities. 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.



ACEP Platform Provision

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

Coastal craft fleet

RV uKwabelana
RV Phakisa
RV Observer

Acoustic Tracking Array Network (ATAP)

148 submerged listening stations between Cape Town and Ponta do Ouro
 National ATAP database

GeMaP- Geophysics and Mapping Platform

Multibeam sonar

Marine Remote Imagery Platform (MARIP)

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

Competitive access to other national marine platforms

Algoa Bay Sentinel Site (SAEON Elwandle)

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

Science Advancement

Objective: Raising awareness and educating the public, learners and students about marine science. This phase will be orientated around the following key programmes:

SciFest Water World – Learners and public
 Working World Exhibition
 HDI field trips – UFH, WSU and UZ
 Summer Schools

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:

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ACEP Management and Technical Team (SAIAB)

Dr Angus Paterson Mr Thor Eriksen Prof. Paul Cowley
 Mr Ryan Palmer Mr Koos Smith Mr Matt Parkinson
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 Mr Thamsanqa Wanda Dr Anthony Bernard Mr Lishini Kokose

ACEP Phuhlisa Team

Mr Garth van Heerden Mr Zipho Canda Mr Lucky Dlamini

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SAEON

Prof. Tommy Bornman Prof. Juliet Hermes Ms Nozipiwo Hambaze



ACMP 2022 statistics

Phuhlsa

4 HDIs
nineteen
supervisors
64 students




4
open call
projects
2021-2023


 **peer-reviewed**
publications
19 new in
2022
68% first authored by
researchers from
designated groups

marine
platforms
45 students
supported



87% designated
groups

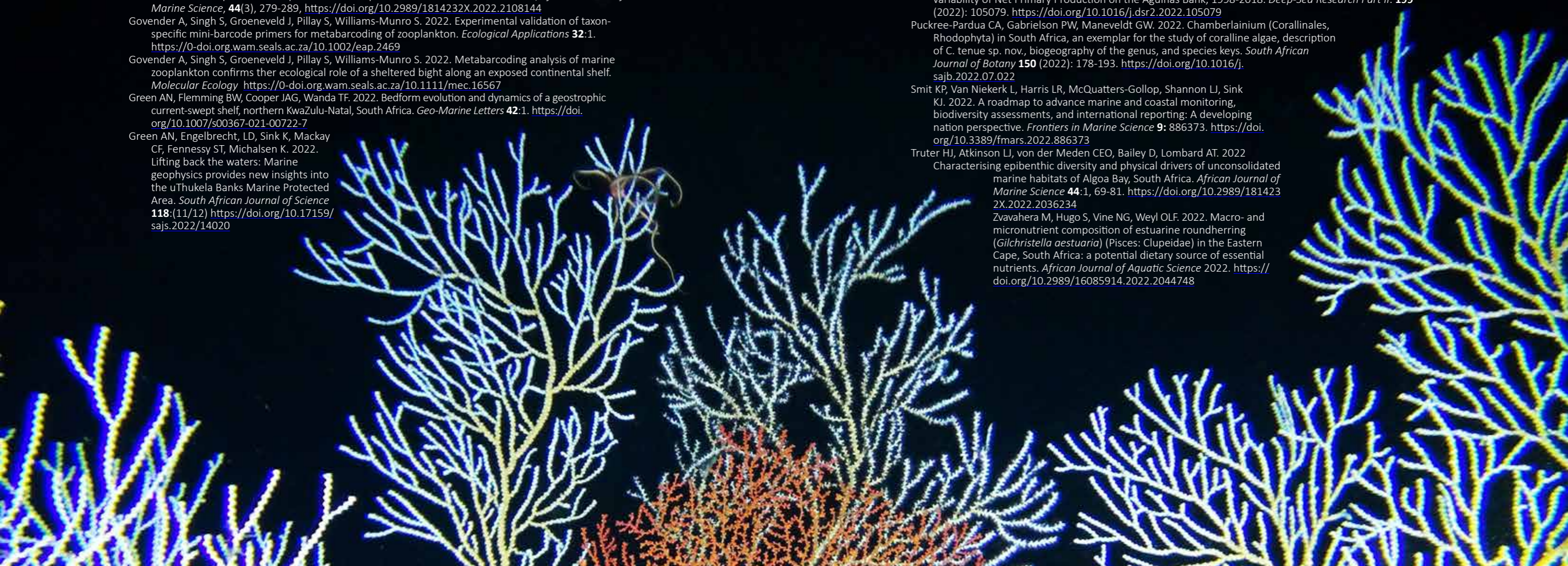


ACEP Publications 2022

ACEP has supported a total of 248 peer reviewed papers before 2022. These publications listed below are the 19 new publications for 2022. These publications specifically acknowledge ACEP and include publications that only benefitted from ACEP funding.

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Acronyms & Abbreviations

AAM	Aquaculture Africa Magazine	PCA	Principal component analysis
AASA	Aquaculture Association of Southern Africa	PCA	Principal Component Analysis
ABC	Agulhas Bank Connections	PCR	Polymerase chain reaction
ACEP	African Coelacanth Ecosystem Programme	PER	Protein efficiency ratio
AchE	Acetylcholinesterase	PP	polypropylene
APMS	Automated Penguin Monitoring Systems	PS	polystyrene
AS	aerobic scope	PSSA	Phycological Society of Southern Africa
ATAP	Acoustic Tracking Array Platform	RAS	Recirculating Aquaculture System
CEC	Contaminants of Emerging Concern	RASSPL	The Rock And Surf Super Pro League
CF	Condition Factor	RFID	Radio Frequency Identification
CoCT	City of Cape Town	ROV	Remote operated vehicle
CSIR	Council for Scientific and Industrial Research	RU	Rhodes University
CTD	Conductivity, temperature, depth	SAAMBR	The South African Association for Marine Biological Research
DAFF	Department of Agriculture, Forestry and Fisheries	SAEON	South African Environmental Observation Network
DFFE	Department of Forestry, Fisheries and Environment	SAERI	The South Atlantic Environmental Research Institute
DIFS	Department of Ichthyology and Fisheries Science	SAIAB	South African Institute of Aquatic Biodiversity
DUT	Durban University of Technology	SALPA	South African Linefish Physiology Assessment
DW	Disc width	SAMSS	Southern African Marine Science Symposium
EAS	European Aquaculture Society	SANBI	South African National Biodiversity Institute
EDX	Energy Dispersive X-Ray	SANCOR	South African Network for Coastal and Oceanic Research
EKZNW	Ezemvelo KZN Wildlife i	SANParks	South African National Parks
ELIDZ	East London Industrial Development Zone	SAWS	South African Weather Service
ENM	Engineered nanomaterial	SDG	Sustainable Development Goals
ETN	European Tracking Network	SEEC	Statistics in Ecology, Environment and Conservation
FCR	Food Conversion Ratio	SEM	Scanning Electron Microscope
FHARU	Fort Hare Aquaculture Research Unit	SGR	Specific growth rate
FPN	Final Population Number	SMCRI	Shallow Marine and Coastal Research Infrastructure
FT-IR	Fourier-transform infrared (FT-IR) spectroscopy	SMR	Standard Metabolic Rate
GCC	Global Climate Change	SOSF	Save Our Seas Foundation
GDP	Gross Domestic Product	SPE	Solid-phase Extraction
HSI	Hepatosomatic index	SS	Shark Spotters
IFREC	Inter-Faculty Ethics Committee	TAN	Total Ammonia N
IMTA	Integrated Multi-Trophic Aquaculture	TOAF	Two Oceans Aquarium Foundation
IP	Interactive Petrophysics	TOC	Total organic carbon
IPTEI	International Periodic Table of Elements and Isotopes	UCT	University of Cape Town
ISEC	International Statistical Ecology Conference	UFH	University of Fort Hare
IUCN	International Union for Conservation of Nature	UJ	University of Johannesburg
IUPAC	International Union of Pure and Applied Chemistry	UKZN	University of KwaZulu-Natal
KZN	KwaZulu-Natal	UNIZUL	University of Zululand
MARIP	Marine Remote Imagery Platform	UP	University of Pretoria
MIC	Minimum Inhibitory Concentration	UPLC	Ultra performance liquid chromatography
MINTEC	Ministerial Technical Committee	UWC	University of the Western Cape
MMR	maximum metabolic rate	VME	Vulnerable Marine Ecosystem
MPA	Marine Protected Area	WCS	Wildlife Conservation Society
MS-222	Methanesulfonate	WIOMSA	Western Indian Ocean Marine Science Association
NGS	Next-generation Sequencing	WITS	University of Witwatersrand
NMR	Nuclear Magnetic Resonance	WWTP	Waste Water Treatment Plants
NRF	National Research Foundation	XRD	X-Ray diffraction analysis
ORI	Oceanographic Research Institute	XRF	X-ray fluorescence
PAH	polycyclic aromatic hydrocarbon		
PASA	Petroleum Agency South Africa		





 National Research Foundation	 South African Institute for Aquatic Biodiversity	 A C E P	 science & innovation Department: Science and Innovation REPUBLIC OF SOUTH AFRICA
 forestry, fisheries & the environment Department: Forestry, Fisheries and the Environment REPUBLIC OF SOUTH AFRICA	 SMCRI Shallow Marine & Coastal RESEARCH INFRASTRUCTURE	 National Research Foundation	 SAEON South African Environmental Observation Network

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