South African Institute for Aquatic Biodiversity

ANNUAL RESEARCH REPORT 2021

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The South African Institute for Aquatic Biodiversity

NRF - SAIAB ANNUAL RESEARCH REPORT

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NRF-SAIAB Annual Research Report for 2021

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INNOVATE, DISCOVER

Promote Globally Competitive Research and Innovation

EXPLORE

Platform Provision and Infrastructure Development

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NETWORK

Research Overview 2021

The South African Institute for Aquatic Biodiversity (NRF-SAIAB) serves as a hub for national and international scientific research into the country's most precious resource – water – and the diversity of life supported by our marine, coastal and inland freshwater ecosystems. The NRF-SAIAB's mandate is to undertake research for the sustainability of Africa's marine and freshwater environments. To this end, NRF-SAIAB provides research platforms and infrastructure that enable a wide range of multi-disciplinary and multi-institutional research into inland fisheries and freshwater ecology, constantly changing coastal systems, and the movement ecology of marine animals. All the research undertaken at NRF-SAIAB contributes knowledge about how water-based ecosystems function, including the impact of societal demands on the country's coastal, estuarine and freshwater resources. This information is crucial for understanding and managing these essential natural resources for the long-term benefit of South Africa's people.

In line with its status as a National Facility, NRF-SAIAB's unique research platforms are available to the broader research community in the National System of Innovation (NSI). These platforms include the aquatic biodiversity collections; associated specialist laboratories and services which integrate modern molecular, ecophysiology and bio-banking systems; a community-driven marine flagship programme (the African Coelacanth Ecosystem Programme - ACEP), and marine platform provision, including coastal craft, in situ instrumentation, a Remotely Operated Vehicle (ROV), Remote Underwater Video Systems, the Acoustic Tracking Array Platform (ATAP) and the Geophysics and Mapping Platform (GeMaP). The NRF-SAIAB also hosts the DSI/NRF Research Chair in Inland Fisheries and Freshwater Ecology and provides a regional platform for freshwater African aquatic biodiversity research through collaborations and project management with a number of sub-Saharan countries.

The NRF-SAIAB interacts with a broad range of universities and local and national government departments regarding current environmental issues, which require integrating evidence-based science with management, and providing scientific advice that policymakers can apply in formulating national environmental policy. Areas of national concern in which NRF-SAIAB is involved are socio-economic development, water security issues, ecosystem degradation and the influence of climate change on food security.

The productivity of NRF-SAIAB research staff, students, postdocs and Honorary Research Associates continued at a high level during 2021, with 124 ISI-rated (International Scientific Indexing) scientific papers published. Some research highlights follow.

The Acoustic Tracking Array Platform (ATAP), a nationwide network of acoustic receivers that monitor the coastal movements and migrations of tagged aquatic animals, continues to go from strength to strength. This past year (2021) saw no less than seven students using data collected by the platform for their various degrees. Studies ranged from assessing the feasibility of using boat-based acoustic receivers, to improving data collection of tagged sharks within the ATAP (which was also presented at the 6th Southern African Shark and Ray Symposium in November 2021), to gaining a better understanding of the coastal movements of sub-adult and adult leervis, *Lichia amia*, to assessing the movement behaviour of juvenile river snapper, *Lutjanus argentimaculatus*, in the Kosi Bay Lake System, KwaZulu-Natal.

MSc student, Tayla Dominy (registered with the Rhodes University Geography Department, supervised by Geography's Prof. Ian Meiklejohn and co-supervised by NRF-SAIAB's Dr Taryn Murray) received a distinction for her MSc thesis entitled "Geospatial analysis on the effect of environmental variables on the space use patterns of four marine predators occurring in Algoa Bay, Eastern Cape, South Africa". Both examiners commended her on her high level of work, stating that the maps created in ArcGIS Pro were of a particularly high quality.

During 2021, the Marine Remote Imagery Platform (MARIP) carried out remotely operated vehicle (ROV) and baited remote underwater stereo-video (stereo-BRUV) surveys to support three NRF African Coelacanth Ecosystem Programme (ACEP) projects and four independently funded projects. This included baseline surveys of established (Robberg, Hluleka and Dwesa-Cwebe) and new (Protea Banks) marine protected areas (MPAs). The South African Polar Research Infrastructure (SAPRI) platform was approved, and MARIP will manage the Seafloor Node of the infrastructure platform. This will see a greater emphasis on supporting deep-sea and polar research by MARIP and associated research groups. Dr Anthony Bernard, MARIP Platform Manager, and Dr Rick Stuart-Smith (University of Tasmania) were awarded funding from the Scientific Committee for Oceanic Research for co-chairing a working group that aims to advance standardisation and utility of coastal and nearshore demersal fish visual census techniques.

The ACEP SMART Zones MPA project, led by Dr Errol Wiles, saw the collection of 77 km^2 of multibeam bathymetry data within, and adjacent to, the uThukela MPA using the ACEP Geophysics and Mapping Platform's (GeMaP) Reson 7101 multibeam echosounder. This is the first systematic high resolution, multibeam bathymetry survey of reefs within different management zones of a South African MPA, including reefs outside the MPA control zone. Beyond high-resolution bathymetry surfaces, data derivatives (slope, aspect, rugosity) will: 1) describe and classify the seafloor in terms of geomorphological habitat, 2) provide an unprecedented view of the seafloor for biological sampling campaigns, and 3) provide geospatial context to marine research in the region. Reefs of the South African east coast are biological hotspots, contributing to the Blue Economy though ecosystem services, tourism, and fisheries. Once the data collection phase is complete, analysis of data from the various project teams will link geomorphological habitat to a variety of biological indicators, enabling quantification and classification of seafloor ecosystems by area. Marine Geologist and Nelson Mandela University PhD candidate, Mr Thamsanqa Wanda, has presented at several local and international conferences and submitted his first manuscript based on the bathymetry data from the uThukela MPA. Ultimately, the outputs from this research will feed directly into marine spatial planning, enabling better informed management of marine resources.

2021 was an exceptionally productive year for the Coastal and Ocean Sciences Team (COST), under Dr Francesca Porri's leadership. Eleven peer-reviewed papers were published, two of which were in very good impact factor journals: one on the state of global mangroves (Proceedings of the National Academy of Science) and the other on the physiological vulnerability of early ontogeny of marine invertebrates respectively (Limnology and Oceanography Letters). A great achievement for the COST in 2021 was the award of the NRF three-year innovative project, Indigenous Marine Innovations for Sustainable Environments and Economies (IMIsEE Project). Later in the year, Dr Porri was conferred Honorary Professorship within the Department of Zoology and Entomology at Rhodes University. Despite a year of COVID-related confinement, Dr Porri was invited to present in person at the International Marine Connectivity conference in Paris, France in December 2021.

Postdoctoral Fellow, Dr Kerry-Ann van der Walt, associated with COST, published two peer-reviewed articles in international journals (Marine Environmental Research and Frontiers in Marine Science) based on her PhD research. Dr van der Walt completed two online courses: 1) on the Blue Economy with VUSSC and the University of Seychelles, 2) on Intellectual Property (IP), Traditional Knowledge (TK) and Traditional Cultural Expressions (TCEs) with the World Intellectual Property Organization (WIPO). Dr van der Walt produced three digital storytelling videos in association with the Aquatic Eco-physiology Research Platform (AERP), SAFER research team and COST research team for National Marine Week 2021, highlighting research being carried out by researchers and students.

During 2021, Dr Nikki James and her research team focussed on the relative value of different coastal nursery habitats for marine and estuarine fish species, as well as the impact of climate change on fish species. A team of six PhD students, Ms Phakama Nodo, Ms Phumza Ndaleni, Ms Melissa Pollard,

Ms Lauren Murray, Ms Carla Edworthy and Mr Cuen Muller, as well as three MSc students, Mr Thembani Mkhize, Mr Mihle Gayiza and Mr Aiden Jacobs, were involved in this research in 2021. Highlights for the year were: the graduation of Dr Carla Edworthy, the awarding of an NRF marine and coastal research grant to continue this research, and the appointment of Dr James as a visiting professor in the Department of Ichthyology and Fisheries Science at Rhodes University, as well as in the Institute for Coastal and Marine Research (CMR) at Nelson Mandela University.

Dr Carla Edworthy graduated from the Department of Ichthyology and Fisheries Science at Rhodes University in April 2021, with a PhD focussing on assessing the eco-physiological impacts of ocean acidification on early stage fishes. Dr Edworthy began an NRF PDP Postdoctoral Fellowship at NRF-SAIAB in May 2021 and joined the Seascape Ecology Research group. Her current focus is on continuing her research on ocean acidification and its impact on coastal species, by developing a strategy to monitor coastal pH conditions, specifically in potentially important macroalgal ocean acidification refugia in Algoa Bay.

During 2021, Dr Albert Chakona and the freshwater research team added five species of freshwater fish to the list of freshwater fishes of South Africa through description of new species and revalidation of synonyms. One of the newly described species is *Enteromius mandelai*, which was named in honour of the first democratic president of South Africa. This species is endemic to the Eastern Cape Province of South Africa.

Also part of the freshwater research team, Postdoctoral Fellow, Dr Pedro de Bragança, focussed mainly on specimens in the NRF-SAIAB Collection during 2021. This led to redescriptions and new descriptions of southern African freshwater species, as well as the description of two new miniature species from north-eastern Gabon, and a range extension of a small livebearer fish in the Brazilian Amazon.

Dr Mandla Magoro, Postdoctoral Fellow at NRF-SAIAB, gave a keynote presentation at the 2021 World Fisheries Congress in September, which was hosted via a hybrid format in Adelaide, Australia, and he presented at the 2021 Fisheries Society of the British Isles Conference, which was hosted by KU Leuven in Belgium. The freshwater research team also participated in the first phase of the Waterberg Biodiversity Project, which is funded by the Foundational Biodiversity Information Programme (FBIP).

Dr Lizaan de Necker, Postdoctoral Fellow based at North-West University, attended and presented at the British Society for Parasitology Online Conference in June 2021. She also published a paper on the effects of drought on aquatic invertebrate communities in a naturally saline lake of South Africa.

In 2021, the Draft National Freshwater (Inland) Wild Capture Fisheries Policy for South Africa was published by the Department of Forestry, Fisheries and the Environment (DFFE). The aim of this policy is to develop the inland fisheries sector for the benefit of society by ensuring food security, job creation and economic development. Much of the late Professor Olaf Weyl's work as the South African Research Chair in Inland Fisheries and Freshwater Ecology was research to underpin and inform this development. Of note in this respect is the key research published posthumously at the start of 2021: Weyl, O.L.F., et al. "Ten research questions to support South Africa's inland fisheries policy." African Journal of Aquatic Science 46.1 (2021): 1-10. This publication arose from an Inland Fisheries workshop convened by the South African Society for Aquatic Scientists in June 2018 to develop a list of priority knowledge requirements for inland fisheries in the country. The 15 authors of this paper, from southern Africa, North America and Europe combined their broad range of expertise to develop a top-ten list of research questions for inland fisheries. The purpose of this paper is to guide future research to accomplish the goals of the new policy. After the passing of Prof. Weyl in 2020, Dr Josephine Pegg, a Postdoctoral Fellow within the South African Research Chair: Inland Fisheries and Freshwater Ecology, stepped in as Interim SARChI Chair during 2021, overseeing the research group and post-graduate students linked to the Chair.

Rhodes University/NRF-SAIAB student, Takudzwa Comfort Madzivanzira, graduated with a PhD in freshwater ecology in 2021, with a thesis entitled "Evaluating and predicting impacts of Australian Redclaw crayfish, *Cherax quadricarinatus*, and Louisiana Red Swamp crayfish, *Plocambrus Clarkii*, invasions". This work has raised concerns about the potential of introduced crayfish to spread to important ecosystems and cause socio-economic harm. Dr Madzivanzira's work has been widely commended and he is the recipient of a number of prestigious awards, including notably, the National Research Foundation Research Excellence Award for Next Generation Researchers 2021, and the South African Society for Aquatic Scientists Bronze Medal.

Prof. Francesca Porri

Senior Scientist: NRF-SAIAB Science Leadership Team

Innovate, Discover

Promote globally competitive research and innovation

Ecology of Coastal Ecosystems

Prof. Francesca Porri, Senior Scientist

Background and objectives

The research carried out by members of the Coastal and Ocean Sciences Team (COST) focuses on the ecology of natural and urbanised coastal ecosystems, considering the spatio-temporal processes of early transitional forms and connectivity of, mostly, but not only, benthic invertebrates. Most research is carried out through individual projects pursued by post-graduate fellows, aimed at filling gaps in knowledge on the population-to-organism patterns and processes of coastal biodiversity in response to environmental and human pressure, often using a range of multi-disciplinary applications, taxa and life stages.

The research carried out by the COST speaks to several of the 12 principles included in the Convention on Biological Diversity and addresses at least 10 of the 17 sustainable development goals, closely interlocking human capacity efforts and directed research. Some of these goals are covered by South Africa's National Development Plan, with the overall common objective of sustainably preserving the South African biodiversity and boosting the Blue Economy in the long term.

Research activities

Research operations in 2021 were still limited from a field point of view, but laboratory-based research focused on a study on the optimisation of the protocols for a molecular study on the phylogeography of the sea urchin, *Parechinus angulosus*, and associated microbiome. Results from samples collected for a study on the effects of urbanisation on the diversity and functioning of larval assemblages were also gathered.

Seshnee Reddy (MSc candidate) drilling on the rocks to secure thermal loggers.

Background image: View of rocky shores at Strandfontein.

Training and supervision

The set transformation goals that the COST aggressively tackles through an inclusive and personal integration of the individuals from under-represented demographic groups, and which account for their individual growth, educational needs and back-ground continued in 2021. While the team has thinned as a consequence of no uptakes of new post-graduate positions during 2020 and 2021, the mentoring of one MSc and two PhD students, and the hosting of one Postdoctoral Fellow has filled 2021, with the successful completion of one MSc, Ms Oko Sotshongaye.

Outcomes

2021 was an exceptional year for the team in terms of outputs, with 11 papers published by several members of the Coastal and Ocean Sciences Team (COST), the award letter, in September 2021, of a new NRF project, as well as the promotion to Honorary Professorship of the team manager, Dr Francesca Porri. The 2021 research advances by COST highlight co-authorship in two global studies: the analysis of complexity-biodiversity relationships on marine artificial structures and a functional analysis that reveals extremely low redundancy in global mangrove invertebrate fauna, published in Global Ecology and Biogeography and Proceedings of the National Academy of Sciences, respectively. Further outputs on the thermal physiology and role of microhabitats for early life stages, as well as structural complexity of habitats providers in mangroves signal the excellent and timeous completion and wrap-up of successful doctorate research by Dr Lyle Vorsatz.

Impact for society

Since early-stage processes are key drivers of population dynamics, they determine the onset of marine biodiversity and hence provide important functions and services. Early-stage processes are important indicators of food webs, vulnerability and fitness of ecosystems exposed to climate and can be lost due to human pressure, such as the discharge of contaminants and nutrients in the water and the hardening of the natural shorelines.

Happy sampling for Seshnee Reddy (MSc candidate), Kerry-Ann van der Walt (Postdoctoral Fellow), Ntokozo Mdubeki (DST intern) and Magnus Janson (MSc candidate, Sweden) on natural rocky shores at Bushman's River Mouth.

Involvement in national research programmes with key societal links, such as marine spatial planning (community of practice in Algoa Bay) and strategic co-partnerships in global research (e.g., World Harbour Project), reinforces the importance of the focus on coastal processes and the maintenance of functional ecosystems for a healthy and sustainable provision of services.

Despite the limited allowance for international travel, Prof. Porri was afforded the opportunity to participate in person, as an invited presenter, at an international meeting: the 7th International Marine Connectivity Conference, held in Paris, France in December 2021. Prof. Porri presented an international collaborative overview on barriers and corridors to connectivity in southern Africa.

Future work

The newly NRF-funded project: Indigenous Marine Innovations for sustainable Environments and Economies (IMIsEE project), transdisciplinarily merges innovative nature-based approaches and indigenous cultural expressions to counteract the adverse impacts of coastal armouring by improving the values of coastal habitats in terms of early stage usage, functioning and diversity. This research will form the bulk of the activities by COST members for the period 2022–2024.

Additional information

This research has been supported by several funding agencies: NRF-ACEP; NRF-Community of Practice; Rhodes University.

Prof. Francesca Porri, PI of the Coastal and Ocean Sciences Team (COST), rinsing larval samples while sampling on the rock shores during the False Bay project.
Photo credit: Morgan Trimble.

Evaluating resiliency of early life stages of fish and invertebrates in urban coastal systems using green eco-engineering

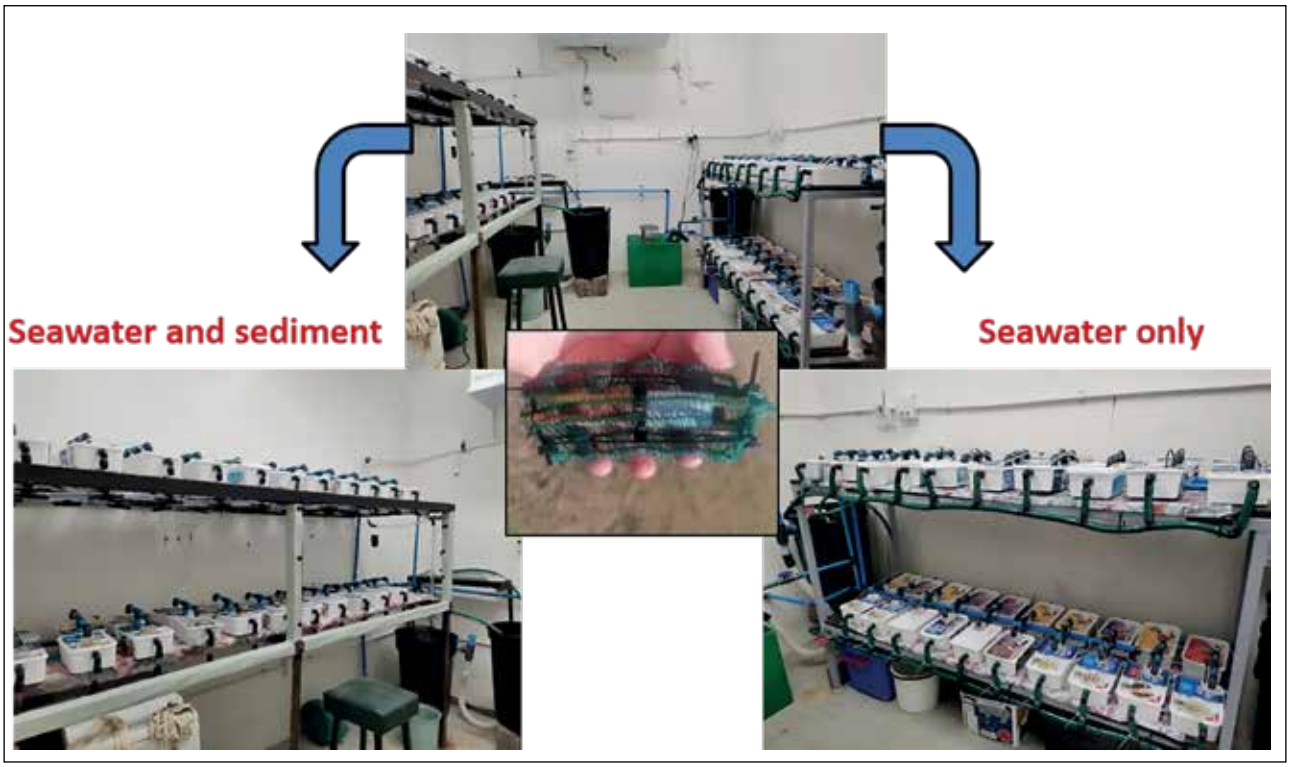
Dr Kerry-Ann van der Walt, Postdoctoral Research Fellow

Background and objectives

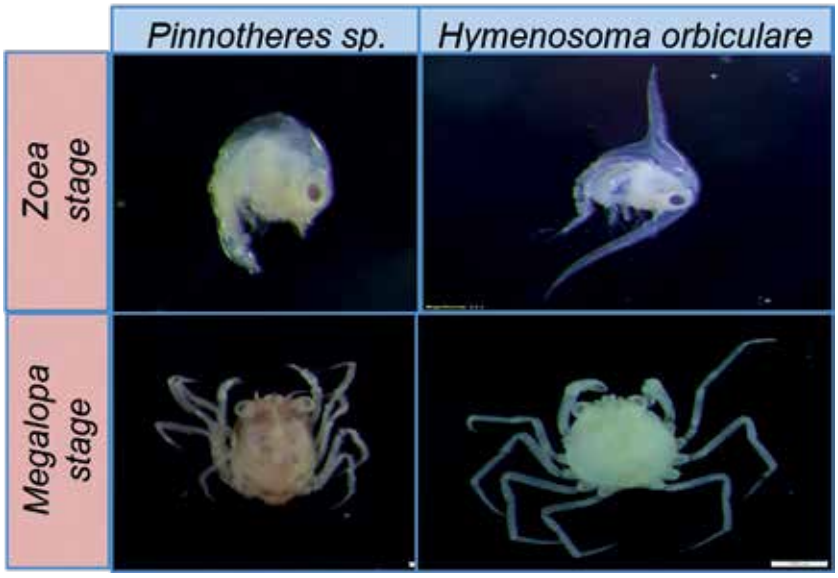
Dr Kerry-Ann van der Walt has focussed on new research aiming to use innovative nature-based eco-engineering structures that can counteract the adverse impacts of coastal armouring in a more sustainable manner and improve the value of coastal habitats in terms of early stage usage, functioning and diversity. This is being achieved by collaborating with a local community from the coastal region of the Eastern Cape Province, the Keiskamma Trust, to develop innovative, complexifying, nature-based structures using indigenous knowledge; to test the durability of both the material and complexifying green structures; and to test the thermal performance of fish and invertebrate larvae exposed to acute increases in temperature. This project, therefore, aligns with the global Sustainable Development Goals (SDGs) being: no poverty (goal 1); decent work and economic growth (goal 8); industry, innovation and infrastructure (goal 9); climate action (goal 13); and life below water (goal 14).

Research team for fieldwork conducted in 2021 (from the left): Cebo Mvubu, Dr Kerry-Ann van der Walt and Prof. Francesca Porri.

The material, imizi grass, used for durability testing in seawater and the development of the nature-based eco-engineered prototype structures.



Laboratory setup for durability testing of the material in seawater used for the development of the nature-based eco-engineered prototype structures. The setup is made up of recycled plastic containers.



Crab species used at two larval stages (zoea and megalopa) for respirometry trials conducted at five test temperatures.

Research activities

In terms of this research, and to get a better understanding of the community's role and use of their indigenous knowledge, Dr van der Walt completed a certified online course on Intellectual Property (IP), Traditional Knowledge (TK) and Traditional Knowledge Expressions (TCEs) with the World Intellectual Property Organization (WIPO) in 2021. The knowledge gained from the course further assisted in drafting a Memorandum of Agreement between NRF-SAIAB and the Keiskamma Trust for the research being planned over the project. Significant progress made thus far includes: testing the durability of the material and nature-based prototype structures in seawater over an eight-month period, in the Port Alfred Marina, as well as in a developed controlled laboratory environment within the Aquatic Ecophysiology Research Platform (AERP); replicated respirometry trials at five different test temperatures for two larval stages, (zoeae and megalopae) for two species of crabs (*Pinnotheres* sp. and *Hymenosoma orbiculare*), over the same time period, to evaluate the physiological metabolism of these selected species in an urban environment.

In conjunction with this research in 2021, Dr van der Walt attended the Conservation Symposium (1–5 November 2021) and presented a guest seminar lecture for 2nd year fish physiology students at the University of Stellenbosch entitled: "Too hot to handle? Thermal tolerance and the potential effects of climate change on coastal and estuarine organisms, Eastern Cape, South Africa", demonstrating the different methods used to measure physiology (thermal tolerance).

Outcomes

Outcomes for 2021 included: publishing two peer-reviewed articles in international journals (*Marine Environmental Research* and *Frontiers in Marine Science*) based on PhD work; producing an article for NRF *Science Matters* Magazine special edition on climate change, based on the previous two peer-reviewed articles published; completing a certified online course on the Blue Economy with the Virtual University for Small States of the Commonwealth (VUSSC) and the University of Seychelles; producing three digital storytelling videos in association with the AERP, SAFER research team at the Department of Ichthyology, Rhodes University and the COST research team at NRF-SAIAB for National Marine Week 2021, highlighting research being carried out by researchers and students. (https://youtube/nTeDJluJOLE; https://www.youtube.com/watch?v=Nv6dq197DEo; https://www.youtube.com/watch?v=Ph4qOq3p6wc)

Future work

Future work related to the project in 2022 includes supervision of a PhD student who will be assessing the role of nature-based eco-engineered structures on early life stages of invertebrates and fish from a complexity, soundscape and physiological perspective in small urban harbours, large urban harbours, and natural habitats. The next step in advancing this project would be to monitor the usage of the nature-based eco-engineered structures by early life stages of coastal fish and invertebrates in coastal urban habitats (small harbours, large harbours) and natural habitats as well as the usage by juveniles and adult stages. A traditional monitoring and research approach that may accomplish the above is the use of non-invasive remote underwater video (RUV) cameras. The RUV cameras will be deployed, either baited or un-baited, to record organisms in these urban and natural habitats. This will assist in developing appropriate strategies for coastal environment management and conservation to enhance local biodiversity.

Additional information

This study has been supported by several funding agencies:
NRF-ACEP; NRF-Community of Practice; Rhodes University.

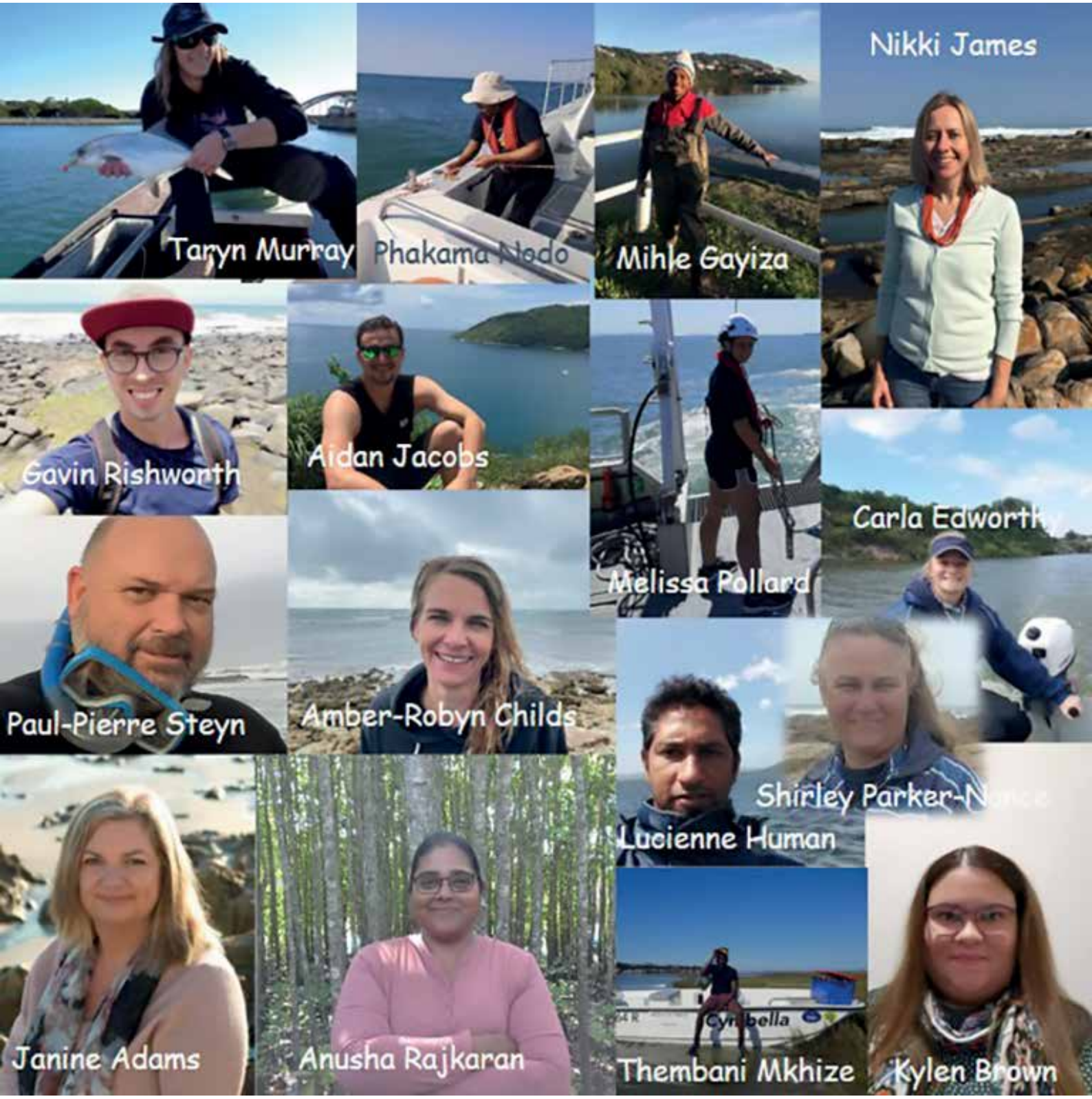
Shallow water seascape connectivity

Prof. Nikki James, Senior Scientist and Project Principal Investigator

Deploying acoustic receivers in a mosaic of coastal habitats, Algoa Bay

Background and objectives

Habitat degradation and loss of structural complexity are major threats to coastal ecosystems, with impacts associated with climate change placing additional pressure on these valuable environments. Seascape ecology (which focuses on mosaics of spatially discrete and recognisable patches of habitat) is an emerging science that strives to understand spatial pattern-process linkages in marine environments. Understanding multi-scale linkages between seascape structure, function and change can better support sustainable ocean development, biodiversity protection, and help to understand the consequences of human activity. This research, which started in 2019, uses mixed-method approaches to assess the relative value of different coastal nursery habitats for marine and estuarine fish species, as well as the impact of climate change on fish species. The main aim of the research is to assess nursery habitat structure, quality, usage, and connectivity of fish within shallow-water seascapes. Identifying highly productive areas (especially nursery areas) affords managers the evidence-based resources needed to target, protect, or restore these areas. This work directly addresses the NRF Marine Research Plan (2014–2024), which aims to understand the role of biodiversity in maintaining ecosystems functionality, the relationships between human pressures and ecosystems, and the impact of global change on marine ecosystems. The research also aligns directly with the UN Decade of Ocean Science for Sustainable Development (2021–2030) and the Life Below Water SDG by contributing towards ensuring that important socio-ecological resources such as the South African linefishery, upon which many recreational, subsistence and commercial stakeholders depend, are best managed in the face of a changing climate.



Seascape researchers and students

Significant research aligned events

The fieldwork for the MSc and PhD students involved in this research was completed in 2021. In partnership with Innovasea, through an equipment loan agreement, the team used the smallest available acoustic tags (which have never been used in South Africa before) to assess the movement and residency of young-of-the-year sparids within a shallow, seaweed-dominated cove.

Training and supervision

A team of six PhD students, Ms Phakama Nodo, Ms Phumza Ndaleni, Ms Melissa Pollard, Mr Cuen Muller, Ms Lauren Bailey, and Ms Carla Edworthy, together with four MSc students, Mr Thembani Mkhize, Mr Mihle Gayiza, Mr Aiden Jacobs and Ms Kylen Brown were involved in this research in 2021, with Ms Carla Edworthy graduating in 2021.

Outcomes

Highlights for the year were the graduation of Dr Carla Edworthy; Ms Phakama Nodo, Mr Cuen Muller and Mr Aiden Jacobs completing their degrees and the awarding of an NRF marine and coastal research grant (2022–2024) to continue this research. Dr James was also appointed as a visiting professor in both the Department of Ichthyology and Fisheries Science at Rhodes University and in the Institute for Coastal and Marine Research (CMR) at Nelson Mandela University.

Impact for society

Spatial data and findings from this project were shared with the project lead of the Algoa Bay Marine Spatial Plan and during a Swartkops EWR (Estuarine Water Reserve) and rehabilitation workshop and report (8–11 June 2021).

Future work

The team received funding from the NRF Marine and Coastal Research Grants to continue this research in 2022–2024 and therefore will extend the scale of the current research beyond individual habitat patches in Algoa Bay to incorporate a broader and more comprehensive seascape approach, which focuses on spatial patterns (seascape configuration and con-nectivity) and seascape change (climate change) within two different coastal seascapes.

Additional information

NRF Marine and Coastal Research Grant (UID 116042), Innovasea (Equipment loan and support).

Ocean acidification monitoring and its impacts on coastal species

Dr Carla Edworthy, NRF PDP Research Fellow

Background and objectives

Ocean acidification (OA) has come to the forefront as a significant threat to marine life, which is already being impacted by several global change stressors. Despite being a global problem, OA has the most significant impact on local scales, yet there is a paucity of local pH data and information on the threat of ocean acidification to local biodiversity, marine living resources, and ocean services. Contributing local information is a key step in addressing global change impacts on a locally relevant scale, which will inform strategies for adaptation, and subsequently mitigate the human impact.

Dr Carla Edworthy

This research conducted by Dr Edworthy aims to continue the monitoring of coastal pH and temperature in Algoa Bay, assess the role of coastal nurseries as OA refugia and assess the impacts of OA and other associated global change stressors (e.g., temperature, microplastics) locally on important species.

This project contributes to both global and local initiatives that promote sustainable development which is cognisant of the environment and its importance to society. The data collected through this project inform SDG 12 (climate action) and SDG 14 (life below water). The SDG 14 further specifies the aim to reduce the impacts of OA under Target 14.3, for which this research is particularly relevant. On a national level, this research addresses key concepts outlined in the National Development Plan (NDP) which emphasises the need for climate change resilience in South Africa. Until now, OA has rarely been acknowledged as a concern in South Africa, mainly due to lack of data and information on its impacts at a local scale. However, OA is starting to receive more attention, although there is still an urgent need for data to understand local OA and its impacts on resources and ocean services.

Research activities

Three field trips were conducted around Algoa Bay to deploy the continuous monitoring sensors for baseline pH and temperature data measurements. Monthly sampling of intertidal sites in the bay were also conducted.

Dr Edworthy gave a plenary talk in September 2021 at an "OA-week" event hosted by the Global Ocean Acidification Observing Network, where this project was presented. Dr Edworthy also participated as a virtual panellist at the IUCN World Conservation Congress for a session on climate-related multi-stressors hosted in Marseille, France in September 2021.

Training and supervision

Carla Edworthy graduated with a PhD in April 2021.

Outcomes

Main outputs by Dr Edworthy include completion of her PhD thesis titled "Coastal pH variability and the eco-physiological and behavioural response of a coastal fish species in light of future ocean acidification" and publication of a popular article in Quest Magazine titled "Ocean Acidification" (Quest Volume 17 no. 2).

Impact for society

The local pH and carbonate chemistry data collected was submitted to the IOC-UNESCO which facilitates data submissions towards SDG Indicator 14.3.1: "Average marine acidity (pH) measured at an agreed suite of representative sampling stations" using the SDG Target 14.3 data portal. This data will be included in the United Nations SDG report for 2021.

Data was also submitted to the National Open Data Portal, Marine Information Management System (managed by the South African Environmental Observation Network, DOI: doi.org/10.15493/dea.mims.26500019).

Future work

Local information on OA and pH variability is currently limited in South Africa. To address this data deficiency, OA monitoring and experimental research assessing its impacts are ongoing and will be integrated into new projects. The ocean acidification monitoring discussed in this report uncovered some interesting local variability in pH which highlighted the potential refuge function of coastal macroalgal habitats. Further monitoring and experimental research are required to understand the drivers of variability and their impact on coastal marine life. An ocean acidification component has been included in a proposal for new Seascape Ecology projects, including experimental research on local seaweed species as well as improved continuous monitoring to assess the role of macroalgal nursery habitats as OA refugia.

A project looking at the combined impacts of ocean acidification and microplastic ingestion by early-stage fishes is planned to commence in 2022 in collaboration with the Sustainable Seas Trust.

Additional information

This research was funded by the National Research Foundation Incentive Funding for Rated Researchers and supported by: the Shallow Marine and Coastal Research Infrastructure platform (research equipment and infrastructure); the South African Environmental Observation Network (data); the Aquatic Eco-physiology Research Platform (research equipment); the OA Capacity Development Program of the Global Ocean Acidification Observing Network (GOA-ON), for which funds were provided by the US Department of State and administered by The Ocean Foundation (equipment).

Monthly sampling.

Fish movement and protected areas

Dr Taryn Murray, ATAP Instrument Scientist and ATAP Manager

Background and objectives

Well-enforced protected areas are powerful management tools for protecting fishes residing within their boundaries. These animals are, however, only protected for as long as they remain within the protected areas. Much of the work done by the research team led by Dr Murray assesses the movements of multiple species in relation to marine protected areas (MPAs) and estuarine protected areas (EPAs) using acoustic telemetry. The overarching goal of this research is to assess the efficacy of these protected areas, and to provide new knowledge which can be used to develop new, or expand existing protected areas.

This research is strongly aligned with Sustainable Development Goal (SDG) 14 Life below water to address objectives relating to the management of coastal ecosystems, sustainable use of fishery resources, scientific knowledge to conserve biodiversity, and development of research capacity. The SDGs 4 Quality Education, 5 Gender Equality, 2 Zero hunger and 12 Responsible Consumption and Production are also supported through this research.

Training and supervision

During 2021, much of the work carried out by the ATAP research team remained online. As such, this saw post-graduate students using existing data collected by the Acoustic Tracking Array Platform for projects. Training and capacity development of one Postdoctoral Fellow, two PhD students, four MSc students, three BSc Honours students and one intern was provided for through Dr Murray's research. Mr Bantony Ziko and Miss Tayla Dominy (both MSc, Ichthyology and Geography, respectively) graduated in 2021. Dr Chantel Elston expanded her postdoctoral work in the Keurbooms Estuary at Plettenberg Bay, where she continues to conduct research assessing the presence of stingrays in this system.

Outcomes

This past year has been a slow one in terms of scientific publications; however, several science communication outputs were compiled, including a popular article in Quest Magazine by MSc student, Miss Vuyolwethu Mxo, entitled "Tracking inshore fish". Dr Murray also presented an NRF-SAIAB Seminar in July 2021, highlighting the research done for the Acoustic Tracking Array Platform. In line with this, she was asked to be part of an international panel discussion at the Ocean Tracking Network Symposium in November 2021.

Impact for society

Because much of Dr Murray's research is orientated around the movements of animals, feeding these results into fisheries management initiatives is key if the decline in many species is to be halted (and improved). Some of the research pursued by Dr Murray and team provides knowledge on the efficacy of protected areas to many important fishery species, particularly related to the timing of presence within these areas, as well as the relative amount of time spent in them (when there). This allows the team to assess whether the coastal network of marine protected areas is sufficient for protection, particularly for migratory species. This work is often exposed on social media through three platforms (Facebook, Twitter, Instagram), as well as through the publication of popular articles.

Future work

While much of this work is ongoing, significant focus will be placed on assessing the movements of various sharks and rays along the South African coastline, and feeding this information into the development of a greater Shark Conservation Plan for South Africa.

Funders

Ocean Tracking Network (infrastructure), Save Our Seas Foundation and the African Coelacanth Ecosystem Programme (running expenses), SA-Norway Research Co-operation Programme; SAN-COOP and SANOCEAN (infrastructure and running expenses), WILDTRUST (infrastructure and running expenses from the Blue Action Fund and the Shark Conservation Fund); NRF (infrastructure, bursaries and running expenses), Shallow Marine Coastal Research and Infrastructure Programme (salary), NRF Thuthuka Grant (research).

A two-for-one special, two dusky kob, *Argyrosomus japonicus*, caught in the De Hoop Nature Reserve Marine Protected Area wait to receive long-life acoustic transmitters.
Photo credit: JD Filmalter.

An adult black musselcracker, *Cymatoceps nasutus*, caught in the Pondoland Marine Protected Area. Photo credit: Bruce Mann.

Dr Chantel Elston deploying the Baited Remote Underwater Video System to survey the underwater life of the Keurbooms Estuary.
Photo credit: Carmen Claire van der Westhuizen.

What lives in the Keurbooms estuary?

Dr Chantel Elston, Postdoctoral Research Fellow

Background and objectives

2021 saw the start of a new project that aimed to survey the underwater fauna of the Keurbooms Estuary, Plettenberg Bay. It is well known that estuaries are important habitats to various animals, providing productive and safe environments. Consequently, many fish will spend some or all of their lives in estuaries, especially as juveniles. Unfortunately, given the proximity of estuaries to human populations, marine species often suffer negative impacts through fishing, pollution, and habitat degradation.

South Africa has one of the most diverse elasmobranch faunas (sharks and rays) in the world, but research has been skewed towards a few large, charismatic species (e.g., the great white, and ragged-tooth sharks) and research on rays has been mostly non-existent. This is of concern, given the conservation status of South African rays, with most species listed as Data Deficient or threatened (Vulnerable, Endangered, Critically Endangered) by the IUCN Red List of Threatened Species. Consequently, there is a need for basic ecological data, such as identifying the most important habitats for these species, so that they can be effectively managed and conserved. Rays have been shown to rely on specific habitats, most notably sheltered ones such as coastal bays. However, the extent to which rays may rely on sheltered estuaries is not well understood, particularly in South Africa, where estuary use by rays has not been investigated at all.

Anecdotal evidence suggests that rays have been encountered in the Keurbooms Estuary, making it the perfect location to investigate estuary use by this taxon. Additionally, the Keurbooms Estuary is valuable to local subsistence and recreational fisheries. Quantifying fish community composition in the estuary, and understanding how the environment influences these species, is therefore necessary to ensure that this ecosystem and its inhabitants, are sustainably managed for local socio-economic benefit.

Research activities

Fieldwork for the highlighted research began in March 2021, and three sites were selected in the Keurbooms Estuary to survey. A Baited Remote Underwater Video System (BRUVS), consisting of a weighted rig with a GoPro camera attached to one end and a bait bag to the other, was deployed for one hour at each site as close to weekly as possible, and a range of environmental parameters were recorded (like temperature and salinity).

A common eagle ray swimming over the shallow sandflats of the Keurbooms Estuary.

Training and supervision

While Dr Elston, the project lead, was identifying and quantifying the presence of elasmobranchs in the estuary, an MSc student, Thembelihle Ndlovu, focused on the teleost fish community. Through involvement in the project, Thembelihle has learned how a BRUVS works and has learned how to successfully identify different fish species from the footage.

Outcomes

To date, over 200 hours of footage has been collected and over 25 species of fish, rays, sharks, octopus and cuttlefish identified. The most abundant species have been, as expected, fishes known to rely on estuaries. However, the project has also uncovered some surprises, with a few marine fish species being recorded in an estuary for the first time. Additionally, a critically endangered stingray species (the common eagle ray, *Myliobatis aquila*) has been present in the estuary year-round, revealing this habitat to be essential for this species.

Impact for society

The results so far suggest that the Keurbooms Estuary is in a healthy state, providing habitat to estuary-associated species, marine species that have not been associated with estuaries before, and endangered elasmobranch species. Healthy ecosystems such as this have important socio-economic benefits through supporting subsistence and recreational fisheries, while also aiding in the conservation of endangered species not targeted by these fisheries (i.e., elasmobranchs).

Future work

The project will collect underwater footage for two years and, as such, data collection will be ongoing on a short- to mid-term basis. However, as this project uncovered the first estuary in South Africa to be a year-round essential habitat to an endangered ray species, further aspects will be added, such as quantifying abundance and behaviour of the rays to elucidate the population structure and details of habitat use.

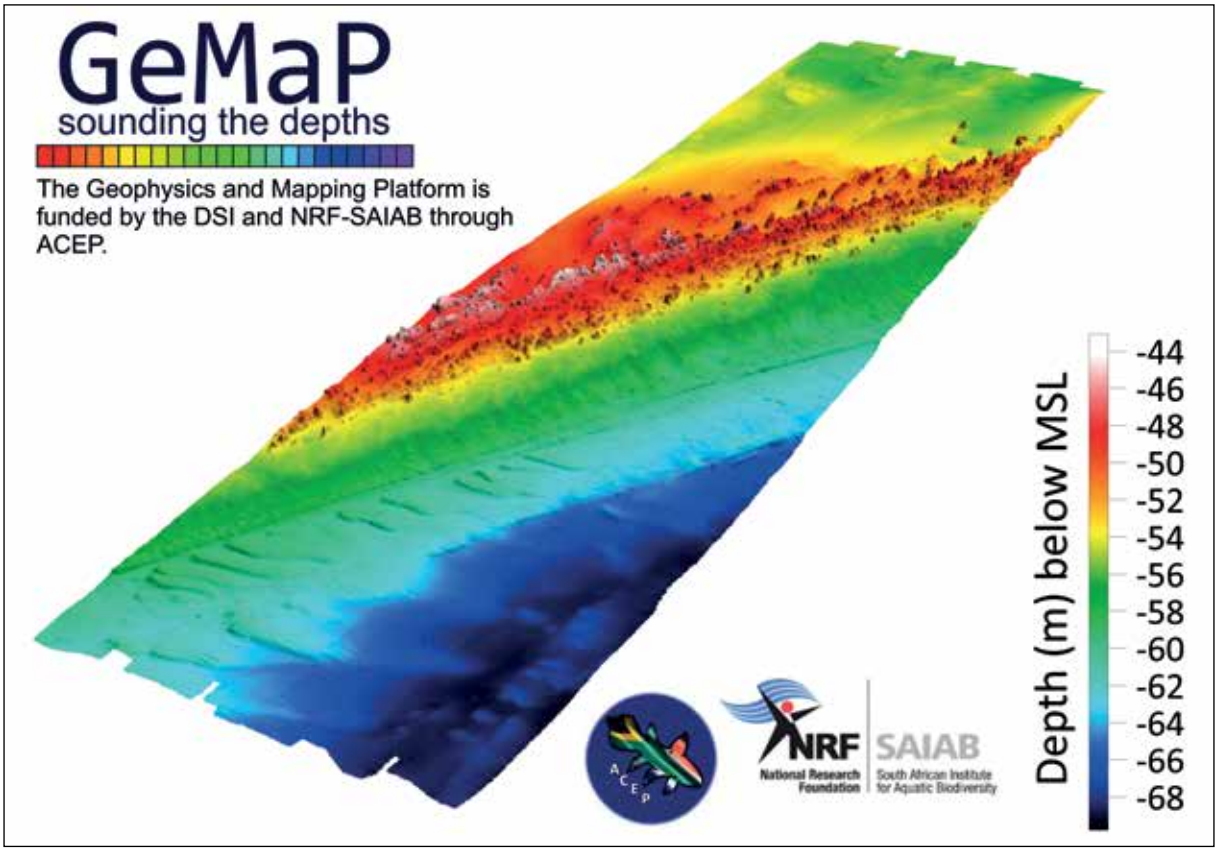
Additional information

This work is supported by the NRF (PDP programme) and the Oceans Research Conservation Africa (ORCA) Foundation who provide the operational and fieldwork costs.

A common eagle ray Myliobatis aquila Photo credit: Melissa Nel

Geomorphology of upper mesophotic reef systems of the uThukela Banks MPA/ ACEP SMART Zones MPA – Geological Component

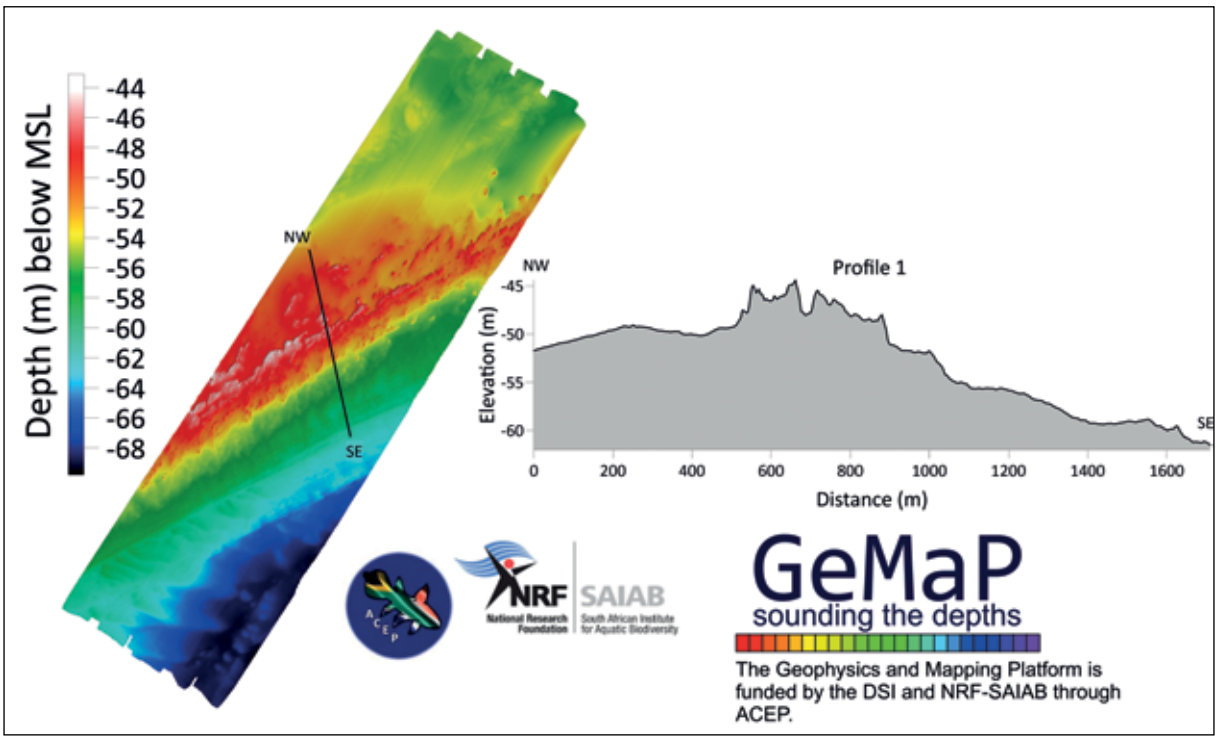
Dr Errol Wiles, Geophysical Instrument Scientist



Three-dimensional perspective view of reef off-shore Zinkwazi area (MB04_2021)

Background and objectives

The South African exclusive economic zone is critically understudied in the context of geomorphological habitat and marine resource characterisation. Many, if not most, of South Africa's MPAs lack geospatial context as they have not been mapped with multibeam echosounders. The geological component of SMART Zones aims to survey reef complexes within and adjacent to the uThukela MPA. This research aligns well with the NRF, national and continental-scale visions (Republic of South Africa, 2014; Government of South Africa, 2019a; Agenda 2063, 2015; Africa Blue Economy Strategy, 2019; AFRICA 2030, 2021). Broadly, these strategies strive to improve quality of life and sustainably optimise the Blue Economy through acquisition of data, innovative thinking and techniques, and generation/sharing of knowledge across disciplines. Bathymetry data are the foundation of marine spatial planning and an essential component required to optimise the Blue Economy to the benefit of proximal and regional stakeholders.



Most East Coast reefs are palaeo-shorelines comprising lithified beach and sand dune sediments. Calcium carbonate cements help preserve these features, which are the foundation of geomorphological habitat supporting biodiversity within the uThukela MPA. The shape and extent of these palaeo-shorelines is clearly evident in cross-sectional profiles (Profile 1).

Significant research aligned events

Survey sites throughout the uThukela MPA were selected in 2021 and will be surveyed over the coming year as conditions allow. This includes a three-week effort out of Richards Bay Port to cover the northern sites, while southern sites will be tackled from the Port of Durban.

Distinguished visitors / international visits / conferences

Project rationale and context were presented at two conferences (WIOGEN Conference on Ocean Governance 2021, The Conservation Symposium 2021) to launch the project.

Training and supervision

Mr Thamsanqa Wanda joined the team as a doctoral candidate. Registered at NMU and closely affiliated with NRF-SAIAB, Mr Wanda is supervised by Dr Errol Wiles (NRF-SAIAB), Dr Hayley Cawthra (Council for Geoscience) and Dr Anton De Wet (NMU). This supervision brings three strong institutes together to support Mr Wanda as he tackles the complexities of geomorphological habitat within the uThukela MPA. He will focus on the use on multibeam bathymetry to characterise and classify the geomorphology of selected reefs within the MPA. Area, slope, length, width, rugosity, and depth data will be used to quantify the reefs as the foundation of future research. This work will feed into biological research by providing critical geospatial context to point-source biological data. Linking the physical habitat to biodiversity will make it possible to quantify the relationship between the two components and extrapolate findings across an entire reef system. In this way, biodiversity can be quantified per unit area based on the geomorphological habitat.

Outcomes

Data collection is ongoing.

Impact for society

Outcomes of this project will provide an unprecedented view of the seabed and enable classification and quantification of geomorphological habitat in a marine protected area (MPA). As regions of exceptional biodiversity, MPAs offer a range of socio-economic benefits to proximal communities. Provision of environmental services requires a healthy ecosystem which, in turn, supports fisheries (recreational and subsistence) and tourism. These three facets add value to the local economy through means of employment directly or indirectly related to tourism and fisheries. Outcomes of this project, combined with other project components will enable better management of the uThukela MPA, leading to medium- and long-term socio-economic benefits.

Future work

The project will continue to collect data in 2022 in order to cover all the selected sites. Future work will build on this by working to connect patches of multibeam bathymetry data together with additional surveys. This expanded coverage will lead to more robust analysis and better understanding of the relationship between geomorphological habitat and biodiversity on the South African east coast.

Additional information

This research benefits form the competitive ACEP Open Call funded by the DSI and NRF.

PhD candidate, Mr Thamsanqa Wanda (left), on board "Sparky" testing shallow water, cost-effective sonar equipment in the Mlalazi Estuary.

Reef Ecology and Conservation

Dr Anthony Bernard, Instrument Scientist

Background and objectives

Subtidal rocky and coral reef ecosystems extend from the shoreline down into the deep sea. These ecosystems support high biodiversity and essential services that contribute significantly towards the well-being of humans. These essential services include the provision of nutrition and jobs for millions of people from different cultural and economic backgrounds, the protection of coastal communities, and numerous valuable natural products. However, reef ecosystems are exceptionally vulnerable to anthropogenic impacts. Equally, global climate change is causing warming and acidification of the oceans, intensifying storms, and changing ocean currents and upwelling systems; all of which have knock-on effects on ecosystem structure and species distributions. Investigating the effects of natural environmental variables on the structure of reef ecosystems provides fundamental knowledge to improve our basic understanding of these systems. This fundamental knowledge is essential to understand the scale, extent, and impact of anthropogenic disturbances, and is the foundation for meaningful applied research.

Within this theme, this research contributes towards sustainability by advancing the reef ecological research through method development and by providing knowledge suitable to inform and optimize biodiversity and resource management. To this end, the research is conducted under three key objectives:

Aseeqah Davids (Intern) and Bontle Mataboge (MSc student) while collecting data for Bontle's MSc research project.

1) To advance understanding of how environmental factors influence the structur-al and spatial ecology of reef ecosystems from the shallow subtidal into the mesophotic zone. Current research: Long-term monitoring of warm-temperate reefs; determining reference states for fish assemblages; assessing how environmental variation effects the structure of reef fish assemblages within South Africa and the WIO.

2) To determine the impact of pressures and management interventions on the structure and functioning of subtidal reef ecosystems. Current research: measuring the effectiveness of MPAs at conserving biodiversity and fisheries species within South Africa and the broader WIO; assessing the impacts of cumulative pressures on reef ecosystem condition; testing hypotheses for fishing and climate change refugia associated with increased water depth.

3) To advance subtidal research methodology and research. Current research: development of untethered stereo-BRUVs for deep-sea benthic and demersal research; investigating optimal approaches to collect and process eDNA samples and the types and scale of ecological questions suited to the method.

Research activities

Field surveys and expeditions are an integral component of this research theme. In 2021, Dr Bernard spent over two months in the field collecting stereo-BRUVS data between Gansbaai on the temperate south coast and Shelly Beach on the subtropical east coast.

eDNA and stereo-BRUVs sampling off the coastal craft Observer. Pictured are the PhD student working on the eDNA project, Mpilonhle Nyawo (middle, back) and her team of field assistants (left to right): Ferdy Jacobs, Jade Vermeulen, Matsobane Malebatja and Thembelihle Dube.

Training and supervision

Research undertaken within this theme is supported by the NRF-SAIAB's strong post-graduate programme, and includes students based at NRF-SAIAB or at other local and international institutions. Although from diverse backgrounds, these students have a common interest in life underwater, ecology and the sustainable management of our oceans. Furthermore, this research involves a diverse suite of local and international collaborators from various governmental and non-governmental organizations, and where required, this contributes towards the training of early career scientists.
Five MSc and three PhD students were supervised during 2021; three MSc students and 0ne PhD student graduated.

Impact for society

By improving the understanding of the structure and functioning of reef ecosystems in South Africa and the WIO, the research conducted under this theme enables the measurement of the impacts of fisheries and conservation initiatives and tracks the effects of climate change. The findings provide critical information to support marine spatial planning, MPA management, and sustainable biodiversity and resource management.

Future work

In 2022, a research project will be initiated in the newly proclaimed uThukela Banks MPAs. This project is supported by ACEP and the Blue Action Fund; it aims to develop and fast-track effective management of the protected area.
Dr Anthony Bernard will be joining the Nekton Mission.

Lastly, an exciting new working group has been set up, funded through the Scientific Committee for Oceanic Research (SCOR). The CoNCENSUS focus is on advancing the development of a global community of practice for Coastal and Nearshore CENSUS techniques to deliver FAIR data on fish essential ocean variables required by various stakeholders for biodiversity reporting and fisheries management.

Additional information

This research is supported by: Wildlife Conservation Society (collaboration, funding), NRF-Marine and Coastal Research programme (funding), NRF-SAIAB (collaboration, funding), Wild Oceans (collaboration, funding), ACEP (funding), Scientific Committee for Oceanic Research (funding).

Sunrise at Rocktail as the NRF-SAIAB and Wild Oceans research teams prepare to head out to sea.

Diversity, Distribution and Systematics of Freshwater Fishes in Southern Africa

Dr Albert Chakona, Senior Scientist

Dr Albert Chakona (NRF-SAIAB), Dr Wilbert Kadye (RU) and Dr Taurai Bere (Chinhoyi University of Technology, Zimbabwe), sampling in fast-flowing habitats in the Pungwe River system, in the Eastern Highlands of Zimbabwe.

Background and objectives

Accurate documentation of biodiversity and knowledge of species distribution patterns provide the basic information for managing natural resources to safeguard provision of ecosystem services essential for human well-being, particularly in developing countries where many rural populations rely heavily on freshwater systems and inland fisheries for their livelihoods and nutrient security.

Evidence from molecular studies shows that a remarkable proportion of the diversity of freshwater fishes in southern Africa remains scientifically undocumented, and distribution patterns of many fish species are poorly known. The underestimation of taxonomic diversity and poor understanding of species distribution patterns have profound conservation implications as freshwater systems within our region are highly threatened by multiple impacts. This information gap also hampers policy development and management of conflict species. There is, therefore, an urgent need for an approach that can be used to assign specimens to known species as well as accelerate the pace of species discovery in order to identify priorities for taxonomic research and conservation actions.

The NRF-SAIAB initiated an ongoing multi-institutional research programme including national (provincial conservation agencies), regional (University of Zimbabwe, Chinhoyi University of Technology, Zimbabwe Museum of Natural History, WWF Zambia) and international collaborators (the Royal Museum for Central Africa, Cornell University Museum of Vertebrates and SNSB – Bavarian State Collection of Zoology) to undertake comprehensive surveys to collect DNA tissue samples and voucher specimens (including topotypes) to provide updated information on the distribution patterns and to accelerate systematic and biogeographic studies and taxonomic revisions of freshwater fishes in southern Africa. At a systematic and biogeographic level, the relationships between taxa will be interpreted within the framework of the previously suggested biogeographic history of southern African freshwater fauna. At an intraspecific level, genetic diversity will provide information to assist in formulating conservation plans for threatened fish species. Examples are comprehensive mapping of the distribution of pure and hybridised populations of native *Oreochromis* species to inform sustainable aquaculture development in the region.

Findings of this research will contribute towards addressing the "taxonomic impediment" identified by the Convention on Biological Diversity (CBD), to assessing the conservation status of species through the IUCN criteria, and achieving SDGs linked to: ending poverty (SDG 1), achieving food security (SDG 2), ensuring healthy lives (SDG 3), promoting sustainable economic growth (SDG 4) and promoting sustainable resource utilisation (SDG 12) through implementing science-based decisions in natural resources management.

Research activities

Major field surveys were conducted in 2021 to collect comprehensive tissue samples and voucher specimens of *Oreochromis* and other co-distributed species in the Limpopo and Mpumalanga provinces of South Africa. Dr Chakona was appointed as the Regional Chair (Southern Africa) for the IUCN Freshwater Fish Specialist Group. Dr Chakona submitted a multi-institutional research proposal (with Ms Dewidine van de Colff as Co-PI) to the Foundational Biodiversity Information Programme (FBIP). The Refresh Project was awarded funding for three years (2022–2024).

Dr Albert Chakona examining mormyrid fishes during a research visit to the Cornel University Museum of Vertebrates (CUMV) where he was hosted by Prof. Carl Hopkins and Dr John Sullivan.

Training and supervision

Manda Kambikambi (PhD) graduated in October 2021; Craig Rennie completed his MSc and will be graduating in April 2022.

Ongoing supervision of six post-graduate students: Tholoana Ntokoane (PhD); Yonela Sithole (PhD); Martinus Scheepers (PhD); Tadiwa Mutizwa (PhD); Thulisile Nkomo (MSc); Nenekazi Mthombeni (MSc).

Five Postdoctoral Fellows were part of the research team: Dr Mandla Magoro; Dr Lubabalo Mofu; Dr Dumisani Khosa; Dr Lizaan de Necker; Dr Pedro Bragança.

All members of the research team gave oral presentations at the virtual conference of Southern African Society of Aquatic Scientists (SASAqS).

Outcomes

A total of 10 peer-reviewed publications were produced in 2021. These included the description of 10 species new to science, and the revalidation of three species of freshwater fish from southern Africa. In addition, ten distinct genetic lineages (candidate species) were identified within the southern African genus, *Heteromormyrus*. These are currently being formally described.

Impact for society

More accurate knowledge of fish distributions, discovery of unique lineages and description of new species will be incorporated in the IUCN Red List Assessments of freshwater fishes of southern Africa, as well as knowledge for defining national freshwater fish sanctuaries as part of the National Freshwater Ecosystems Priority Areas (NFEPA) initiative. These sanctuaries will be used to define priority freshwater areas for conservation in South Africa. The NFEPAs are a critical tool for freshwater conservation planning in the country. The data will also be used to help define alien fish areas for South Africa's new National Environmental Management: Biodiversity Act. These maps will be used to allow restricted activities to continue in defined areas for certain valuable alien fish species, while at the same time, prohibiting the occurrence of these species in sensitive biodiversity areas. The data are shared with regional conservation agencies to inform conservation planning and prioritisation. This has, for example, already led to a more informed permit evaluation process within CapeNature and other regional conservation agencies.

Future work

There is a growing network of collaboration with other research teams working in other regions on the continent, particularly in central, east, and west Africa, which will result in data sharing and more coordinated systematic studies that are envisaged to provide better understanding of the diversity and distribution of freshwater fishes in our region. Research efforts will continue to focus on filling information gaps in least explored regions in southern Africa.

Additional information

Research funding: Rhodes University Research Council Grant; NRF under the Foundational Biodiversity Information Programme (FBIP); the Rufford Small Grants for Nature Conservation (RSG); the International Foundation for Science (IFS); the Mohammed bin Zayed Foundation and the NRF-SAIAB Institutional Support System; PDGD-RMCA (Belgium).

Integrative taxonomy, conservation and biogeography of African and Neotropical freshwater fishes.

Dr Pedro Bragança, NRF Postdoctoral Research Fellow

Background and objectives

This project aims to provide more accurate species estimates through the application of integrative taxonomy approaches. The use of different and independent methods, relying on both morphology and molecular data to define species limits, is a key element to identifying, understanding, and describing the world's biodiversity. Integrative taxonomy approaches are particularly needed when considering the major challenges represented by the taxonomic impediment in a rapidly changing world where natural habitats and biodiversity are under threat. Species delimited by different and independent methods and information on their current distribution is the basic information necessary that will allow their conservation and inform decision/policy makers.

Another goal of the present project is to understand what the current species distribution can tell us about how the world's landscape changed. In Africa, this multi-disciplinary science field known as biogeography, especially when analysing freshwater fishes, can reveal information and date estimates for the main historic events that shaped the continent. In this context, it was possible to track the diversification patterns within *Aplocheilichtys spilauchen* since the early Miocene, and correlate distribution range extensions to wetter and moister climate conditions and contractions during dry periods. It was also possible to link the dispersion of the southernmost lineage to Angola (Cuanza River), only after the establishment the current Congo River mouth in the Pliocene. This research illustrates the historical importance and information present in extant species and their distributions.

A third, but equally important objective, is the capacity and need to inform and warn authorities and the general public about the threat to biodiversity and natural resources represented by policies and decisions taken without a scientific background. The responsibility to inform and denounce bad practices and decisions is the only way natural scientists will be able to assist humanity in the current and future climatic, health, and food security issues.

Research activities

Examination and identification of African freshwater fishes housed at the NRF-SAIAB fish collection, which increases the collection's data quality. The barcoding of African freshwater fish species, in particular the ones belonging to the families Procatopodidae and Cichlidae, were done at the genomics laboratory platform at NRF-SAIAB. The sequenced cichlids belong to the genus *Oreochromis*, the target group of the Tilapia Project, directed to identify and estimate the hybridisation between native *Oreochromis* and the invasive Nile Tilapia.

Dr Bragança was an invited virtual speaker for the Institute of Oceanography and Environment (INOS) in Terengganu (UMT), Malaysia (May 2021), where he presented on "The importance of natural history collections in understanding and guiding humanity in a climate change scenario." Dr Bragança also had the opportunity to present at the Southern African Society of Aquatic Scientists on the current work being carried out on the southern African fish species of the genus *Lacustricola*.

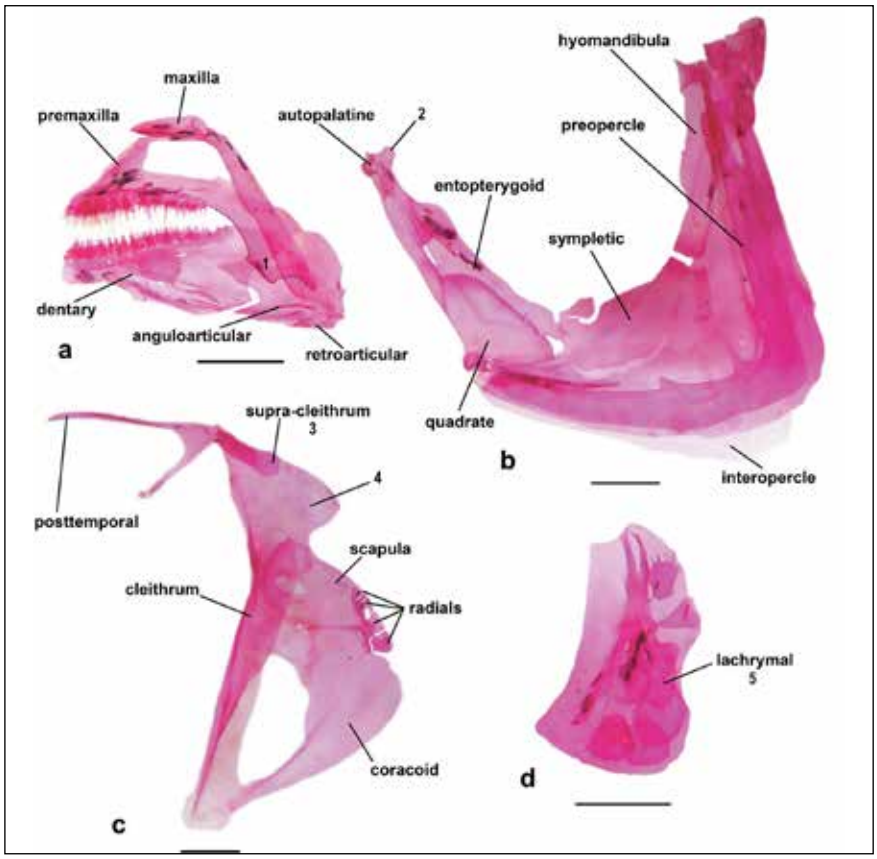
Training/ supervision

During the year, knowledge transfer and training of students into the best fish taxonomy and systematic practices were carried out.

Outcomes

Peer-reviewed articles were published describing new African freshwater species belonging to the family Procatopodidae. One species, *Lacustricola pygmaeus*, was described from Angola, Namibia, and Botswana, and a second species, *Plataplochilus eliasi*, from the rainforests of the Republic of Congo. In addition, a paper on the diversification, biogeography, and evolution of the brackish water Lampeye species, *Aplocheilichthys spilauchen*, revealed a correlation between diversification and past events of climate change. Two taxonomy papers, one on the status of the poeciliid, *Poecilia kempkesi*, and the other on the validity of the cichlid species, *Heros autochthon*, were published, providing relevant information on the availability of these names. A distribution range extension for the Amazonian poeciliid fish, *Pamphorichthys scalpridens*, and a first record of the invasive *Xiphophotus maculatus* were published. A warning about the threat represented by recent political decisions to Brazilian mangroves was published.

Live colouration of *Plataplochilus eliasi*, holotype, male, 41.0 mm SL.



Osteological plate showing the bone structures of *Plataplochilus eliasi*.

Impact for society

The new species descriptions, the papers dealing with nomenclature issues, the distribution range extension and the new record of an invasive species have a direct impact on the information available for delineating future conservation policies. The biogeography study on *Aplocheilichthys spilauchen* evolution indicated how the African continent landscape and climate has changed since the Miocene, and it was the first study on African west coast fishes revealing a clear timing for the identified biogeographical patterns. This is a significant example of the impact that systematics can have on our understanding of the planet. The paper about the threats to Brazilian mangroves had a major impact, calling the attention of both the scientific community and media to the importance of mangroves and the recent political decisions weakening the current legislation protecting this environment.

Future work

Integrative taxonomy approaches will be applied to different South African and African freshwater fish groups that are still little known. Within this context, the REFRESH Project, a barcoding initiative focusing on seven different freshwater South African taxonomic groups will take place in 2022. Another major project is the Tilapia Project, the main goal of which is to develop a useful method to identity hybrids between the native *Oreochromis* species and the invasive *Oreochromis niloticus*, the Nile Tilapia. Finally, further efforts will be made to describe and sample African procatopodids and to improve the capacity of knowledge transference to students.

Additional information

This research was funded by the National Research Foundation.

Invasive Nile tilapia

Dr Mandla Magoro, Postdoctoral Research Fellow

Background and objectives

As recognised by several legislative instruments, including the National Environmental Management: Biodiversity Act (NEM:BA), Alien Invasive Species (AIS) are a major threat to South Africa's biodiversity and AIS management is now a legislated priority in South Africa. Management is complicated by conflict species that are valuable economically, but harm biodiversity, as the different value sets associated with them result in considerable conflict between user groups. In South Africa, conflict species are typically angling species such as trout, largemouth bass and carp, or aquaculture species such as Nile tilapia. Management of such species requires proactive approaches to management, such as the proposed zoning scheme on national maps, which includes permitted and prohibited zones for AIS. A severe lack of data has, however, resulted in decisions being made based on expert opinion rather than on the basis of strong scientific information. This constrains the effective development of management strategies and weakens the national response to public organizations who oppose the AIS regulations and strategy.

Filling these knowledge gaps and developing decision support data will be a major component of the National Invasive Species Strategy and Action Plan under development by the Department of Forestry, Fisheries and Environment (DFFE). The most important priority species is currently Nile tilapia, *Oreochromis niloticus*, because its invasions can result in hybridisation with native tilapia (e.g., Mozambique tilapia, *Oreochromis mossambicus*), but it is also the most favourable species for warm-water aquaculture, a sector which, despite considerable attempts at development, has remained

Dr Magoro, Dr Lubabalo Mofu and Dr Darragh Woodford sampling for *Oreochromis* specimens in Limpopo Province.

Dr Lubabalo Mofu sampling *Oreochromis* in the Noord-Sandrivier in Mpumalanga

stagnant. Current knowledge of Nile tilapia distribution is therefore essential for better-informed decision-making.
The primary aim of the 2021 project was to determine the current extent of the spread of Nile tilapia in the Limpopo and Mpumalanga provinces. Field collecting at selected sites determined the presence or absence of Nile tilapia, or their hybrids. The second phase of the project was to involve the use of molecular genetics to confirm morpho-logical identifications and determine the presence of hybrids. The project addresses SDG 2 (Zero hunger), in that the data collected during this project can help inform policy on future freshwater aquaculture developments and activities in the Limpopo and Mpumalanga provinces.

Research activities

Two major surveys were conducted in the Limpopo and Mpumalanga provinces in 2021.
In September 2021, Dr Magoro gave a keynote presentation for the online World Fisheries Congress, Adelaide, Australia, on the current distribution of non-native Nile Tilapia (*Oreochromis niloticus*) in the Limpopo and Mpumalanga provinces and the implications for Mozambique tilapia conservation and South Africa's fish farming industry.

Outcomes

To date, 148 sites have been surveyed in the two provinces, with work ongoing to survey a further 20 sites. The project has produced an up-to-date map of the current distribution of Nile tilapia in the rivers and dams of the two provinces, and also revealed key areas currently inhabited by pure strains of our native Mozambique tilapia. The details of the outcomes of the project are contained in the final Tilapia Project Report.

Impact for society

Aquaculture plays an important role as far as the country's food security is concerned, and this study aided in the process of demarcating zones where use of Nile tilapia will be permitted for sustainable use in aquaculture facilities, with prospects for job creation.

Future work

The data from the project have revealed a need for mapping Nile tilapia distribution in other provinces of South Africa. Surveys in the KwaZulu-Natal Province will commence in December 2022, with the prospect of the project further expanding into the North West Province in the near future.

Additional information

The South African National Biodiversity Institute (SANBI) and Department of Forestry, Fisheries and the Environment (DFFE) are the main sponsors for the Nile tilapia project.

Current distribution of Nile tilapia in the Limpopo and Mpumalanga provinces.

Dr Lubabalo Mofu, NRF PDP Research Fellow

Background and objectives

The biodiversity of South Africa is seriously threatened by invasive alien species. When invasive species are introduced and allowed to proliferate into freshwater ecosystems and habitats where they do not belong, the environment in general, and biological diversity in particular, may suffer. The NRF-South African Institute for Aquatic Biodiversity (NRF-SAIAB), the South African National Biodiversity Institute (SANBI), and the Department of Forestry, Fisheries and Environment (DFFE) are working together on a project to ascertain the current extent of the spread of the invasive alien Nile tilapia (*Oreochromis niloticus*) in the Limpopo and Mpumalanga provinces in response to the need to understand invasives.

Research activities

More than 150 sites in the two provinces were surveyed during 2021; this involved the use of multiple gears, such as cast net, seine net, and electrofishing.

Outcomes

The study has developed an up-to-date map of the Nile tilapia's current distribution in the rivers and dams of the two provinces and highlighted important regions where pure strains of our native Mozambique tilapia are now found. The final Tilapia Project Report contains details of the project's results.

Impact for society

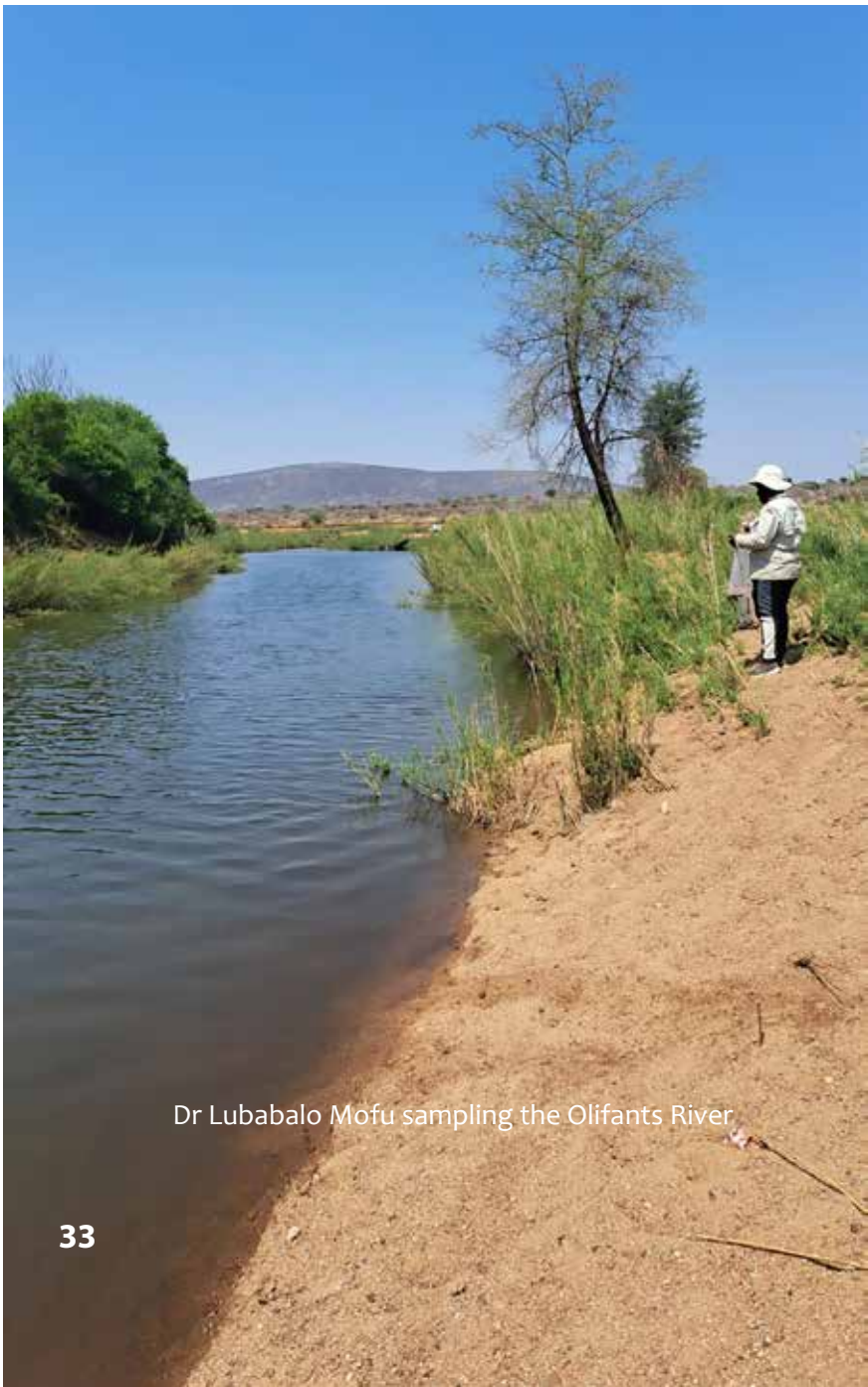
Aquaculture is crucial for the nation's food security. This study helped to identify the areas where Nile tilapia will be allowed for sustainable usage in aquaculture facilities, with the potential to create jobs.

Future work

The NRF-SAIAB, the SANBI, and the DFFE are currently looking at extending the surveys into KwaZulu-Natal.

Additional information

The Nile tilapia project is mainly funded by the SANBI and the DFFE.



Dr Lubabalo Mofu sampling the Olifants River

Current status and future predicted distribution patterns of bilharzia-transmitting snails under climate change, and implications for vector-borne diseases in South Africa

Dr Lizaan de Necker, NRF PDP Research Fellow/ Principal Investigator

Background and objectives

The last comprehensive snail distribution studies in South Africa took place in the 1950s to 1960s as part of the collections for the National Freshwater Snail Collection (NFSC) of South Africa. Given that temperatures and rainfall have already changed in the past 60 years, the distribution of snails may also have changed, particularly in regions that were on the distribution fringes of the schistosomiasis intermediate host snails. The ongoing study (2020–2024) addresses the lack in knowledge regarding the present distribution of schistosomiasis in South Africa, using a combined field and desktop-based study approach. This is an ongoing project that started in 2020 and will be completed in 2024.

The overarching aim of this project is to determine whether the ranges of the intermediate host snails and associated parasites have expanded, how affected communities perceive and experience these changes, and whether changes may further expand and increase the potential prevalence of the disease in humans and animals, given future predicted climate change.

The team involved in molluscan sampling in August 2021: Herman Le Roux, Dr Lizaan de Necker, Dr Wynand Malherbe and Chantelle Barendze.

University of Limpopo students who assisted with distributing household questionnaires to communities in Limpopo.

This project works towards achieving the WHO targets for elimination of schistosomiasis transmission by 2030 by providing much needed updated knowledge regarding schistosomiasis in South Africa.

This project will also improve awareness of the health-risk schistosomiasis poses to people, thus contributing to the UN SDGs of "Clean water and sanitation", and further our understanding of the effects of climate change and invasive species on the distribution of vector-borne diseases such as schistosomiasis, thus also contributing to the UN SDGs of "Climate action" and "Life below water".

Research activities

Three surveys were undertaken in 2021 for this research study. Two of these surveys were for the collection of molluscs and water quality variables for the MSc projects of Mr Herman Le Roux and Mr Hanro Pearson. These surveys took place in the Limpopo region during the high flow (April/May 2021) and low flow (August 2021) sampling seasons. The third survey was undertaken in August 2021 as part of the MSc project of Ms Nape Mothapo and involved conducting more than 300 household questionnaires regarding people's knowledge of schistosomiasis. Ms Mothapo was assisted by 14 University of Limpopo Honours students during her fieldwork.

Distinguished visitors / international visits / conferences

Dr Lizaan de Necker attended and presented findings of the project at the British Society of Parasitology online Conference in June 2021.

Training / supervision

Eight students associated with the project are working towards achieving the various objectives of the study in 2021. These include one PhD, four MSc students and three Honours students.
All three Honours students completed their projects in 2021 with Ms Alyssa Coetsee receiving a distinction for her degree.

Outcomes

A great deal of data were collected in 2021 that will work towards achieving the end goals of the project as well as the preparation of publication and student reports for submission in 2022 and 2023.

Impact for society

This project works towards updating the current knowledge of schistosomiasis in South Africa, which affects millions of humans and animals each year and is being achieved by updating the current distribution of the vectors that transmit schistosomiasis as well as using desktop-based modelling to determine how the distribution of this disease may change in the future.

Through the household questionnaires, the team will also gain a better understanding of local people's knowledge regarding schistosomiasis which will assist local government in determining how best to work towards education and spreading awareness of the risks involved around schistosomiasis.

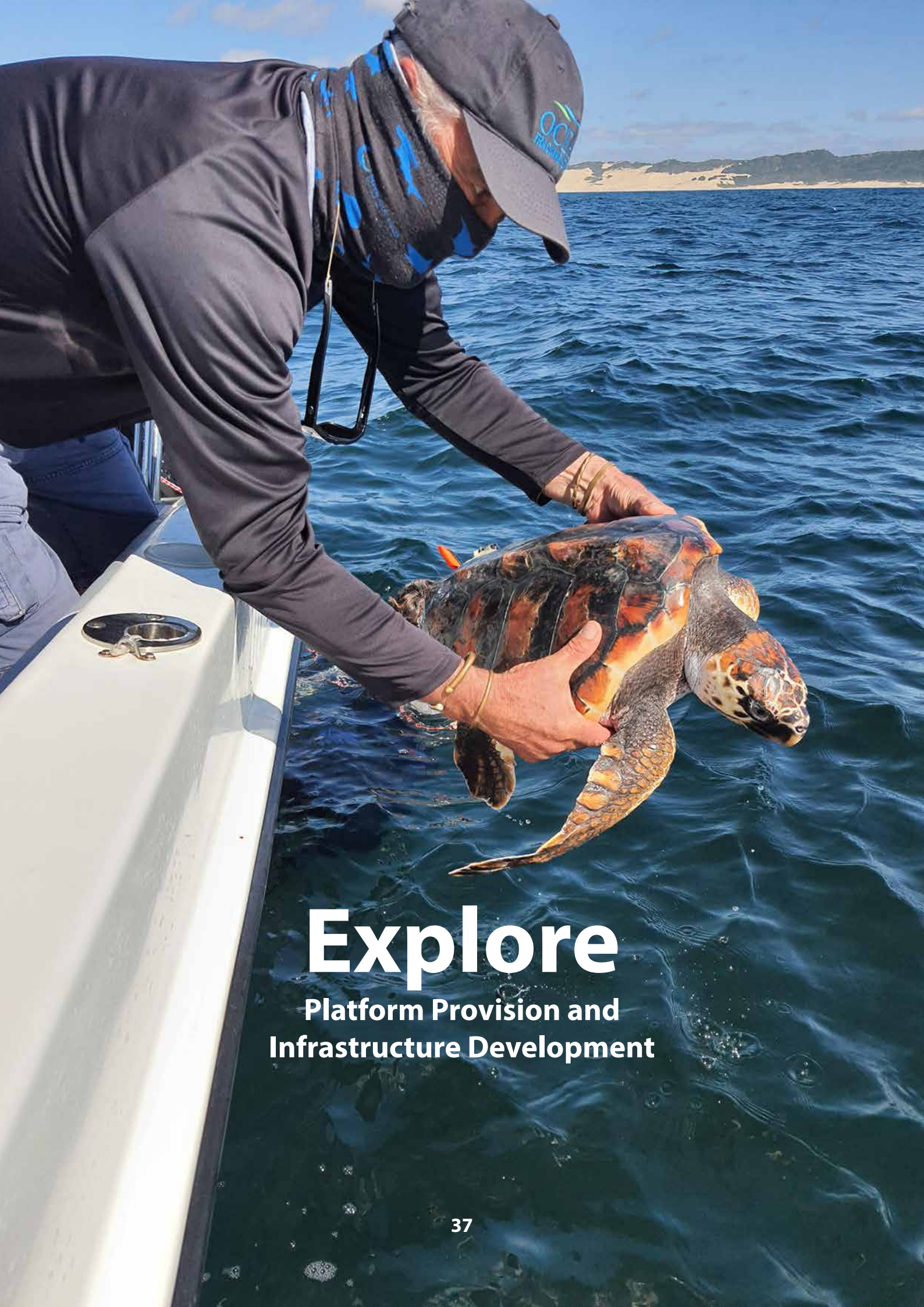
Future work

A community workshop is currently being planned to be held in 2023 with the local community that was involved in the household questionnaires. The goal of this workshop will be to educate children and adults of the local community about water health and water-related diseases, spread awareness of schistosomiasis and provide feedback on the results from this study.

The research team is currently working alongside the Centre for Teaching and Learning at NWU to create a short educational video regarding schistosomiasis that will be provided to the local community as part of the workshop. The goal is to produce a video in the local language of the community to make it easily accessible and to distribute via social platforms such as WhatsApp and Facebook.

Additional Information

This project is financially supported by the Water Research Commission (WRC Project No C2019/2020-00151) and is carried out in collaboration with the University of Limpopo.



Explore

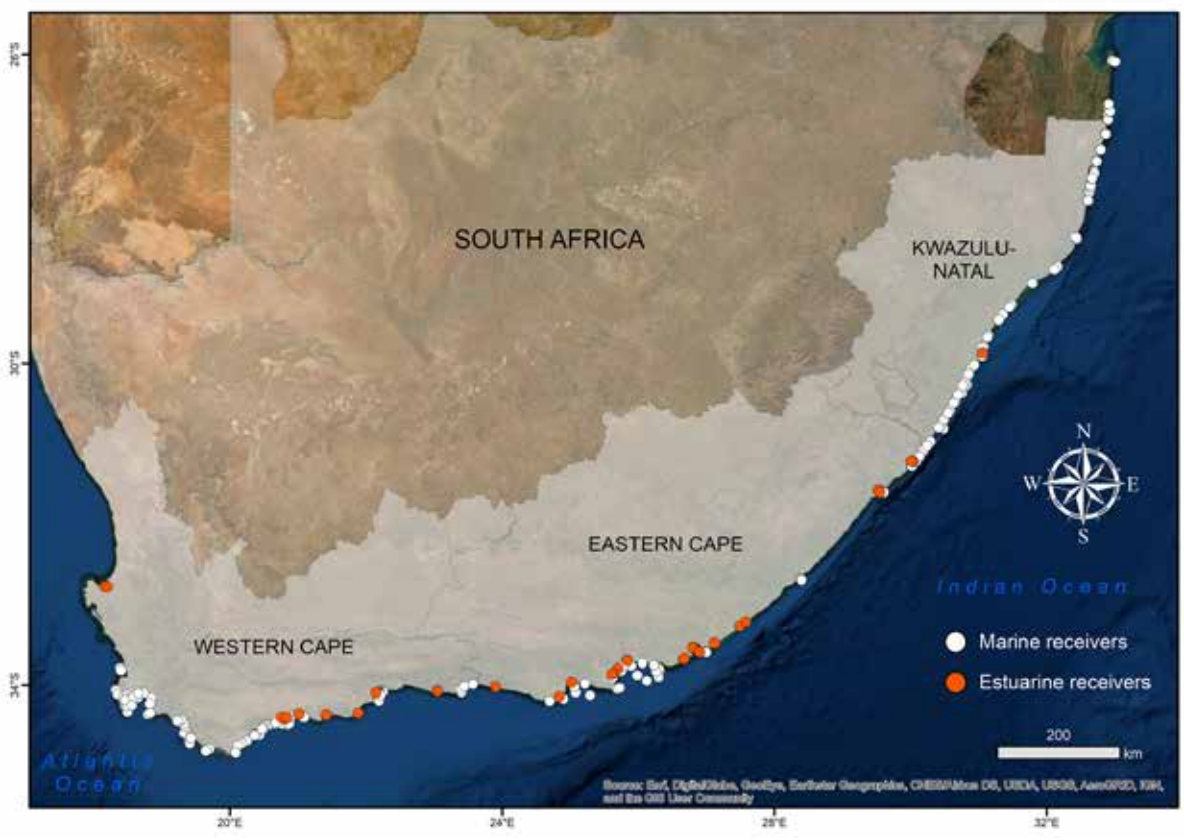
Platform Provision and Infrastructure Development

Acoustic Tracking Array Platform - ATAP

Dr Taryn Murray, ATAP Instrument Scientist, ATAP Manager

Background and objectives

The Acoustic Tracking Array Platform (ATAP), a nationwide network comprising more than 280 acoustic receivers deployed in the nearshore marine environment and selected estuaries along 2200 km of the South African coastline, has grown in maturity, reaching its decadal milestone in October 2021, and providing the hardware needed to conduct nationwide movement studies. The ATAP continues to witness steady growth in terms of the number of species (50 fishes, sharks, rays and turtles) and individuals (1800+) tagged. While the ATAP continues to monitor the movements of several important fishery species, and sharks and rays, the large-scale array, in its current form, also allows researchers to assess the fate and movements of aquarium-released animals, including ragged tooth sharks (Two Oceans Aquarium), giant kingfish (uShaka Sea World Aquarium) and three species of rehabilitated turtle (East London Museum and Bayworld). The long-term animal movement data collected by the ATAP can be used to work towards a) sustainable use of marine resources (SDG 14: Life below water), b) improving food security with sustainable consumption patterns (SDG 2: Zero hunger and SDG 12: Responsible consumption and production), and c) poverty alleviation (SDG 1: No poverty). The ATAP aims to develop human capacity, with an emphasis on training students from HBUs and involving female researchers (SDG 4: Quality education and SDG 5: Gender equality) by working with, and providing support to, scientists from more than 28 organisations. Additionally, the ATAP maintains a close relationship with the Canadian-based Ocean Tracking Network (OTN) (SDG 17: Partnerships for the goals).



The current ATAP array covering ~2200 km of the South African coastline from Saldanha Bay in the west to Ponta do Ouro in the east.

Significant research-aligned events

The ATAP continues to provide infrastructure and data management support to two projects managed by the Wild Oceans programme of the WILDTRUST, funded by the Shark Conservation Fund ("Protection for Threatened Sharks and Rays in South Africa") and the Blue Action Fund ("Oceans Alive – Oceano Vivo" project). To date, animals from at least seven different species have been tagged, and data have been incorporated into a Shark Conservation Plan which is to be published as a scientific manuscript in 2022. The ATAP joined teams with Sea Search, where Dr Simon Elwen, a marine mammal researcher from Sea Search, deployed hydrophones in Saldanha Bay and St Helena Bay along the west coast of South Africa to gain a better understanding of noise levels in the vicinity prior to some industrial work being conducted in the area. Through this collaboration, our listening power along the west coast has expanded with very little cost to the ATAP.

A bronze whaler shark has a long-life acoustic transmitter surgically implanted into it as part of a PhD project assessing the largescale movements of this species along the coastline. © Shark Spotters.

Conferences

With the world slowly opening up post-COVID-19, global travel remained limited throughout 2021. A conference important for southern African elasmobranch (sharks and stingrays) researchers—the 5th Southern African Shark and Ray Symposium (SASRS)—was held in Gansbaai in November 2021. The SASRS was attended by ~100 delegates from at least 22 different organisations and saw oral presentations cover a variety of topics from Telemetry and Movement to Genetics and Identification. The ATAP Instrument Scientist, Dr Taryn Murray, gave an oral presentation describing how passive acoustic receivers could be used in a more active way via boat-based tracking. Owing to the high number of researchers who make use of acoustic hardware present at SASRS, the ATAP also held its annual stakeholder workshop at the symposium on Wednesday, 17 November 2021.

Supervision

The number of post-graduate students making use of ATAP data is steadily increasing, with ATAP having provided data for no less than 25 students from six universities to date. Dr Chantel Elston, who joined the ATAP as a Postdoctoral Fellow in 2020, has proved invaluable in terms of data analysis and writing, and is analysing and writing up much of the existing ATAP data. Mr Godfrey Padare, previous MSc student working with the ATAP, joined the team as an intern in October 2021, and will be with us until September 2023. Two ATAP-supervised students, Tayla Dominy (MSc in Geography, Rhodes University) and Bantony Ziko (MSc in Zoology, University of Fort Hare), also graduated, with Tayla receiving a distinction for her thesis. Her project was a geospatial analysis on the effect of environmental variables on the space use patterns of four marine predators occurring in Algoa Bay, Eastern Cape.

Outcomes

The ATAP is recognised as a mature cooperative telemetry network and continues to be mentioned in international literature, including 10 papers published in 2021. During 2021, ATAP received 56 requests for data reports from its stakeholders/beneficiaries—another increase on requests made in 2020 (41 requests). The increasing trend for data requests continues to provide testimony of data maturity and we anticipate that in the near future (the next two to five years) a number of publications will result from the data currently being collected.

Impact for society

Acoustic telemetry provides a powerful tool to evaluate the benefits of marine protected areas (MPAs), and ATAP supports projects within several southern African MPAs, including the De Hoop Nature Reserve, Greater Addo Elephant National Park MPA, Pondoland MPA and iSimangaliso MPA. It is essential to understand the degree of efficacy and connectivity between these MPAs, as without protection, fishes would be overexploited, stocks would collapse, and resources would be consumed unsustainably, which would lead to hunger and a major loss of biodiversity – all of which would have a severe impact on society. The ATAP conveys these issues to the public via social media (Facebook, Twitter, and Instagram) and science engagement (e.g., SciFest, public talks) activities.

Future work

The ATAP recently expanded its work into the reptilian realm, tagging Vulnerable loggerhead turtles, Endangered green turtles, and Critically endangered hawksbill turtles as part of a collaboration with Bayworld and East London Museum – branching out to SAAMBR uShaka Sea World Aquarium and Two Oceans Aquarium. The ATAP will also focus on the movement behaviour, habitat connectivity, and ecology of multiple estuarine species, including important food fish species, such as mullet, and continue work in MPAs, expanding into the Amathole (black musselcracker and dageraad) and Goukamma (roman) MPAs.

Additional information

Support has been received for running expenses (Save Our Seas Foundation, and African Coelacanth Ecosystem Programme) and for acoustic telemetry hardware (Ocean Tracking Network, the Shallow Marine and Coastal Research Infrastructure Programme, and NRF).

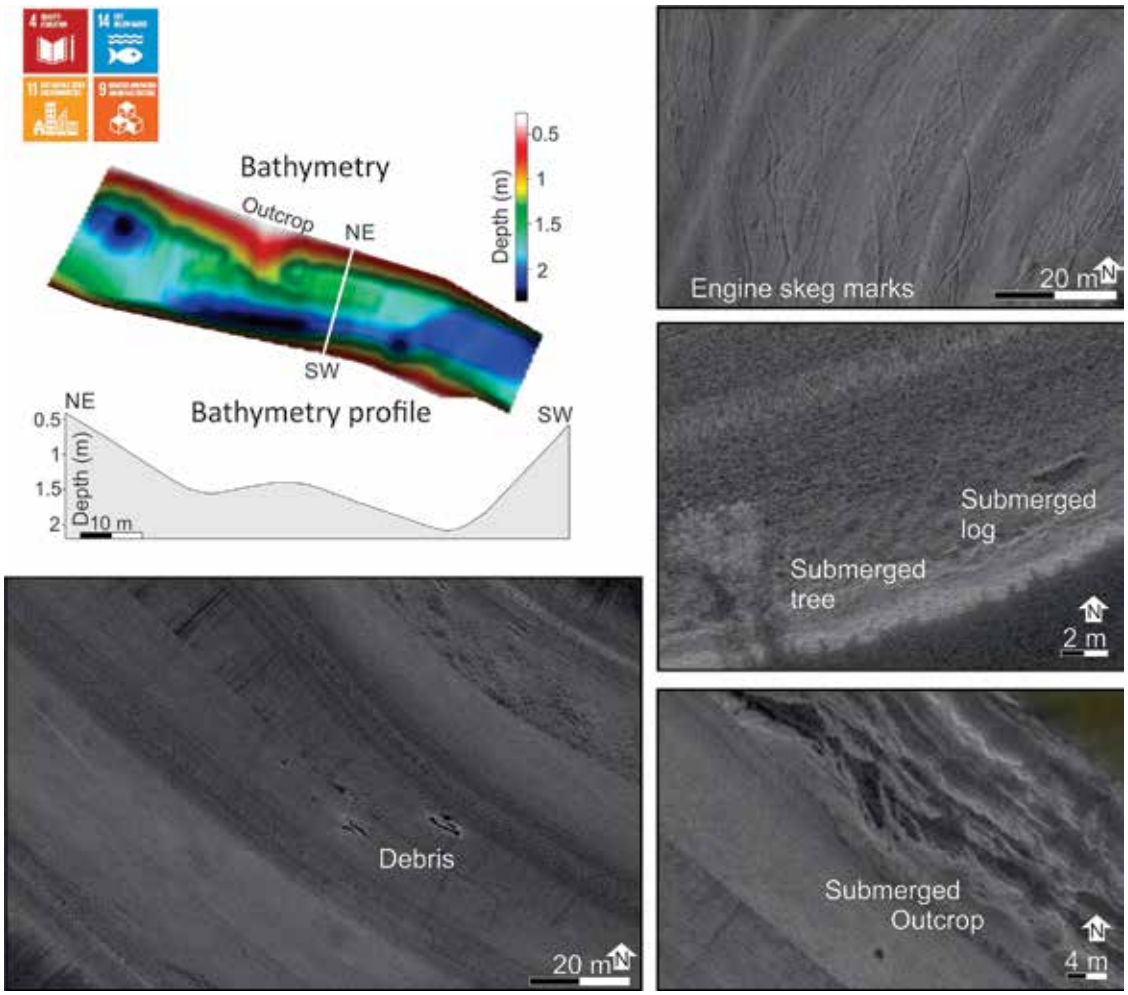
Geophysics and Mapping Platform - GeMaP

Dr Errol Wiles, Instrument Scientist, GeMaP Manager

Background and objectives

Sustainable growth of the Blue Economy requires holistic and sound marine spatial planning (MSP) which must be based on the best available data. Within MSP, ecosystem-based marine spatial planning represents the future of sustainable resource optimisation as it considers biodiversity and key ecosystem processes/services. The South African exclusive economic zone is critically understudied in the context of geomorphological habitat and marine resource characterisation. The GeMaP is the only competitively awarded research platform in the country able to address this shortfall and is available to the marine scientific research community through the ACEP Open Call at no cost to researchers and with specialist support from platform personnel.

The GeMaP is centred around a Reson SeaBat 7101 multibeam echosounder, SBG Systems Inertial Navigation System (INS), and HYPACK survey software, along with auxiliary supporting equipment and software amounting to a ~R5 500 000.00 invest-ment in infrastructure. GeMaP is supported by ACEP and SMCRI coastal craft (up to 16 m in length) from which the sonar transducer is deployed



Preliminary results from Mlalazi Estuary, KZN north coast, are promising with bedrock outcrop, debris and other features clearly resolved by the system.

during operation. A Lowrance Elite Ti2 system is in a testing phase to allow shallow water (rivers/ estuaries) mapping. While not as advanced as the multibeam echosounder, the Lowrance system enables exploration in shallow systems previously out of reach due to their depth and turbidity.

Significant research aligned events

GeMaP completed four surveys bathymetric surveys in 2021 in support of the ACEP SMART Zones MPA project. In addition, the Platform moved into estuaries where cost-effecting sonar surveying techniques were assessed and used to map the middle and upper Mlalazi Estuary. These data provide geospatial context to support biological sampling campaigns to understand the connectivity between studied environments.
Training/ supervision

The Platform is currently supporting a Doctoral candidate (Geology) at Nelson Mandela University and a BSc Honours candidate based at the University of KwaZulu-Natal. Although the platform is new and opportunities at sea are still limited, students or researchers interested in learning more about the computer systems and data to produce three-dimensional seabed models are encouraged to get in touch with Dr Wiles, the GeMaP Manager.

Outcomes

During 2021, data from four survey sites and seven survey days were acquired and processed. The data have been used for ROV and BRUV deployments, enabling scientists to make informed decisions on site selection based on seabed geomorph-ology, which highlights the relief and distribution of reef and unconsolidated sediments.

Impact for society

Outcomes of this project will allow an unprecedented view of the seabed and enable classification and quantification of geomorphological habitat in a marine protected area. As regions of exceptional biodiversity, MPAs offer a range of socio-economic benefits to proximal communities. Provision of environmental services requires a healthy ecosystem which, in turn, supports fisheries (recreational and subsistence) and tourism. These three facets add value to the local economy through means of employment directly or indirectly related to tourism and fisheries. Outcomes of this project, combined with other project components will enable better management of the uThukela MPA, leading to medium and long-term socio-economic benefits.

Future work

GeMaP is growing in project support across a range of small- and large-scale surveys. To keep up with demand, a new system is in the pipeline. This will enable greater access to infrastructure and greater data collection.

Additional Information

GeMaP is supported by ACEP and SMCRI, backed by the DSI and NRF.

African Coelacanth Ecosystem Programme - ACEP

Ryan Palmer, ACEP Technical and Scientific Manager

Background and objectives

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 (NRF-SAIAB), the South African Environmental Observation Network (SAEON), the Department of Forestry, Fisheries and Environment (DFFE), and the NRF's Research and Innovation Support Agency (RISA).

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

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

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

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

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

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

ACEP Marine Platform Provision: 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 (NRF-SAIAB)
Acoustic Tracking Array Platform – ATAP (NRF-SAIAB)
Coastal Craft Platform (NRF-SAIAB)
Geophysics and Mapping Platform - GeMaP (NRF-SAIAB)
ACEP also facilitates competitive access to Sentinel Site data (SAEON)

ACEP research platforms have been further enhanced by the DSI: South African Research Infrastructure

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

ACEP Phuhlisa Programme

At the beginning of 2016, the DSI requested the ACEP Phuhlisa Programme to extend support to the University of Zululand and University of the Western Cape. Subsequent to this expansion, the programme now supports 19 supervisors and 70 post-graduate 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 the University of Zululand (UniZulu), 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 post-graduate students. These post-graduate student bursaries are awarded in line with the national imperative of equity and redress which prioritises support for appropriately qualified students from designated groups, that is, black, female, and persons with disabilities. The set equity targets are 90% black, 55% women, and 1% students with disabilities, as directed by the DSI Ministerial Guidelines on Equity and Redress (Ministerial Guidelines on Bursaries and Fellowships, 2013). Additionally, these guidelines are intended to assist the NRF to improve representivity, to expand the skills produced by the South African science system, and to assist the DSI to direct and coordinate the development of high-level skills in the system. The ACEP Phuhlisa Programme is a key transformation programme within the South African Marine Research Strategy and contributes directly to the Operation Phakisa Ocean Governance Laboratory.

ACEP Open Call - Research

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

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

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

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

Prof. Kerry Sink (South African National Biodiversity Institute): Deep Connections aims to increase and apply multi-disciplinary information on biological, physical, and socio-cultural connectivity into

spatial assessment and management of marine ecosystems, threatened species and biodiversity benefits by piloting new approaches across the biodiversity value chain.

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

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

ACEP Joint Marine Laboratories Programme

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

The DSI/NRF Joint Marine Labs Programme (JMLP) aims to address key marine, social and economic opportunities and challenges facing South Africans. This 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 National System of Innovation (NSI). The Marine Platform was impacted heavily by COVID-19 lockdown restrictions, seeing complete closure of the platforms for parts of 2020, and then a phased ramp-up over the remainder of the year. This resulted in some projects being postponed until 2021, which has had a knock-on effect. This change has been factored into the 2021–23 ACEP schedule. Demand from the South African marine science community has necessitated the expansion of the platform, which has been done with the build of a new research vessel, RV Observer.

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

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

Coastal Craft — The Coastal Craft platform is one of ACEP's most successful research platforms. To date, it consists of a 13 m LeeCat, RV *uKwabelana*, based in Durban, which is set up as a dedicated multibeam survey vessel, a 15 m Legacy Cat, RV *Phakisa*, based in Durban, and the RV *Observer* based

in Gqeberha (Port Elizabeth). The coastal craft are primarily accessed through the ACEP Open Call. The ACEP's partner platforms include the SAEON Sentinel Site and the NRF-SAIAB ATAP, GeMaP, and MARIP, which are serviced on a regular basis by the Coastal Craft.

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

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

ACEP Deep Forests students Sinothando Shibe and Mari-Lise Franken assisting Ferdy Jacobs deploy the ROV off RV *Observer*

Coelacanths in Jesser Canyon, Jesser Canyon, iSimangaliso Wetland Park, KwaZulu-Natal.

Impact for 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. The 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. The ACEP also ensures that human capacity is developed to equip future generations to manage the changes that our planet is experiencing.

Sinothando Shibe (ACEP Deep Forests MSc student) is studying seapens which are also a potential indicator species of vulnerable marine ecosystems.

Marine Remote Imagery Platform – MARIP

Dr Anthony Bernard, MARIP Instrument Scientist

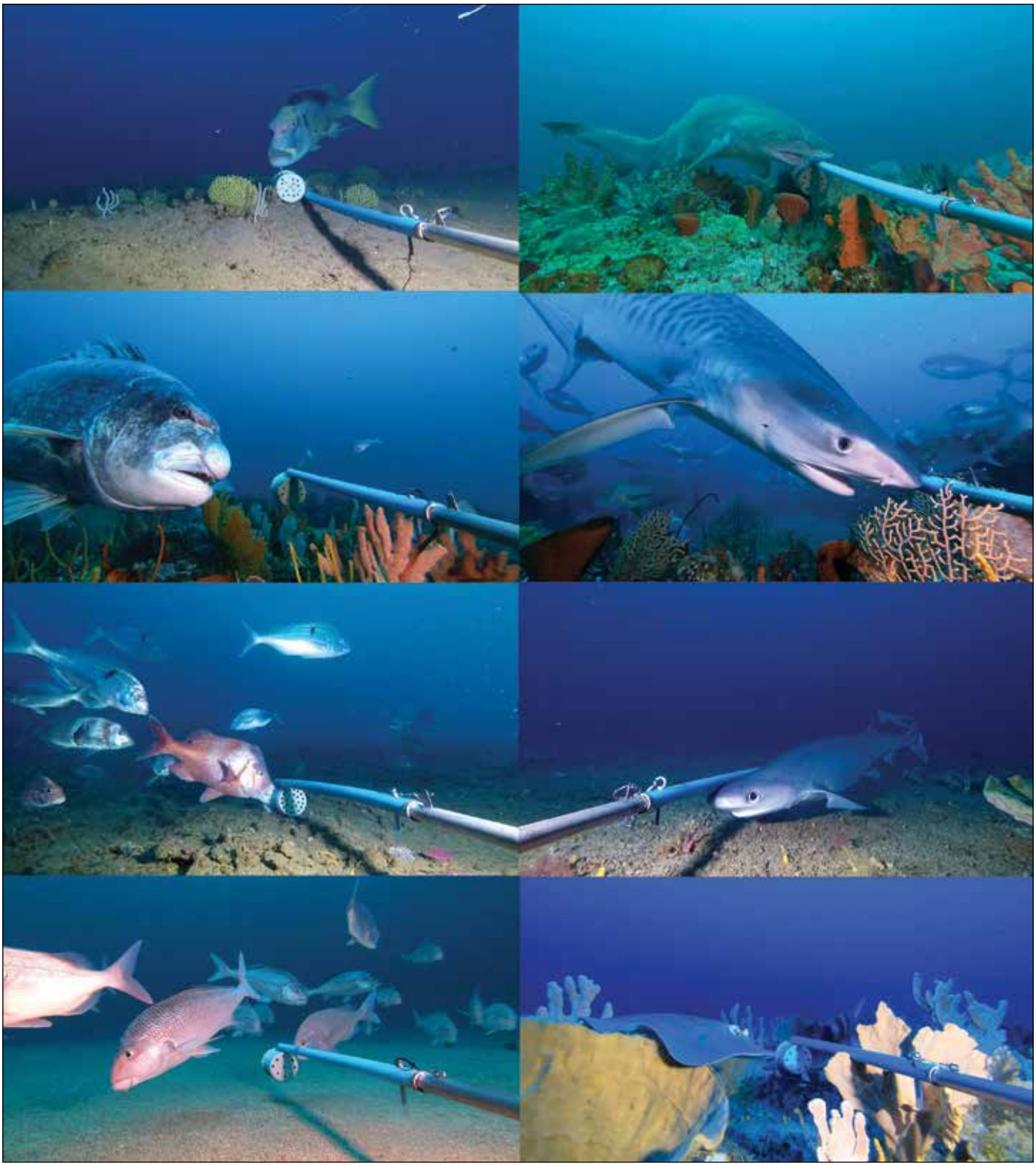
Background and objectives

The marine remote imagery platform provides researchers from South Africa and the Western Indian Ocean (WIO) access to a variety of 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 1000 m. The equipment includes a 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. The MARIP has its own research vessel and tow vehicle to enable access to remote locations within the waters of South Africa and its neighbouring countries. The platform includes a computer laboratory with all the required software for processing the imagery data, a large network-attached storage system for long-term archiving all imagery samples, and a comprehensive biodiversity data management system linked into the Specify software system used for managing biological specimen collections. The MARIP is the largest of its kind in South Africa and provides our scientists unprecedented access to research opportunities to enable cutting-edge research of underwater ecosystems. The platform directly aligns with the United Nations SDGs 4 (quality education), 9 (industry innovation and infrastructure) and 14 (life under water). Importantly, the platform works towards South Africa's NDP by improving education, training, and innovation, while the research that the MARIP enables works towards environmental sustainability.

Research activities

Work carried out in 2021 included the planning for the new ACEP projects and research support for the other NRF-SAIAB infrastructure platforms (e.g., ATAP, AGRP), and independent research projects. The independent projects currently supported by the platform include: (1) assessing and long-term monitoring of South Africa's Marine Protected Areas (MPAs); (2) testing the effectiveness of the environmental DNA (eDNA) for surveying subtidal reef fish assemblages; (3) investigating essential habitats for threatened sharks in South Africa; (4) assessing elasmobranchs in the Western Indian Ocean; (5) monitoring reef fish populations in the Tofu marine reserve in central Mozambique; (6) assessing the mesophotic ecosystems at Vamizi Island in Northern Mozambique. Numerous fieldtrips were carried out in 2021 for the supported research projects, including baseline surveys of the Robberg, Dwedsa-Cwebe, Hluleka and the Protea Banks MPAs; and eDNA and stereo-BRUVs research in and adjacent to the Tsitsikamma, Bird Island and Wild Coast MPAs.

The Wild Oceans and MARIP research teams after successfully completing an elasmobranch survey in the Protea Banks MPA.



Stereo-BRUVs image montage from samples collected in the Wild Coast and Protea Banks MPA.

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

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

Training and supervision

Twenty post-graduate students made use of equipment, data and resources provided by the MARIP. The platform provides the students involved in the projects with relevant training in the use of the equipment and the management and processing of the data. The MARIP worked on the organizing committee and participated in the Benthic Imagery training workshop hosted by DFFE, Oceans and Coast. This involved providing training on the use of stereo-BRUVs to ~100 young scientists from the WIO. In addition, MARIP provided training to research staff from Walter Sisulu University on how to design and conduct research with stereo-BRUVs.

Impact for society

By providing advanced research infrastructure to scientists in South African and the WIO, the MARIP serves a critical role in advancing marine science in our region. Much of the research supported by the platform is relevant to society and directly feeds the development of recommendations and strategies for the sustainable management and utilisation of South Africa's marine biodiversity. The platform supports a diverse group of post-graduate students, ensuring the development of the next generation of scientists. Furthermore, the platform works extensively with other counties in Africa, supporting regional development.

Future work

Research activities planned for 2022 will focus on advancing the research agendas for the current ACEP projects, and completing fieldwork for the eDNA research project. MARIP will be providing infrastructure, technical capacity, and research expertise on the NEKTON Mission Maldives project.

Additional information

Support for the platform: ACEP and the Shallow Marine and Coastal Research Infrastructure project.

Researchers from Walter Sisulu University receive training to conduct stereo-BRUVs research in shallow marine ecosystems.

Aquatic Ecophysiology Research Platform
Aquatic Ecophysiology Research Platform - AERP

Seshnee Reddy, AERP Co-ordinator

Background and objectives

The Aquatic Ecophysiology Research Platform (AERP) was established in 2014, after formal collaboration between the South African Institute of Aquatic Biodiversity (NRF-SAIAB) and Rhodes University, Department of Ichthyology and Fisheries Science (DIFS) to equip researchers with the tools to determine the effects of global climate change on the relationship between living organisms and their surrounding environment, how these effects are likely to unfold, and what actions might prevent their effect in the future.

Climate change research is receiving increasing attention on a global scale, and it is essential that South Africa maintains an active standard in its research in this field. Since climate change is an ongoing phenomenon, it is crucial to improve our understanding of the effects of environmental changes across a range of species from various taxa and ecosystems to understand the potential effects on our aquatic resources. The organismal responses at the physiological, metabolic, and behavioural levels are central to research that addresses adaptation and resilience to environmental long-term and extreme changes.

Research conducted at the AERP mainly involves scientists at NRF-SAIAB and DIFS, as well as post-graduates at the Honours, MSc, PhD, and postdoctoral levels.
A total of seven projects were carried out during 2021, two of which made use of AERP equipment off-site, while the other five projects were conducted in-house, involving varying degrees of field

An AERP lab user loading mussel settlers and/or recruits into a microplate for measurement of oxygen consumption.

work, equipment, and facility usage. The above-mentioned projects included research by three PhDs, three MScs and one Postdoctoral Fellow.

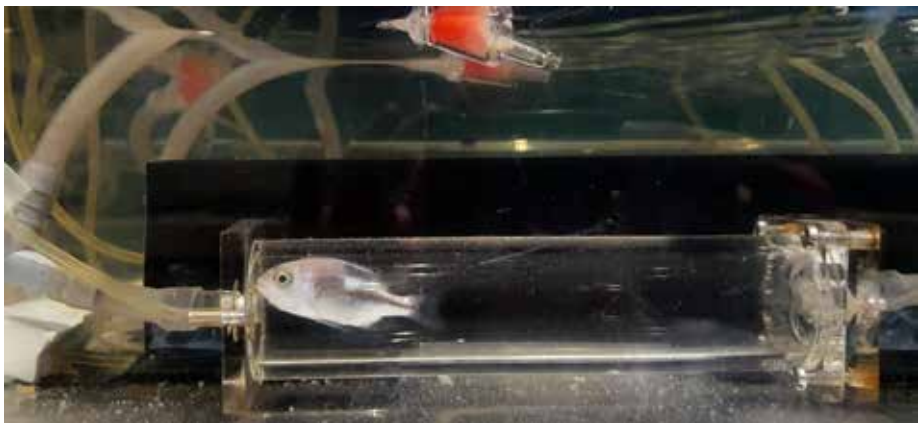
Academic achievements and highlights included a PhD graduation by Cuen Muller, who submitted and was awarded his PhD in 2021 after utilising the AERP throughout his degree. He investigated the effects of exploitation on the resilience of the roman seabream offspring from fished and protected populations. The study revealed the potential of exploitation to alter the evolutionary trajectory of a population by exposing offspring from different populations to an environmental stressor.

The AERP participated in the National Marine Week 2021 by creating a series of three short digital stories/video clips which showcased the theme (The Ocean: Life and Livelihoods) of the event and linked this to the work conducted by researchers and student users of the AERP. This was a collaborative project with Dr Kerry-Ann van der Walt (NRF-SAIAB Postdoctoral Fellow), who also made use of the AERP for her PhD as well as her current post-doctoral studies. The first video showcased the equipment, controlled environment rooms and system setups that are available at the AERP and briefly explained how these work via a short demonstration/existing video footage from AERP research projects. The second and third video clips focused on the research groups that make up the majority of users at the AERP (COST and SAFER lab) by featuring the research group leader/s and respective students.

Future work

Future projects (as per current projects) will target small-scale and short-term experiments/research focused on larval, juvenile, and adult invertebrates and fish, as current fully operational facilities of the AERP allow for this type of research.

Potential interest for collaborative work on terrestrial invertebrates can also be considered, as well as continuing projects on biological control agents. Further enhancement of the scientific understanding of climate change and ocean acidification can be achieved by developing protocols and procedures of a global standard. With potential expansion into new fields, bio-economy, food security and energy security can be addressed. A paradigm shift in the AERP platform would translate as an advance in international research and innovation, while simultaneously and directly addressing the need for the economic growth of the country. This objective would be attained by bottom-up progress of research capacity in South Africa achieved through training new graduates, as well as by attracting and retaining excellence, hence boosting research capacity and growth. This research uniquely tackles the ecological issues behind climate change in a selection of sensitive systems of ideal and diverse model organisms, including the most vulnerable early life history stages. This approach is unusual and possibly unique for aquatic research in the country.



Juvenile red roman in a respirometry chamber.

Aquatic Genomics Research Platform - AGRP

Taryn Bodill, AGRP Manager, and Dr Gwynneth Matcher, Instrument Scientist and AGRP Manager

Background and objectives

The Aquatic Genomics Research Platform (AGRP) provides workspace for researchers in the field of aquatic genetics research. It is strongly positioned in terms of its link to the National Fish Collection, the NRF-SAIAB biobank, and to active researchers. The platform provides national genomics infrastructure for aquatic research, thereby contributing to global SDG 14. Research undertaken in which the platform was utilised includes both freshwater and marine sectors, with topics related to aquaculture, aquaponics, bioprospecting for pharmaceuticals, biodiversity, barcoding, ecology, and genome studies. The platform is equipped with laboratory equipment for capabilities that extend from DNA extraction through to Sanger sequencing, as well as next-generation sequencing (MiSeq). High-performance computational hardware in the form of a server with 2TB RAM was acquired in 2019 that enables analysis of the large datasets generated by next-generation sequencing. Primarily, the server has been used to assemble genomes from metagenomics data. The platform is operated on a cost-recovery basis, allowing users access to equipment and training that would otherwise be prohibitive.

The general laboratory area where platform users conduct their genomics research.

Training and supervision

The platform is an invaluable teaching resource. Staff provide technical support to all platform users, allowing those with little or no practical experience to gain the skills needed to obtain their qualifications or to pursue a career in the molecular field. There are no other platforms that offer this type of hands-on training. The AGRP was operational during 2021, albeit at reduced capacity owing to the pandemic. The platform was utilised by 49 students and staff in 2021 and included researchers from the South African Environmental Observation Network (SAEON), Rhodes University, the Albany Museum, the South African Association for Marine Biological Research (SAAMBR), University of KwaZulu-Natal, University of the Western Cape, Cape Peninsula University of Technology, and the University of Fort Hare. The AGRP laboratory space was expanded to accommodate additional platform users and is currently being suitably equipped. The platform also hosted the annual workshop on next-generation sequencing, dataset curation/quality assurance, and metabarcoding data analysis. This included hands-on practical experience in analysing metabarcoding data (from dataset curation all the way through to generating publication-ready graphs). Owing to the pandemic, this workshop was held virtually. Individual one-on-one training was also supplied for barcoding, qPCR and shotgun metagenomics.

Additional information

In November 2021, Taryn Bodill resigned from NRF-SAIAB to take up a post in Cape Town and Dr Matcher took over as interim manager until the post could be filled.

Taryn Bodill operating the Sanger 3500 genetic analyser

Collections and Specialised Laboratories Platform

Nkosinathi Mazungula, Collections Manager

Background and objectives

The Collections Division Platform provides access for bona fide researchers, and students from South Africa and all over the world to a growing collection of biomaterials (specimens, tissue and DNA extracts, skeletons and associated data) for research. The platform is home to 127 503 lots of samples with over one million individual fish specimens, and over 40 000 associated tissue and DNA extracts in its Biobank. The platform has other growing collections of amphibians, cephalopods and tunicates through institutional collecting programmes and donations from curators. Specimens held in our collections represent over five decades of NRF-SAIAB's aquatic research and are the largest collection of fishes on the southern African continent, south of the Democratic Republic of Congo.

The Platform has a state-of-the-art curatorial infrastructure through the JLB Collection Management Centre (CMC), which provides accommodation for collection staff, researchers, and students. The dedicated collections building has two large temperature-controlled specimen stores, three wet sorting laboratories, a Biobank with -80°C freezers, an X-Ray room, a chemical store, a recycling room, and a dermestarium. The Specify database software has been used to organise specimen information successfully for over 20 years and the data is published in the Global Biodiversity Information Facility (GBIF).

Compactum shelving with catalogued samples of fishes

Team

Staff: Nkosinathi Mazungula, Amanda Gura, Nonkoliso Mgibantaka, Mzwandile Dwani, and Vuyani Hanisi

SANBI Curation Technicians: Zinzi Sinazo Somana, Siphamandla Mceleli

Curators: Fishes: Roger Bills (NRF-SAIAB) – Freshwater; Ofer Gon (retired, NRF-SAIAB) – Marine; Dr Dave Ebert (Moss Landing, USA) – Chondrichthyans

Amphibia: Dr Michael Cunningham (associate at Melbourne Museum, Australia) and Dr Werner Conradie (Bayworld, Port Elizabeth)

Diatoms: Dr Jonathan Taylor (North-West University)

Cephalopods: Dr Marek Lipinski (retired)

Tunicates: Dr Shirley Parker-Nance (Nelson Mandela University)

Significant research aligned events

Seven hundred lots of samples and 2932 individual specimens, 4838 tissue and DNA extracts were catalogued. The SANBI Curation Technicians processed and incorporated 3481 specimens from fishes from South African Museum, Albany Museum and Natal Museum into the NRF-SAIAB collection. Thirty-one loans with 3567 individual specimens, 21 gifts with 653 tissue samples were processed and made available to support research during COVID-19 restrictions. The Biobank freezer audit was completed, which improved the physical organisation of tissue and DNA extracts. The Natural Science Collection Facility (NSCF) DNA barcoding project (Barcode of Wildlife Project) was restarted in 2021 with the initial stages assessing previous work, cataloguing, and sequencing. We took part in the NSCF Health and Safety Discussion Forum.

Distinguished visitors / international visits / conferences

There were no international visitors due to COVID-19 restrictions. The platform provided a virtual tour of the National Fish Collection to delegates of the American Institute for Conservation (AIC) and the Society for the Preservation of Natural History Collections (SPNHC) joint virtual annual meeting. Another virtual tour was done for the NSCF virtual forum under the theme 'Caring and Sharing'. Zinzi Somana, Siphamandla Mceleli and Collections Manager, Nkosinathi Mazungula, submitted a short write-up as part of the NSCF 3rd digital edition showcasing the Value of Collections, focusing on iconic and historically important specimens.

Training/ supervision

Under normal circumstances, numerous post-graduate students have used the facilities, especially the CMC, but numbers dropped in 2021 owing to COVID-19 restrictions. The platform does not supervise any students, but provides support through specimen loans. Roger Bills gave lectures to the Department of Zoology and Entomology Honours students at the University of Fort Hare (UFH) in Alice. Nkosinathi Mazungula did a 'role modelling session' at the UFH Virtual Science Communication Workshop.

Outcomes

Dave Ebert, the platform chondrichthyan Curator, published an annotated shark checklist, much of it based on NRF-SAIAB collections. As part of her PhD study, Manda Kambikambi described a new species and named it in honour of the first post-apartheid president of South Africa, Nelson Rholihlahla Mandela (*Enteromius mandelai*). Yonela Sithole, PhD student, authored a taxonomy paper that resulted in all *Serranus cabrilla* specimens from South Africa and Mozambique being moved to *Serranus knysnaensis*. These studies all used specimens from the National Fish Collection.

A specimen of *Barbus bellcrossi*

Impact for society

Natural history collections are records of biodiversity which detail each specific species that was present at a specific location during a specific time. They are a critical infrastructure for the fields of taxonomy and systematics and provide important data for the study on biodiversity and conservation. The National Fish Collection is a 'goldmine' as research on its collection and related data has over the 50 years addressed issues of national and global relevance.

Future work

The NSCF DNA barcoding project (Barcode of Wildlife Project) will continue into 2022. The IUCN Red data projects will continue to be supported, as has been done over the last 30 years, with the provision of main data sets for freshwater fishes and frogs.

Additional information

Funding and support through the Natural Science Collection Facility (NSCF).

Above:
Large fibreglass tanks for specimens too large to fit into glass jars

Right: Vuyani Hanisi recycling old formalin and alcohol using the three recyclers (specialised distillation units).

Information Platform: Biodiversity Information Unit

Advancing Biomaterial Curation through Effective Data Management

Dr Willem Coetzer, Biodiversity Information Manager

Background and objectives

Data management is easily taken for granted amid ubiquitous and powerful web applications that reinforce the unfortunate idea that "the data will fall into place as they should". The human effort required to manage data will only increase as our requirements for data become more complex and nuanced. Firstly, the security of a dataset needs to be assured. A safe dataset can be continuously improved without the fear of data integrity and data quality becoming compromised. Data curation is the process of creating, organising, and maintaining datasets so that data can be accessed and used by people looking for useful information. Like any field of research, Biodiversity Science has unique and meaningful concepts with long definitions that need to be represented by, or reduced to, mere words or numbers ("the data"). The Data Manager is responsible for this process of "translation" between concepts and words or numbers, which culminates in making many arduous decisions about how to structure and store the data to extract rich meaning in the future.

Biodiversity Information Manager, Dr Willem Coetzer.

Training

In the last 12 months several in-house training sessions have been carried out, recognising that information technology develops rapidly and requires staff to keep abreast of new techniques and ideas in biodiversity information management. The NRF-SAIAB continues to engage with other organisations in South Africa and abroad, to exchange ideas and share experiences of success and failure. The NRF-SAIAB Systems Administrator is recognised as a proficient administrator of the Specify7 Platform, which employs current web-enabled database technology for collection management. This expertise has allowed NRF-SAIAB to offer this platform to the South African research community at a low cost.

Outcomes

Biodiversity data management at NRF-SAIAB has continued to evolve over the years, encompassing new concept clusters to keep abreast of researchers' diversifying needs. International biodiversity data standards have guided NRF-SAIAB's biodiversity informatics work in two main areas: data about preserved specimens or observations fall into one area, and data about genomic samples into another, that is, tissue samples or DNA extractions, stored in a biomaterial bank. In the last 12 months the focus has been on the curation of biomaterial data. A workflow was developed to audit genomic samples and verify metadata, to enable future researchers to interpret the data with the requisite scientific confidence.

Impact for society

In accordance with the status of NRF-SAIAB as the National Aquatic Biobank, the Biodiversity Information Unit is in the process of developing standardised data management procedures so that data safety and integrity are assured. To advance these objectives, NRF-SAIAB will collaborate with Biodiversity Biobanks South Africa, a DST and NRF-funded Research Infrastructure dedicated to advancing the curation of biomaterial samples collected from biodiversity specimens. This work, which depends on best practices in data management, is not only important in the field of Biodiversity Conservation, but will also be relevant to applications in crop and livestock improvement and the development of new medicines or foods.

Future work

Much work remains to be done to optimise the efficiency of established data management procedures, and to give other organisations the opportunities to learn from the experience of NRF-SAIAB staff.

Information Platform: Margaret Smith Library

Maditaba Meltaf, Senior Librarian

Maditaba Meltaf working in the journal collection.

Background and objectives

The Margaret Smith Library is a resource shared with the Rhodes University Library. Being part of the Rhodes University community means that NRF-SAIAB students have the same level of access to the University E-learning Resources. The Margaret Smith Library also serves as the primary library for the Rhodes University Department of Ichthyology and Fisheries Science (DIFS). Our literature collection is specialised and focused only on ichthyology, aquaculture, and fisheries. When building the collection, emphasis is on relevance, with material that speaks to the needs / demand of our users. This method has resulted in high circulation of books and an excellent user satisfaction survey.

Research activities

The Margaret Smith Library survey was sent out in 2021 to all users and stakeholders. The survey aimed to identify weaknesses and strengths of the Margaret Smith Library with regard to customer service and library infrastructure. During this reporting period, Library users were still happy with

the customer service of the Margaret Smith Library and its relevant literature resources. The Library processed 124 ISI-rated papers for submission for the Research and Innovation Reward Programme (RIRP) and is currently awaiting a call for submission to the NRF Grants Management and Systems Administration office.

Training and supervision

The Margaret Smith Library conducts annual library user training for NRF-SAIAB interns and students and for Rhodes University DIFS undergraduate and post-graduate students. This training is also offered on an ad hoc basis any time on request.
In October 2021, Andisile Klaas was appointed as a Communications Intern at NRF-SAIAB, shared by the Margaret Smith Library.

Outcomes

The Margaret Smith Library is a member of IAMSLIC – the International Association of Aquatic and Marine Science Libraries and Information Centres. This membership proved to be very beneficial to the Library during the Covid-19 Pandemic when the Library was closed. Library services remained available to users through the IAMSLIC consortium, enabling libraries to lend each other articles or book chapters.

During 2021, the Library was able to purchase new books to the amount of over R35 000.00.
The Margaret Smith Library was granted permission to digitise three old Nelson Mandela University (NMU) theses from the 1980s.

Impact for society

The Margaret Smith Library supports Open Access, and the digitisation of the above-mentioned NMU theses to VitalSeals Platform, which is an open repository, has benefited ichthyologists. The overall internet exposure gained by digitising and having them Open Access is overwhelming as they have +300 hits, +300 visitors and 70 downloads. Without this initiative and effort, many people would not have had access to the theses.

Future work

Because of Covid-19 restrictions, the library missed the digitisation targets for 2021, but plans are in place to improve on this in 2022. The Smithiana Monograph Number 4 (Whitfield, A.K., 2019. Fishes of Southern African estuaries: From species to systems) will be digitised and uploaded to the Biodiversity Heritage Library (BHL). The Ichthyological Bulletins by JLB Smith and edited by MM Smith (Volume 1: 1-20; Volume 2: 21-32) have not been digitised as yet; but will be in the near future, as will other reference works, particularly from the African continent.

Additional information

The Librarian, Ms Maditaba Meltaf, is a Sesotho narrator for audiobooks at the South African Library for the Blind.

Transform

Human Capacity Development

African Coelacanth Ecosystem Programme – ACEP Phuhlisa Programme

Garth van Heerden, Transformation Manager

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

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

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

Custom training courses help students catch up on academic writing, presentation, and other skills in order to address the articulation gap of students coming from a disadvantaged background. Supervisors and their post-graduate students are provided with academic and professional development opportunities, including supervisory, scientific and life skills training courses, like swimming and driving lessons, skippers' licences, and diving qualifications, as well as first aid training. Owing to the COVID-19 pandemic, these courses were put on hold until conditions could once again allow these interventions to continue.

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

Phuhlisa continues to work closely with NRF Human and Innovation Capacity Development (HICD) to secure Marine Science bursaries for most of the 70 post-graduate students, and the 19 researchers receive project running costs funding for their post-graduate students. Support is also provided for researchers to attend conferences and training workshops to improve the technical skills required in their field of study. However, a significant challenge for the programme is securing funding for postdocs who have successfully come through the programme.

The ACEP Phuhlisa programme has not been unaffected by the COVID19 lockdown. The pandemic highlighted the gross inequality which still persists among Institutions of Higher Education in South Africa, favouring researchers and student groups who are privileged enough to be at the better resourced universities of the country. This again highlighted the necessity for interventions like the Phuhlisa programme. However, student challenges during lockdown were further exacerbated by

delays in bursary pay-outs at HDIs. Studies for almost all MSc and PhD students had to be extended by a further 12 months. Human and Infrastructure Capacity Development (HICD) provided extension bursaries to a small group of students, and NRF-SAIAB had to make funding available to see these post-graduate students over the line.

The programme is now in a position where the need for laboratory-based infrastructure at partner universities has been identified as a key gap in developing marine science at HDIs. The provision of infrastructure has to date been beyond the budget of ACEP. The Department of Science and Innovation has recognised the need to address this gap and has made available an initial amount of R18 million to establish four marine laboratories at the four partner universities (see African Coelacanth Ecosystem Programme – ACEP Joint Marine Laboratory Platform chapter).

African Coelacanth Ecosystem Programme – ACEP Joint Marine Laboratory Platform

Garth van Heerden, Transformation Manager

"Taking excellence to the people"

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

The DSI/NRF JMLP aims to address key marine, social and economic opportunities and challenges facing South Africans. The programme includes the development of technical skills to co-manage these joint research platforms.

NRF-SAIAB has finalised MoAs and is in the process of establishing joint marine laboratories with our partner Universities:

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

UWC – Microplastics Laboratory: Prof. Anusha Rajkaran is setting up a clean laboratory with associated instrumentation. Refurbishment of the laboratory space is complete and procurement of a FT-IR spectrometer is at an advanced stage. The laboratory is planned to open in July 2022.

UFH – Bio-discovery Laboratory: Prof. Bradley is setting up a tissue culture laboratory and associated Ultra High Pressure Liquid Chromatography (UPLC) for novel compound research. The UPLC has been commissioned and was launched on 10 March 2022.

WSU – Coastal Livelihood & Ecology Laboratory: WSU plans to rebuild their marine field station at Dwesa-Cwebe Nature Reserve, and money has been secured via the Department of Higher Education and Training (DHET). The DSI will twin with DHET to provide the scientific infrastructure for the field station. The WSU team is working closely with Eastern Cape Parks and Tourism Agency (ECPTA) senior management to get the Environmental Impact Assessment (EIA) underway. This project has a longer time frame and is envisaged to be completed by March 2023.

Marine and estuarine ecotoxicology laboratory

The Marine and Estuarine Ecotoxicology Laboratory is split into two sections:

- The Analytical Laboratory is where all the analyses take place and where the capital equipment is housed. Capital equipment in this laboratory 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).

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

Challenges and future plans:
The refurbishment of both labs took longer than expected, partly due to COVID-19, which meant some supplies were unavailable, and the KZN-wide looting incidents. Refurbishment of the Exposure Laboratory has been completed. It is envisaged that the Analytical Laboratory will be completed by October 2022.

Microplastics laboratory

Status update: This laboratory has been refurbished with new desktops, shelves, cupboards, and a sink area. The design of the laboratory will allow for a laminar flow unit (purchased and received) as well as a water system (purchased, waiting for delivery). The laboratory is ready for students, and some have begun to use the space. Estimated date of completion is July 2022, but this depends on the challenges presented below.

Challenges and successes:
The main challenge has been the process of getting the Fourier Transform Infrared spectrometer. The main success was the approval of the NRF Marine and Coastal Grant for 2022–2024.

Bio-discovery laboratory

The laboratory has been prepared for the equipment. The main equipment, the UPLC, has been delivered and commissioned. Planned date for the launch: 10 March 2022.

Challenges and successes: The laboratory will be functional in early 2022, with Dr Ntombekhaya Nqumla to be appointed as technician to run the instrument.

Network

Strategic Engagement and Collaboration

Amphibian diversity and conservation

Prof. Louis du Preez, North-West University
(NRF-SAIAB Honorary Research Associate)

Following a series of field trips to the Soutpansberg Mountains during 2021, the amphibian species survey and barcoding of all species collected were completed.

The first highlight was the discovery of a healthy population of the Udzungwa grass frog (*Ptychadena uzungwensis*) on top of the mountains, confirming the presence of this east African species in South Africa. A second highlight was finding the illusive northern forest rain frog (*Breviceps sylvestris taeniatus*) with its "clown face" at different localities in wet forest patches.

Following countless attempts over a time span of 25 years to find an adult Table Mountain ghost frog (*Heleophryne rosei*), Prof. Du Preez saw the ghost frog for the first time in its natural habitat.

A field trip to the remote Naye-Naye pans and Khaudom Reserve in north-eastern Namibia revealed several surprises and big range extensions for various amphibian species. Barcoding is being finalised on the species collected. Thirteen peer-reviewed papers on various aspects of amphibians and their parasites were published.

Above left: Udzungwa grass frog

Above right: Table Mountain ghost frog

Left: Northern forest rain frog

Wetland ecology

Dr Tatenda Dalu, University of Mpumalanga
(NRF-SAIAB Honorary Research Associate)

In 2019, the drafting of a wetland book project was initiated in collaboration with Prof. Ryan Wasserman (Rhodes University); the book was edited in 2021, and will have a 2022 publication date. The authors collaborated with 76 scientists from all continents of the world to publish the book on Fundamentals of Tropical Freshwater Wetlands: From Ecology to Conservation Management. Book chapter key sections include: Abiotic properties and processes (5 chapters), Biota and biotic processes (12 chapters), and Monitoring, conservation, and management (5 chapters), plus a general introduction. This book project was strongly supported by collaboration and support from NRF-SAIAB.

Together with colleagues from the SADC-Groundwater Management Institute, University of the Western Cape (UWC), the University of Venda (UNIVEN), Rhodes, University of the Free State, and SANPARKs, baseline wetland monitoring projects in the Khakhea-Bray Transboundary Aquifer system, Kruger National Park and Limpopo wetland systems were initiated. These projects monitor plants, invertebrate and vertebrate diversity within and along the edges (i.e., reptile and vegetation

The Khakhea-Bray Transboundary Aquifer Groundwater Dependent Systems project.
From left to right: Dr Chad Keates (herpetologist), Chipo Mungenge (PhD student, Rhodes), Frank Bute (MSc student, Rhodes), Mangana Rampheri (PhD student, UWC), Dr Tatenda Dalu (Biodiversity Project Leader), Fannie Masina (MSc, UMP), Farai Dondofema (GIS/Remote Sensing Leader), Prof. Ryan Wasserman (ecologist), Kudzai Mpakairi (MSc student, UWC).
Photo credit: Chad Keates

Stakeholder (Makuleke Village elders, SANPARKs, DFFE) site visit in the Ramsar declared Makuleke Wetlands, Kruger National Park with Fannie Masina, measuring water quality parameters in the pan.

surveys) of these wetland systems so as to gain a better understanding of the regional diversity. Several MSc and PhD students from the University of Mpumalanga, UWC, Rhodes and UNIVEN were involved in these projects, with students expected to complete their studies in 2022 and 2023.

Dr Tatenda Dalu currently supervises several PhD and MSc students across different fields of aquatic ecology within South Africa and abroad with the Aquatic Systems Research Group (ASRG).

Dr Dalu visited Wissenshaftskolleg zu Berlin, Germany for 2.5 months; the trip was very successful as it led to over 10 publications; Dr Dalu was also invited to serve as the Associate Editor of *Frontiers in Water, and Ecology and Evolution*.

Research questions to support fisheries management in South Africa

Prof. Nicholas Mandrak, University of Toronto, Scarborough
(NRF-SAIAB Honorary Research Associate)

On behalf of Prof. Olaf Weyl, Prof. Nicolas Mandrak was honoured to give a plenary presentation entitled, "Ten research questions to support fisheries management in South Africa" at the 8th World Fisheries Congress in Adelaide, Australia in September 2021.

Dr Mandrak was invited to give a similar presentation to honour Olaf at the Society of Southern African Aquatic Scientists (SASAqS) virtual conference held in November 2021. The presentations were based on a recently published paper co-authored by many leading authorities on South African fisheries, including NRF-SAIAB staff and associates, that resulted from a workshop that Olaf held in 2017 at St. Francis Bay, South Africa.

Olaf and Nick at Jonkershoek in 2017.

People, fish, and crocodiles

Dr Francois Jacobs, Kamutjonga Inland Fisheries Institute, Namibia
(NRF-SAIAB Honorary Research Associate)

During 2021, a project entitled "People, Fish, and Crocodiles" was initiated. This is the first study of its kind in Africa and it will contribute to our understanding of problems faced by rural riparian communities in relation to the risks of obtaining daily basic needs from the Kavango River, that is, drinking water and fish for nourishment. Recent studies have shown that the fish stocks have declined significantly, which not only has a negative impact on food security, but has caused an increase in human/crocodile conflict as fish up to 260 cm TL in the diet of Nile crocodiles are estimated at 98%.

Some of the key interests are:

i) Do potential man-eating crocodiles have any seasonal, short-term, or daily migration or behaviour patterns?

ii) On a seasonal and daily scale, when are the crocodiles occurring in areas of potential conflict with people?

iii) Are there any behavioural patterns in crocodiles that can be related to increased or reduced risks of crocodile attacks on people?

iv) Can the variation in behaviour of crocodiles be connected to the fish stocks and/or fish behaviour (e.g., spawning aggregations or migrations) or human behaviour patterns and/or abiotic factors (e.g., temperature or water discharge)?

Oreochromis andersonii radio tagged to monitor their behaviour in relation to crocodiles.

Nile crocodile with sattelite tag to monitor movement patterns in close proximity to people.

Nile tilapia invasion?

Prof. Jay Stauffer Jr., Penn State University
(NRF-SAIAB Honorary Research Associate)

The Nile tilapia, Oreochromis niloticus, is a cichlid indigenous to the tropical and subtropical parts of eastern and western Africa and is being cultured in the catchment basin of Lake Malawi in Tanzania. The probability of the Nile tilapia dispersing throughout Lake Malawi, once it escapes from the culture facilities, is enhanced by its fast growth rate, large size relative to native Oreochromis spp., and its diverse repertoire of feeding options. Additionally, the success of its invasion has been attributed to high levels of parental care and its ability to produce multiple broods throughout the year. If the Nile tilapia were to become established in Lake Malawi it would:

1) cause the extirpation of native fishes;

2) hybridize with endemic Oreochromis spp.;

3) damage the livelihoods of existing artisanal fishermen.

It was concluded that control methods used for other alien fishes such as chemicals, physical barriers, and biological agents would be ineffective in Lake Malawi.

Cape Maclear, Lake Malawi.

Edibility of fish

Dr Sean Marr (NRF-SAIAB Honorary Research Associate)

The year 2021 saw the publication of a chapter: "Case Studies of Fisheries Potential of South African Inland Fisheries", in the WRC Report on *Inland Fisheries Contributions to Rural Livelihoods: An assessment of fisheries potential, market value chains and governance arrangements*.

Through a project at the University of Limpopo, which Dr Sean Marr was involved in while still a Postdoctoral Fellow at NRF-SAIAB, Dr Marr published a full WRC Report on: *Predicting the edibility of fish in the Flag Boshielo system*.

Three papers were published in 2021, all of which Prof. Olaf Weyl had been involved in before he passed away.

Dr Marr also gave 12 lectures on Freshwater Ecology in the Zoology second-year course and four lectures on Aquatic Research Techniques in the Zoology third-year course at the University of Fort Hare (September to November 2021).

Dr Sean Marr and Mr Thabo Mohlala electrofishing on the Klaserie River (Limpopo), as part of the NRF-SAEON Klaserie River Survey.

A golden moment

Prof. Paul Skelton (Managing Director Emeritus)

For Prof. Paul Skelton, the highlight of 2021 was to be awarded the Southern African Society of Aquatic Scientists (SASAqS) Gold Medal for "Lifetime Achievements".

The lockdown allowed for good progress to be made on the revision of the book *A complete Guide to the Freshwater Fishes of Southern Africa*.

The Annual Smith Memorial Lecture, "Time and the River", which Prof. Skelton presented in September 2021, also focused attention on the biogeography of freshwater fishes at the southern extremity of Africa. Systematic ichthyology has, in the past 50 years, experienced extensive revolutionary changes in both paradigmatic and technological aspects. As a result, we have witnessed what can only be described as a tsunami of change in the understanding of earth history, phylogenetic relationships of freshwater fishes, and the links between the two. This lecture explored these aspects with particular regard to the freshwater fishes of the far south of Africa. A revision of the topic is underway.

Various collaborations realised papers on the taxonomy of fishes from Angola.

Prof. Alan Whitfield presented Prof. Paul Skelton with the SASAqS Gold Medal for "Lifetime Achievements".

New species descriptions of fishes from the Andaman Sea

Dr Peter Psomadakis, Food and Agriculture Organization
of the United Nations (FAO) (NRF-SAIAB Honorary Research Associate)

Dr Peter Psomadakis was senior author on several papers published in 2021: first, a paper published in *Zootaxa* entitled: "Description of two new species of sandlances, genus *Bleekeria* (Perciformes, Ammodytidae) from the Andaman Sea (north-eastern Indian Ocean)". These new species were described from specimens collected in the Andaman Sea off the coast of Myanmar in 2015 and 2018. The species are distinguished from each other and from congeners by a combination of morphological and meristic characters, as well as fin colouration and genetic variance.

Dr Psomadakis was senior author on another paper in *Zootaxa*: "Two new species of the genus *Chelidoperca* (Perciformes: Serranidae) from the Andaman Sea, eastern Indian Ocean" and of a publication in *Raffles Bulletin of Zoology* titled, "Description of a new species of *Obliquogobius* (Teleostei: Gobiidae) from the Andaman Sea (north-eastern Indian Ocean)". This description was based on four specimens collected by the *RV Dr F. Nansen* off Myanmar.

Obiquogobius eptactis

Taxonomic revision of Mullidae and selected Ophidiidae genera

Dr Franz Uiblein, Institute of Marine Research, Norway
(NRF-SAIAB Honorary Research Associate)

The goatfishes (Mullidae) are a highly diverse group of marine fishes currently consisting of 99 species, of which about one-third have been described in the last thirty years, demonstrating the importance of continued taxonomic efforts. Dr Franz Uiblein has described 25 new species as the lead author in collaboration with many scientists and fish collections featuring many goatfish lots and specimens. Many of these goatfish specimens were collected during research cruises with *RV Dr F. Nansen*, supported by Dr Uiblein's home institution (the Institute of Marine Research, IMR) and the IMR-associated Nansen Research Programme. Recently Dr Uiblein has intensified his research of the genus *Parupeneus*, for which he has described two new species and re-described *P. jansenii*. These are all under consideration of similar and/or closely related congeners of the so-called *heptacanthus* and *posteli* species groups. Dr Uiblein is currently working on a redescription of *P. diagonalis*, based on specimens collected by *RV Dr F. Nansen* off the Mascarenes.

Both the goatfish (Mullidae) and the cuskeel families (Ophidiidae) are highly diverse and still require taxonomic revisions. Dr Franz Uiblein's goal is to revise the entire Mullidae family (with many individual projects focusing on species, genera or regions, and many collaborators) and two genera of the Ophidiidae (in collaboration with Jørgen Nielsen and Peter Møller, ZMUC); for this purpose, Dr Uiblein will plan further visits to NRF-SAIAB to study additional material of both groups.

Dr Frans Uiblein working with a specimen of the goatfish genus *Mulloidichthys* from the Red Sea at the Natural History Museum, Vienna, Austria.

Artisanal fishers identify barriers to implementing sustainable fisheries initiatives in African SIDS

Prof. Jessica Glass, University of Alaska Fairbanks (NRF-SAIAB Honorary Research Associate)

Dr Jessica Glass was part of a Seychellois-led team of international scientists who set out to establish the feasibility of establishing a seafood labelling system in Seychelles and to understand specific considerations that are unique to Small Island Developing States (SIDS). Seafood labelling systems (e.g., SASSI) are used worldwide to provide consumers with information on the status of the fish they are eating, enabling them to choose more sustainable options and driving fishers to target more sustainable species. To date however, no sustainable seafood labelling initiative has been established in African SIDS, or in any SIDS globally. Although SIDS depend on healthy marine ecosystems, these nations are some of the most vulnerable to climate change and over-exploitation of fisheries resources. Small-scale fishery resources are critical for food security and economic livelihoods in SIDS.

Thirty-three artisanal fishers were interviewed to gauge the level of support for such an initiative and to understand the perceived barriers and potential incentives for implementation. Of the respondents, 64% would like to see a programme implemented, but only 34% thought it would be successful. The barriers mentioned by fishers included concerns over how such an initiative would be regulated and enforced within the industry, and lack of control by fishers over species caught. The most frequently perceived benefit was the potential to increase the price of a broader range of species. Interviews are now being conducted with additional stakeholder groups to understand the implications of a seafood labelling system across the whole value-chain. This will enable a more informed approach to implementing such programmes in Seychelles and other African SIDS.

The study findings were published in *Frontiers in Marine Science* in a Special Issue on African Marine Conservation and Sustainability.

The project was funded by the Seychelles Conservation and Climate Adaptation Trust (SeyCCAT). doi: 10.3389/fmars.2022.931407

Artisanal fishers in Mahé, Seychelles. Photo credit: Jessica Glass.

Sharks of the world

Dr David Ebert, Pacific Shark Research Centre, Moss Landing, California
(NRF-SAIAB Honorary Research Associate and Honorary Curator: Chondrichthyans)

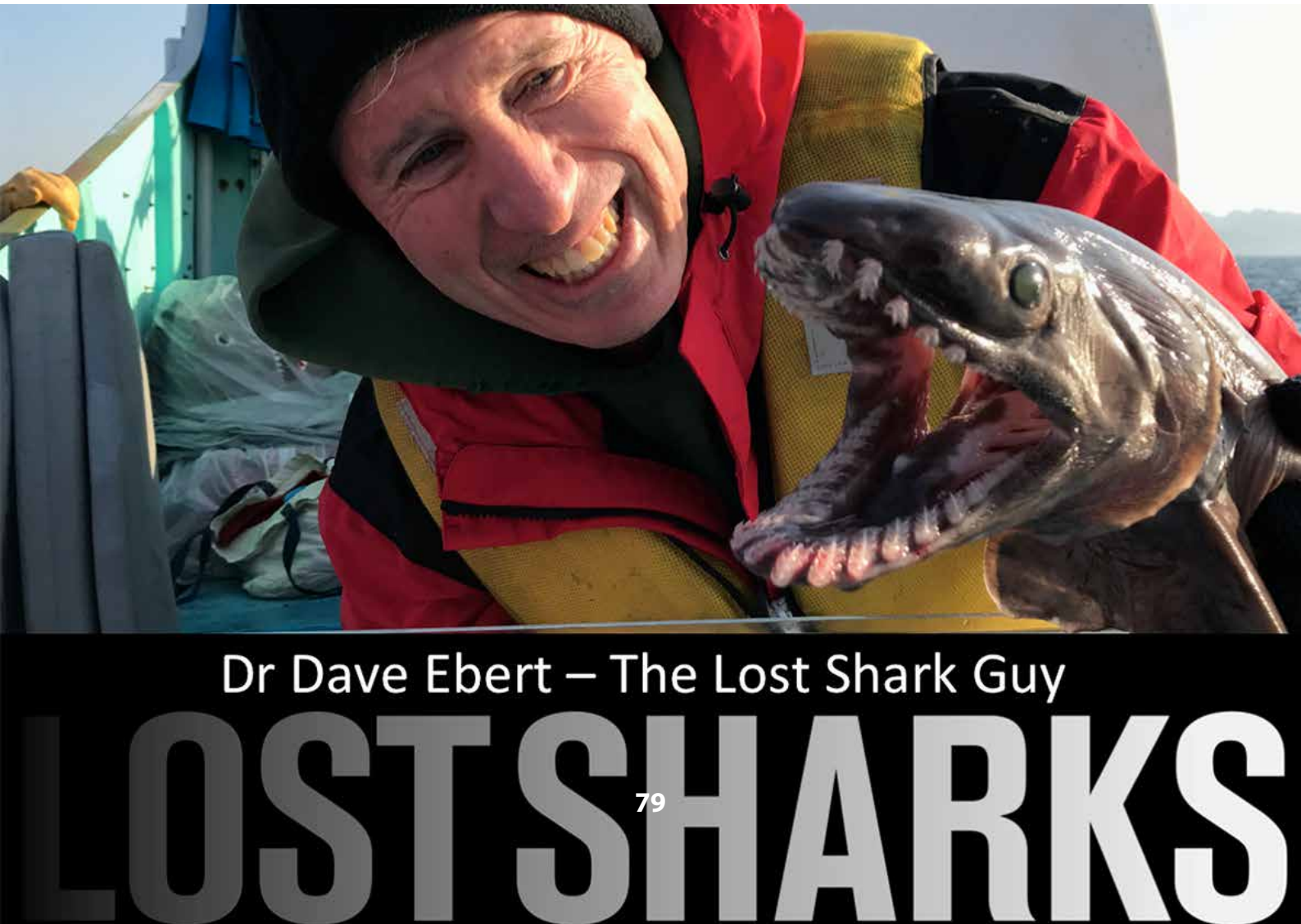
Dr Ebert completed his final year as President of the American Elasmobranch Society (AES) and continues to serve on the executive committee for the IUCN Shark Specialist Group.

He gave the keynote plenary presentation at the annual American Elasmobranch Society meeting in July 2021.

The major projects undertaken in 2021 were the publication of a monograph entitled "An Annotated Checklist of South African Chondrichthyans", and two books: Field Guide to the Sharks of the World and Pocket Guide to the Sharks of the World published by Princeton University Press. In addition, Dr Ebert described and published five new shark species, four of which are from southern Africa and the Western Indian Ocean, including one species near-endemic to South Africa and another endemic to Madagascar. In addition to the books, Dr Ebert published 15 peer-reviewed papers.

In May 2021 Dr Ebert gave a presentation as part of the NRF-SAIAB Seminar Series, entitled: "Beyond Jaws: Rediscovering South Africa's Lost Sharks". Also known as "The Lost Shark Guy", Dr Ebert spearheads global efforts to find and discover little and unknown sharks, with his research forming a foundation to develop future research and improved conservation and management policies.

Dr. Dave Ebert with a possible new shark species discovery.



From capture stress response in endemic sharks to social studies on the perception of water users on shark risk mitigation measures

Dr Enrico Gennari, Oceans Research Institute
(NRF-SAIAB Honorary Research Associate)

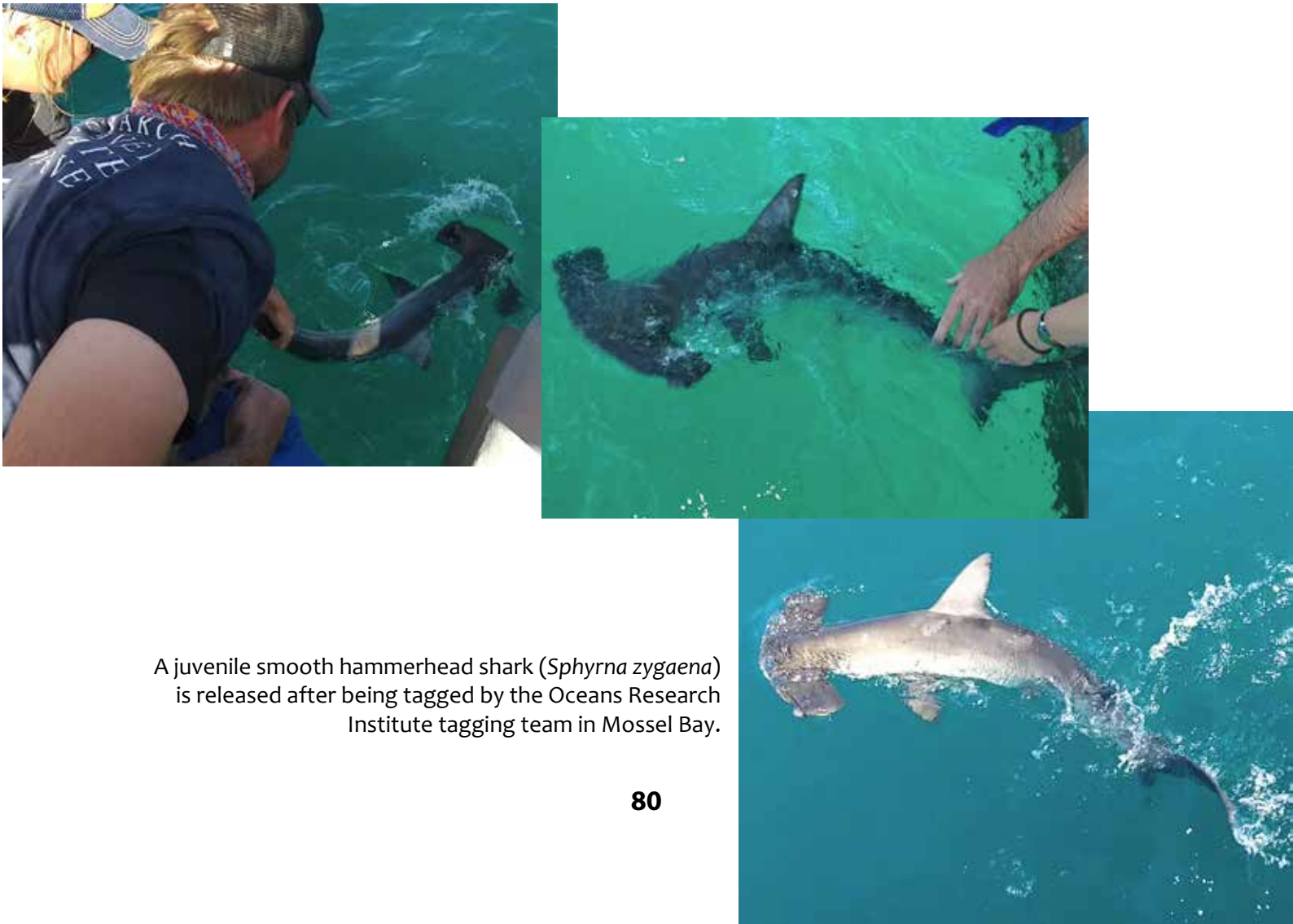
In 2021, collaborative research resulted in seven papers spanning physiological studies on capture stress response in endemic sharks in South Africa, to social studies on the perception of water users on lethal versus non-lethal shark risk mitigation measures.

The research team tested the "mistaken identity" theory behind shark bites on humans using a computer-generated view of what sharks see from their perspective. Another study used genetics to assess divergence on the common smooth hound shark.

Dr Gennari participated in a review on the conservation challenges of the most endangered dolphin species in the Western Indian Ocean.

These collaborations linked NRF-SAIAB to the UK, Italy, and Australia.

During 2021, four white sharks, nine smooth-hound sharks and six hammerhead sharks were acoustically tagged.



A juvenile smooth hammerhead shark (*Sphyrna zygaena*) is released after being tagged by the Oceans Research Institute tagging team in Mossel Bay.

Crocs, sharks, and rays

Dr Ryan Daly, Save our Seas Foundation
(NRF-SAIAB Honorary Research Associate)

In 2021, Dr Ryan Daly published seven peer-reviewed papers on a range of topics relating to the marine ecology of top predatory fish and sharks. Some highlights included a publication on the opening of St Lucia estuary mouth where we recorded and tagged the first Zambezi shark (*Carcharhinus leucas*) pups recruiting into the system in over a decade. Dr Daly also published a paper on the movement and conservation status of giant sandsharks (*Rhynchobatus djiddensis*) which highlighted that the South African population had declined by 62% over the last 40 years, confirming the endangered status and need for improved conservation management of these sandsharks. A paper was published on the ontogenetic habitat use of the giant trevally (*Caranx ignobilis*) in Seychelles, showing that it may take these fish more than two years to utilise the full extent of their home range.

Dr Daly has continued his work on the spatial ecology of sharks and rays in southern Africa and managed to deploy over 50 acoustic tags on multiple species of sharks in South Africa and Mozambique during 2021.

A sandshark (*Rhynchobatus djiddensis*) is fitted with an acoustic tag by shore-based anglers in southern KZN, South Africa.

Cephalopods in the NRF-SAIAB Collection

Dr Marek Lipinski (NRF-SAIAB Honorary Research Associate)

During 2021, two papers were published, one in the *African Journal of Marine Science*, and one in *Folia Malacol*. Both papers concerned *Loligo reynaudi*i. Four more papers were in various stages of preparation during 2019, among them a "Redescription and systematic assessment of *Sepia typica* (Steenstrup, 1875) (Cephalopoda: Sepiidae)". This paper is the fourth, and last, describing small endemic cuttlefish of the southern African shelf and slope. These small cuttlefish are the topic of molecular biology research led by Professor Louise Allcock from Ireland.

Sepia typica lateral view. Scale: 10 mm.

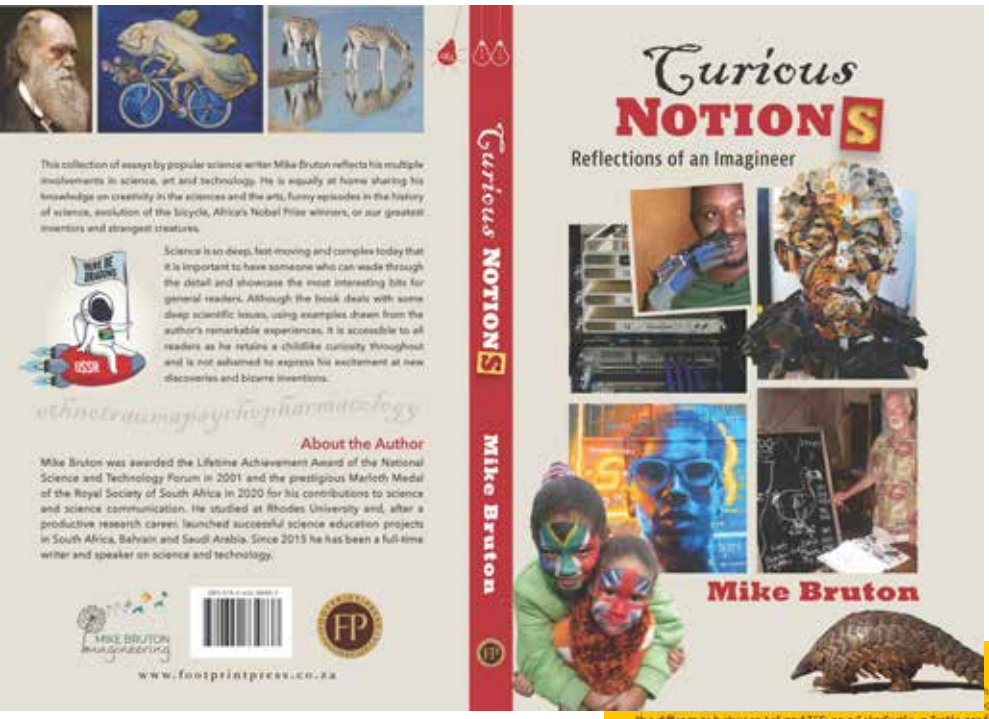
Sepia typica (male), dorsal view , from the West coast.

Curious Notions. Reflections of an Imagineer

Dr Mike Bruton, Imagineering (NRF-SAIAB Honorary Research Associate)

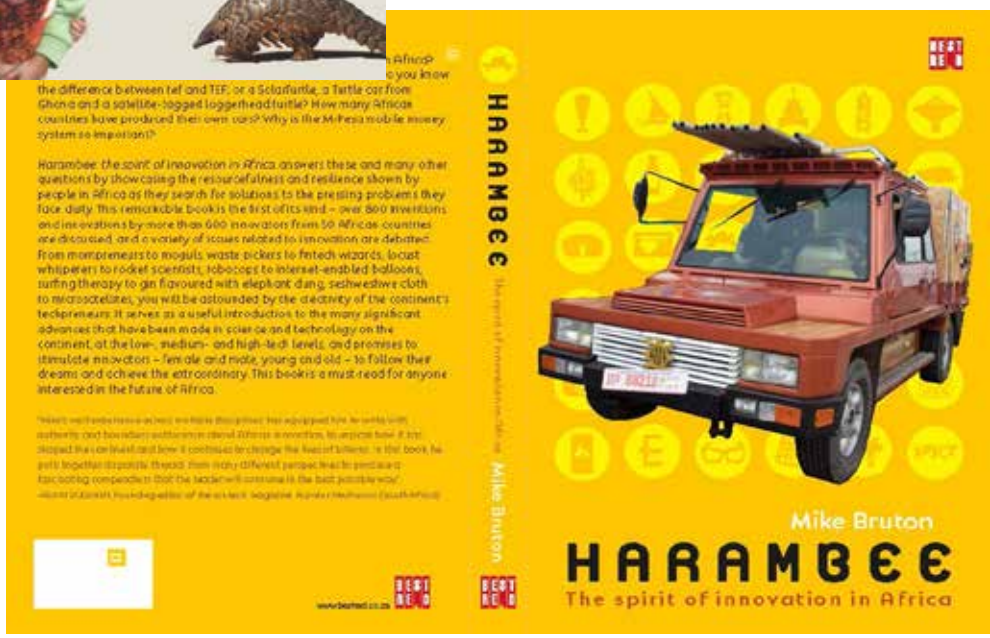
During 2021, Dr Mike Bruton completed the book *Curious Notions. Reflections of an Imagineer*, which comprises a series of essays on his multiple involvements in science and technology, including two chapters on coelacanth research. This book was published in August 2021 and has been well received. The text and editing of an additional book, *Harambee: The Spirit of Innovation in Africa*, was also completed and was due to be published by the Human Sciences Research Council in 2021, but publication was delayed until early 2022. This is the first attempt to review the contributions of innovators and inventors throughout the "bright continent".

Dr Bruton was awarded the Marloth Medal for Lifetime Contributions to Science and Science Awareness, by the Royal Society of South Africa; due to Covid interruptions, the medal will only be handed over at the Royal Society banquet in October 2022.



In December 2021, the *South African Journal of Science* announced that the paper Dr Bruton co-authored with A. Cooke and M. Ravolololoharinjara, on the status of coelacanths in Madagascar, had received the "highest attention rating" of all papers published in that journal in 2021.

The write-up of a book on Dr Bruton's experiences in teaching science and operating science museums in the Middle East, as well as a sequel entitled *More Curious Notions* have commenced.



Appendix A: NRF-SAIAB RESEARCH OUTPUTS 2021

(a) Thomson Reuters Web of Science Index Publications by NRF-SAIAB Scientists, Honorary Research Associates and Post-graduate Students

1. Albano, P.S., Fallows, C., Fallows, M., Schuitema, O., Bernard, A.T.F., Sedgwick, O. & Hammerschlag, N. 2021. Successful parks for sharks: No-take marine reserve provides conservation benefits to endemic and threatened sharks off South Africa. *Biological Conservation* 261, art. no. 109302.
2. Allison, C., Muller, C., Childs, A-R., Froneman, W., Bailey, L.A. & Potts, W.M. 2021. *African Journal of Marine Science* 43(2), 239–249. (Early Access).
3. Anderson, M.E. 2021. Obituary Phillip Clarence Heemstra (1941-2019). *Ichthyology & Herpetology*. 109 (1), 324-326.
4. Attermeyer, K., Casas-Ruiz, J.P., Pegg, J., Bodmer, P., et al. 2021. Carbon dioxide fluxes increase from day to night across European streams. *Communications Earth & Environment* 2(1), 118.
5. Bajaba, S. Z., Hugo, S., van Wyk, A. J., Marr, S.M., Vine, N. & Weyl, O.L.F. 2021. Can bait improve the efficiency of underwater video monitoring of fish in headwater streams? A case study from the Rondegat River, South Africa. *African Journal of Aquatic Science* 46(2), 246–249.
6. Baptista, N.L., Pinto, P.V., Keates, C., Edwards, S., Rödel, M-O. & Conradie, W. 2021. A new species of red toad, *Schismaderma* Smith, 1849 (Anura: Bufonidae), from central Angola. *Zootaxa* 5081(3), 301–332.
7. Bennett, R.H., Ebert, D.A., Sitoe, J.J., Fernando, S., Harris, M., van Beuningen, D. & Davids, A. 2021. Range extension of the Critically Endangered shorttail nurse shark, *Pseudoginglymostoma brevicaudatum* (Orectolobiformes: Ginglymostomatidae), to include Mozambique, with implications for management. *Marine Biodiversity* 51(1), art. no. 7.
8. Bornman, E., Cowley, P.D., Adams, J.B. & Strydom, N.A. 2021. Daytime intra-estuary movements and harmful algal bloom avoidance by *Mugil cephalus* (family Mugilidae). *Estuarine Coastal and Shelf Science* 260, art. no. 107492.
9. Bragança, P.H.N. & Ottoni, F.P.2021. On the availability of the name *Poecilia kempkesi* Poeser 2013 (Cyprinodontiformes: Poeciliidae), *Zootaxa* 4927(2), 294–296.
10. Bragança, P.H.N., Van der Zee, J.R., Chakona, A., Schmidt, R.C. & Stiassny, M.L.J. 2021. Following the mangroves: diversification in the banded lampeye, *Aplocheilichthys spilauchen* (Dumeril, 1861) (Cyprinodontiformes: Procatopodidae), along the Atlantic coast of Africa. *Hydrobiologia* 848(7), 1433–1453.
11. Broom, C.J., South, J. & Weyl, O.L.F. 2021. Prey type and temperature influence functional responses of threatened endemic Cape Floristic Ecoregion fishes. *Environmental Biology of Fishes* 104 (7), 797–810. (Early Access).
12. Bullock, K, Wood, A., Dames, V.A., Venter, J.A. & Greef, J. 2021. A decade of surf-zone linefish monitoring in the Dwesa-Cwebe Marine Protected Area, with a preliminary assessment of the effects of rezoning and resource use. *African Journal of Marine Science* 43(3), 309–323. (Early Access).
13. Butler, E.C., Childs, A-R., Milner, M.V., Farthing, M.W., Duncan, M.I., Winkler, A.C. & Potts, W.M. 2021. Do contemporary age-growth models overlook life-history complexities in protandrous fishes? A case study on the large protandrous polynemid, the giant African threadfin, *Polydactylus quadrifilis*. Fisheries Research 233, art. no. 105770.

14. Button, R.E., Parker, D., Coetzee, V., Samaai, T., Palmer, R.M., Sink, K. & Kerwath, S.E. 2021. ROV assessment of mesophotic fish and associated habitats across the continental shelf of the Amathole region. *Scientific Reports* 11, art. no. 18171
15. Byrnes, E.E., Daly, R., Leos-Barajas, V., Langrock, R. & Geiss, A. 2021. Evaluating the constraints governing activity patterns of a coastal marine top predator. *Marine Biology* 168(1), art. no. 11.
16. Cannicci, S., Lee, S.Y., Bravo, H., Cantera-Kintz, J.R., Dahdouh-Guebas, F., Fratini, S., Fusi, M., Jimenez, P.J., Nordhaus, I., Porri, F. & Diele, K. 2021. A functional analysis reveals extremely low redundancy in global mangrove invertebrate fauna. *Proceedings of the National Academy of Sciences of the United States of America* 118(32), 10.1073/pnas.2016913118.
17. Cawthra, H.C., Bergh, E.W., Wiles, E.A. & Compton, J.S. 2021. Late Quaternary deep marine sediment records off southern Africa. *South African Journal of Geology* 124(4), 1007–1032.
18. Cooke, A., Bruton, M., & Ravololoharinjara, M. 2021. Coelacanth discoveries in Madagascar, with recommendations on research and conservation. *South African Journal of Science* 117(3-4), 80–90.
19. Cooke, S.J., Twardek, W.M., Lynch, A.J., Weyl, O.L.F., Britton, J.R., et al. 2021. A global perspective on the influence of the COVID-19 pandemic on freshwater fish biodiversity. *Biological Conservation* 253, art. no. 108932.
20. Cowx, I.G., Mandrak, N., Skelton, P. & Tweddle, D. 2021. Obituary Professor Olaf Lawrence Fredrick Weyl (1972-2020). *Journal of Fish Biology* 98(1), 4–5.
21. Curran, S.S., Dutton, H.R., Warren, M.B., Du Preez, L.H. & Bullard, S.A. 2021. Two new species of *Cephalogonimidae Looss*, 1899 (Digenea: Plagiorchioidea) from Africa (Mozambique and Guinea), including a new phylogenetic hypothesis for related plagiorchioids. *International Journal for Parasitology – Parasites and Wildlife* 14, 228–240.
22. Cuthbert, R.N. Dalu, T., Wasserman, R.J., Sentis, A. & Dick, J.T.A. 2021. Prey and predator density-dependent interactions under different water volumes. *Ecology and Evolution* 11(11), 6504–6512.
23. Cuthbert, R.N., Pattison, Z., Taylor, N.G., Dalu, T., Wasserman, R.J., Courchamp, F., et al. 2021. Global economic costs of aquatic invasive alien species. *Science of the Total Environment* 775, art. no. 145238.
24. Dalu, T., Cuthbert, R.N., Weyl, O.L.F. & Wasserman, R.J. 2021. Community structure and environmental factors affecting diatom abundance and diversity in a Mediterranean climate river system. *Science of the Total Environment* 810, art. no. 152366.
25. Daly, R., Filmalter, J. D., Peel, L. R., Mann, B.Q., Lea, J., Clarke, C.R. & Cowley, P.D. 2021. Ontogenetic shifts in home range size of a top predatory reef-associated fish (*Caranx ignobilis*): implications for conservation. *Marine Ecology Press Series* 664, 165–182.
26. Daly, R., Le Noury, P., Hempson, T.N., Ziembicki, M., Olbers, J.M., Brokensha, G.M. & Mann, B.Q. 2021. Bull shark, *Carcharhinus leucas*, recruitment into the St Lucia Estuary, South Africa, after prolonged mouth closure, and the first observation of a neonate bull shark preyed on by a Nile crocodile, *Crocodylus niloticus*. *African Journal of Marine Science* 43(3), 417–421. (Early Access).
27. Daniels, S.R., Barnes, A., Marais, H. & Gouws, G. 2021. Surveys of Afrotemperate forests yield two new freshwater crabs (Decapoda: Potamonautidae: *Potamonautes* MacLeay, 1838) from South Africa. *European Journal of Taxonomy* 782, 82–107.
28. De Bragança, P. H. N., Skelton, P. H., Bills, R., Tweddle, D. & Chakona, A. 2020. Revalidation and redescription of "*Lacustricola*" *chobensis* (Fowler, 1935) and description of a new miniature "*Lacustricola*" species from southern Africa (Cyprinodontiformes: Procatopodidae). *Ichthyology & Herpetology* 109(1), 123–137.

29. de Necker, L., Gerber, R., van Vuren, J.H.J., Wepener, V., Smit, N.J. & Brendonck, L. 2021. Temporal dynamics of a subtropical floodplain pool after two years of supra-seasonal drought: a mesocosm study. *Hydrobiologia* 849(3), 795–815.
30. Dulvy, N.K., Pacoureau, N., Rigby, C.L., Pollom, R.A., Jabado, R.W., Ebert, D.A, Finucci, B., Pollock, C.M., Cheok, J., Derrick, D.H., Herman, K.B., Sherman, C.S., VanderWright, W.J., Lawson, J.M., Walls, R.H.L, Carlson, J.K., Charvet, P., Bineesh, K.K., Fernando, D., Ralph, G.M., Matsushiba, J.H., Hilton-Taylor, C., Fordham, S.V. & Simpfendorfer, C.A. 2021. Overfishing drives over one-third of all sharks and rays toward a global extinction crisis. *Current Biology* 31(21), 4773–4787.
31. Du Preez, L.H. & Theunissen, M. 2021. A sucker for the job: morphology and functioning of suckers of polystomatid monogeneans. *Folia Parasitologica* 68, art.no. 006.
32. Duncan, M.I., James, N.C., Potts, W.M. & Bates, A.E. 2021. Different drivers, common mechanism; the distribution of a reef fish is restricted by local-scale oxygen and temperature constraints on aerobic metabolism. *Integrative and Comparative Biology* 61, Supplement 1, E123–E124.
33. Dutton, H.R., Du Preez, L.H., Verneau, O., Whelan, N. & Bullard, S. 2021. First record of a polystome from alligator snapping turtle, *Macrochelys temminckii* (Cryptodira: Chelydridae) or Mississippi; with comments on "*Neopolystoma orbiculare* (Stunkard, 1916)" and its junior subjective synonyms. *Journal of Parasitology* 107(1), 74–88.
34. Dutton, H.R., Du Preez, L.H., Urabe, M. & Bullard, S.A. 2021. *Paraharmotrema karinganiense* n. gen., n. sp. (Digenea: Liolopidae) infecting the intestine of serrated hinged terrapin (*Pelusios sinuatus*), east African black mud turtle (*Pelusios subniger*), and South African helmeted turtle (*Pelomedusa galeata*) and a phylogenetic hypothesis for liolopid genera. *International Journal for Parasitology – Parasites and Wildlife* 17, 43–52.
35. Ebert, D.A., Wintner, S.P. & Kyne, P.M. 2021. An annotated checklist of the chondrichthyans of South Africa. *Zootaxa* 4947(1), 1–127.
36. Elston, C., Cowley, P.D., von Brandis, R.G. & Lea, J. 2021. Residency and habitat use patterns by sympatric stingrays at a remote atoll in the Western Indian Ocean. *Marine Ecology Progress Series* 662, 97–114.
37. Filmalter, J.D., Bauer, R.K., Forget, F., Cowley, PD. & Dagorn, L. 2021. Movement behaviour and fishery interaction of silky sharks (*Carcharhinus falciformis*) in the tropical tuna purse seine fishery in the Western Indian Ocean. *ICES Journal of Marine Science* 78(7), 2474–2485.
38. Forget, F., Muir, J., et al. Dagorn, L. 2021. Quantifying the accuracy of shark bycatch estimations in tuna purse seine fisheries. *Ocean & Coastal Management* 210, art. no. 105637.
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(b) Reports and theses

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2. Edworthy, C. 2021. Coastal pH variability and the eco-physiological and behavioural response of a coastal fish species in light of future ocean acidification. PhD Rhodes University.

3. Madzivanzira, T. 2021. Evaluating and predicting impacts of Australian redclaw crayfish, *Cherax quadricarinatus* and Louisiana red swamp crayfish, *Procambarus clarkii* invasions. PhD Rhodes University.

4. Sotshongaye, O. 2021 Larval fish dynamics within the coastal nearshore of the Eastern Cape, South Africa. MSc Rhodes University.

(c) Popular articles and other publications

1. Dlamini, L. Inland waters of southern Africa. World Water Day article. 22 March 2021. https://www.saiab.ac.za/saiabnews/inland-waters-of-southern-africa.htm
2. Dlamini, L. 2021. Shark Awareness Day – Acoustic telemetry in shark research. July 2021.
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11. Glass, J. Haworth, P. Dlamini, L. 2021. First global DNA study of two iconic kingfish reveals new populations. *Featured Research Nugget*. 4 June 2021.
12. Janse van Rensburg. L. 2021. NRF-SAIAB Research Group contributions to the FSBI 2021 Virtual Symposium. August 2021.
13. Madzivanzira, T. 2021. Pioneering study on the Australian redclaw crayfish in the Mighty Zambezi Basin, across four southern African countries. *Featured Research Nugget*. November 2021.
14. Mxo, V. Tracking inshore fish. Quest 17(1), 15–16.
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15. Pegg, J. Carp in South Africa – The good, the bad and the muddy. Institute of Fisheries Management magazine called 'Fish'. March-April 2021. https://www.saiab.ac.za/features/carp-in-south-africa-%E2%80%93-the-good,-the-bad-and-the-muddy.htm
16. Skelton, P. 2021. Time and the River—Annual Smith Memorial Lecture. *Featured Research Nugget*. September 2021.
17. Somana, Z., Mceleli, S. & Mazungula, N. 2021. Iconic specimen: A fish of a lifetime. Published in the NSCF's publication 'Why our collections matter – Showcase No. 3 Iconic, Extinct & Historically Important Specimens' pp 27–28. October 2021.
18. South, J. 2021. How do lionfish decide what to eat at a buffet? *CIB Research Nuggets*.
   https://blogs.sun.ac.za/cib/how-do-lionfish-decide-what-to-eat-at-a-buffet/ March 2021.
19. van der Walt, K. 2021. Too hot or too cold to handle? Projected impacts of climate change and vulnerability of coastal species in a warm-temperate African region. *NRF Science Matters Magazine* 4(2), 18–21. December 2021.
20. Whitfield, A. 2021. Tragedy of an abused estuary. *SANCOR Newsletter* 225, 4–5. September 2021.

Engaged research video productions

1. Dlamini, L. World Water Day. 22 March 2021.
2. Dlamini, L. & Paterson, A. World Oceans Day – message from NRF-SAIAB MD. 8 June 2021.
3. Dlamini, L. Meltaf, M. & Ntokoane, T. Rendition – Finding Old Four Legs: the coelacanth. 8 June 2021.
4. Edworthy, C. & James, N.C. An underwater journey into fish nursery habitats in Algoa Bay, South Africa. 11 October 2021.
5. van der Walt, K. – Save Oceans, Save life. 30 March 2021.
6. NRF-SAIAB Collection Facility – Virtual tour of Collections presented at NSCF Forum. 23 March 2021.
7. NRF-SAIAB Collection Facility – 2nd Virtual tour of Collections presented at an international conference. June 2021.
8. Freshwater Five (FW5) - YouTube Series (Nine episodes of short films in African languages)
9. Shark Awareness Week series – produced by Taryn Murray (ATAP Platform) – July 2021.
10. eascape Ecology Project: Flat Rocks receiver deployment – August 2021.
11. Dlamini, L. – NRF-SAIAB video for National Marine Week – October 2021.
12. Seascape Ecology – An underwater journey into fish nursery habitats in Algoa Bay, South Africa – October 2021.
13. Aquatic Ecophysiology Research Platform (AERP) – Celebrating National Marine Week with the AERP – October 2021.
14. Southern African Fisheries Ecology Research Lab (SAFER Lab) – October 2021.
15. Coastal and Ocean Sciences Team (COST) – October 2021.
16. Acoustic Tracking Array Platform (ATAP) – October 2021.
17. NRF-SAIAB Student Symposium video recordings of research student presentations – December 2021

(d) Conference and symposium presentations

1. Bragança, P.H.N. 2021. Updates on the taxonomy of the southern Africa Lampeyes (Cyprinodontiformes: Procatopodidae). Southern African Society of Aquatic Scientists (SASAqS) Congress. November 2021.
2. Haworth, P. 2021. Current transformation in the science-society relationship: Learning from practice. And roundtable discussion with Lucky Dlamini, Anne Dijkstra (University of Twente, NL), Lenka Hebakova (Technology Centre CAS), Sikke Jansma (University of Twente, NL) and Padraig Murphy (Dublin City University). PCST+1 Virtual Global Conference. May 2021.
3. de Necker, L., Cilliers, D., Burger, R., Smit, N.J., Wepener, V. 2021. The current and future predicted status of schistosomiasis in South Africa under climate change. British Society for Parasitology Online Meeting. June 2021.
4. Dlamini, L. 2021. Scrutinising South African media companies' strategies for Generation Z's news consumption. Highway Africa Conference. June 2021.
5. Edworthy, C., James, N.C., Potts, W.M. & Dupont, S. 2021. A story of ocean acidification research in South Africa. GOA-ON OA-week, September 2021.
6. Edworthy, C. 2021. Intervention: ocean climate multi-stressors. IUCN World Conservation Congress, September 2021.

7. Elston, C. 2021. Site affinity and habitat connectivity of blue stingrays along South Africa's south coast. South African Shark and Ray Symposium. November 2021.
8. Khosa, D., Hargrove, J.S, Peatman, E. & Weyl, O.L.F. 2021. The extent of hybridisation between Largemouth Bass and Florida Bass across two river systems in South Africa. Southern African Society of Aquatic Scientists Congress, November 2021.
9. Magoro, M.L., James N.P.E. & Weyl, O.L.F. 2021. The distribution of non-native Nile Tilapia (Oreochromis niloticus) in the Limpopo and Mpumalanga Provinces. Fisheries Society of the British Isles Symposium 2021, KU Leuven, Belgium. July 2021.
10. Magoro, M.L., James N.P.E. & Weyl, O.L.F. 2021. The current distribution of non-native Nile Tilapia (Oreochromis niloticus) in the Limpopo and Mpumalanga Provinces – Implications for Mozambique tilapia conservation and South Africa's fish farming industry. World Fisheries Congress 2021, Adelaide, Australia. September 2021.
11. Mofu, L., Dalu, T., Wasserman, R.J., Woodford, D.J., Khosa, D. & Weyl, O.L.F. 2021. Seasonal variation and drivers of zooplankton, macroinvertebrates and littoral fish communities from irrigation ponds in a semi-arid region in the Eastern Cape (South Africa). Southern African Society of Aquatic Scientists Congress. November 2021.
12. Wanda, T., Wiles E., Cawthra, C. & de Wit, A. 2021. Taking a closer look at the seafloor: Multibeam bathymetry as a basis for marine spatial planning. The Conservation Symposium. November 2021.
13. Wanda, T., Wiles E., Cawthra, C. & de Wit, A. 2021. Taking a closer look at the seafloor: Multibeam bathymetry as a basis for marine spatial planning. WIOGEN Conference on Ocean Governance. October 2021
14. Watkeys, M., Perritt, S., Kretzinger, W., Ovechkina, M., Wiles, E. & Jokat, W. 2021. The potential of marine mining of ferromanganese encrustations and polymetallic nodules in the deep marine environment offshore of south-east Africa; Seminar and workshop presentations. The Conservation Symposium. November 2021.
15. Watkeys, M. & Wiles, E. 2021. Marine mining: Why, what, where, and how? The Conservation Symposium. November 2021.
16. Wiles, E. & Watkeys, M.2021. Bathymetry, substrate, and currents: Towards ground up marine spatial planning, conservation and marine mining. The Conservation Symposium. November 2021.

(e) Seminar and workshop presentations

1. Bernard, A.T.F. 2021. Conducting BRUVs and stereo-BRUVs research. WIOMSA & DFFE Benthic Imagery Training Workshop; invited workshop speaker and organizing committee member, Makhanda, South Africa. September 2021.
2. de Necker, L. 2021. Biodiversity and ecological structures of an African subtropical river and associated wetlands. University of Leuven online Symposium for the Living Lab in Sustainable Development.
3. Elston, C. 2021. Making scientists more human and science more relatable. University of Fort Hare Virtual Science Communication Workshop. Invited workshop speaker. May 2021. Online.
4. Juby, R. 2021. Baited remote underwater stereo-video system (stereo-BRUVs): Video processing, Habitat descriptions & Quality Assurance & Quality Control. WIOMSA & DFFE Benthic Imagery Training Workshop; invited workshop speaker and organizing committee member, Makhanda, South Africa. September 2021.
5. Khosa, D. 2021. Mapping Using ArcGIS. NRF-SAIAB, Online Tutorial. October 2021.

6. van der Walt, K-A. 2021. Presentation and Poster guidelines: "Face-to-face" and "Virtually". University of Fort Hare Virtual Science Communication Workshop. Invited Workshop Speaker, Makhanda, South Africa. May 2021. Online.
7. van der Walt, K-A. 2021. Digital storytelling – What is it and why is it effective? – What I learned from writing "Save Oceans, Save Life". NRF-SAIAB Science Communication Workshop with Dr Marina Joubert. Invited workshop speaker, Makhanda, South Africa. August 2021. Online.
8. van der Walt, K-A. 2021. Too hot to handle? – Thermal tolerance and the potential effects of climate change on coastal and estuarine organisms, Eastern Cape, South Africa. Invited seminar speaker for 2nd year Fish Physiology students at Stellenbosch University, South Africa. August 2021. Online.

(f) Public presentations

1. Bruton, M.N.B. 2021. What is science, and why is it so important today? NRF-SAIAB Seminar Series: Webinar. October 2021.
2. De Bragança, P.H. 2021. Natural history collections as windows for understanding the biological impacts of global change. Seminar Series of the Institute of Oceanography and Environment (INOS), Universiti Malaysia Terengganu. May 2021.
3. Dorrington, R. 2021. Harnessing the metabolic potential of indigenous marine biodiversity – a multidisciplinary drug discovery pipeline? NRF-SAIAB Seminar Series: Webinar. November 2021.
4. Ebert, D. A. 2021. Beyond Jaws: Rediscovering South Africa's Lost Sharks. NRF-SAIAB Seminar Series: Webinar. May 2021.
5. Elston, C 2021. Interesting marine life in the Keurbooms estuary. Public presentation. June 2021.
6. Elston, C. 2021. Using acoustic telemetry to track stingray movements: from fine- to large-scale insights. Public presentation to APEM. July 2021. Online.
7. Glass, J. 2021. Using the micro to understand the macro: How genetics and chemistry help us tackle big questions in fisheries and evolutionary biology. NRF-SAIAB Seminar Series: Webinar. June 2021.
8. Jackson, J. 2021. Deep waters in British Columbia mainland fjords show rapid warming and deoxygenation from 1951 to 2020. NRF-SAIAB Seminar Series: Webinar. November 2021.
9. Khosa, D. 2021. Current status of black bass invasion in South Africa. Sol Plaatje University Seminars. May 2021.
10. Martin, M., Azmi, A.M. & Muhamad, J. 2021. Linking citizen science and natural history specimens through effective education and displays. NRF-SAIAB Seminar Series. April 2021.
11. Mazungula, N., Gura, A., Dwani, M. & Somana, Z.S. 2021. Health and Safety in Collection. NSCF Discussion Forum: Webinar. October 2021.
12. Murray, T. 2021 ATAP comes of age – the first decade of aquatic animal tracking in South Africa. NRF-SAIAB Seminar Series: Webinar, July 2021.
13. Skelton, P.H. 2021. Time and the River. Smith Memorial Lecture. Webinar. September 2021.
14. South, J. 2021. Reflections on the swamp. NRF-SAIAB Seminar Series: Webinar. May 2021.

Appendix B: NRF-SAIAB RESEARCH DIVISION 2021

RESEARCH AND MANAGEMENT STAFF

Dr A.W. Paterson, PhD (Rhodes University)	Managing Director
Prof. P.D. Cowley, PhD (Rhodes University)	Principal Scientist
Dr A. Chakona, PhD (Rhodes University)	Senior Scientist
Prof. N.C. James, PhD (Rhodes University)	Senior Scientis
Prof. F. Porri, PhD (Rhodes University)	Senior Scientis
Dr A.T.F. Bernard, PhD (Rhodes University)	Instrument Scientist
Dr T.S. Murray PhD (Rhodes University)	ATAP Instrument Scientist
Dr E.A. Wiles, PhD (University of KwaZulu-Natal)	Geophysics Instrument Scientist
Dr W. Coetzer, PhD (University of KwaZulu-Natal)	Biodiversity Information Manager
Mr I.R. Bills, MSc (Rhodes University)	Senior Curator
Mr D.N. Mazungula, BSc Hons (Rhodes University)	Collections Manager
Ms T. Bodill, MSc (Rhodes University)	Molecular Laboratory Manager
Ms S. Reddy, BSc Hons (Rhodes University)	Ecophysiology Laboratory Co-ordinator
Mr R. Palmer, MSc (Rhodes University)	ACEP Technical & Scientific Manage
Mr T. Eriksen, BSc (UNISA)	ACEP Marine Technician
Mr S. Benya, BSc Hons (Walter Sisulu University)	ACEP Marine Technician
Mr K. Smith	ACEP Marine Technician
Mr M. Parkinson MSc (Rhodes University)	ATAP Instrument Technician
Dr A. Wood, PhD (Rhodes University)	Senior Marine Research Assistant to MD
Mr F. Jacobs	Marine Field Assistant
Mrs V.T.J. Rouhani, MSc (Rhodes University)	Research Support Administrator

POSTDOCTORAL SCIENTISTS

Name	Primary study area	Institute collaborator
Dr P. de Bragança	Freshwater taxonomy	Dr A. Chakona
Dr L. de Necker	Freshwater ecology	Prof. O. Weyl
Dr C. Edworthy	Ecology, eco-physiology, climate change	Prof. N. James
Dr C. Elston	Fish movement studies	Prof. P. Cowley
	Fish movement studies	Prof. P. Cowley
Dr D. Khosa	Invasions and freshwater ecology	Prof. O. Weyl
Dr M. Magoro	Invasions and freshwater ecology	Prof. O. Weyl
Dr L. Mofu	Invasions and freshwater ecology	Prof. O. Weyl
Dr J. Pegg	Invasions and freshwater ecology	Prof. O. Weyl
Dr K-A. van der Walt	Larval ecology	Prof. F. Porri

HONORARY RESEARCH ASSOCIATES

Name	Status
Dr E. Anderson, PhD (College of William & Mary)	Curator Emeritus
Dr R. Bennett, PhD (Rhodes University)	Honorary Research Associate
Dr M. Bruton, PhD (Rhodes University)	Honorary Research Associate
Dr R. Chalmers, PhD (Rhodes University)	Honorary Research Associate
Prof A. Channing, PhD (Natal University)	Honorary Research Associate
Mr W. Conradie, MSc (North-West University)	Honorary Research Associate
Dr R. Cuthbert, PhD (Queen's University of Belfast/ University of Reading)	Honorary Research Associate
Dr T. Dalu, PhD (Rhodes University)	Honorary Research Associate
Dr R. Daly, PhD (Rhodes University)	Honorary Research Associate
Prof. R. Dorrington PhD (University of Cape Town)	Honorary Research Associate
Prof. L. du Preez, PhD (University of the Free State)	Honorary Research Associate
Dr D. Ebert, PhD (Rhodes University)	Honorary Research Associate
Dr B. Ellender, PhD (Rhodes University)	Honorary Research Associate
Dr J. Filmalter, PhD (Rhodes University)	Honorary Research Associate
Dr E. Gennari, PhD (Rhodes University)	Honorary Research Associate
Dr Jessica Glass, PhD (Yale University)	Honorary Research Associate
Mr O. Gon, MSc (University of Jerusalem)	Curator Emeritus
Dr G. Gouws, PhD (University of Stellenbosch)	Honorary Research Associate
Dr J.S. Hargrove, PhD (University of Florida)	Honorary Research Associate
Mrs E. Heemstra, Dip. Ed. (University of Rhodesia)	Honorary Research Associate
Dr E. Heyns-Veale, PhD (Rhodes University)	Honorary Research Associate
Dr J. Hill, PhD (Rhodes University)	Honorary Research Associate
Mr W. Holleman, MSc (Rhodes University)	Honorary Research Associate
Dr J. Jackson, PhD (University of British Columbia)	Honorary Research Associate
Dr M. Jackson, PhD (Queen Mary University of London)	Honorary Research Associate
Dr F. Jacobs, PhD (University of KwaZulu-Natal)	Honorary Research Associate
Dr H. James, PhD (Rhodes University)	Honorary Research Associate
Dr M. Jordaan, PhD (Stellenbosch University)	Honorary Research Associate
Dr W. Kadye, PhD (Rhodes University)	Honorary Research Associate
Mr D. King, Pr Eng (Ewell Technical College)	Honorary Research Associate
Dr A. Kock, PhD (University of Cape Town)	Honorary Research Associate
Dr M. Lipinski, DSc (University of Lodz)	Honorary Research Associate
Dr N. Mandrak, PhD (University of Toronto)	Honorary Research Associate
Dr S. Marr, PhD (University of Cape Town)	Honorary Research Associate
Dr M. Martin, PhD (Australian Maritime College/ University of Tasmania)	Honorary Research Associate
Dr G. Matcher, PHD (Rhodes University)	Honorary Research Associate
Dr T. Miya, PhD (Rhodes University)	Honorary Research Associate
Dr T.F. Næsje, DSc (University of Trondheim)	Honorary Research Associate

Dr S. Parker-Nance, PhD (Nelson Mandela University)	Honorary Research Associate
Dr R. Peel, PhD (Rhodes University)	Honorary Research Associate
Dr W. Potts, PhD (Rhodes University)	Honorary Research Associate
Dr P. Psomadakis, PhD (Polytechnic University of Marche)	Honorary Research Associate
Dr U. Schliewen, PhD (Ludwigs-Maximilians-University)	Honorary Research Associate
Prof. P. Skelton, PhD (Rhodes University)	Honorary Research Associate
Dr M. Smale, PhD (Rhodes University)	Honorary Research Associate
Dr J. South, PhD (Queens University Belfast)	Honorary Research Associate
Dr J. Stauffer, PhD (Blackburg State University)	Honorary Research Associate
Dr N. Strydom, PhD (Rhodes University)	Honorary Research Associate
Dr M. Tagliarolo, PhD (Université de Bretagne Occidentale)	Honorary Research Associate
Dr G. Taylor, PhD (Rhodes University)	Honorary Research Associate
Dr J. Taylor, PhD (North-West University)	Honorary Research Associate
Mr D. Tweddle, BSc (University of Wales)	Honorary Research Associate
Dr F. Uiblein, PhD (University of Vienna)	Honorary Research Associate
Dr S. Viana, PhD (University of São Paulo)	Honorary Research Associate
Dr E. Vreven, PhD	Honorary Research Associate
Dr R. Wasserman, PhD (Rhodes University)	Honorary Research Associate
Prof. A. Whitfield, PhD (University of Natal) DSc (Rhodes University)	Chief Scientist Emeritus
Dr D. Woodford, PhD (University of Canterbury)	Honorary Research Associate

NRF-SAIAB SUPERVISED STUDENTS GRADUATED

Name	Degree	Higher Education Institution	Institute supervisor/ co-supervisor
Ms V. Dames	MSc	Rhodes University	Dr A. Bernard
Mr E. da Silva Oliveira	MSc	Federal University of Maranhao, Brazil	Dr J. Pegg
Ms L. de Vos	MSc	Rhodes University	Dr A. Bernard
Ms T. Dominy	MSc	Rhodes University	Dr T. Murray
Ms M. Phillips	MSc	Rhodes University	Dr A. Bernard
Ms O. Sotshongayo	MSc	Rhodes University	Prof. F. Porri
Ms C. Edworthy	MSc	Rhodes University	Prof. N. James
Ms M. Kambikambi	PhD	Rhodes University	Dr A. Chakona
Mr T. Madzivanzira	PhD	Rhodes University	Prof O. Weyl, Dr J. South

Appendix C: Acronyms, Abbreviations, Definitions

ABC	Agulhas Bank Connections
ACEP	African Coelacanth Ecosystem Programme
AERP	Aquatic Ecophysiology Research Platform
AGRP	Aquatic Genomics Research Platform
AIC	American Institute for Conservation
AIS	Alien Invasive Species
ASRG	Aquatic Systems Research Group
ATAP	Acoustic Tracking Array Platform
BRUVS	Baited Remote Underwater Video System
BHL	Biodiversity Heritage Library
CBD	Convention on Biological Diversity
CMC	Collections Management Centre
CMR	Institute for Coastal and Marine Research
CoNCENSUS	**C**oastal and **N**earshore CENSUS Techniques
COST	Coastal and Ocean Sciences Team
DFFE	Department of Forestry, Fisheries and Environment
DIFS	Department of Ichthyology and Fisheries Sciences (Rhodes University)
DSI	Department of Science and Innovation
ECPTA	Eastern Cape Parks and Tourism Agency
eDNA	environmental DNA
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
EPA	Estuarine Protected Area
EWR	Estuarine Water Reserve
FAIR	Findability, Accessibility, Interoperability, Reusability
FAO	Food and Agriculture Organisation
FBIP	Foundational Biodiversity Information Programme (NRF-FBIP)
GBIF	Global Biodiversity Information Facility
GeMaP	**Ge**ophysics and **M**apping **P**latform
GOA-ON	Global Ocean Acidification Observing Network
HBUs	Historically Black Universities
HDIs	Historically Disadvantaged Institutions
HICD	Human and Infrastructure Capital Development
IAMSLIC	The International Association of Aquatic and Marine Science Libraries and Information Centres
ICP-OES	Inductively Coupled Plasma- Optical Emission Spectrometry
IFS	International Foundation for Science
IMIsEE	Indigenous Marine Innovations for Sustainable Environments and Economies
IMR	Institute of Marine Research
INOS	Institut Oseanografi dan Sekitaran (Institute of Oceanography and Environment)

INS	Inertial Navigation System
IOC-UNESCO	Intergovernmental Oceanographic Commission – United Nations Educational, Scientific and Cultural Organization
IP	Intellectual Property
ISI	International Scientific Indexing
IUCN	International Union for the Conservation of Nature
JMLP	Joint Marine Labs Programme
KZN	KwaZulu-Natal
MARIP	Marine Remote Imagery Platform
MARS	Marine and Antarctic Research Strategy
MiSeq	The MiSeq is an integrated instrument that performs clonal amplification, sequencing, and data analysis in a single run
MPA	Marine Protected Area
MSP	Marine Spatial Planning
NDP	National Development Plan
Nekton	A not-for-profit research foundation, working with the University of Oxford and a wide range of partners to accelerate the scientific exploration and protection of the ocean
NEM:BA	The National Environmental Management: Biodiversity Act
NFEPA	National Freshwater Ecosystems Priority Areas
NFSC	National Freshwater Snail Collection
NMU	Nelson Mandela University
NRF-SAEON	South African Environmental Observation Network
NRF-SAIAB	South African Institute for Aquatic Biodiversity
NSCF	Natural Science Collections Facility
NSI	National System of Innovation
OA	Ocean Acidification
ORCA	Oceans Research Conservation Africa
OTN	Ocean Tracking Network
PDP	Professional Development Programme
PDGD-RMCA	Royal Museum for Central Africa
Refresh	Renewing data and filling knowledge gaps for freshwater species of South Africa to inform species and ecosystem conservation
RIRP	Research and Innovation Reward Programme
RISA	Research and Innovation Support Agency
RMCA	Royal Museum for Central Africa
RSG	Rufford Small Grants for Nature Conservation
ROV	Remotely Operated Vehicle
RU	Rhodes University
RUV	Remote Underwater Video cameras
RV	Research Vessel
SALPA	South African Linefish Physiology Assessment
SAAMBR	South African Association for Marine Biological Research

SANBI	South African National Biodiversity Institute
SANCOOP	South Africa-Norway Co-operation Programme
SANOCEAN	**SA/N**orway joint research programme on **ocean** research
SANParks	South African National Parks
SAPRI	South African Polar Research Infrastructure
SARChI	South African Research Chairs Initiative
SARIR	South African Research Infrastructure Roadmap
SASAqS	Southern African Society of Aquatic Scientists
SASRS	South African Shark and Ray Symposium
SCOR	Scientific Committee for Ocean Research
SBRUVS	Stereo-Baited Underwater Remote Underwater Video Systems
SDG	Sustainable Development Goal
SeyCCAT	Seychelles Conservation and Climate Adaptation Trust
SIDS	Small Island Developing States
SMCRI	Shallow Marine and Coastal Research Infrastructure project
SPNHC	Society for the Preservation of Natural History Collections
Stereo-BRUVs	Stereo-Baited Underwater Remote Underwater Video systems
TCEs	Traditional Cultural Expressions
TK	Traditional Knowledge
TOC/TN	Total Oxygen and Carbon/Total Nitrogen
UFH	University of Fort Hare
UMP	University of Mpumalanga
UMT	University Malaysia Terengganu
UNIVEN	University of Venda
UniZulu	University of Zululand
UPLC	Ultra High Pressure Liquid Chromatography
UWC	University of the Western Cape
VUSSC	Virtual University for Small States of the Commonwealth
WIO	Western Indian Ocean
WIOGEN	Western Indian Ocean Governance Exchange Network
WIPO	World Intellectual Property Organisation
WSU	Walter Sisulu University
WWF	World Wide Fund for Nature
ZMUC	Zoological Museum University of Copenhagen (Denmark)

SUPPORT & COLLABORATION