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Practical actions to strengthen capacity for deep-water research in Africa

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Challenger 150 Programme

PRACTICAL ACTIONS TO STRENGTHEN CAPACITY FOR **DEEP-WATER RESEARCH IN AFRICA**

An initiative of the Challenger 150 Programme's African Network of Deep-water Researchers

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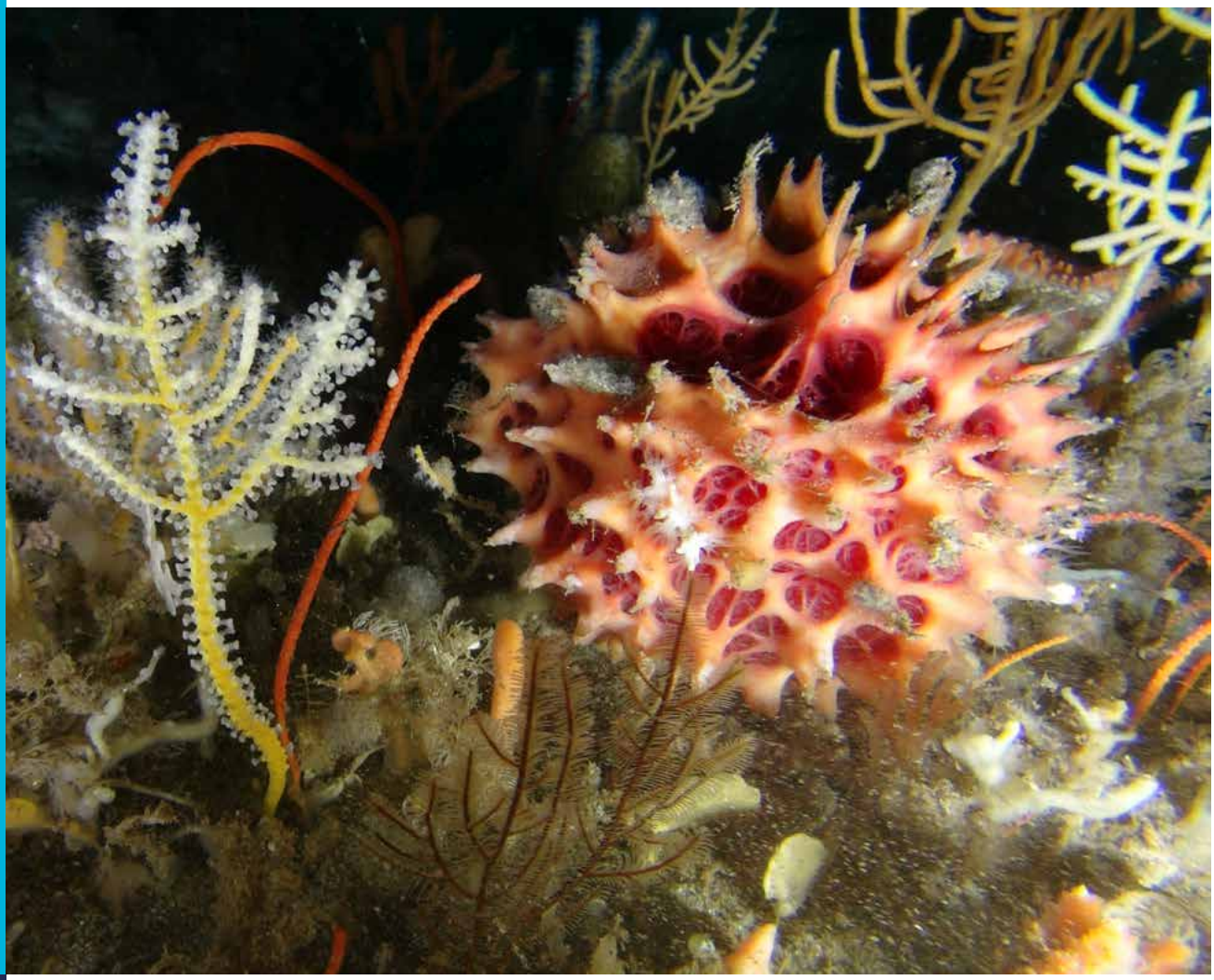

Image credit: One Ocean Hub Capacity Development Cruise

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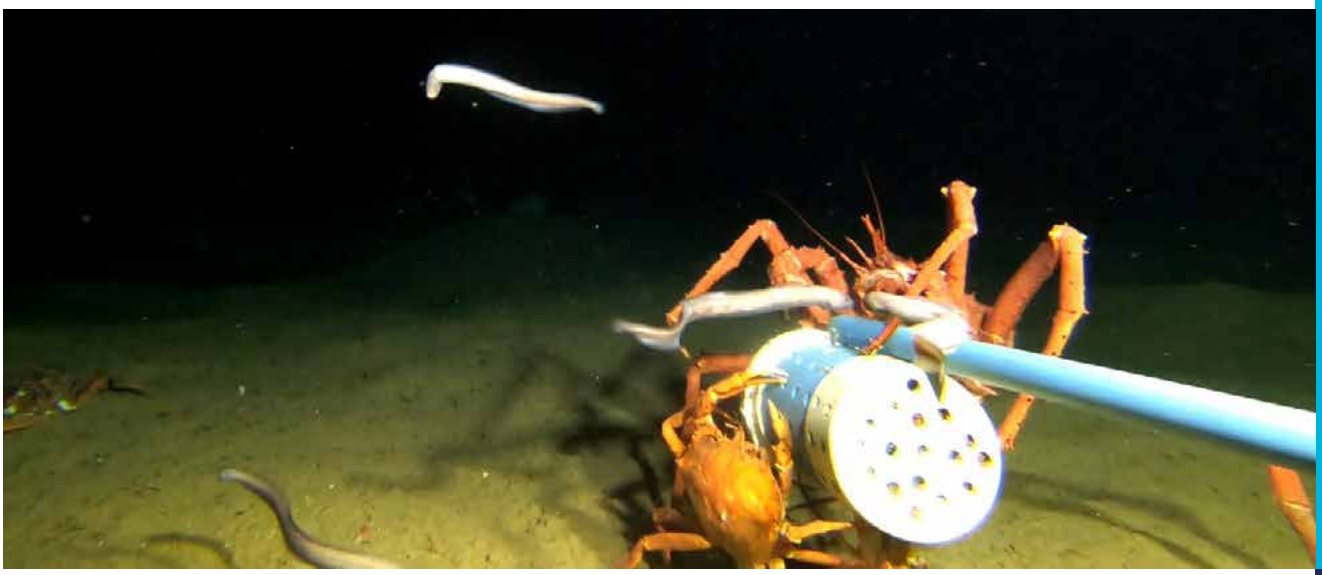


Image credit: One Ocean Hub Capacity Development Cruise

SUMMARY

Africa's abundant marine biodiversity supports ecosystem services vital for human well-being and holds great economic potential. Key deep-water sectors of the blue economy rely on healthy ecosystems, and knowledge of these systems is necessary to enable sustainable development. Recognizing global disparities in deep-sea science, the *African Network of Deep-water Researchers (ANDR)* developed under the United Nations Decade of Ocean Science for Sustainable Development endorsed *Challenger 150 Programme,* to build on Africa's deep-water research capacity. Established in March 2023, the ANDR encompasses diverse disciplines and sectors, fostering collaboration for deep-water research.

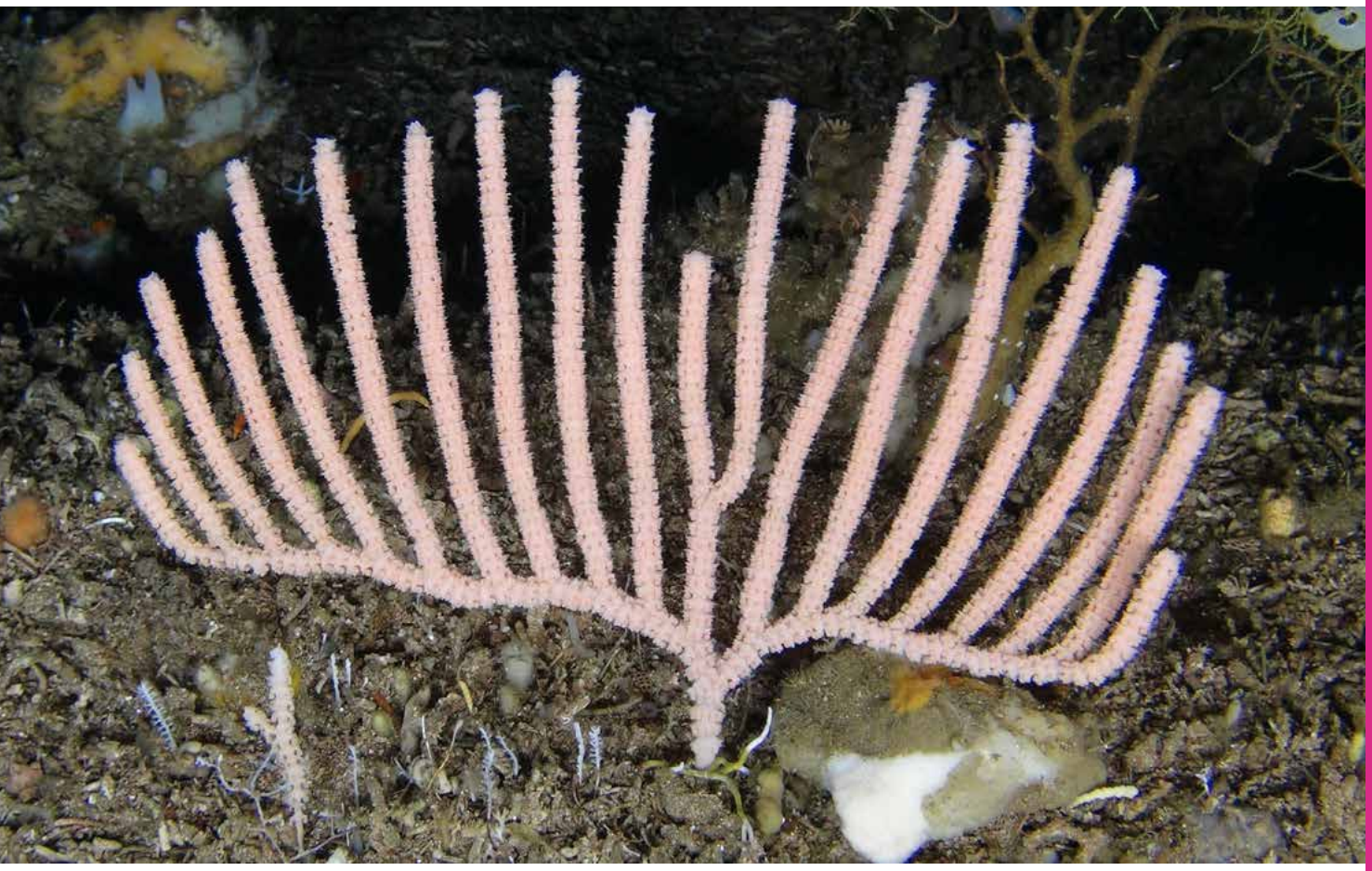
As a starting point, the ANDR initiated a series of workshops to identify practical actions to strengthen capacity for deep-water research and establish a framework for subsequent activities. The approach involved a multi-phased online workshop series focused on three key topics: (1) identifying challenges and barriers to deep-water research; (2) outlining potential solutions to overcome these; and (3) proposing practical actions to strengthen capacity and advance deep-water research in Africa. The outputs incorporate the views of 98 individuals across 19 African countries, representing diverse disciplines, career stages, and genders.

Challenges and barriers to entering deep-water research and advancing this field in Africa fit under six broad themes: (1) societal barriers and disconnection; (2) limited expertise; (3) lack of infrastructure; (4) insufficient financial resources; (5) limited and closed collaborations and partnerships; and (6) governance challenges. Potential solutions and pathways to address these include: (1) ocean literacy efforts; (2) human capacity development; (3) incremental infrastructure development; (4) fundraising; (5) collaboration, networking and partnerships; and (6) improved governance, legal frameworks and policies.

Building on the identified potential solutions, various focused activities are proposed to increase African capability for deep-water research. In the short term (1-2 years), actions include strengthening the ANDR, communicating opportunities for research and training, inventorying existing researchers and resources, identifying training and research priorities, promoting capacity development projects, and engaging partners. Medium-term actions (2-5 years) involve ongoing ANDR enhancement, project development, training initiatives, and technology transfer. Finally, in the longer-term (5-10+ years), actions focus on extensive training, curriculum integration, regional research programmes, hosting symposiums, advocating for research, and influencing policy platforms for sustainable deep-water development.

The proposed actions demonstrate clear links to the *Ocean Decade Africa Roadmap,* particularly regarding support for sustainable ocean management, ocean observations and forecasting, and capacity development for Early Career Ocean Professionals, contributing to Africa's response to the Ocean Decade.

Image credit: ACEP Deep Forests.



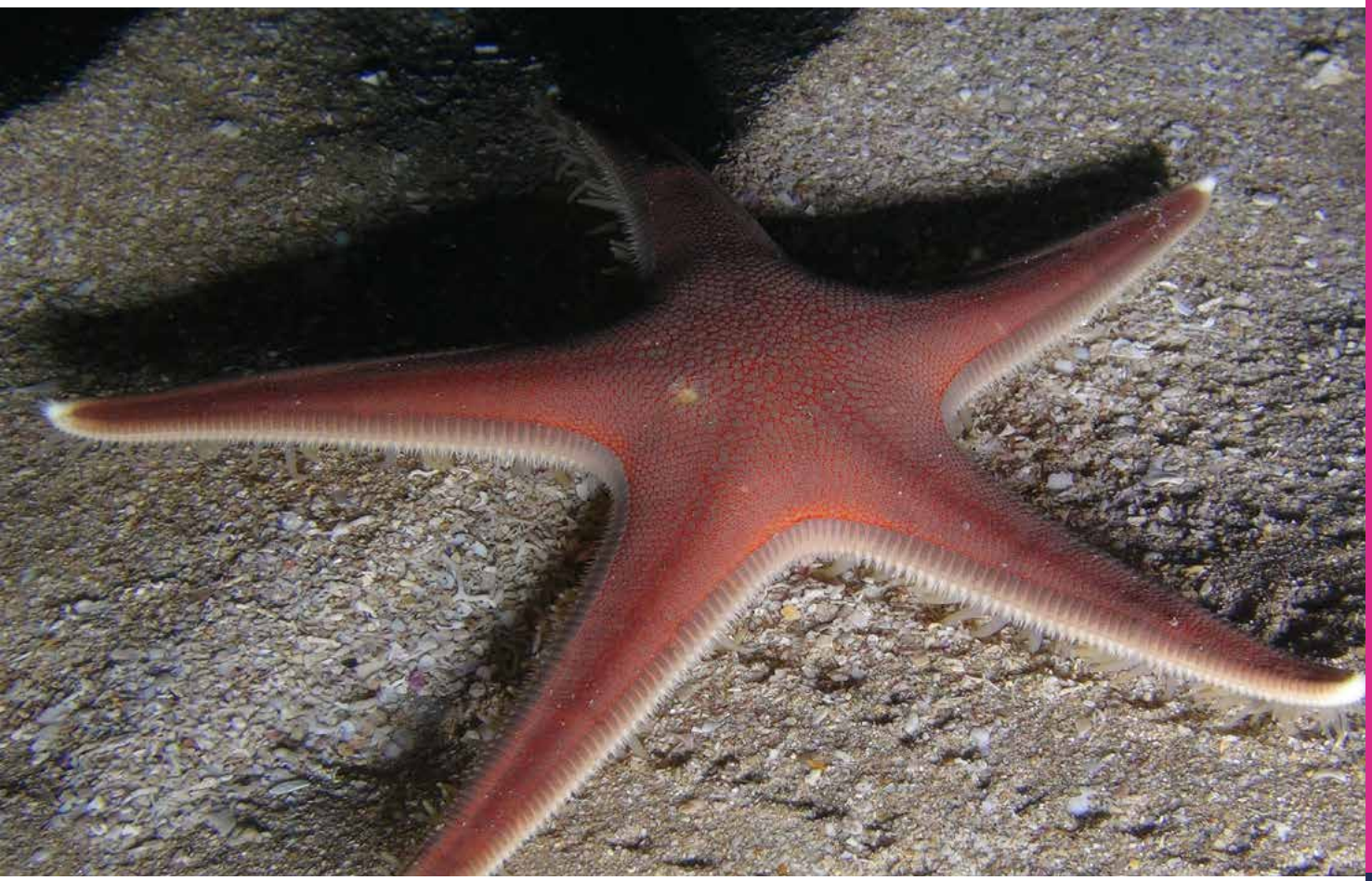


Image credit: ACEP Imida Frontiers

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BACKGROUND AND CONTEXT

Africa is a continent rich in marine biodiversity and resources, with great potential to support a thriving and equitable economy through sustainable development. Deep-water industries like fisheries or oil and gas, as well as emerging seabed extractive activities and marine bioprospecting, are key blue economy sectors dependent on healthy and diverse ecosystems. The sustainable development of these sectors requires a comprehensive understanding of natural ecosystems to ensure that economic activities are managed responsibly, and vital services provided by our oceans are safeguarded.

The United Nations (UN) Decade of Ocean Science for Sustainable Development (2021-2030) (the Decade) provides a platform for the generation of such knowledge and expertise. The Decade was launched to support efforts to reverse the decline in ocean health and gather ocean stakeholders worldwide behind a common framework. This framework will ensure that ocean science can fully support countries in creating improved conditions for sustainable development of the ocean. The Decade is centred on 10 Challenges, which should be addressed to achieve the pre-defined Decade outcomes. These Challenges are:

Challenge 1: Understand and beat marine pollution
Challenge 2: Protect and restore ecosystems and biodiversity
Challenge 3: Sustainably feed the global population
Challenge 4: Develop a sustainable and equitable ocean economy
Challenge 5: Unlock ocean-based solutions to climate change
Challenge 6: Increase community resilience to ocean hazards
Challenge 7: Expand the global ocean observing system
Challenge 8: Create a digital representation of the ocean
Challenge 9: Deliver skills, knowledge and technology to all
Challenge 10: Change Humanity's relationship with the ocean

Under the auspices of this global effort, African ocean professionals partnered to produce *The Ocean Decade Africa Roadmap* [1], a strategic document identifying regional scientific gaps, capacity development needs and cross-cutting priorities to provide a vision and plan for future Decade Actions in Africa. Through a Regional Gap Analysis, issues and knowledge gaps for each of the Decade Challenges were identified, including, "insufficient fundamental knowledge/research on species diversity and taxonomy" and "insufficient understanding of ecosystem functions and services". Priority future Decade Actions outlined in the Roadmap call for activities to support "Sustainable Ocean Management in Africa", with a vision to "strengthen the data, knowledge-base and expertise required to develop and implement sustainable ocean plans in Africa". Other key strategic documents for the continent such as the *African Union Agenda 2063: 'The Africa We Want'* [2], the *2050 Africa's Integrated Maritime Strategy*[3] and the *Africa Blue Economy Strategy (2019)* [4] all recognise the blue economy as a driver of future growth and transformation.

[1] https://oceandecade.org/wp-content/uploads/2022/06/Ocean-Decade-Africa-Roadmap.pdf

[2] https://au.int/en/agenda2063/overview

[3] https://nairobiconvention.org/clearinghouse/sites/default/files/2050%20Africa%E2%80%99s%20Integrated%20Maritime%20%28AIM%29%20Strategy.pdf

[4] https://www.au-ibar.org/sites/default/files/2020-10/sd_20200313_africa_blue_economy_strategy_en.pdf

Global inequities in deep-sea science are becoming increasingly evident and, as the human right to science clarifies, are a matter of international human rights law. Africa lacks capacity for deep-sea and offshore research [5], a critical limitation in the management of key deep-water blue economy sectors. Building on and strengthening Africa's capacity to undertake research and generate knowledge of our important deep-water ecosystems is crucial to support the continent's sustainable development objectives. In this context, and with the advancement of the Decade and increased focus on Africa, it was determined that a new network of offshore and deep-sea (collectively "deep-water") researchers in Africa under the *Challenger 150 Programme* [6] could support action towards strengthening deep-water research capacity.

Challenger 150 is a global cooperative dedicated to the development of deep-ocean expertise and advancing understanding of deep-sea ecosystems, with the focus of "A Decade to Study Deep-Sea Life". The programme is an endorsed Decade Programme, identified through the *Ocean Decade Africa Roadmap* with partners across the continent. At its core, *Challenger 150* seeks to enhance development of deep-ocean expertise, particularly in developing nations, in order to achieve a global generation of stewards working together to maintain the integrity of deep-ocean ecosystems. Furthermore, through supporting the development of new technologies and the expansion of observations, *Challenger 150* aims to advance understanding of the diversity, distribution, function and services provided by deep-ocean biota.

The *African Network of Deep-water Researchers (ANDR)* [7] was established in March 2023 and is open to African nationals working globally and individuals based in African institutions who share an interest in deep-water research. Deep-water research is defined here as research conducted from a vessel deeper than 30m (excluding scuba diving), recognising that capacity in this realm is a precursor to working in the deep sea proper (>200m). The ANDR is inclusive of all deep-water-related disciplines (such as ecology, oceanography, geology and law) and is open to researchers from all sectors. Currently, the ANDR has over 250 members from 27 African nations, representing more than 140 institutions. Notably, 76% of the membership comprises Early Career Researchers (ECRs) [8].

At the initiation of the ANDR, it was agreed that establishing a strategy to enhance capacity for deep-water research in Africa is crucial, serving as a foundational framework for all subsequent activities within the ANDR. This report shares the outcomes of a series of workshops aimed at generating ideas for practical actions to strengthen capacity and advance deep-water research in Africa.

Participants from the launch of the African Network of Deep-water Researchers.
Image credit:
Dr Isa Elegbede.

[5] Bell et al. 2023. Exposing inequities in deep-sea exploration and research: results of the 2022 Global Deep-Sea Capacity Assessment. *Front. Mar. Sci* 10. DOI: 10.3389/fmars.2023.1217227.

[6] https://challenger150.world/

[7] https://challenger150.world/african-network-of-deep-water-researchers/

[8] As of March 2024

WORKSHOP SERIES

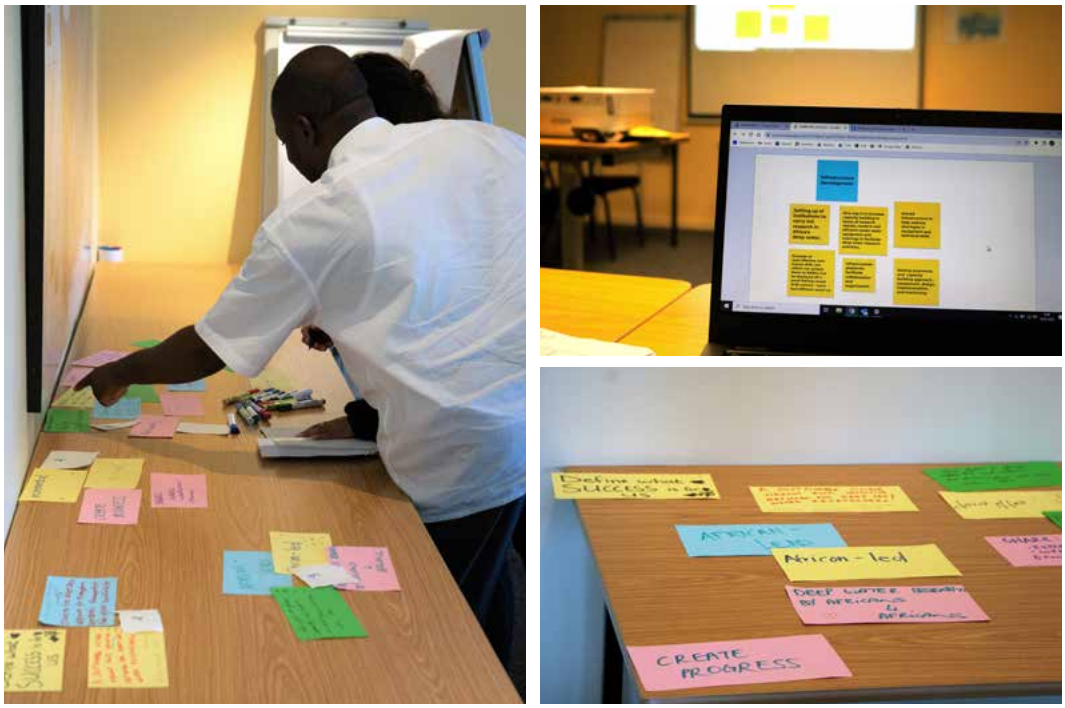
This report details a process centred on: (1) identifying challenges and barriers to deep-water research; (2) outlining potential solutions to overcome these; and (3) proposing practical actions to strengthen capacity and advance deep-water research in Africa.

The approach involved multi-stage online workshops accessible to all ANDR members and interested individuals from Africa. This was supplemented by calls for written input, ensuring the inclusion of diverse voices and experiences (Table 1). The first online workshop collected initial inputs and ideas on the key topics outlined above. These were then synthesised by a core writing team representing diverse disciplines, geographic areas, genders, and career stages. The second online workshop presented the initial outputs of the synthesis to participants, gathering additional feedback and input. This workshop also included deliberation of actions to strengthen capacity and advance deep-water research. The report was then finalised by the core writing team, incorporating inputs from the second online workshop and written contributions.

To accommodate participant availability, each online workshop was conducted on two different days. The workshops consisted of introductory presentations followed by breakout sessions for small group discussion on specific topics. These discussions were followed by group feedback and plenary discussion sessions. Various tools, such as Jamboards, the Zoom chat function, and note-taking, were used to collect and record inputs, feedback, and discussions. Additionally written contributions were invited from interested parties unable to attend the online workshops.

Table 1. Approach and timelines

May - July 2023	**Review** Existing material on barriers and challenges preventing progress in deep-sea research in Africa and more generally reviewed.
July 2023	**Workshop 1 (Online)** Challenges and barriers to deep-water research discussed based on review. Additional challenges identified. Pathways and actions to address challenges explored and discussed. Written contributions obtained from those unable to attend workshop.
July - August 2023	**Writing** Outputs of Workshop 1 and written contributions synthesised during a meeting of the core writing team. First stage draft report produced on behalf of participants, including proposed potential actions.
August 2023	**Workshop 2 (Online)** First stage draft report presented to workshop participants for further consideration, input and editing. Written contributions obtained from those unable to attend workshop.
August - December 2023	**Writing** Second stage draft report produced, including inputs from Workshop 2 and written contributions, for review by core writing team.
March 2024	**Final report published.**



The core writing team synthesised inputs from online workshops. **Image credits:** Kirsty McQuaid

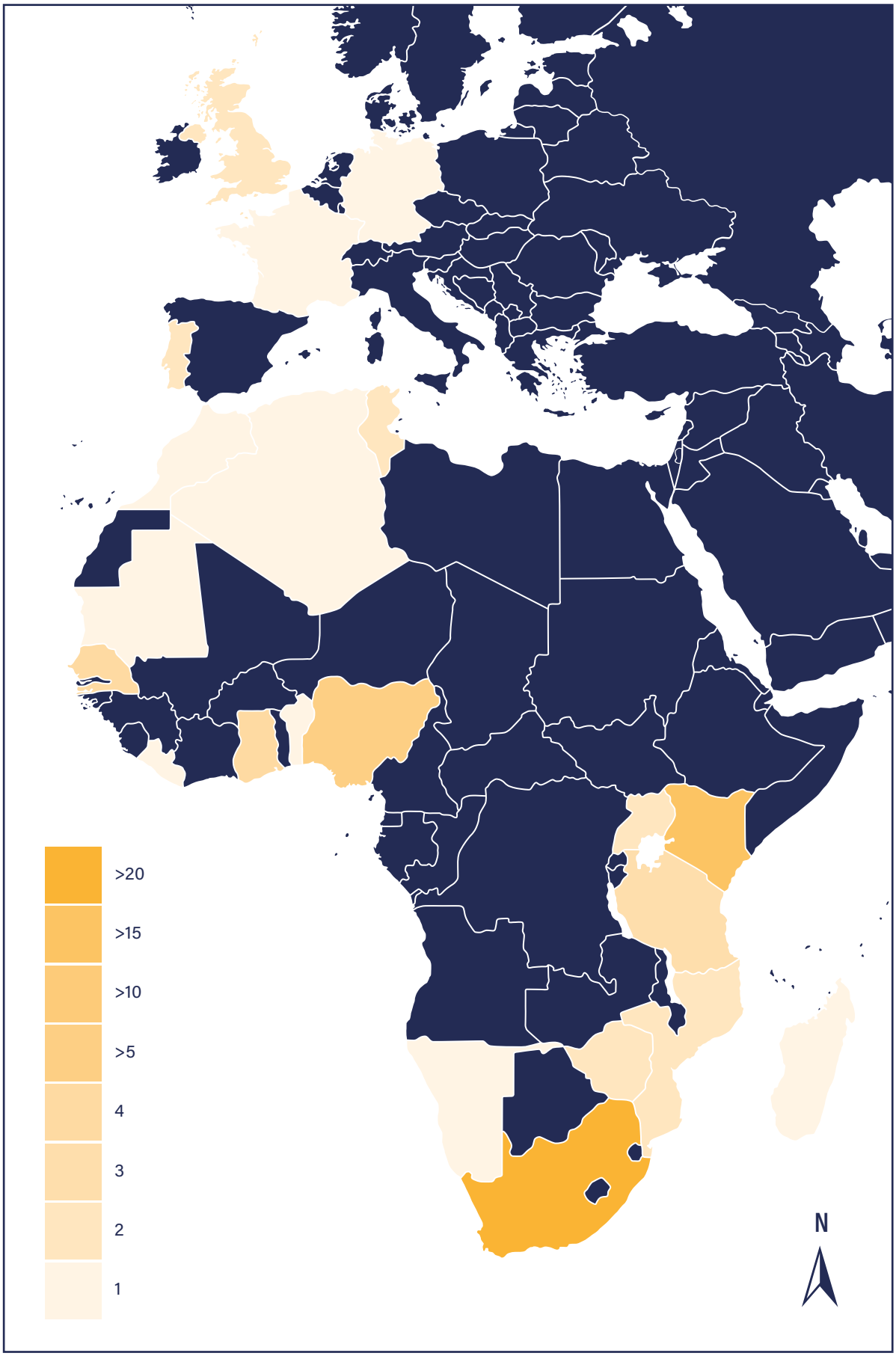
Participation

The views presented here represent those of 98 individuals, from 19 African countries, spanning different geographic regions, disciplines, career stages and genders. ECRs were self-identified as "being early in their career (10 years or less of professional experience)", following the definition used by the global UN Decade Early Career Ocean Professionals (ECOP) Programme. Although both ECRs and ECOPs are individuals at the early stages of their careers, ECRs are focused on research, while ECOPs are professionals working in any ocean-related discipline and industry, for example researchers, practitioners, policymakers, and other professionals involved in studying, managing, conserving, and utilising ocean environments and resources. In the context of this report, ECRs thus fall under the umbrella of ECOPs.

Percentage of Early Career and Established Researcher participants. Six percent of participants were unsure of their status

Early Career Researchers (73%)

Established Researchers (20%)



Number of participants by country

OVERVIEW OF KEY FINDINGS

Challenges and barriers to deep-water research

Challenges and barriers to entering deep-water research or advancing this field in Africa fit under six broad themes. These are: (1) societal barriers and disconnection; (2) limited expertise; (3) lack of infrastructure; (4) insufficient financial resources; (5) limited and closed collaborations and partnerships; and (6) governance challenges. Integrated into these are systemic barriers to gender equality, with deep-water research, like many STEM (Science, Technology, Engineering, and Mathematics) fields, demonstrating higher representation of men. Here we explore each of these broad themes and some of the key challenges associated with them.

1. Societal barriers and disconnection

In some communities there may be limited awareness about the interconnection of the ocean, including the deep sea, and how ocean processes support the well-being of humankind. This knowledge gap perpetuates a disconnection between the ocean and society. In addition, there is often limited access to the ocean for people and communities living both inland and close to the sea. Superimposed on this, is a lack of exposure to deep-water content for the general public, particularly at early development stages. Such content may primarily be accessible at the university level, if available at all. Consequently, a profession in ocean science is frequently overlooked or disregarded.

This general limited exposure to the ocean extends to swimming and water safety skills for many communities, leading to a fear of drowning, and further exacerbating a disconnection with the ocean. Spiritual and cultural beliefs shape diverse approaches to celebrating the oceans, and ultimately how many communities interact with the environment. In specific cases, the ocean elicits reverence and/or fear through generational knowledge passed down within traditional structures. Whilst fear of the ocean is compounded by multiple socio-economic factors, the outcome presents a challenge for the advancement of deep-water research. For example, apprehension linked to the unknown aspects of the ocean may discourage individuals from pursuing ocean science careers and therefore limit the pool of researchers.

In most African countries that have an interest in pursuing a career in ocean and/or deep-water research, materials, expertise and infrastructure to support deep-water research are inadequate. Study materials and outputs are generally translated to a limited number of languages, perpetuating language barriers. Of note, the participation of African countries active in deep-water research in international fora is impeded by the widely accepted definition of the “deep sea”, which generally excludes the mesophotic zone (50-200 m).

2. Limited expertise

There is a severe shortage of trained professionals to undertake deep-water research in Africa. This causes a scarcity of skills across the deep-water research pipeline, from survey or experimental planning to data collection, processing, management and dissemination. As well as affecting capacity to undertake research, this translates to a lack of academic leadership, support and supervision on deep-water research, limiting opportunities for theoretical and practical training of the next generation of deep-water researchers.

Low retention of experts, often owing to poor job prospects and earning potential, also exacerbates the lack of expertise. Other factors include undocumented and/or dormant knowledge and expertise caused by limited visibility and findability of relevant experts, and/or overburdened experts. These issues lead to a lack of skills transfer to the next generation, which can be

particularly detrimental in highly specialised fields such as taxonomy. In some cases, senior researchers may also be territorial over their subject matter and unwilling to effectively mentor ECRs.

In cases where African students undertake training at international institutions, implementation of new skills in their home countries may be difficult due to the unavailability of appropriate research infrastructure. This can force experts to either remain abroad or work in unrelated fields.

3. Lack of infrastructure

In the Ocean Discovery League's global assessment of deep-sea research capacity [9], it was found that in Africa, the level of in-country expertise often outweighed access to deep-sea research infrastructure and technology. This is supported by the experiences of our participants. In most African countries, there is a lack of equipment, technology, vessels, platforms, institutes, and facilities to conduct deep-water research across the research pipeline from data collection to processing, management and sharing. For example, there is often very limited or no access to vessels and tools to carry out sampling (such as dredges or camera systems to conduct image-based surveys). However, this can also apply to rudimentary infrastructure such as internet access and data management systems.

4. Insufficient financial resources

A lack of funding has a major role to play in limiting entry into and progress in the field of deep-water research. Compared to many areas of research, this is an expensive field, and this greatly restricts involvement to only a handful of nations. Funding limitations apply across the pipeline of deep-water research, from a lack of financial resources to acquire, run and maintain infrastructure for data collection to prohibitively high publication costs that limit research dissemination and lack of support to attend scientific meetings (although the latter are not challenges unique to the field of deep-sea research).

This affects both the ability to undertake deep-water research and produce new knowledge of Africa's deep-water ecosystems, and the development of expertise in the next generation of researchers. For example, a lack of funding impacts ECRs not only through limited sea-going opportunities, but also by preventing the development of university and other courses aimed at developing skills and knowledge for deep-water research. This is made more difficult for inland institutions requiring additional budget to take students to the field.

Funding limitations are seen at a national, regional and international level. Government funding can be insecure between different government administrations and may be affected by issues such as interpersonal influence. In addition, equity issues arise where African nations must compete with international scientists for access to international funding and highly bureaucratic processes for managing grants and accessing funding worsen the situation. Ring-fenced international funding which supports research collaborations with developing nations is helping this.

On a smaller scale, where financial resources are provided to support travel for researchers to events such as conferences, workshops and meetings, processes requiring reimbursement can exclude many individuals from taking up these opportunities or slow reimbursement can affect researchers' personal circumstances. This particularly affects ECRs.

5. Limited and closed collaborations and partnerships

As a starting point, poor visibility and findability of relevant researchers and overburdened experts can hinder the development of collaborations and partnerships. Where collaboration is desired, mobility issues within the continent can restrict opportunities for networking and collaboration amongst African researchers. This can be caused by factors such as high visa fees and long processing times. Collaboration may be further stifled by limited access to tools and technologies to support interactions, for example restrictions on bandwidth or access to software, as well as language and cultural barriers which may hinder the development of relationships. There are also difficulties integrating methodologies and ways of knowing for multi-, inter- and trans-disciplinary research.

[9] https://deepseacapacity.oceandiscoveryleague.org/

There is also often limited communication amongst researchers of opportunities for collaboration and channels for discussion of African-focused research. Some exceptions to this include platforms such as the Western Indian Ocean Marine Science Association, the South African Network for Coastal and Oceanic Research, the Southern African Marine Science Symposium and the Benguela Current Commission. Linked to ocean governance issues, there may also be insufficient understanding on the mechanisms in place to support collaboration.

Within countries and regions institutional rivalry and a lack of participative processes may restrict collaboration. Collaboration opportunities can also be impeded by unmatched priorities and resources, conflicts of interest and domination of a field by senior scientists. A lack of trust and transparency among partners can lead to data sharing constraints and restricted access to data. Bureaucratic grant processes and lack of administrative support can also limit participation and hinder access to opportunities for new entrants. Similarly, difficult processes for partnerships with commercial entities, government institutes and/or foreign institutes often restrict access to potential collaborations and existing data.

Some of these issues also apply to collaborations with international (non-African) researchers. Closed networks that are based on existing relationships can limit new entrants into international collaborations by creating few and imbalanced opportunities for collaboration. Parachute science practices where local researchers are not included in meaningful collaborations can limit the potential of these and damage progress of local science.

6. Governance challenges

In some instances, the absence of national and regional legal frameworks hampers support for deep-water research and scientific collaboration. This deficiency often extends to a lack of integrated governance for cross-boundary resources. Notable exceptions to this include the Nairobi Convention in the Western Indian Ocean Region, the Abidjan Convention in the South-east Atlantic and the Benguela Current Commission.

Even when such frameworks exist, limited and inadequate ocean governance education or a lack of political will can result in an incomplete understanding and implementation of the legal and policy structures designed to facilitate scientific research and collaboration. This gap may extend to the interpretation of the UN Convention on the Law of the Sea and the recently adopted agreement on Biodiversity Beyond National Jurisdiction. Bureaucratic and institutional issues among ministries and departments are also common, contributing to delays in progress.

Furthermore, researchers often fall short in engaging with politicians and politics, displaying insufficient effort to comprehend or demonstrate how their research relates to policy, governance and decision-making.

South African lace corals **Image credit:** ACEP Deep Forests

Potential solutions to advance deep-water research

Despite the challenges and barriers to deep-water research in Africa, there are clear pathways to address some of these, many of which build off local success stories (Box 1-4). These include: (1) ocean literacy efforts; (2) human capacity development; (3) incremental infrastructure development; (4) fundraising; (5) collaboration, networking and partnerships; and (6) improved governance, legal frameworks and policies. Although the ANDR's ability to address systematic barriers to gender equality is somewhat limited, actions can be taken within the Network to foster an inclusive and supportive community where everyone feels valued and respected. These are highlighted here.

1. Ocean literacy efforts

Ocean literacy efforts are important for a number of reasons. Firstly, they help to raise the profile of the ocean (and deep sea) in society's minds in general. Education and outreach for the general public and youth, including coastal communities, is important to demystify deep water environments, and can be supported through activities like live streaming of research in local languages or cartoons. There is also an opportunity to redefine ocean literacy programmes to learn from African nations where connection to the ocean is strong, and co-develop these programmes with indigenous knowledge holders. Taking this a step further, including deep-water content at multiple levels of education (from primary school to university) is important to raise awareness around deep-water research and may encourage the next generation of researchers to study the subject. Tailoring curricula to specific regions, smaller scales and local subject matter may provide more meaningful content.

Secondly, ocean literacy can promote the importance of deep-water research, by highlighting its significance in a broader sustainable development context. In addition to efforts directed at the general public, customising ocean literacy initiatives to policy and decision-makers by focusing on specific or high-level issues could enhance and support environmental management. Where national governments and regional bodies are faced with many pressing issues, communicating the benefits and services of deeper waters (such as food provision and poverty alleviation) and deep-water research could play an important role in leveraging funding for research. As well as building a case for deep-sea research, this could include communicating research needs to local governments.

Finally, ocean literacy efforts could also include hosting special issues in local and international journals and exploring mechanisms to reduce publication costs.

Image credit: Kirsty McQuaid

2. Human capacity development

Human capacity development is a key step to building on African capacities to undertake deep-water research and can take many different forms. Crucial components include theoretical and practical training in deep-water research (including safety at sea training, infrastructure development, use and maintenance, survey planning and execution, data analysis and management), mentoring programmes and internships for all career stages, and knowledge exchange activities both among African researchers and between African and non-African researchers. Train-the-Trainer approaches can amplify the positive effects of training programmes if this knowledge is passed on more widely. Providing research experience for ECRs to build academic and technical experience is also critical. Data synthesis projects, for example, could be an effective low-cost avenue for short- to medium-term training and research as they would make the most of existing data which might otherwise remain unused, develop skills in data curating, processing and analysis and would provide a basis for strategic planning of future data collection.

Importantly, developing training programmes under local conditions and tailored to local needs can make a big difference (e.g., Box 1). Often training programmes teach individuals about equipment or species that are not present in their home countries, or under conditions that are different to those experienced locally. It is also important to ensure that human capacity development initiatives realistically acknowledge the time and exposure required for effective skills development. Rigorous skills transfer/capacity development criteria must be established and integrated into project assessments to ensure accountability. This ensures that the financial investment is not geared towards parachute science, but is specifically tailored to address local research needs. This applies to learning across African nations and between African nations and international collaborators. Where possible, human capacity development and knowledge exchange activities should be built into local, regional and international project proposals. Including ECRs in international programmes, for example, can help to build expertise.

To create a pipeline of talent for future deep-water researchers, initiatives that encourage girls and young women to pursue STEM education should be supported. Furthermore, women should be included in research teams and leadership roles to enhance creativity and bring different perspectives to problem-solving.

Box 1. Empowering ECRs to lead: An alternative model for at-sea training

In 2023, a multidisciplinary research cruise was held in South Africa, aimed at developing and strengthening the offshore research capacity of Early Career Researchers (ECRs). In contrast to conventional training models, this two-week cruise was designed, planned, executed and led by 11 local ECRs. The cruise leveraged local infrastructure, capacity and knowledge to synergistically address the ECRs' research questions (many of which contributed to on-going postgraduate studies) and national research priorities. The ECRs also engaged in meaningful knowledge exchange and networking to establish professional relationships. This cruise was made possible by the One Ocean Hub project, the South African Environmental Observation Network and the South African Institute for Aquatic Biodiversity.

Image credit: Kerry Sink

Image credits: Luther Adams

Image credit: Kerry Sink

3. Incremental infrastructure development

Infrastructure is used here to include all elements of equipment, technology, facilities and vessels across the entire pipeline of research, thus considering and promoting the development of end-to-end capability. As well as sampling equipment and laboratory facilities, this would include, for example, information and communications systems to support research activities. Other technical aspects could include data flow, management and storage, computer vision and machine learning, genetic research (eDNA), biotechnology and specimen and tissue collections.

Perhaps the very first step to incrementally improve infrastructure capabilities is to determine infrastructure requirements by defining research goals. A next step would be to document existing government, commercial and private infrastructure with a view to building on this. Key is to start small and build on what is already available (e.g., Box 2). This could mean, for example, strengthening deep-water research capacity of small boats that may already be available (e.g., through installation of winch systems). This could also be through identifying and securing low-cost technology or developing shared infrastructure platforms and networking institutions for greater infrastructure sharing. Employing a diversity of tools will allow different research goals to be met. Importantly, the safety of small boat operations in deeper waters depends on the conditions of the local system (i.e., topography, currents, distance of shelf to shore) and should be assessed.

Securing, developing and networking champions for infrastructure development could support progress in this regard. Additionally, dedicated training for infrastructure use and maintenance is needed. This could be through specific training programmes, or integrated into university courses that focus on key skills. Specific knowledge exchange programmes would also aid in the exchange of technical expertise and could include sharing of designs for low-cost technology that is supported by local infrastructure or regional specimen and tissue collections for deep-water taxa. Partnerships with other disciplines and research fields may also be important, particularly where there are resources to develop equipment.

Image credit: Luther Adams

Box 2. Incremental growth of South Africa's deep-water research capacity

South Africa's African Coelacanth Ecosystem Programme (ACEP) has demonstrated an approach to incrementally building deep-water research capacity, and through this challenged the notion that only large institutions with sizable vessels can undertake research in deeper water environments. Starting with small, coastal vessels the programme gradually incorporated technologies like multibeam systems and small CTDs (conductivity, temperature, and depth sensors). Landers equipped with scientific instruments and sensors were developed in-house and their depth rating was gradually increased through incremental improvements. Cost-effective drop camera systems and stereo-BRUVs (Baited Remote Underwater Video systems) were also deployed to gather imagery and other data. These capabilities were strengthened by small observation-class remotely operated vehicles (ROVs) in place of large, expensive work class ROVs. Together with successful efforts by government departments, research institutes and facilities to bring a biodiversity focus to trawl monitoring and the development of offshore field guides, this has helped to build a more complete picture of deep-water ecosystems in the country. This highlights the viability of a scaled, regionally tailored and strategic approach to progressively improving deep-water research capabilities.

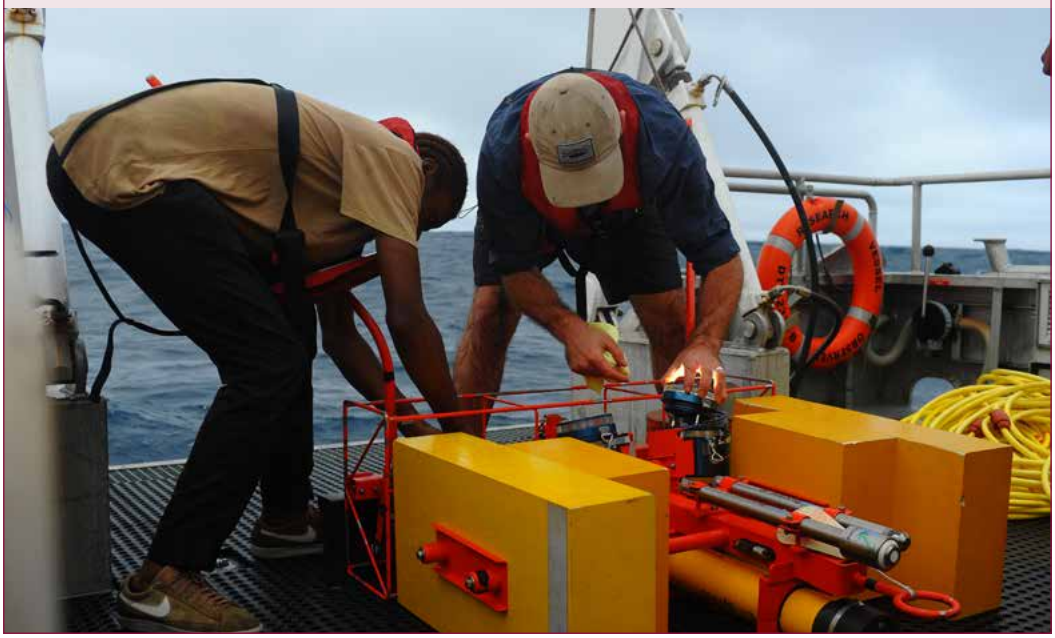


Image credit: Luther Adams

4. Fundraising

To address a lack of financial resources, which affects nearly every element of capacity gaps, several measures are required. Ideally, long-term, stable funding solutions should be sought, for example through government investment in research activities and infrastructure. A dedicated, organised fundraising team that is able to prepare proposals and approach potential funders could play a major role in bridging the gap, whether at a national or regional level.

For researchers, a priority action is to identify, distil and communicate research and capacity development priorities (both at a national and regional level) for articulation in funding calls. Included in this, is a need to communicate the societal impacts and benefits of deep-water research. It may be that research interests need to be aligned with funding priorities to leverage financial resources from existing opportunities. It is important to have a platform to share funding calls and opportunities, and when seeking funding, researchers should consider project costs from inception to data archiving and publication.

On a smaller scale, financial support offered for participation of individuals in events like conferences, workshops and meetings should be provided at least in part upfront. This would ease the burden of slow reimbursement processes that can prohibit participation, particularly by individuals from developing states and ECRs. Specific funding to support ECRs should be sought, and this could include dedicated funding for bursaries, conference sponsorship, travel support and training opportunities. Equity considerations should be taken into account in accessing resources and funding.

5. Collaboration, networking and partnerships

An important first step in supporting improved collaboration, networking and partnerships is making African deep-water researchers easier to find, for one another and international collaborators. This could be done, for example, through the development of an expert database or the integration of African deep-water researchers into existing databases (such as the IOC-UNESCO Ocean Expert database [10]). Integrating deep-water research into existing platforms, events and agreements will also be important for building relationships and new collaborations. This could mean, for example, identifying existing research partnership agreements and exploring how deep-water research could fit into those (e.g., the Africa-EU Partnership[11] or the All-Atlantic Ocean Research and Innovation Alliance [12]). Hosting international events or thematic workshops (such as the 14th International Polychaete Conference in South Africa, or the first West Africa Marine Science Symposium in Ghana in 2023) could also make deep-water research more accessible and play an important role in bringing together African researchers.

At a national level, exploring opportunities for partnerships and collaboration with relevant offshore industries or government research programmes could be a first step to building knowledge of deep-water ecosystems, as has been successfully demonstrated in Namibia (Box 3) and South Africa. This requires building trust and transparency with industry and other partners and can take time, but it can unlock important data. Other opportunities that match private vessels with marine research could also be explored (for example, Yachts for Science [13]). In the longer term, development of science programmes at a national or regional scale would promote collaboration, particularly if a regional forum were established that does not rely on government funding.

Overarching all of this, is the need to develop meaningful and respectful relationships with collaborators who promote fair research practices nationally, regionally and internationally, including co-creation, co-design, co-analysis and co-publication (e.g., Box 4). To realise this, local research priorities need to be identified and communicated and interventions to promote inclusion of local researchers in international projects at the proposal phase through to field programmes are necessary. In addition, opportunities for local researchers to lead local deep-water research efforts should be a priority. Fostering partnerships between the global north and south is important, but so too should opportunities be created to learn from African nations where deep-water research is already undertaken. Networking, collaboration and mentorship opportunities for women in particular should be explored to provide access to valuable professional connections.

Image credit: Kirsty McQuaid

[10] https://oceanexpert.org/
[11] https://international-partnerships.ec.europa.eu/policies/africa-eu-partnership_en
[12] https://allatlanticocean.org/
[13] https://yachtsforscience.com/

Box 3. Collaboration for enhanced data collection in Namibia

Namibia's Ministry of Fisheries and Marine Resources conducts annual scientific surveys along its coast, spanning from the Kunene River to the Orange River. These surveys, conducted at depths between 80-800m, focus on assessing the biomass and health of crucial commercial fish stocks such as hake, deep-sea red crabs, and monkfish. However, the demersal trawl surveys also provide valuable data on benthic invertebrates, obtained as by-catch. A collaborative effort with the Fisheries Observers Agency (FOA) involves training grade 2 observers during these surveys, enhancing their ability to collect sophisticated biological data from commercial catches. This collaboration, initiated in 2021, has educated over sixty observers, who, working on commercial vessels, contribute vital insights into marine species behaviour and ecosystems. The synergy between scientific research and operational observers improves data accuracy, enabling informed conservation and management policies for sustainable marine resource management. Real-time data on catch compositions, bycatch, and environmental factors further enhances adaptive resource management for a resilient and sustainable future.

Image credit: Namibian Ministry of Fisheries and Marine Resources

Box 4. Characterising deep-water habitats of the Seychelles through affordable technology and meaningful collaboration

A meaningful international collaboration in the Seychelles seeks to overcome challenges associated with the inaccessibility and high cost of deep-sea exploration, a barrier that disproportionately affects Small Island States. Local researchers are working together with international collaborators (Ocean Discovery League, Oceanic, the University of Oxford and the Nekton Foundation) to carry out the first nationally-led visual surveys of the Seychellois Exclusive Economic Zone below 200m. Researchers are using a low-cost, high-tech camera system, the Maka Niu, to characterise deep-water habitats of known productive systems and explore fish-seabed interactions. The data collected will support effective ocean management and community engagement efforts. This project demonstrates an international partnership built on trust and a common goal to secure affordable technology and co-analyse collected data, while ensuring local leadership.

6. Improved governance, legal frameworks and policies

To support research, sustainable management and improved governance, deep-water could be integrated into existing agreements and legal frameworks. However, researchers need to effectively communicate the importance of deep-water research and the policy and governance relevance of this for it to influence policy- and decision-making processes. This could include aligning and engaging with intergovernmental platforms, governance frameworks (like the Abidjan Convention and the Nairobi Convention), and national political agendas. Ideally, researchers should co-design research with relevant stakeholders, including government, to increase opportunities for policy uptake.

Action from governments could include the development of science programmes that support deep-water research and advance the field. Measures requiring offshore industries to make publicly available non-sensitive and non-confidential environmental data as part of licensing agreements (e.g., the International Seabed Authority's DeepData database) could also unlock existing data on deep-water environments for science.

Image credit: Kirsty McQuaid

PRACTICAL ACTIONS TO STRENGTHEN CAPACITY FOR DEEP-WATER RESEARCH IN AFRICA

Building on potential solutions identified during the workshops, proposed here are several targeted actions which could help to strengthen capacity for deep-water research in Africa. These reflect the views of the research community and should be tailored to meet national and regional level needs where appropriate.

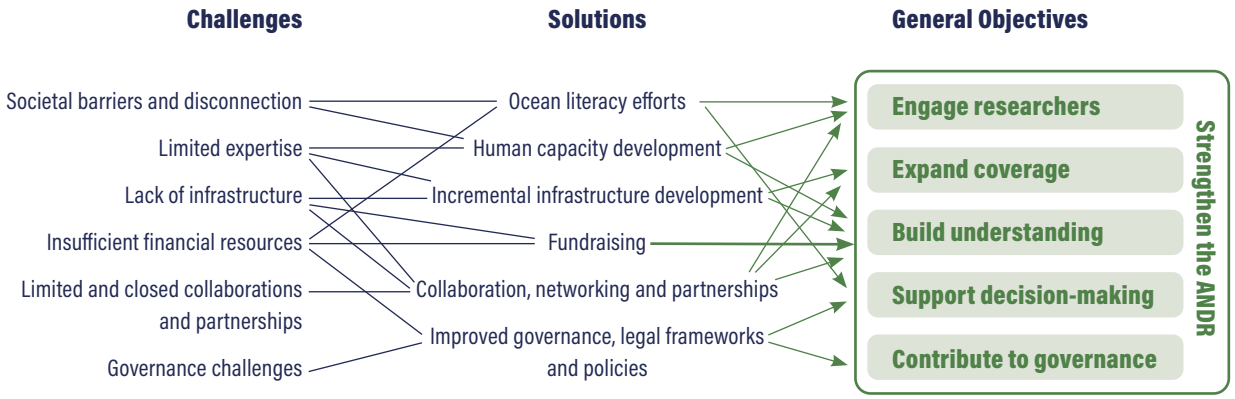
Actions are categorised according to identified solutions into short (1-2 years), medium (2-5 years) and longer (5-10+ years) term actions and speak to several general objectives, which are to strengthen the *African Network of Deep-water Researchers*; engage marine researchers, including ECRs, in deep-water research; expand the coverage and frequency of deep-water research in Africa; build understanding of deep-water ecosystems and services; increase the use of deep-water knowledge in decision-making; and contribute to governance and policies to support sustainable ocean management and development. Gender considerations should be taken into account on implementation of these actions.

In the short term (1-2 years), actions emphasise the importance of building a robust foundation through strengthening of the ANDR. There is a focus on creating visibility through inventories of researchers, disciplines, and infrastructure, and establishing training needs and research priorities. Additionally, communication and collaboration are also key components, as seen in actions related to promoting opportunities for research, training, and capacity development and a focus on engaging key partners, funders, and collaborators to support the development of project proposals. As the timeline extends into the medium (2-5 years) and longer term (5-10+ years), actions focus on scaling up efforts, with convergence on themes such as continued strengthening of the ANDR, co-development of project proposals, roll-out of training, mentoring, knowledge exchange and networking programmes, and engagement with educators and policy-makers to improve ocean literacy and advocate for the relevance and importance of deep-water research. This underscores the comprehensive and interconnected approach necessary for deep-water research and sustainable development in the African context.

None of these proposed actions are achievable without highly collaborative efforts and funding to support planning and implementation. As such this report does not prescribe detailed timelines nor plans for implementation. The ANDR is actively seeking funding to support some of these proposed actions and welcomes collaborative engagement to take them forward.

Table 2. Practical actions to strengthen capacity for deep-water research in africa

Theme		Action		Short Term (1-2 yrs)	Medium Term (2-5yrs)	Longer Term (5-10+yrs)
0	Strengthen the African Network of Deep-water Researchers	0.1	Seek funding for a coordinator(s)	■		
		0.2	Establish a Network structure	■		
		0.3	Develop and review plans for implementation of activities, fundraising and communication	■	■	■
		0.4	Build the brand of the Network	■	■	■
		0.5	Develop quantifiable assessment targets for monitoring and evaluation	■	■	
		0.6	Fundraise	■	■	■
		0.7	Monitor and evaluate progress		■	■
		0.8	Plan for life beyond the Decade		■	■
1	Ocean literacy efforts	1.1	Produce materials making the case for African deep-water research		■	
		1.2	Articulate connections between deep-water research and the Sustainable Development Goals (SDGs)		■	
		1.3	Engage with educators to incorporate marine and/or deep-sea curriculum content, including training for educators, at the school and/or university level		■	■
		1.4	Produce briefs or factsheets addressing policy-relevant deep-water issues, co-designed with relevant roleplayers		■	■
2	Human capacity development	2.1	Communicate opportunities for research, funding, training, collaboration, networking and mentoring through the ANDR	■	■	■
		2.2	Inventory and make visible existing opportunities for participation in research cruises and other relevant training	■		
		2.3	Identify and evaluate national and regional training needs	■	■	
		2.4	Pilot one small-scale (10-15 participants), regional-level, co-developed training programme	■		
		2.5	Initiate and implement a recurring training programme, including technical training		■	■
		2.6	Establish a mentoring scheme		■	■
		2.7	Initiate and implement a knowledge exchange programme		■	■
		2.8	Secure funding for a master's programme to support postgraduate studies in deep-water research			■
3	Incremental infrastructure development	3.1	Compile and make visible an inventory of existing deep-water research infrastructure	■		
		3.2	Identify and inventory national- and regional-level research activities	■	■	
		3.3	Identify national and regional research priorities	■	■	■
		3.4	Promote and facilitate technology transfer and sharing between ANDR member countries		■	■
		3.5	Support local innovation to advance deep-water technologies			■
		3.6	Articulate to relevant authorities in ANDR member states the necessary infrastructure for deep-water research			■
4	Fundraising	4.1	Promote co-development of regional and national multi-, inter- and transdisciplinary project proposals by members of the ANDR	■	■	■
		4.2	Identify and engage key funders who can contribute to the development of multi-, inter- and transdisciplinary project proposals for capacity development and research	■	■	■
		4.3	Secure funding for a master's programme to support postgraduate studies in deep-water research			■
5	Collaboration, networking and partnerships	5.1	Compile and make visible an inventory of researchers and disciplines	■		
		5.2	Identify and inventory national- and regional-level research activities	■	■	
		5.3	Establish and document a knowledge baseline		■	
		5.4	Identify national and regional research priorities	■	■	■
		5.5	Promote co-development of regional and national multi-, inter- and transdisciplinary project proposals by members of the ANDR	■	■	■
		5.6	Identify and engage key partners and collaborators who can contribute to the development of multi-, inter- and transdisciplinary project proposals for capacity development and research	■	■	■
		5.7	Launch and roll-out an ECR virtual networking programme		■	■
		5.8	Support African researchers to participate in international conferences	■	■	■
		5.9	Host a deep-water research-related international conference in Africa (e.g., the Deep-Sea Biology Symposium)			■
		5.10	Strengthen, network and engage African institutes in deep-water research			■
		5.11	Establish regional research programmes			■
		5.12	Produce interventions on the inclusion of local researchers in international field programmes occurring within Exclusive Economic Zones			■
		5.13	Promote and facilitate African-led research in Areas Beyond National Jurisdiction			■
6	Improved governance, legal frameworks and policies	6.1	Produce materials making the case for African deep-water research		■	
		6.2	Articulate connections between deep-water research and the Sustainable Development Goals (SDGs)		■	
		6.3	Produce briefs or factsheets addressing policy-relevant deep-water issues, co-designed with relevant roleplayers		■	■
		6.4	Facilitate connections between deep-water researchers and policy- and decision-makers, advisors, diplomats, and/or negotiators for national and/or international processes in ANDR member states			■
		6.5	Obtain ANDR representation in policy platforms/processes across African regions			■
		6.6	Develop a co-designed strategy to inform policies related to deep-water development			■
		6.7	Contribute to the harmonisation of national and international legal frameworks			■



Cross-walking broad challenges for deep-water research in Africa with potential solutions and general themes for actions to strengthen capacity and advance deep-water research

South African coelacanths **Image credit:** ACEP Deep Connections

LINKS TO THE OCEAN DECADE AFRICA ROADMAP

The *Ocean Decade Africa Roadmap* is a strategic document that outlines regional scientific gaps, capacity development needs and cross-cutting priorities to provide a vision and plan for future Decade Actions in Africa. The Roadmap highlights issues and gaps for each of the ten Decade Challenges, including aspects such as inadequate foundational knowledge and research on species diversity and taxonomy, insufficient understanding of ecosystem functions and services supported by different ecosystems, and limited mapping of marine and coastal ecosystems to achieve the objectives of Decade Challenge 2 (Protect and restore ecosystems and biodiversity).

The Roadmap identifies nine priority future Decade Actions:

1. **Sustainable Ocean Management in Africa**
2. **Ocean and Human Health in Africa**
3. **Unlocking the Blue Carbon Potential of Africa**
4. **Fisheries and Illegal, Unreported and Unregulated (IUU) Fisheries in Africa**
5. **Strengthening Multi-hazard Early Warning Systems and Community Resilience**
6. **Ocean Observations and Forecasting Systems for Africa**
7. **Digital Twin for Africa - Establishing an African Ocean Knowledge Hub**
8. **Strengthening Capacities and Skills of African Early Career Ocean Professionals (ECOPs)**
9. **Regional Ocean Literacy Programme for Africa**

There are several clear links between the practical actions identified in this report, and the issues and priorities highlighted in the *Ocean Decade Africa Roadmap* (Table 3). Notably, there is particular overlap with the Roadmap's Priority Actions 1, 6, and 8.

In the context of Priority 1, centred on sustainable ocean management in Africa, this Priority is focussed on enhancing the data, knowledge-base and expertise necessary to develop and implement sustainable ocean plans across the continent. Given the significance of deep-water industries in various African nations, encompassing activities such as fishing and oil and gas extraction, there is alignment with several actions proposed here aimed at increasing the data and knowledge-base for deep-water environments in Africa and their application to sustainable management. These actions include promoting capacity development and research opportunities by collaboratively developing project proposals (ANDR proposed actions 4.1, 5.5), identifying and engaging key partners, collaborators and funders (4.2, 5.6), identifying research priorities (3.3, 5.4), establishing regional research programmes (5.11), strengthening, networking and engaging African institutes in deep-water research (5.10), articulating links between deep-water research and SDGs (1.2, 6.2), connecting researchers with policy- and decision-makers (6.4, 6.5), ocean literacy efforts aimed at addressing policy-relevant deep-water issues (1.4, 6.3), and developing co-designed strategies to inform deep-water development policies (6.6). These actions contribute to the overarching objective of Priority 1 on sustainable ocean management. They are also applicable to Priority 3, addressing unlocking the Blue Carbon Potential of Africa, where information on deep-water habitats relevant to blue carbon is concerned.

Concerning Priority 6, which focuses on ocean observations and forecasting systems for Africa, proposed actions on implementing research programmes and gathering data are relevant. There is a degree of overlap here with Priority 1. Beyond the pertinent actions outlined for Priority 1, actions on compiling and publicising an inventory of infrastructure (3.1), initiating technical training (2.5),

promoting technology transfer between countries (3.4), and supporting local innovation to advance deep-water technologies (3.5) contribute to the foundation for effective ocean observations and forecasting systems. The data collected through these efforts could also hold significance for Priority 7, which aims to create a digital twin for Africa and establish an African ocean knowledge hub.

Finally, a number of practical measures have been proposed that are directly aligned with Priority 8 on strengthening capacities and skills of African Early Career Ocean Professionals. In the short term, actions to communicate opportunities for research, funding, training, networking and mentoring (2.1) and inventory and publicise existing cruise and training initiatives (2.2) aim to raise awareness around opportunities for ECRs. Additionally, actions to identify and evaluate training needs aim to inform future training programmes (2.3, 2.4). In the medium term, multiple actions collectively aim to enhance the capacity of deep-water researchers, including specific actions tailored towards ECRs. These include continuing to co-develop project proposals for capacity strengthening and research (5.5), and initiating training, mentoring, knowledge exchange and networking programmes (2.5, 2.6, 2.7, 5.7). Finally, in the longer term, these actions are expected to continue, together with actions to incorporate marine and/or deep-sea content into curricula at different levels (1.3) and secure funding for a masters programme (2.8). These are expected to be crucial steps toward supporting the development of ECRs and Early Career Ocean Professionals more generally.

As well as addressing these specific Priority Actions of the Roadmap, there are similar overarching aims around networking and coordination, regional engagement and collaboration, capacity development, research promotion, data and knowledge management and dissemination, communication and advocacy to create an enabling environment for ocean and deep-water research in Africa. By recognizing these connections, it becomes evident that the actions identified in this report collectively contribute to addressing priorities identified for Africa's response to the Decade, fostering a holistic and integrated approach to ocean management and research in Africa.

Table 3. Links between the Ocean Decade Africa Roadmap and proposed actions identified in this report.

African Roadmap priority future Decade Action	Proposed ANDR actions
Priority Action 1: Sustainable Ocean Management in Africa **Priority Action 3:** Unlocking the Blue Carbon Potential of Africa* * where research relates to blue carbon	• Collaboratively develop project proposals (4.1, 5.5) • Identify and engage key partners, funders and collaborators (4.2, 5.6) • Identify research priorities (3.3, 5.4) • Establish regional research programmes (5.11) • Strengthen, network and engage African institutes in deep-water research (5.10) • Articulate links between deep-water research and SDGs (1.2, 6.2) • Connect researchers with policy- and decision-makers (6.4, 6.5) • Ocean literacy efforts aimed at addressing policy-relevant deep-water issues (1.4, 6.3) • Develop co-designed strategies to inform deep-water development policies (6.6)
Priority Action 6: Ocean Observations and Forecasting Systems for Africa **Priority Action 7:** Digital Twin for Africa - Establishing an African Ocean Knowledge Hub	• Collaboratively develop project proposals (4.1, 5.5) • Establish regional research programmes (5.11) • Compile and publicise an infrastructure inventory (3.1) • Initiate technical training (2.5) • Promote technology transfer between countries (3.4) • Support local innovation to advance deep-water technologies (3.5)
Priority Action 8: Strengthening capacities and skills of African Early Career Ocean Professionals	• Communicate opportunities for ECRs (2.1) • Inventory and publicise existing cruise and training opportunities (2.2) • Identify and evaluate training needs (2.3, 2.4) • Co-develop project proposals for capacity strengthening and research (5.5) • Initiate a training programme (2.5) • Establish a mentoring scheme (2.6) • Initiate knowledge exchange programme (2.7) • Launch an ECR virtual networking programme (5.7) • Incorporate marine and/or deep-sea content into curricula at different levels (1.3) • Secure funding for a masters programme (2.8)

CHALLENGER 150
A DECADE TO STUDY DEEP-SEA LIFE

2021 2030 United Nations Decade of Ocean Science for Sustainable Development