United Nations Ocean Decade for Africa

The Science we Need
for the Ocean we Want in Africa

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United Nations Decade
of Ocean Science
for Sustainable Development

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Intergovernmental
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Commission

WESTERN INDIAN OCEAN
EARLY CAREER SCIENTISTS NETWORK
WIO - ECSN

WIOMSA
Coasts Ocean and People

WESTERN INDIAN OCEAN
MARINE SCIENCE ASSOCIATION

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Acronyms and abbreviations

CTD	Conductivity, temperature and depth
ECOPs	Early Career Ocean Professionals
EEZ	Exclusive economic zone
FAO	Food and Agriculture Organization of the United Nations
GDP	Gross Domestic Product
GoG	Gulf of Guinea
GOOS	Global Ocean Observing System
UCN	International Union for Conservation of Nature
IHE	International Institute for Hydraulic and Environmental Engineering
IOC	Intergovernmental Oceanographic Commission
MARPLASTICCs	Marine Plastics and Coastal Communities Project
MHEWS	Multi hazard early warning systems
MPA	Marine protected area
MSP	Marine spatial planning
NGO	Non-governmental organization
ODCs	Ocean Decade Challenges
SAEON	South Africa Environmental Observation Network
SWIO	Southwest Indian Ocean
TAFIRI	Tanzania Fisheries Research Institute
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNGA	United Nations General Assembly
WaPOR	FAO portal to monitor Water Productivity through Open access of Remotely sensed derived data
WIO-ECSN	Western Indian Ocean-Early Career Scientists Network
WIOMSA	Western Indian Ocean Marine Association
WWF	Worldwide Fund for Nature

Acknowledgements

Introduction

The United Nations Decade of Ocean Science for Sustainable Development was proclaimed by the United Nations General Assembly to run for a period of ten years, commencing on 1 January 2021.

The Intergovernmental Oceanographic Commission (IOC) of The United Nations Educational, Scientific and Cultural Organization (UNESCO) was requested to prepare an implementation plan for the Decade. This Decade aims to encourage international scientific collaboration as well as sustainable management of our oceans and coasts through the interplay of science and policy. It also aims to mobilize citizens from all cultures and peoples, across gender and generational lines for the preservation of the ocean because it is about our very survival as a species.

The Decade is especially important for Africa as its coastal and ocean waters are increasingly gaining importance as a potential source of economic growth and employment. The continent is endowed with vast ocean territories, providing opportunities for fisheries, aquaculture, shipping, coastal tourism, offshore oil and gas, and other blue economy-related activities. However, natural processes and human activities are increasing pressures on the ocean ecosystems, leading to coastal erosion, pollution, ocean acidification, natural disasters, and other negative impacts.

Early career scientists from a wide variety of South African universities aboard the *SA Agulhas II* for SEAmester II. Source: © Juliet Hermes, SAEON.

There are large gaps in knowledge of the resources available and the impact of different types of pressures on the ocean ecosystems. The continent will also have to address the challenges of ocean governance and security, including piracy, the delineation of ocean borders and the sharing of transboundary resources.

The implementation of the UN Ocean Decade provides an opportunity to structure and boost scientific efforts through a global collective research and investment framework. The Regional Consultative Workshop on the UN Decade of Ocean Science for Sustainable Development for Africa and the Adjacent Island States (27-29 January 2020) hosted by the Government of Kenya, and the virtual workshop on "Co-designing the Ocean Science we need for Africa" held on 3 November 2020, offered platforms to co-design mission-oriented research strategies and actions. These consultative co-design events identified key focus areas for the Ocean Decade in Africa, including empowering Africa's youthful population via ocean literacy and skills development programmes, catalysing research across a number of ocean-related fields, and establishing university-based ocean innovation incubators. In short, the Ocean Decade must enable a major leap from just supporting scientific progress to ensuring knowledge and innovation to transform lives and support well-being.

However, Africa is not starting from scratch. The African Union Commission has already developed regional frameworks to support the development of the ocean economy, including the African Union Agenda 2063: "The Africa We Want", the 2050 Africa's Integrated Maritime Strategy (2050 AIMStrategy) and the Africa Blue Economy Strategy (2019). These strategic documents recognize that the blue economy shall be a major contributor to the continent's transformation and growth, outline actions to foster increased wealth creation from Africa's ocean regions and provide guidance to member states and regional institutions for the development of an inclusive and sustainable blue economy. The African Union has also declared the period 2015 to 2025 as "Africa's Decade of Seas and Oceans", and 25 July as the "African Day of Oceans and Seas". These demonstrate that the continent recognizes the importance of its ocean resources and is determined to ensure they are sustainably used for development.

There are numerous examples of national/ joint initiatives that countries in the region have implemented to improve the management and exploitation of their ocean economy and resources.

The United Nations Decade of Ocean Science for Sustainable Development provides an opportunity to develop ocean science and technology that will not only support the harnessing of the ocean economy but also provide the knowledge and information required to address the pressures on the ecosystem and improve their resilience, and that of the coastal populations.

This booklet provides an overview of challenges that need to be addressed in the region in order to achieve "the science we need for the ocean we want in Africa". The ten Ocean Decade Challenges (ODCs) are presented in individual chapters, each chapter referring to a specific challenge.

The structure of the "challenge" chapters is the same: each starts with a goal, then describes the background and details of the challenge. A case study relating to the challenge and a set of recommendations to address the challenge are also presented. The final chapters include:

- A call to action, defining the decade action hierarchy and endorsement process;

- Endorsed Ocean Decade actions in Africa, with a map that provides an overview of current actions;

- Coordinating mechanisms that describe the governance and coordination arrangements for the Decade that will facilitate collaboration across groups of actors to optimize the use of existing structures wherever possible;

- The Early Career Ocean Professionals in the Decade presents the ambition for strengthening networking and professional development opportunities with local to global institutions through the framework of the UN Ocean Decade;

- The Reference section includes all the sources quoted in the various chapters, as well as further reading and useful links; and

- The Appendix presents the details of endorsed Ocean Decade actions from Africa.

Challenge

Understand and beat marine pollution

Understand and map land and sea-based sources of pollutants and contaminants and their potential impacts on human health and ocean ecosystems, and develop solutions to mitigate or remove them.

Lurio University students drying marine litter items to categorise them as part of the WIOMSA and African Marine Waste Network Marine Litter Monitoring Project. Inhaca, Mozambique © Gélica Inteca.

Under the vision of the Ocean Decade "The science we need for the ocean we want" marine pollution caused by plastic waste, nutrient pollution from agriculture run-off, eutrophication such as algae blooms, seaweed and oil spills, among others, is rapidly increasing in African countries (Patnode and Bosire, 2020). This is due to the increasing population growth, rapid urbanization, discharge of untreated household and industrial effluents and the use of plastic products such as plastic shopping bags. A report produced by Grooten and Almond (2018) estimated that nearly 8 million tonnes of plastic waste are discarded into the African marine environment annually, with only 16 percent recycled. These pollutants have a negative impact on aquatic and marine ecosystems and human health, particularly the loss of biodiversity and contamination of the aquatic food chain.

Addressing the negative impacts of marine pollution has been a challenge for various governments because of a lack of source-to-sink understanding and assessment of pollutants, including impacts on ecosystems and human health. This has exacerbated the sheer amount of pollution and a lack of technical knowledge to respond to marine pollutants and to efficiently dispose of or recycle the pollutants.

A multidisciplinary approach is required to address the negative impacts of marine pollution given the sources, types and end products, and whether they are recyclable or hazardous to society.

Case Study: Marine Plastics and Coastal Communities Project

In 2017, a four-year African and Asian marine pollution initiative – Marine Plastics and Coastal Communities initiative (MARPLASTICCs) – with funding support from the Swedish International Development Cooperation Agency and the International Union for Conservation of Nature (IUCN) was launched to address marine pollution globally. The selected countries from Africa were the republics of Kenya, Mozambique and South Africa.

The aim of MARPLASTICCs is to:

- assist governments and regional bodies in Africa and Asia to strengthen, develop and implement legislation and other measures that reduce plastic pollution;

- equip governments, industry and civil society with tools, knowledge, capacity and policy options to help close the plastic tap; and,

- ensure that the full life cycle of plastics is taken into consideration, not just the impacts of downstream marine litter.

Beside the aims of MARPLASTICCs, IUCN is also developing tools to assess the plastic entering the environment from source-to-sea. It is also partnering with African countries to co-generate credible, salient, and legitimate data and analysis to understand their current plastic waste status, set targets, agree and implement actions and track progress.

The programme's achievements are broken down into four categories:

- Developed knowledge: IUCN collaborated with the five nations to co-generate credible, relevant, and authentic data and analysis in order to better understand their existing plastic leakage situation, set goals, and agree on and carry out actions.

- Enhanced capacity: to promote and implement circular economy measures, share best practices, and spur national action to combat plastic pollution.

- Found policy solutions: the study aided in the reform and formulation of national programmes, including action plans.

- Engaged business: the study collaborated with industry to establish a plastic footprint technique and advocate its use to prevent plastic leakage.

References

www.iucn.org/theme/marine-and-polar/our-work/close-plastic-tap-programme/marplasticcs

Practical laboratory session for the analysis of litter samples collected during a marine litter monitoring training organized by WIOMSA and the Kenya Marine and Fisheries Research Institute (KMFRI), Mombasa, Kenya. Source: © KMFRI.

Recommendations

The following are some of the actions and interventions that can aid in understanding and beating marine pollution in Africa:

- Implementation of monitoring and assessment programmes for marine litter and microplastics, eutrophication, invasive species and chemical pollution (including oil spills), based on harmonized methodologies, including modelling, datasets and indicators.

- Establishment of networks of research institutes, universities, observatories, associations including community-based organizations (CBOs), as well as non-governmental organizations (NGOs), and businesses in Africa to support the monitoring and protection of the marine environment, the improvement of institutional and human capacities, and the development of environment

friendly pollutant removal technology incorporating the use of indigenous knowledge.

- Establishment and implementation of management and conservation plans for coastal and deep-sea ecosystems, including marine protected area (MPA) networks.

- Strengthen ocean governance, including legislative measures for effective management of marine pollution.

- Create awareness campaigns to promote ocean literacy in schools and community engagement to improve knowledge of oceans and reduce humans' negative impact on the ocean and coastal ecosystem health.

The Arena Recycling Industry, Women in Recycling Foundation, Sustainable Ocean Alliance Tanzania, the Ocean Foundation, and Msasani Beach Management Unit, and WIO-ECSN engaging the community in a beach clean-up of Msasani beach, Dar es Salaam, Tanzania. Source: © David Ailars.

Challenge | 2

Protect and restore ecosystems and biodiversity

Understand the effects of multiple stressors on ocean ecosystems, and develop solutions to monitor, protect, manage and restore ecosystems and their biodiversity under changing environmental, social and climate conditions.

Learning by Doing: field training on the community based ecological mangrove restoration approach in the Rufiji Delta, Tanzania. Source: © Menno de Boer, Wetlands International.

Our ocean ecosystems are diverse and provide many resources that are beneficial to marine life and humankind for survival and well-being. However, the growing demand by humans coupled with global climate change and other stressors has increased the pressure on different ecosystems and the loss of marine biodiversity in Africa. It is estimated that over 40 percent of the marine environment off the African coast is already impacted by multiple stressors.

The challenge of protecting and restoring marine ecosystems and biodiversity is compounded by the limited knowledge of what represents healthy and resilient marine ecosystems, including ecosystem functions and the services they provide. Also lacking is an understanding of marine and coastal biogeographic patterns and associated biodiversity (species diversity and taxonomy), the impacts of alien and invasive species, and what makes ecosystems resilient. Other areas where understanding is weak include: the structure and function of the ocean, the mapping of marine and coastal ecosystems, the increasing pressure on resources, and the linkages between ecosystem services and human beings (Pendleton, 2016).

Case Study: The multi-stakeholder approach to mangrove restoration and beekeeping at Makoba Bay, Zanzibar, Tanzania

Policymakers can propose measures to protect, manage and restore the ocean ecosystems and biodiversity, but if this is not done through effective and proper channels, then the probability of success is limited. This is true for Africa and many other regions of the world.

For instance, in Makoba Bay in Zanzibar, Tanzania, a project that integrated the restoration of mangroves with alternative livelihoods, was successful because indigenous communities were involved in the restoration of the ecosystems (UNEP-Nairobi Convention/USAID/WIOMSA, 2020).

This multi-stakeholder approach has had positive impacts for the project. It has led to sensitization on mangrove planting among community members and the restoration of mangroves in degraded mangrove forests areas of Bumbwini-Mkokotoni bay by planting different mangroves species. Community members, in collaboration with government agencies, have also developed their own village by-laws for the management of mangrove ecosystems. The communities were introduced to alternative income generating activities such as beekeeping for the production of honey.

The project is an example of how the integration of ecosystem management (protection, sustainable utilization and restoration) and socio-economic benefits is the best sustainable management strategy to protect and restore ecosystems because it offers socio-economic benefits to the local people, and also encourages them to protect and effectively manage the ecosystems they depend on.

References

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Beekeeping in mangrove areas in Mtwara, United Republic of Tanzania. Source: © Mwita Mangora.

Recommendations

Some recommended actions that can be taken to enhance the realization of a healthy and resilient ocean where marine ecosystems are understood, protected, restored and sustainably managed in Africa are:

- Improving environmental management for the conservation of ecosystems, preservation of their services (fisheries, aquaculture, tourism, culture etc.) and human health.
- Strengthening integrated knowledge such as linkages between biodiversity and social sciences, governance, local knowledge, etc.
- Identifying areas that are potential conflict hotspots which are particularly exposed to the impact of several stressors and propose possible solutions.
- Strengthen fundamental scientific biodiversity knowledge (e.g., taxonomy and systematics research).

Nature Seychelles' reef rescuer, Athina Antoine,cleaning corals at a nursery, in Seychelles. Source: © Camila Marino.
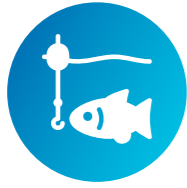
Sustainably feed the global population

Address knowledge gaps related to fishing techniques and mariculture for understanding the effects of unsustainable exploitation of marine resources and for developing solutions to manage fisheries and improve enforcement and marine governance.

Mama Pweza, Amina Juba, a prominent octopus fisher and community leader in Lamu, Kenya showing off her octopus catch. Source: © Roshni Lodhia, The Nature Conservancy (TNC).

Food security and secure livelihoods are among the most important challenges affecting African countries. The ocean provides food (including fish, invertebrates and plants) and supports the livelihoods of more than three billion people worldwide, with a substantial majority belonging to developing countries (FAO, 2018).

The maritime route is also used to transport approximately 60 percent (200 billion tonnes) of food internationally (Bendickson, 2007). The dependence of a large part of the world's population – including in Africa – on the ocean for a source of protein, is undeniable.

The first-sale value of African fisheries (marine, inland and aquaculture) was estimated to be USD 19.7 billion per annum in 2014. An additional USD 2 billion would be available annually for African economies if the fisheries sector were managed sustainably (African Union–NEPAD, 2014).

The contribution of the ocean to the global food system that benefits society by feeding the population via extraction of resources, for instance, capture fisheries or mariculture, is crucial.

Knowledge and tools are essential to support the regeneration of wild fish stocks, deploy sustainable fisheries management practices and support the sustainable expansion of aquaculture, while protecting essential biodiversity and ecosystems (Costello et al., 2020). The knowledge and tools have grown extensively during the past decades in many African countries, such as the republics of South Africa, Madagascar and Mauritius, among others.

Ocean literacy must evolve alongside a country's need to use the ocean to feed its population. To ensure a sustainably harvested and productive ocean to feed the African population, it is important to exploit the ocean resources by giving due consideration to the environment. This can be achieved by better educating and informing people, especially ocean users, about the interdependence of the ocean, climate, humankind and how innovation can lead to a sustainable aquatic food system. However, generally there is a lack of facilities, resources and dedicated funds for creating an enabling environment for ocean literacy in many African countries.

There is also a need to channel resources towards developing innovative but sustainable ways of extracting food resources from the ocean.

Very often, technological advances are implemented without sufficient consideration for the conservation of the oceans, leading to overfishing and marine pollution. There is a gap in new areas of research that should be developed to support ecosystem protection. Additional effort is required to document the potential impacts of environmental and climate changes on the established and emerging maritime industries. These include fisheries and shipping, as well as deep-sea mineral exploration and extraction and offshore energy, respectively. At the same time, monitoring, control and surveillance is vital to ensure that ocean users respect national and international laws of the sea.

According to Costello et al. (2020), research is required to accelerate the development of sustainable and low-carbon alternative feed options for mariculture and the deployment of climate-adapted fisheries practices.

Small-scale fishers offloading catch in Ngomeni, Kenya. Source: © SOLTICE-WIO.

Case study: Status of the seafood sector in the Federal Republic of Nigeria

The Federal Republic of Nigeria is globally rated as third on the list of countries dependent on coastal seafood for food and nutrition security, with the increasing population requiring a large volume of fish (Bradley, et al., 2020). It is the largest producer of seafood products in Africa. However, domestic fish production is about 1.123 million tonnes against a demand of 3.6 million tonnes, leaving a deficit of about 2.5 million tonnes, which is largely supplied through imports. This situation indicates a huge gap in producing sufficient blue protein (Oritse, 2021).

There are several reasons for this shortfall on seafood production, including the excessive cost of inputs, pirate attacks, adopting unimproved breeds in aquaculture, and inadequate access to financial support. Thus, an integrated approach is essential to tackling fish production shortage in the country, which requires capacity building with innovative advancement (Deng, 2020).

Despite these factors, the majority of the fish in the seafood sector in the Federal Republic of Nigeria is produced by local and private sector initiatives, with limited support from the government. The capture fisheries sub-sector that is supposed to promote seafood owing to the vast exclusive economic zone (EEZ), large inland tributary waters and coastal resources, is not well managed. As a result, local fishers face many challenges that inevitably affect their livelihood.

The Federal Republic of Nigeria has great potential to overcome the Ocean Decade Challenges. The country faces numerous challenges to implement its policies; a country with 853 km of coastline with abundant resources and the third largest delta in the world (Zabbey et al., 2019).

The country does not have an agency or a separate ministry for adequate decision-making processes. Likewise, there is inadequate support for food production, especially aquaculture, which is mostly taking place at grassroot levels.

Similarly, there is a need for private sector initiatives that support people in fisheries from a corporate social responsibility (CSR) perspective, by promoting the socio-economic livelihood of the fishers. There is also a need for inclusiveness in decision-making as all stakeholders need to be involved.

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Recommendations

The following are some of the actions and interventions that can aid in addressing knowledge gaps related to fisheries and mariculture in Africa:

- Address gaps in the understanding of biogeographic patterns, biodiversity, fisheries, and ecosystem functions and services at the scale required for relevant management.
- Improve understanding of fishing techniques and technologies needed for sustainable exploitation of marine resources and innovative strategies for alternative livelihoods.
- Upscale gathering and analysis of data and information on the nature and extent of illegal, unreported and unregulated (IUU) fishing in the EEZs of African countries, in the high seas and areas beyond national jurisdiction.
- Expand the provision of historic data, real-time data and modelling with evolving partner networks.
- Promote synchronized efforts by governments, private operators and NGOs for an integrated approach to mariculture.

Length-weight fish monitoring at Kizimkazi village, Tanzania, Zanzibar. Source: © Frank Mirobo.
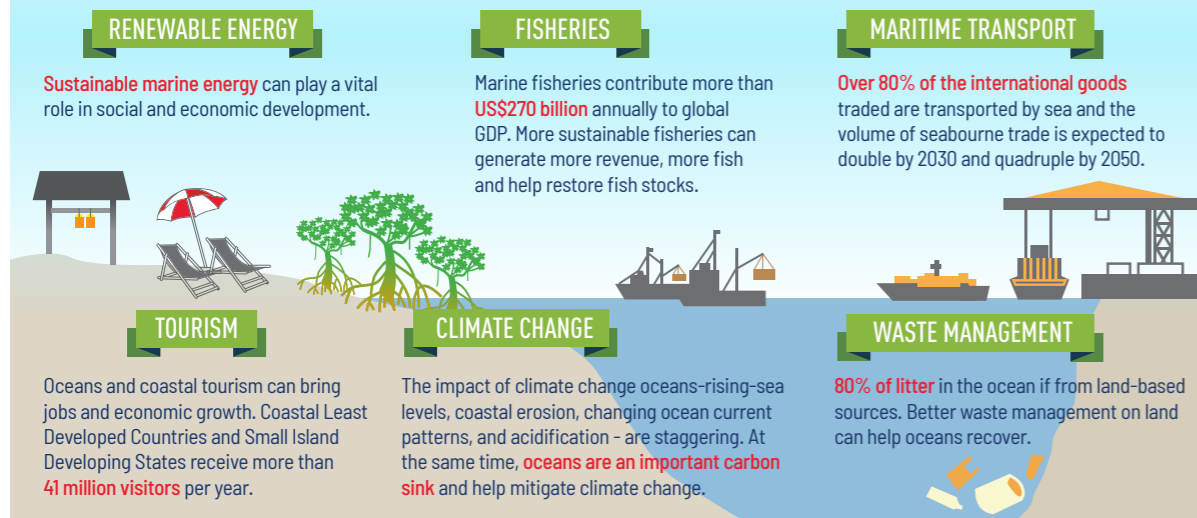
Develop a sustainable and equitable ocean economy

Generate knowledge, support innovation and develop solutions for equitable and sustainable development of the ocean economy under changing environmental, social and climate conditions.

BLUE ECONOMY

The Blue Economy is sustainable use of ocean resources for economic growth, improved livelihoods and jobs, and ocean ecosystem health.

The Blue Ocean encompasses many activities ...

RENEWABLE ENERGY

Sustainable marine energy can play a vital role in social and economic development.

FISHERIES

Marine fisheries contribute more than US$270 billion annually to global GDP. More sustainable fisheries can generate more revenue, more fish and help restore fish stocks.

MARITIME TRANSPORT

Over 80% of the international goods traded are transported by sea and the volume of seabourne trade is expected to double by 2030 and quadruple by 2050.

TOURISM

Oceans and coastal tourism can bring jobs and economic growth. Coastal Least Developed Countries and Small Island Developing States receive more than 41 million visitors per year.

CLIMATE CHANGE

The impact of climate change oceans-rising-sea levels, coastal erosion, changing ocean current patterns, and acidification - are staggering. At the same time, oceans are an important carbon sink and help mitigate climate change.

WASTE MANAGEMENT

80% of litter in the ocean if from land-based sources. Better waste management on land can help oceans recover.

To learn about other aspects of the blue economy, visit www.worldbank.org/oceans

Schematic illustration summarizing the Blue Economy concept. Source: © Worldbank (2017).

The ocean provides an array of products and services that support livelihoods globally. This is achieved through exploitation and development of ocean resources such as oil, gas, fishing, mining and maritime activities to boost economic growth. The Africa Blue Economy Strategy (2019) estimates that the African ocean sectors and associated services can generate USD 296 billion in value and create more than 49 million jobs. It projects that this could increase to USD 405 billion and USD 576 billion in 2030 and 2063 respectively; and provide 57 million and 78 million jobs, respectively (AU-IBAR, 2019) . However, the unsustainable exploitation and development of these resources, the increase of coastal populations which in turn has led to increasing demand for food, jobs, energy and raw materials, coupled with climate change effects, continue to impact negatively on the capacity of the African ocean economy to develop sustainably.

The specific issues related to the development of a sustainable ocean economy in Africa are: inadequate recognition of the role of relevant partnerships and public–private alliances and university networks as engines of environmental research, understanding and management, and as sources of the competent workforce needed for this fast-changing environment; a lack of adequate capacity for and development of entrepreneurship in sustainable ocean economy; poor implementation of management plans for the sustainable exploitation of coastal and deep-sea biotic and abiotic resources; and insufficient understanding of the impact of climate change on the ocean's food production capacity.

Case Study: The ocean economy, a South African experience

Operation Phakisa is an initiative of the Government of South Africa, aimed at identifying key areas for the development of the maritime industry to improve the ocean economy. This has led to tremendous strides in the management and conservation of South Africa's ocean and coastal environment to prevent illegal activities and promote multiple socio-economic benefits.

The strengthening of Marine Spatial Planning (MSP) through empowering the mandated authority, establishing an MSP Act (Act No. 16 of 2018) and a National Framework for MSP, demonstrate the country's commitment to spatial development and sustainable management of its ocean space.

The process began in 2014, when MSP was prioritized as initiative 10 under the ocean economy. An MSP national working group was established, followed by the publishing of a National MSP framework and the MSP Act (Act No. 16 of 2018). Currently, a National Data and Information Report, which provides the evidence base and knowledge for MSP has been finalized for effective planning and management (Department of Forestry, Fisheries and the Environment, 2022).

MSP is a way to support management required during the unlocking of the ocean economy, which will enable society to engage with the ocean, whilst ensuring a healthy marine ecosystem and promoting sound ocean governance.

Through Operation Phakisa, the country now has 41 MPAs located within the mainland exclusive economic zone to protect 5 percent of its oceans (Fielding, 2021; MPAs South Africa, 2022).

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South Africa has declared 42 MPAs, including one that is located a long way from the mainland EEZ. Source: © Marine Protected Areas South Africa website.

Recommendations

A sustainable and equitable ocean economy in Africa can be achieved through:

- Implementation of management plans for sustainable exploitation of coastal and deep-sea biotic and abiotic resources, including gas hydrates, minerals and industrial substances, and conservation and preservation of ecosystem services (fisheries, aquaculture, tourism, etc.).

- Up-scaling and transforming capacity building and marine technology transfer, addressing youth, scientists, decision-makers and stakeholders.

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- Mapping of seabed topography, geomorphology and substrate types, geo-habitats and sensitive habitats, describing the deep sea, with an inventory of the biodiversity, as well as critical fish habitats.

- Sharing of capacities and developing entrepreneurship in sustainable ocean economy sectors, e.g. designing joint education strategies, mixing art, science and education.

An aerial view of Table Mountain Marine Protected Area, Cape Town, South Africa. Source: © Judy Mann.

Challenge | 5

Unlock ocean-based solutions to climate change

Enhance understanding of the ocean-climate nexus and use this understanding to generate solutions to mitigate, adapt and build resilience against the effects of climate change, and to improve services including improved predictions and forecasts for weather, climate and the ocean.

Climate change impacts the fundamentals required for life on Earth and the ocean is central to this. The ocean covers around 71 percent of the planet, and plays a significant role in the climate system. The ocean cools the planet by taking up large amounts of carbon dioxide emitted from human activities. Coastal habitats such as mangroves, saltmarshes and seagrass meadows function as natural carbon sinks by absorbing and storing more carbon per unit area than land forests (Tang *et al.*, 2018).

The ocean is also home to immense biological diversity and is central to economic growth and food production. It supports the well-being of coastal communities by providing protection from floods and storms, as well as providing a place of inspiration, recreation, rejuvenation and discovery. The ocean is also a crucial element in the heritage of many cultures.

Despite these derived benefits, the ocean is under threat from unprecedented climate and non-climate changes. Climate shifts affecting African oceans and seas include:
- increasing temperature
- increasing acidification
- decreasing dissolved oxygen levels
- sea level rise
- changing currents
- more severe extreme events such as storms and cyclones

The effects of climate on land may also affect the ocean, with excessive flooding causing coastal run-off and impacting water quality. Human development and activities – also referred to as non-climate threats – include land and sea-based pollution, overfishing, degradation of coastal habitats and seabed mining, amongst others. Addressing the nexus between climate and the ocean is therefore critical for long-term prosperity and security.

Tanzania Fisheries Research Institute researchers deploying an ocean acidification monitoring buoy as part of the WIOMSA and IOC UNESCO Ocean Acidification Monitoring project, Dar es Salaam, Tanzania. Source: © TAFIRI.

Significant knowledge gaps exist about the climate–ocean relationship

In Africa, the coastal and marine ecosystems are among the least studied globally. Significant knowledge gaps about the climate–ocean relationship exist, including:

1. Reliable and up-to-date information about the oceans. This is necessary for the successful management of human activities that affect the marine environment. Reliable and up-to-date information is also needed to understand the ecosystem, and to forecast the effects of environmental change. If adequate information is not collected, management decisions will not be effective. In parts of Africa, adequate infrastructure for the collection of information about the ocean's behaviour is often lacking.

Although research based in other parts of the world may provide a good understanding of how the oceans function, and of the pressures to which they are subjected, this general understanding must be supplemented by adequate local information. For example, information is needed on what changes occur, where and when they occur, the rates at which they occur, and the social and physical forces that drive those changes. The collection of local information is always likely to be more efficient, effective and economic.

2. Monitoring and observation systems. These are necessary for understanding general ocean functions, for example, on maintaining species, ecosystems, resources and uses. The lack of monitoring, modelling expertise and observation systems has been associated with high costs in technologies and labour. This makes it difficult to establish an environmental baseline or to understand what constitutes serious impacts to coastal ecosystems (Drazen et al., 2020). Regional, continental and global networks, such as the Global Ocean Observing System (GOOS) and Marine Biodiversity Observation Network can assist with the technical advice needed.

3. Projections and modelling. These are vital when building national capacities for addressing climate impacts and uncertainties. Lack of forecast modelling of extreme events and their impacts on coastal zone management hinders, for example, any projections of warming that might affect MPAs. Additional challenges include, for example, modelling of ocean surface waves which often relies on global surface wind data products which may not be accurate enough for regional studies, and therefore need to be validated (Foli et al., 2021).
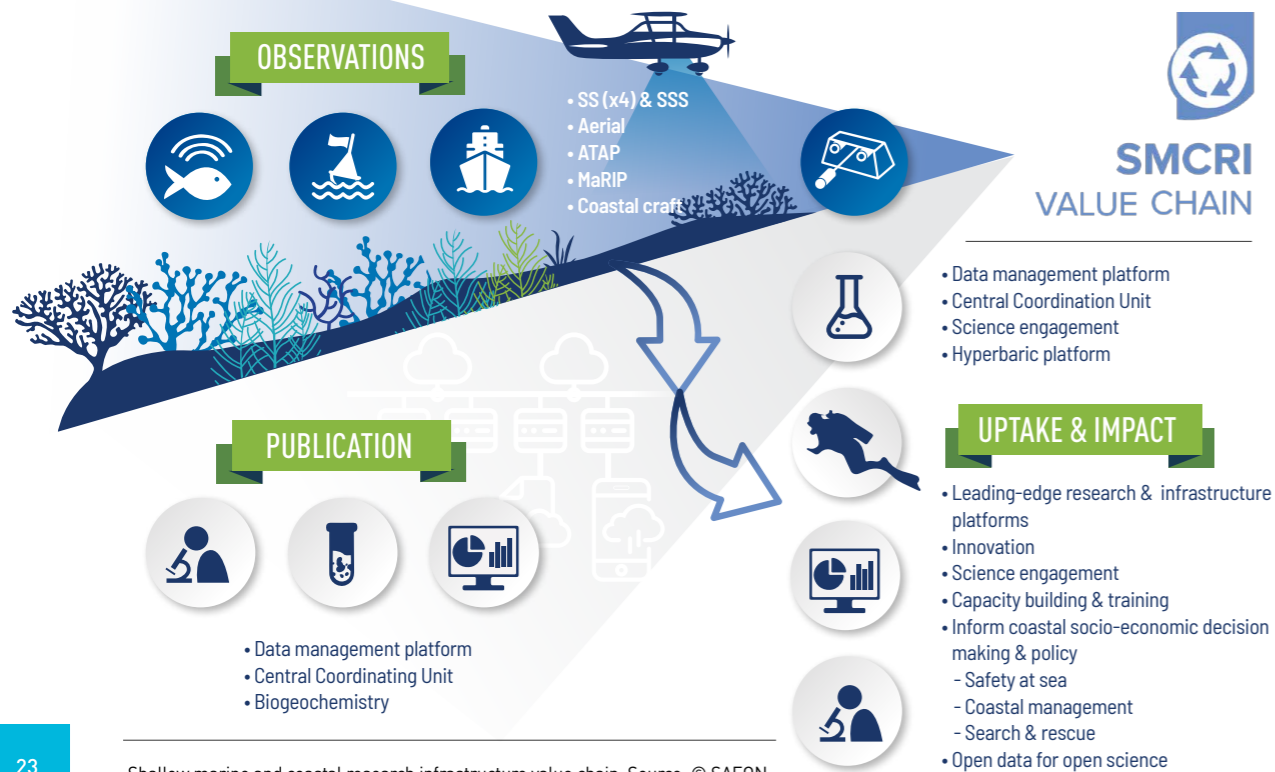
Shallow marine and coastal research infrastructure value chain. Source: © SAEON.

Case Study: Coastal hazards in the Republic of Benin

The West African coast is vulnerable to natural hazards and human interventions. Coastal erosion and other forms of damage to the coastal ecosystems are common occurrences. The low-lying coastal areas of the Republic of Benin, for example, reflect those of other West Africa countries that are particularly affected by erosion and flooding, often with alarming consequences (Croitoru et al., 2019).

In the Republic of Benin, research groups in oceanography and climate science are collaborating to help understand the climate impacts and scientific questions relating to shoreline evolution, coastal erosion trends, wave dynamics, sea level rise, drought, flooding, and modelling of oceanic and atmospheric parameters for past, present and future projections (see figure below).

Different scenarios of climate geoengineering are proposed, and their impacts are being investigated in the Republic of Benin (Yang et al. 2021). An alternative approach using nature-based solutions is recommended.

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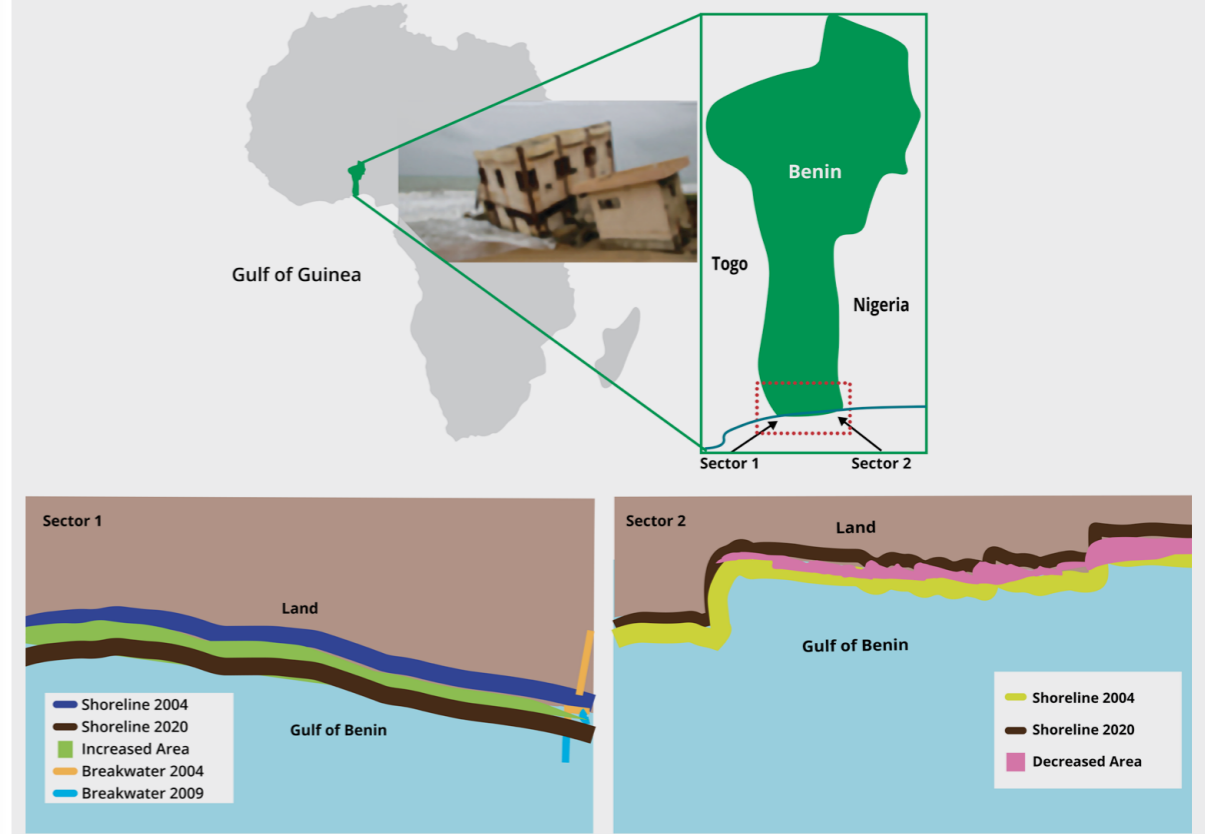
Coastal erosion along the shore of the Republic of Benin. Source: © Modified from Yang et al. (2021).

Recommendations

To unlock ocean-based solutions to climate change, the following are recommended:

- Intra/inter-regional collaboration to advance and harmonize capacities on modelling (meteorological, oceanographic, and climate processes at local and regional scales and for different time scales), including expertise and resources in terms of human capacity, infrastructure and strategies.

- Downscale global ocean models for African seas and sub-basins to simulate regional scale and shelf processes, assess impacts on marine ecosystems and their resources from regional to local scales in strengthening ocean monitoring and observation to better understand ocean dynamics.

- Improve regional and national climate forecasts on different time scales to ensure anticipation of hazards,

in order to minimize their impacts and provide reliable and updated information about ocean behaviour to develop efficient management strategies.

- Enhance responses to the potential impacts of climate change on the maritime sector by including climate change concerns into risk assessment and development of climate adaptation plans for ports.

- Increase awareness among sectoral decision-makers of the impact of climate variability and changes on marine ecosystems. Conduct environmental change scenarios of the impacts of future socio-economic development pathways, policy options, and exploitation on biodiversity and nature benefits.

SMCRI

- ▬ Sentinel Sites
- ◉ Satellite Sentinel Sites

Port Elizabeth = Central Coordinating Unit

- Coastal Biogeochemistry Platform
- Dive and Hyperbaric Chamber Platform
- Data Management Platform

Coastal Craft Platform
- Cape Town
- Port Elizabeth
- Durban

Science engagement platform
- Cape Town
- Port Elizabeth
- Durban

Entire coastline

- Aerial Surveillance Platform
- Acoustic Telemetry Array Platform
- Marine Remote Imagery Platform
- South African Coastal Temperature Network
- South African Estuaries LTER Platform

0 100 200 400 KILOMETERS

N W E S

NORTHERN CAPE

KWAZULU-NATAL
SODWANA
DURBAN
Natal Bight

West Coast

EASTERN CAPE
PORT ST JOHNS

WESTERN CAPE
PORT ELIZABETH

Two Oceans
CAPE TOWN

MOSSEL BAY

Algoa Bay

38°0'0"E
46°40'0"S

PRINCE EDWARD ISLAND
MARION ISLAND
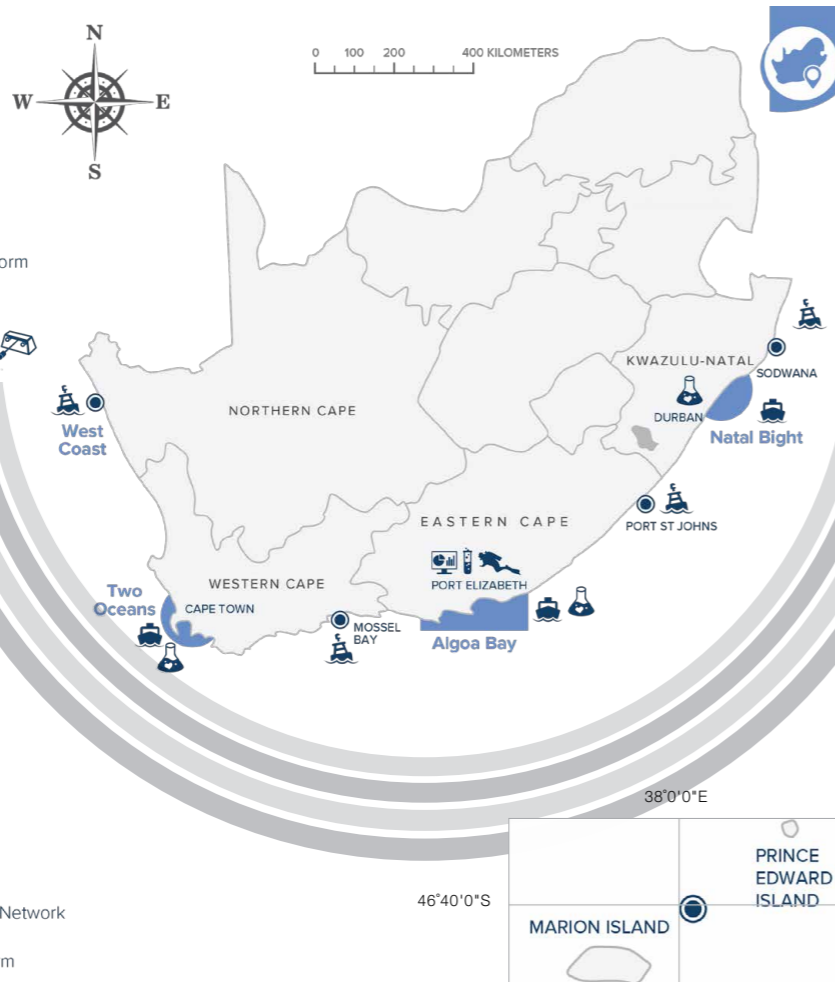
Increase community resilience to ocean hazards

Expand multi-hazard warning systems for all biological, geophysical and weather and climate-related ocean hazards, and mainstream community preparedness and resilience.

Mangrove mortality at the Buzi estuary shortly after Cyclone Idai, May 2019. Source: © National Institute of Disaster Management, Mozambique.

Africa is surrounded by three different oceans and extends into the subtropics in both the northern and southern hemispheres. This results in variable climate characteristics and an intricate connection between land, ocean and weather. The continent has experienced and continues to experience a variety of severe and frequent natural and manufactured hazards, such as droughts, floods, cyclones and ocean heat waves, all of which have significant economic and social consequences (Van Niekerk and Nemakonde, 2017).

The most hazard-prone regions of the continent are located in West Africa, the Horn of Africa and Southern Africa. The Republic of Mozambique, the Federal Democratic Republic of Ethiopia, the Republic of Ghana,

the Republic of Chad and the Republic of Sudan are the most hazard-prone countries. Together, these countries account for approximately one-third of total environmental fatalities and 40 percent of the total affected population (Mohammed and Rahman, 1998). The extreme events affecting Africa are linked to natural changes in the ocean, exacerbated by climate change.

These have far-reaching consequences for Africa, as a large proportion of its population lives in poverty and is extremely vulnerable. Because of Africa's low capacity to adapt to the effects of a changing climate, it is predicted that the effects of these stressors on the continent will worsen as climate change and global warming increase.

Several gaps in knowledge and ability that could improve community resilience to ocean hazards exist, including:

- A limited understanding of natural climate change in oceans surrounding Africa, as well as how this change and the resulting extreme events will be impacted by climate change (Otto et al., 2015). This is attributed to inadequate technical ability to develop methods for effective research in marine technology, as well as a limited ability to develop and deploy multi-hazard early warning systems (MHEWS).

- A lack in the generation, transmission and use of reliable in situ data necessary to model extreme events and their consequences.

- Limited research into the ability of natural barriers to mitigate natural extreme events.

- Under-utilized indigenous knowledge in disaster management and insufficient research on coastal vulnerability and community perceptions of risks.

- Insufficient mapping of highly vulnerable areas.

- A lack of communication and actions that communities can take.

- Limited understanding of the influences driving illegal maritime activities that affect security.

Case Study: Tropical cyclones Idai, Kenneth and Jobo in the Republic of Mozambique

Tropical cyclones Idai and Kenneth wreaked havoc on the Republic of Mozambique in the late austral summer 2019, marking the first time two tropical cyclones of intense status have hit the country in the same season.

Idai hit central Mozambique near Beira in March 2019. Storm surges caused chaos in the country's central coastal region, killing over 1 300 people and affecting over 3 million people directly. Idai was by far the most costly cyclone in the Southwest Indian Ocean, causing USD 2.2 billion worth of damage.

The storm surge reached around 4.5 m in height, and overall water levels were about 5.7 m above the mean sea level, according to a hydrodynamic circulation model for the Mozambique region. The storm surge was much higher than the region's 50-year return period (which is 3 m) for overall water levels, as predicted by the model (Hermes *et al.*, 2021).

Four weeks after cyclone Idai struck, cyclone Kenneth made landfall near the coastal city of Pemba, in the north. Following the crossing of an anticyclonic warm ocean eddy in the northern Mozambique Channel, with favourable ocean heat content, Kenneth intensified rapidly prior to impact. The cyclone would have intensified much more if a cyclonic (cool) eddy had not been present along the coast where the storm made landfall. Tropical cyclone Kenneth was the first storm to make landfall so far north in many years (previous ones being in 1872 and 1952).

In April 2021, tropical cyclone Jobo moved much further north in the Southwest Indian Ocean weakening to a tropical depression before making landfall in Dar es Salaam, with only minor effects. In the Southwest Indian Ocean, tropical cyclones with similar or higher strengths to Idai are becoming more common, which is in line with expected climate change.

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Aerial view of the damage caused by Cyclone Idai, Mozambique. Source: © National Institute of Disaster Management.

Locals stand beside a damaged section of the road between Beira and Chimoio in Nhamatanda district, central Mozambique, on March 19, 2019, after the area was hit by Cyclone Idai. Source: © National Institute of Disaster Management, Mozambique.

Recommendations

- Interventions are necessary to reduce risk, enhance the resilience of communities to coastal hazards and contribute to the achievement of the Sustainable Development Goals (SDGs). Based on the existing gaps, there is a need for the development of strong and reliable MHEWS and contingency plans to prevent loss and damage associated with extreme events.

- The inadequacy of models for predicting ocean hazards also necessitates the establishment of real-time monitoring systems, as well as the development of standard *in situ* methods of measuring data.

- Knowledge and mapping of the potential inundation zones, or the expected disaster events, are also needed to provide mitigation and adaptation advice to coastal areas at risk from coastal hazards.

- Encourage the governments of coastal African nations to participate in relevant ongoing global and regional initiatives (e.g., Tsunami Early Warning and Mitigation System in the Intergovernmental Coordination Group for the North-eastern Atlantic, the Mediterranean and connected seas – ICG/NEAMTWS).

- Indigenous knowledge accumulated over time makes it possible to assess climate change risks and vulnerabilities. Integration with scientific data will also improve the risk abatement efforts and ensure better knowledge sharing and cooperation among stakeholders.

- Implementing sustained observation systems in our oceans and coasts through a coordinated, collaborative and culturally appropriate process is also critical to achieving an improved understanding of extreme events and climate change impacts to meet identified local, national and regional needs (Foltz et al., 2019). In an effort to improve the applicability of MHEWS, indigenous early warning knowledge and practices need to be institutionalized through continuous research and education.

- There is also a need for advocacy to strengthen the region's capability to generate and integrate technical, indigenous and local knowledge and to make these accessible to stakeholders and decision-makers to support joint identification of and commitment to solutions.

- Communication with coastal communities has to be improved throughout Africa to ensure MHEWS adaptation and mitigation strategies are effective. The emphasis must be on developing common alerting protocols that spell out the actions that must be taken to ensure safety and community resilience.

- For a long-term sustainable MHEWS, strong political commitment and durable institutional capacity are required. These are dependent on public awareness and an appreciation of the benefits of effective warning systems.

- Enhance the maritime security unit within the African Union by adopting coordinated methods and approaches to establish a network dedicated to hazard science and policy in Africa.

Expand the Global Ocean Observing System

Develop a network of ocean observing systems and regional forecasting models for the entire African shelf region and create an operational platform to address natural ocean events monitoring, particularly, natural dynamics and anthropogenic modification.

Oceans and sea basins that bathe the 30 500 km of African coastlines.

Africa is a continent with about 30 500 km of coastline. The oceans and seas that surround the continent include the Indian, Southern and Atlantic Oceans, the Red Sea and the Mediterranean Sea. Hence, understanding and uniform investigation and observation processes are crucial to predict changes in the oceans surrounding Africa. Establishing these benchmarks can also present a significant challenge.

The Global Ocean Observing System (GOOS) is a system of organizations that provides a framework for the ocean observation activities of the world, and the organizations, programmes and projects that support them (Summerhayes, 2002). GOOS Africa incorporates 36 member states, and aims to facilitate:

- effective management of coastal environments, controlling pollution and safeguarding human health;
- support for the expanding economic activities in the coastal and offshore zones;

- protection of the growing coastal populations, especially in the great harbour cities of Africa;
- effective management of living marine resources; and.
- mitigation of natural disasters and extreme events, as well as the impacts of climate change.

In Africa, the ocean observation system has been developed from 1997 through various research projects, for example the Atlantic Ocean with Prediction and Research Moored Array in the Tropical Atlantic (PIRATA), and the Indian Ocean with the Research Moored Array for African-Asian-Australian Monsoon Analysis and Prediction (RAMA) that contribute to the global tropical moored buoy system.

The *Dr Fridtjof Nansen* is a research vessel that has been used most for ocean expeditions around African shelf regions, while the *SA Agulhas* was used to deployed two Argo Floats in 2009 in the Southern Ocean along the Good Hope line as part of the South African Argo Program. The challenge is to strengthen and improve the focus on user-driven data and reduce the risk of development of incompatible metadata and data formats that could lead to:

- poor data communication;
- lack of standardized policies linked to open access data;
- technical capacity and resource limitations; and
- lack of trust among networks and organizations preventing them from sharing data.

There is also a need to continuously give input to strengthen the proposed Regional Ocean Observing Framework System to better coordinate ocean observation and operational oceanography across African coastal nations.
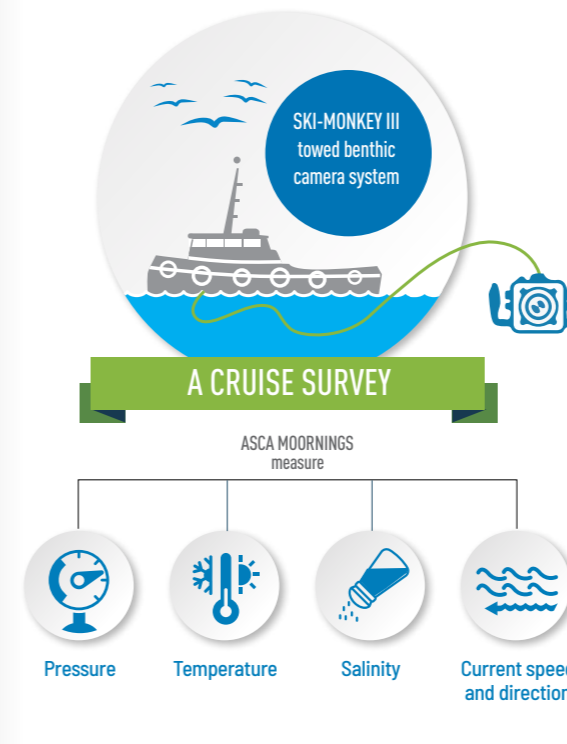
Parameters measured by a cruise survey (above), and tools and devices used to collect ocean data (right) by SAEON. Source: © SAEON Annual Report 2015/2016.

To effectively meet these challenges, the use of state-of-the-art equipment (e.g. South African Environmental Observation Network, SAEON) (see figure above) and the efficient and widespread sharing of information to save time, money and energy is essential.

Gaps in technology, funding, understanding, communication and governance

Several gaps exist that challenge the actions needed for success. These include:

- an inadequate monitoring system;
- the lack of long-term funding from stakeholders, governments and international collaborators;

- a lack of understanding of ocean regions and morphodynamics, and the interactions that exist within them;
- a lack of improved and sustainable ocean observation and coordination activities for accurate decision-making at the global scale;
- poor dissemination of information;
- the lack of personnel to manage observation system technologies;
- poor interpretation of modelling systems and programmes; and
- a lack of governance structures among networks from local and international scientific programmes.

Case Study: The Gulf of Guinea - a richness of resources for Africa and overseas

In West Africa, the Gulf of Guinea (GoG) represents an important fishery-rich resource, a hub of petroleum production and a hotspot of marine biological diversity. The countries that border the GoG depend on it as a principal source of livelihood for their inhabitants. In fact, all along the coast there are major human settlements, industries and harbours.

Despite this, since 1962 when the water column in the GoG was last studied, there remains poor understanding of the relationship between physical and biogeochemical processes, with little information available on subsurface waters from depths of 1 000 m and beyond.

The project on Acquisition of Oceanographic Data in the GoG involves five African institutions, from the Federal Republic of Nigeria, Republic of Benin, Republic of Togo, Republic of Ghana and Republic of Côte d'Ivoire, with the Federal Republic of Germany as the technical partners (Olubunmi *et al.*, 2020).

The project will collect data on seawater characteristics up to the 500 m isobath in the basins and initiate an oceanographic network and regional databank within the West Africa sub-region. In this way, the data acquisition will enhance collaboration with international projects in the region, with the establishment of long-term networks, as well as providing information for human and economic security.

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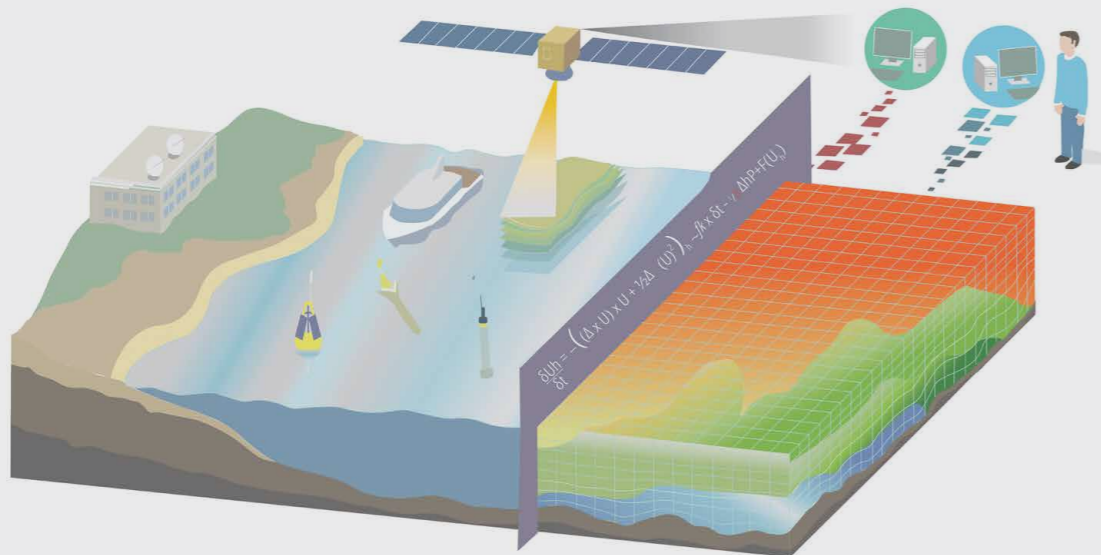
A general scheme of the architecture of the oceanic monitoring and forecasting system. Source: © ETOOFS (2021).

Recommendations

To assist in improving the understanding of, and developing uniform investigation and observation processes for the oceans surrounding Africa, the following are recommended:

- Develop a network of ocean observation systems and regional forecasting models of ocean circulation, to provide baseline information on the oceanographic, biogeochemical and ecological state, changes and trends of the large marine ecosystems.

- Develop operational platforms and a decision matrix to address natural ocean events.

- Establish an operational system of long-term coastal observations to provide information at key locations.

- Sustain existing observing systems (e.g. in the Mediterranean) to ensure systematic and continuous observations of oceanographic data.

- Develop autonomous ships and digital shipping (i.e. from sensors to big data analytics).

- Ensure that the entire African shelf region is routinely monitored (particularly the essential biodiversity variables and essential ocean variables) and that data is near real-time and accessible, and the bathymetry is mapped at high resolution. This should be complemented by autonomous monitoring (including pH through Biogeochemical Argo) being enhanced around Africa.

- Establish a regional calibration and instrument centre that could also develop local instruments.

- Track seafloor morphology in key areas characterized by particular natural dynamics (e.g. coastal erosion, deltaic deposits, mass transport sea-floor current activity, etc.) or anthropogenic modification (e.g. infrastructure, dredging and dumping).
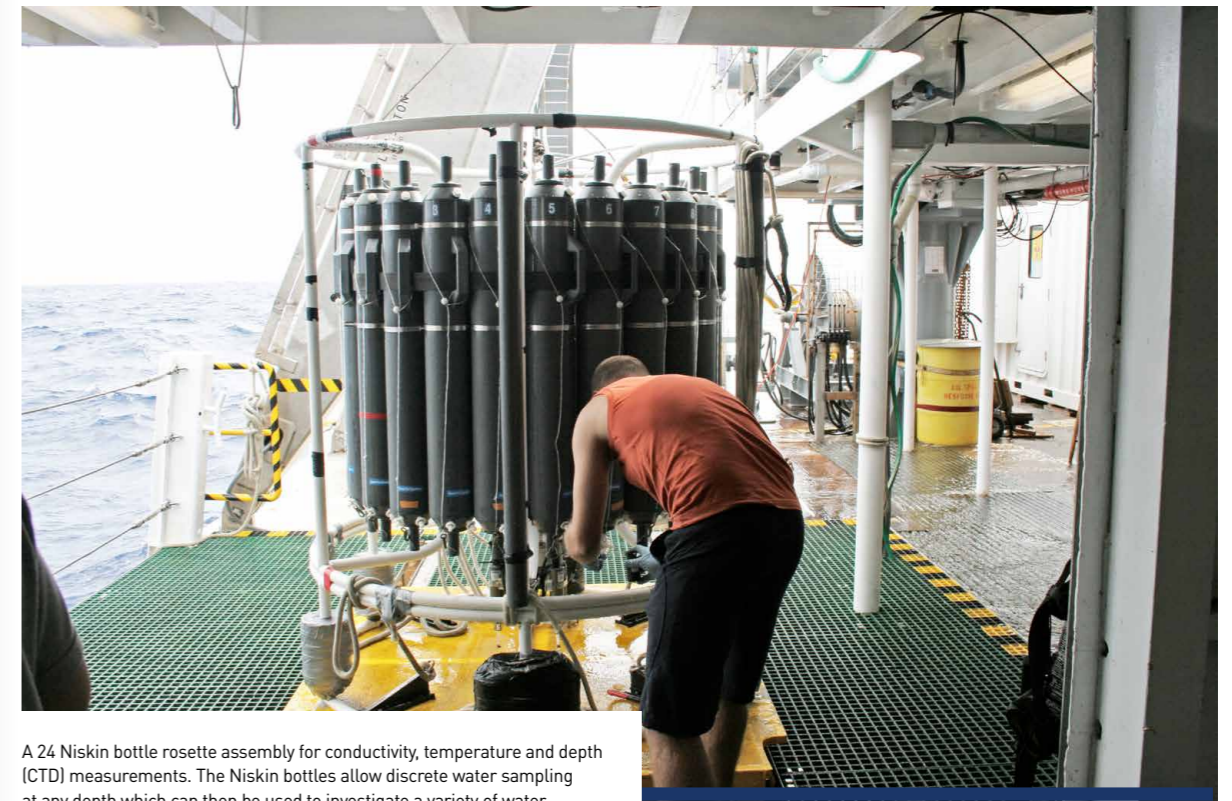
A 24 Niskin bottle rosette assembly for conductivity, temperature and depth (CTD) measurements. The Niskin bottles allow discrete water sampling at any depth which can then be used to investigate a variety of water properties including oxygen content. Source: © Juliet Hermes, SAEON.

Create a digital representation of the ocean

Through multi-stakeholder collaboration, develop a comprehensive digital representation of the ocean, including a dynamic ocean map, which provides free and open access for exploring, discovering and visualizing past, current and future ocean conditions in a manner relevant to diverse stakeholders.
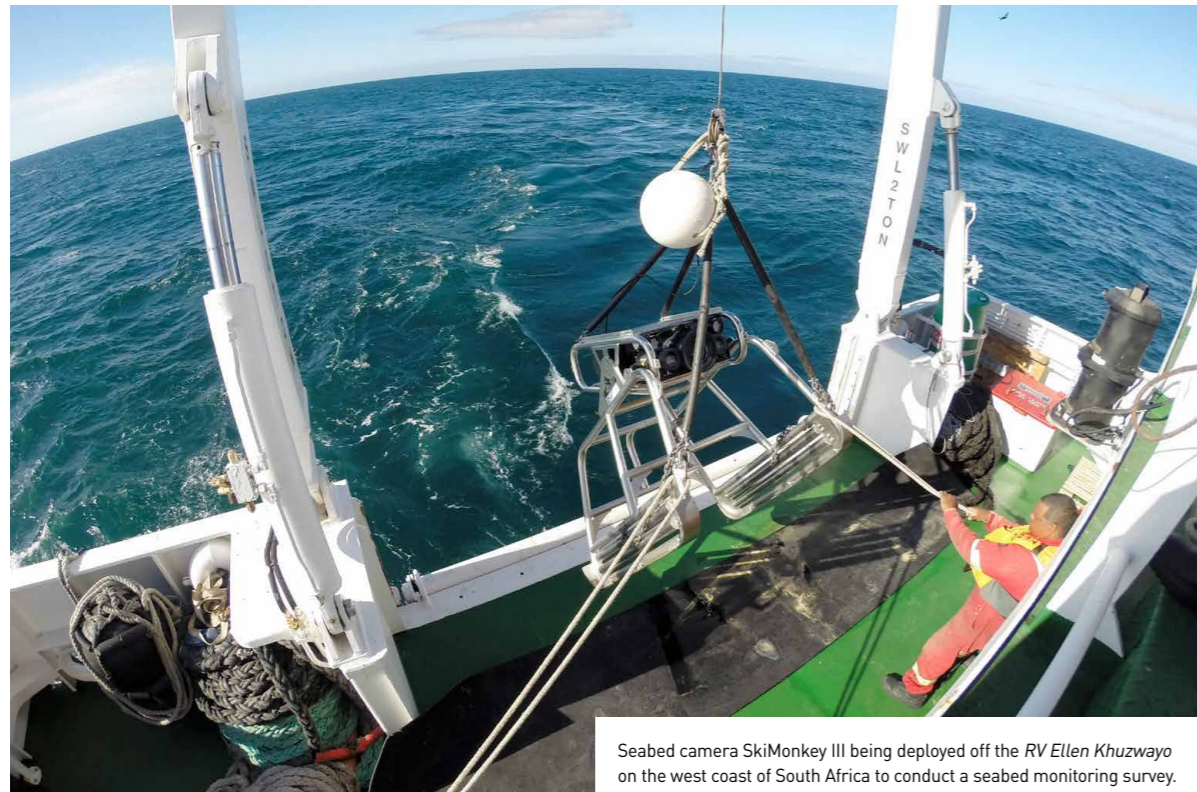
Seabed camera SkiMonkey III being deployed off the *RV Ellen Khuzwayo* on the west coast of South Africa to conduct a seabed monitoring survey. Source: © Juliet Hermes, SAEON.

Digital representation of the ocean describes, in pictures, ocean conditions, resources and processes (Sminov et al., 2011). Collecting all the data needed for this digital representation are a constellation of satellites orbiting the earth, several research vessels, thousands of buoys and underwater robots exploring the oceans. These systems have been around for more than 30 years and some of them are generating data in near-real time, daily, at eight-day periods, monthly and annually. Nowadays, there are massive amounts of ocean data available at a global scale. Several applications are being developed using sophisticated technology, in combination with big data and artificial intelligence, and transformed into a clear picture of ocean conditions in the past, present and future. These systems can assist with environmental and natural resources monitoring, conservation policies, fisheries and aquaculture, marine navigation and safety and disaster responses.

Case Study: Monitoring sea level rise from space

Since 1992, sea level rise has been measured from space by altimetry. Satellite altimetry is a technique comprising an orbiting spacecraft carrying a radar altimeter that takes accurate measurements of the height of the ocean. The radar sends thousands of pulses off the sea surface. By measuring the time it takes for the radar pulse to make a round-trip from the satellite to the sea surface and back, scientists can calculate the height of the ocean surface across the globe. The data these satellites measure cover the entire globe and are stored in online servers, which are usually freely accessible to the public from anywhere in the world.

Sea-level monitoring, sustained over several decades, enables the prediction of the probability of both extreme tides and storm surges. In this instance, developing countries in the Southwest Indian Ocean (SWIO) are particularly vulnerable to sea-level extremes, due to intense annual tropical cyclone activity from October to March. In particular, the Republic of Madagascar often experiences multiple tropical cyclones each year, with an average annual direct loss of USD 87 million (GFDRR, 2017). For the Republic of Madagascar, numerical predictions show that: the average intensity of tropical cyclones will increase with rising mean sea levels and contribute to higher extreme sea levels associated with tropical cyclones; which will exacerbate coastal hazards in the coming years (IPCC, 2019).

Analysis of sea level data from the Climate Risk in the Seacoast (C-RiSe) project has indicated that sea level in the SWIO is rising up to 6 mm a year, almost twice the rate of the global average. A millimetre may sound small, but over time these numbers start to add up. At the current rate of sea level rise, assuming no further acceleration from melting ice caps and continued warming of the oceans, the average global sea level in 50 years from now will be more than 15.25 cm (half a foot) higher than it is today (NESDIS, 2019).

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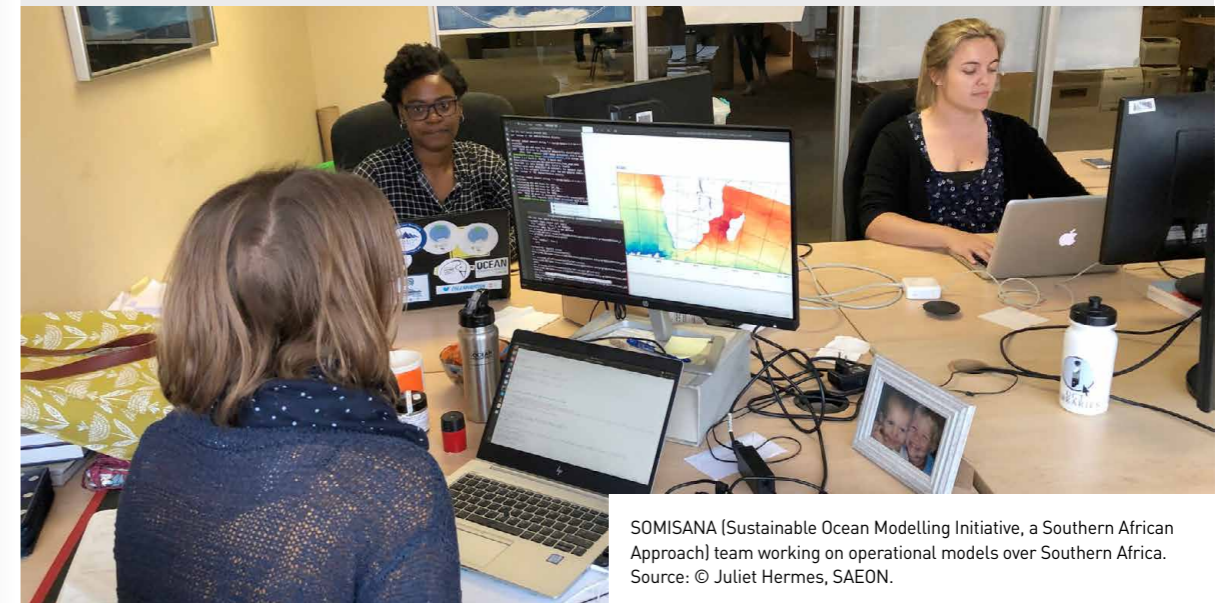
SOMISANA (Sustainable Ocean Modelling Initiative, a Southern African Approach) team working on operational models over Southern Africa. Source: © Juliet Hermes, SAEON.

Recommendations

- Long-term ocean observations to develop regional ocean models to run operational marine forecasts and develop public interest services.

- Provide training on data collection, analysis, and interpretation.

- Develop skills and knowledge in programming and software development to analyse different environmental datasets, for seabed mapping / marine ecosystem mapping.

- Create accessible data sharing platforms, adaptation of technologies, facilities and infrastructure within Africa e.g. GEBCO envisages the training of executives for updating the bathymetry of the seabed.

How marine management and governance challenges in the East African region are supported by interdisciplinary research efforts utilizing advanced observing technologies. Source: © SOLTICE-WIO project.

Provide skills, knowledge and technology for all

Ensure comprehensive capacity development and equitable access to data, information, knowledge and technology across all aspects of ocean science and for all stakeholders.

Thomas Mtontsi, science engagement officer at SAEON and students with bongo nets onboard the *SA Agulhas II*. Source: © Juliet Hermes, SAEON.

Africa is a young continent with more than 60 percent of the population below 30 years of age (UN-DESA, 2019). The demographic dividend represents a huge resource in the revolution for transformative ocean science. Developing technological literacy is critical to harness the potential of the next generation of ocean scientists and policymakers. Technical skills and knowledge-driven programmes are needed to empower the population to use technology to understand, communicate and respond to changing ocean conditions. African countries have invested significantly in ocean sciences (UNESCO, 2017; IOC-UNESCO, 2020). However, despite a significant growth in ocean science publications and prototypes from African countries over recent decades, there remains much to be done to boost Africa's contribution to global scientific endeavour, discovery and innovation.

Gaps in data prevent African countries from finding solutions and developing new technological knowledge

Ocean dependency needs to be empowered with the knowledge and capacity to collect, understand, observe and manage data in Africa. Yet, access to ocean science skills and tools remains unequally distributed across gender, geography and generations. Existing data gaps prevent African countries from finding solutions and developing new technological knowledge, which includes data literacy, programming and modelling. Other challenges include access to data from the oil and gas industry, data collection, quality and management, lack of methodologies to integrate data from local and indigenous knowledge, and weak data policies related to data sharing and use of data repositories. Africa needs to grow more skills to lead and participate in technology and infrastructure development to promote technological advancement and cooperation and peer-to-peer exchange between stakeholders, to encourage and explore opportunities in marine technology and data sharing platforms, linking technology resources with diverse users.

Participants on a rocky shore in Inhaca, Mozambique, during an advanced course on scientific tools for coastal biodiversity assessment.
Source: © José Paula.

Case Study: Water accounting in the Nile River Basin

The Nile River spans 6 695 km across the African continent (see figure below) and provides ecosystem services to between 257 million to 487 million people. Water security is critical across these African countries, with high rates of population growth expected in the next two decades (UN-DESA, 2019). The Water Accounting Plus (WA+) open access data system developed by the International Institute for Hydraulic and Environmental Engineering (IHE) Delft and the Food and Agriculture Organization of the United Nations (FAO) focuses on basin-wide analyses using standardized water collection sheets, earth observation data and open-access databases from 2009 to 2018 (WaPOR v2.0 data – the FAO portal to monitor Water Productivity through Open access of Remotely sensed derived data). The WaPOR v2.0 data has played a central role in supporting nations with data and technology applications, providing access to data for users across all 11 countries.

WaPOR v2.0 data functions as a framework and a storage facility that provides data security, reducing retrieval costs and end-user productivity. The database enables users with user query languages and allows for better decision-making forecasts. This system provides information about the countries' agricultural activities, expenses and income, and gives them access to summary analyses of their monthly activities. The benefits of data sharing and the use of technology ensures equitable access to data that contribute to the sustainable development of country resources across geographies and gender.

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FAO and IHE Delft. 2020. Water accounting in the Nile River Basin. FAO WaPOR water accounting reports. Rome. www.fao.org/3/ca9895en/ca9895en.pdf

	Nile River Basin
	Major Lakes
	Major Rivers
	Country Boundaries
	Major sub-Basins
	Bahr el Ghazal
	Bahr el Jebel
	Baro Akobo Sobat
	Blue Nile
	Lake Albert
	Lake Victoria
	Main Nile
	Tekeze Atbara
	Victoria Nile
	White Nile
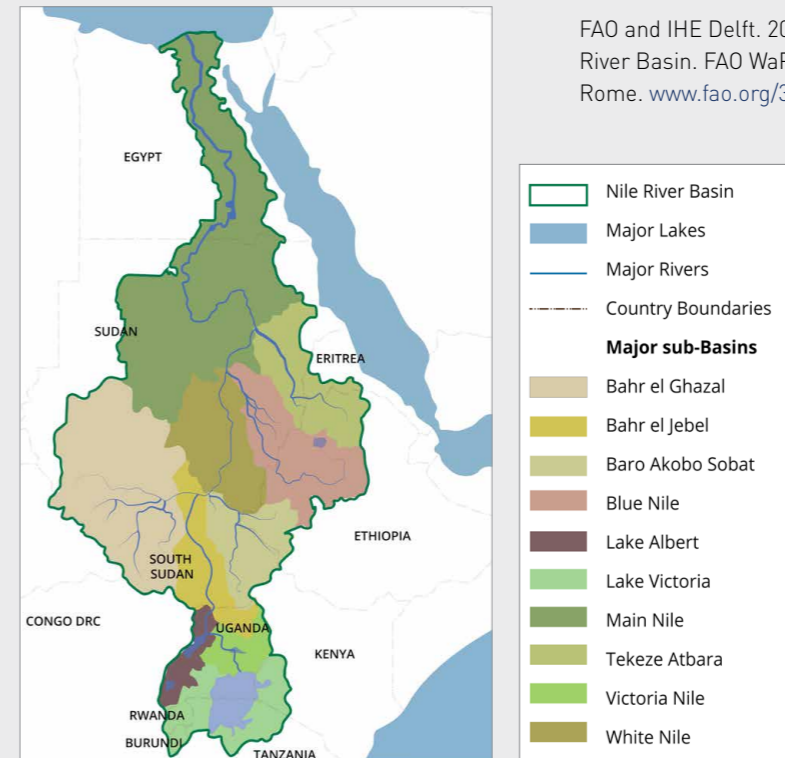
Map showing water accounting and land cover areas along the Nile River Basin Countries. Source © Modified from FAO and IHE (2020). Delft (2020).

Recommendations

- Build network capacity and competency within the region and develop regional platforms and programmes that promote knowledge sharing, including sharing of models, publications and research outputs.

- Establish state-of-the-art regional research facilities across a coordinated network of research institutes, universities, observatories, associations and businesses to define standard protocols for monitoring and protecting species, habitats and ecosystems.

- Pursue marine open data approach to boost advancement in scientific innovation that will provide

standardized training on data collection, digitizing, accessing, storage, managing, analysis and interpretation to facilitate data sharing and uptake/ease of use.

- Promote transparency and accessibility to improve communication of reliable research data provided by private companies and institutes in order to make it accessible to end-users – governments, policymakers, and the public. This requires establishment of an institutional framework to bridge science and policy and facilitate uptake of data and models by decision-makers.
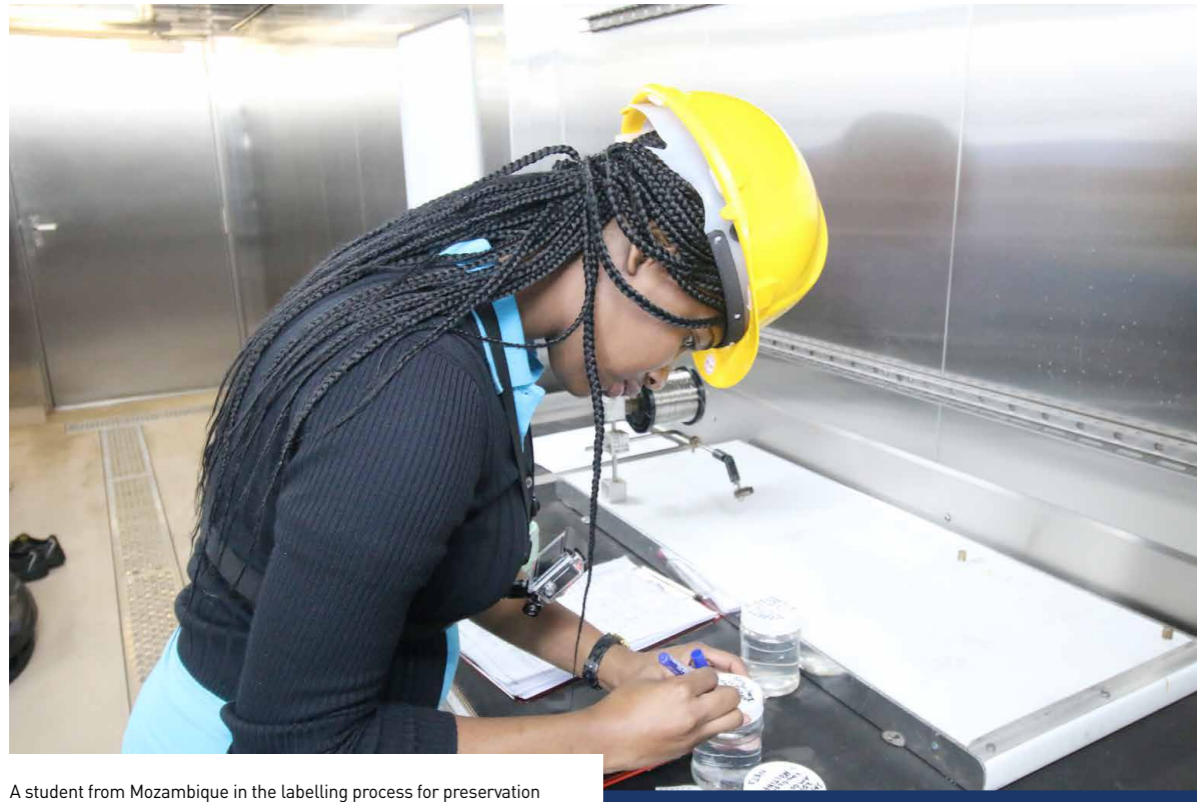
A student from Mozambique in the labelling process for preservation of zooplankton samples collected in the Sofala Bank, on the International Indian Ocean Expedition 2 (IIOE-2). Source: © Paul Sigutya.

Change humanity's relationship with the ocean

Ensure that the multiple values and services of the ocean for human well-being, culture, and sustainable development are widely understood, and identify and overcome barriers to behaviour change required for a steep change in humanity's relationship with the ocean.

Survey for benthic organisms being carried out by students in the intertidal zone of Mauritius. Source: © Deepeeka Kaullysing.

In Africa, most of us live our lives unaware of how our day-to-day actions affect the health and sustainability of the ocean and the many resources on which we depend. Nor do the majority of us recognize how the health of the ocean affects our daily lives. Most people are not aware of the full extent of the medical, economic, social, political and environmental importance of the ocean and seas. However, what some scholars have called "ocean blindness" can be countered by improving access to accurate and compelling ocean education that strengthens the learner's connection with the ocean (Santoro *et al.*, 2017). This is the essence of ocean literacy: an understanding of the ocean's influence on us and our influence on the ocean. Recognizing the lack of ocean-related subjects in formal education, in 2002 a group of ocean scientists and education professionals in the United States of America initiated a collaborative and bottom-up process to develop a comprehensive framework to encourage the inclusion of ocean sciences into national and state standards, and for more teaching about the ocean in K–12 classrooms (from kindergarten to 12th grade). This was the start of the ocean literacy movement

that since then has spread around the world through the development of marine science educator's associations in Canada, the Commonwealth of Australia, Europe and Asia. One focus of the United Nations Decade of Ocean Science for Sustainable Development (2021–2030) is to develop a global partnership to raise awareness on the conservation, restoration and sustainable use of our ocean and its resources and to build an improved public knowledge base across the world's population regarding our global ocean. An equally transformational part of the Decade is about us and our relationship with the ocean. An understanding of the value of the ocean can be nurtured through ocean literacy efforts targeted at diverse stakeholder groups in Africa through focused ocean literacy programmes, supportive skills development and mentoring to better equip beneficiaries to access the job market, and creating new opportunities for employment (Santoro *et al.*, 2017). This will facilitate the unlocking of scientific excellence and the creation of a new generation of ocean experts in Africa.

Case Study: National Blue Schools Network in Namibia

The Blue Schools Network was started in 2021 and is Namibia's answer to promote a project and problem-based approach in schools, with a stronger emphasis on interdisciplinarity and on developing students' critical thinking, behaviour and action towards the ocean. It is also an opportunity to promote and articulate the educational offer of different entities, allowing them to participate in a single and coordinated ocean literacy strategy for schools. The All-Atlantic Blue Schools Network distinguishes the schools working on ocean literacy, certifying them as able to offer an ocean curriculum to their communities.

Initially, the network is open to schools in the two coastal regions of Namibia, namely Erongo and Karas (All-Atlantic Blue Schools, 2021). In the Erongo region, the network will cover towns like Hentiesbay (the head office of BlueGrowth Namibia), Swakopmund and Walvis Bay, while in the Karas region, the network covers towns like Lüderitz and Oranjemund. The only non-coastal school involved in the network in the initial stages is the Hage Geingob High School in Windhoek, which already has a functional Blue Economy School Club. In so far as the provision of knowledge, skills and attitudes related to the ocean space is concerned, the network covers the vital space between the efforts of the University of Namibia, the ministry of Fisheries and Marine Resources and the Benguela Current Commission to bring about much-needed ocean awareness and ocean literacy in the selected Namibian schools (All-Atlantic Blue Schools, 2021).

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Pupils from Hage Geingob Blue School, learning conservation values on keeping the ocean clean and plastic free. Source: © Hage Geingob Blue School, Windhoek, Namibia.

Recommendations

- Promote ocean literacy and participatory research; improve connection and collaboration with existing networks that are working on science communication and outreach, and harmonize among the riparian countries.

- Engage and motivate the youth to appreciate the ocean and acknowledge countries' cultural backgrounds, identifying gaps (e.g., empathy, adaptive capacity and resilience) to improve ocean literacy models to support marine policy outcomes and deliver societal benefits.

- Develop, improve and provide user-friendly tools for the dissemination of climate and ocean information models.

- Improve the understanding of the future links between the economy and societal needs by ensuring the complete openness of scientific knowledge and support the formulation of environmental policy and management plans.

The Locally Empowered Area Protection (LEAP) Junior club, Seychelles seeks to educate students about the ocean, related seascapes and biodiversity, Mahe Seychelles. Source: © Nature Seychelles.

A Call to Action

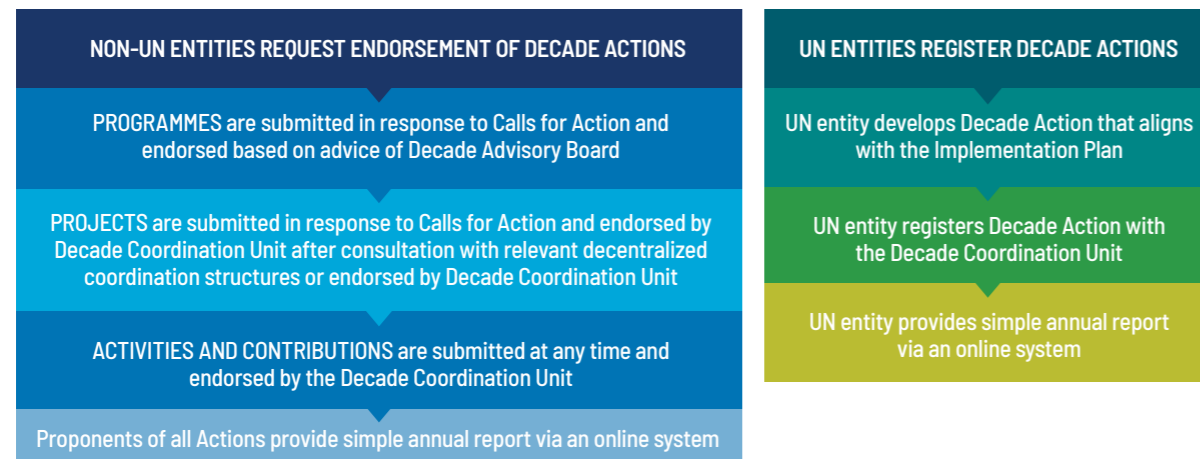## Decade action hierarchy and endorsement process

Decade Actions (programmes, projects, activities and contributions) are the tangible initiatives that are being carried out across the globe over the next ten years to fulfil the Decade vision. Decade Actions are proposed and carried out by a wide range of proponents including, but not limited to, research institutes, governments, United Nations entities, intergovernmental organizations, other international and regional organizations, business and industry, philanthropic and corporate foundations, non-governmental organizations, educators, community groups, or individuals. Requests for endorsement of Decade Actions at the programme and project level are done through periodic Calls for Actions. The Calls target priority geographic areas or themes linked to the Ocean Decade Challenges and are launched online twice per year by the Decade Coordination Unit.

Different levels of Decade Actions that will be implemented, including programmes, projects, activities, and/or contributions, are as follows:

- **A Decade programme** is typically global or regional in scale and will contribute to the achievement of one or more of the Ocean Decade Challenges. It is long-term (multi-year), interdisciplinary and will consist of component projects, and potentially enabling activities.

- **A Decade project** is a discrete and focused undertaking. It may be regional, national or sub-national and it will typically contribute to an identified Decade programme.

- **A Decade activity** is a one-off stand-alone initiative (such as an awareness-raising event, a scientific workshop, or a training opportunity). It will enable a programme or project or directly contribute to an Ocean Decade Challenge.

- **A Decade contribution** supports the Decade through provision of a necessary resource (e.g. funding or an in-kind contribution). A contribution can support either the implementation of a Decade Action or the coordination costs of the Decade.

- **Decade Actions** will include both initiatives to generate and use data and knowledge, and initiatives to create a robust enabling environment for ocean science including capacity development, ocean literacy, and data and knowledge management initiatives.

United Nations entities proposing to carry out Decade Actions will register their Action at any time via the Decade website. Non-UN entities proposing to carry out Decade Actions will request endorsement of their proposed Decade Actions through the process illustrated and described below.

NON-UN ENTITIES REQUEST ENDORSEMENT OF DECADE ACTIONS
PROGRAMMES are submitted in response to Calls for Action and endorsed based on advice of Decade Advisory Board
PROJECTS are submitted in response to Calls for Action and endorsed by Decade Coordination Unit after consultation with relevant decentralized coordination structures or endorsed by Decade Coordination Unit
ACTIVITIES AND CONTRIBUTIONS are submitted at any time and endorsed by the Decade Coordination Unit
Proponents of all Actions provide simple annual report via an online system

UN ENTITIES REGISTER DECADE ACTIONS
UN entity develops Decade Action that aligns with the Implementation Plan
UN entity registers Decade Action with the Decade Coordination Unit
UN entity provides simple annual report via an online system

Detailed endorsement process

When requesting endorsement, or registering their Actions, proponents will provide information on how they meet the criteria below. The criteria are not weighted and proponents need to demonstrate alignment with those criteria that are relevant to their proposed actions:

- Contribute to fulfilling the Ocean Decade Challenges and to achieving the Decade objectives and the associated sub-objectives (Read the Ocean Decade Implementation Plan: https://www.oceandecade.org/wp-content/uploads/2021/09/337521-Ocean%20Decade%20 Implementation%20Plan:%20Summary

- Accelerate the generation or use of knowledge and understanding of the ocean, with a specific focus on knowledge that will contribute to the achievement of the SDGs and complementary policy frameworks and initiatives.

- Allow Decade Actions to be co-designed or co-delivered by knowledge generators and users, and thus facilitate the uptake of science and ocean knowledge for policy, decision-making, management and/or innovation.

- Ensure that all data and resulting knowledge are provided in an open access, shared, discoverable manner in accordance with the provisions of United Nations Convention on the Law of the Sea (UNCLOS), and are appropriately deposited in recognized data repositories consistent with the IOC Oceanographic Data Exchange Policy 10 or the relevant UN subordinate body data policy.

- Strengthen existing or create new partnerships across nations and/or between diverse ocean actors, including users of ocean science.

- Contribute towards capacity development, including, but not limited to beneficiaries in small island developing states, least developed countries and landlocked developing countries.

- Overcome barriers to diversity and equity, including gender, generational and geographic diversity.

- Collaborate with and engage local and indigenous knowledge holders.

Additional criteria may be developed for specific Calls for Actions to meet geographic or thematic priorities for example, for Calls for Action for data, information or knowledge management products.

Endorsed Ocean Decade actions in Africa

The map below shows the eleven Decade Actions endorsed in Africa between the start of the Ocean Decade and March 2022. A total of 13 countries are going to be involved in Ocean Decade Actions. For further details on the African actions see the Appendix.

Number of Decade Projects resulting from the first Call for Decade Actions (No. 01/2020) led by African organizations.

Enhancement of hydrographic and oceanographic observations
National Commission for Education, Sciences and Culture - Kingdom of Morocco (MarocNatCom)
Morocco

Institutional capacity building towards the sustainability of ocean science in light of COVID-19 pandemic
Nipe Fagio
United Republic of Tanzania

Ocean Literacy Educational Program
Ministry of Maritime Economy
Cabo Verde

Low cost real-time monitoring of pollutants and water quality along the coral reefs in Tanzania
Aqua Farms Organization
United Republic of Tanzania

West African Science Service Centre on Climate Change and Adapted Land Use
Atlantic Technical University
Cabo Verde

Protecting the estuaries of WIO region
School of Aquatic Sciences and Fisheries Technology
United Republic of Tanzania

African Youths Sustainable Ocean Campaign
Federal University of Technology Owerri
Nigeria

Sustainable Ocean Management Education Programme
Ministry of Fisheries and Blue Economy
Seychelles

Fenoy-X
WIO Early Career Scientists Network
South Africa

Enhancing ocean observing system within The Republic of Mauritius
Mauritius Meteorological Services
Mauritius

Number of projects

● 1   ● 2   ● 3

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Coordination mechanisms

Decade Actions contributing to the Decade vision will be proposed and undertaken by national, subnational and local governments and a wide range of stakeholders, including research institutes, United Nations entities, intergovernmental organizations, business and industry, philanthropic and corporate foundations, NGOs, educators, community groups, or individuals. Therefore, governance and coordination arrangements for the Decade need to be flexible, agile, facilitate collaboration across groups of actors, and optimize the use of existing structures wherever possible.

The Decade is an UN-wide initiative endorsed by the UN General Assembly (UNGA). UNGA Resolutions 72/73 and 74/19 (A/RES/72/73 and A/RES/74/19) invite the S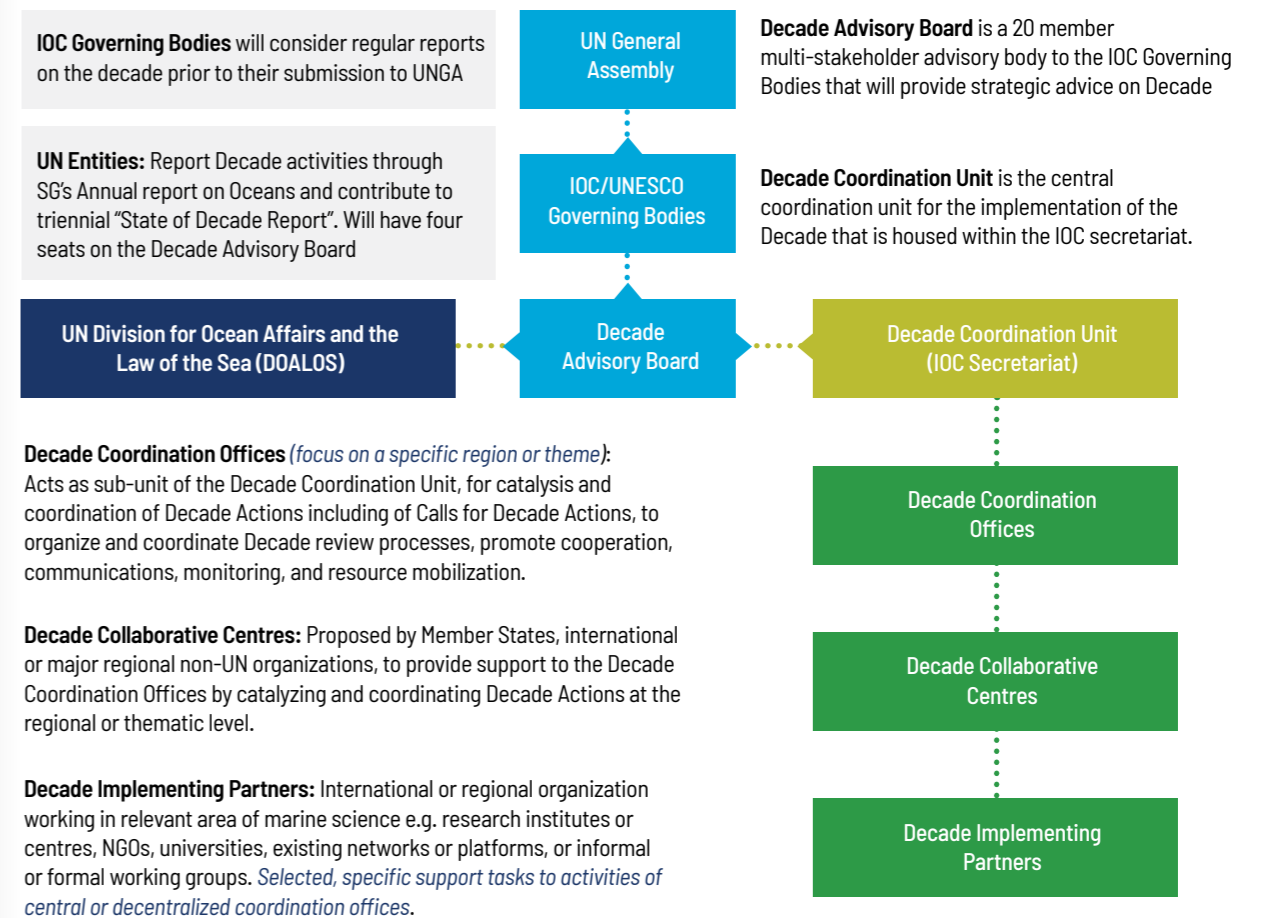ecretary General (SG) to inform the UNGA of the implementation of the Decade, based on information to be provided by the IOC. In accordance with the UNGA Resolutions, IOC will regularly consult with, and report to, United Nations Member States on the Decade and its implementation.

IOC Governing Bodies will consider regular reports on the decade prior to their submission to UNGA

UN Entities: Report Decade activities through SG's Annual report on Oceans and contribute to triennial "State of Decade Report". Will have four seats on the Decade Advisory Board

UN General Assembly

IOC/UNESCO Governing Bodies

UN Division for Ocean Affairs and the Law of the Sea (DOALOS)

Decade Advisory Board

Decade Coordination Unit (IOC Secretariat)

Decade Coordination Offices

Decade Collaborative Centres

Decade Implementing Partners

Decade Advisory Board is a 20 member multi-stakeholder advisory body to the IOC Governing Bodies that will provide strategic advice on Decade

Decade Coordination Unit is the central coordination unit for the implementation of the Decade that is housed within the IOC secretariat.

Decade Coordination Offices *(focus on a specific region or theme)*: Acts as sub-unit of the Decade Coordination Unit, for catalysis and coordination of Decade Actions including of Calls for Decade Actions, to organize and coordinate Decade review processes, promote cooperation, communications, monitoring, and resource mobilization.

Decade Collaborative Centres: Proposed by Member States, international or major regional non-UN organizations, to provide support to the Decade Coordination Offices by catalyzing and coordinating Decade Actions at the regional or thematic level.

Decade Implementing Partners: International or regional organization working in relevant area of marine science e.g. research institutes or centres, NGOs, universities, existing networks or platforms, or informal or formal working groups. *Selected, specific support tasks to activities of central or decentralized coordination offices*.

National Decade Committees

The creation of National Decade Committees will be encouraged to facilitate national contributions to the Decade, engage national stakeholders, and enhance their access to Decade benefits such as data, forecasts, science-based decision support tools, or capacity development opportunities. The National Decade Committees should be multi-agency and multi-stakeholder platforms, involving the political and scientific institutions and actors concerned with the ocean and its management. Existing national coordinating mechanisms may provide the basis for performing such functions. The mandate and role of National Decade Committees will be tailored to the local context but could:

- Act as an information conduit from the Decade structure to the national science and sustainable development community.

- Provide national inputs for the formulation of Decade Actions, including the facilitation of co-design initiatives across groups of stakeholders and/or nations.

- Facilitate the planning and implementation of national priorities and activities, including the development of national Decade programmes or projects that can be endorsed as Decade Actions

- Implement or coordinate national outreach and communications activities in line with the guidance on branding and messaging provided by the Decade Coordination Unit.

- Ensure that outputs of activities implemented under the Decade are available to the community.

- Encourage and facilitate the provision of necessary national funds and logistical support for the implementation of activities contributing to the Decade.

- Encourage voluntary national contributions to the costs of international coordination.

- Assist the Decade coordination structures in planning, implementation and delivery of activities at the national level.

- Provide annual reporting to the Decade Coordination Unit on the Committee's activities.

- Facilitate hosting of regional or international meetings related to the Decade.

Ocean Decade Alliance

The Ocean Decade Alliance is a key component of the resource mobilization efforts for the Decade, focusing on significant voluntary resource commitments. The Alliance is not a funding or grant making facility; rather, it is an engagement platform to connect large-scale resource providers with proponents of Decade Actions. The Alliance will provide a mechanism to organize members' commitments and resources via a "virtual resource pool" into which members of the Alliance could commit in-kind or financial resources to implement priority Decade Actions. Alliance members would include governments, industry, civil society, scientific institutions, philanthropic organizations and United Nations entities.

Membership of the Alliance would initially be for a period of three years that would be renewable based on the continuing commitments. Different levels of membership will be available depending on the scale of resources committed to the Alliance.

Early Career Ocean Professionals in the Ocean Decade

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How Early Career Ocean Professionals can contribute to achieve the decade challenges listed in this booklet and their role in the UN Decade of ocean sciences

Early career ocean professionals during an outreach event to strengthen their capacity and build networks in the WIO region. Source: © WIO-ECSN Zanzibar, Tanzania.

The UN Ocean Decade endorsed the Early Career Ocean Professionals (ECOPS) programme to strengthen networking and professional development opportunities with local to global institutions through the framework of the UN Ocean Decade. In Africa, early career networks assist with capacity development and promote ocean knowledge and human skills development. The diversity of African nations and their inhabitants form the cornerstone in opportunities for networking and support for this collaboration.

Early career networks will aim to foster collaboration and strengthen regional ties through coordinated efforts and various platforms. To meet ECOPs' aims, the programmes need to ensure that the benefits of networking include capacity building to address research gaps and sustainable resources utilization. They also need to address the diverse concerns of early career researchers through co-designing with partners and encouraging networking across the African continent.

How African ECOPs will achieve their goals

African ECOPs need to be equipped with skills, capacity building and better facilities to help them take action for the ocean challenges. African ECOPs need to recognize the difference between the Ocean Decade challenges from one region/country to another and be given a chance for their voices and actions to be heard as they face the challenges in their own localities. In this way, African ECOPs can implement the science required for studying and preserving the ocean in all African areas and finally build a collective and ambitious impact by 2030.

WIO-ECSN officials with IOC UNESCO personnel Vladimir Ryabinin (IOC UNESCO Secretary General), Hellen Gichuhi (Kenya's Deputy Permanent Delegate to IOC UNESCO) Mika Odido, (IOC Coordinator, Africa) at the African Conference on Priority Setting and Partnership Development for the UN Decade of Ocean Science for Sustainable Development Cairo, Egypt. Source: © Alessia Dinoi.
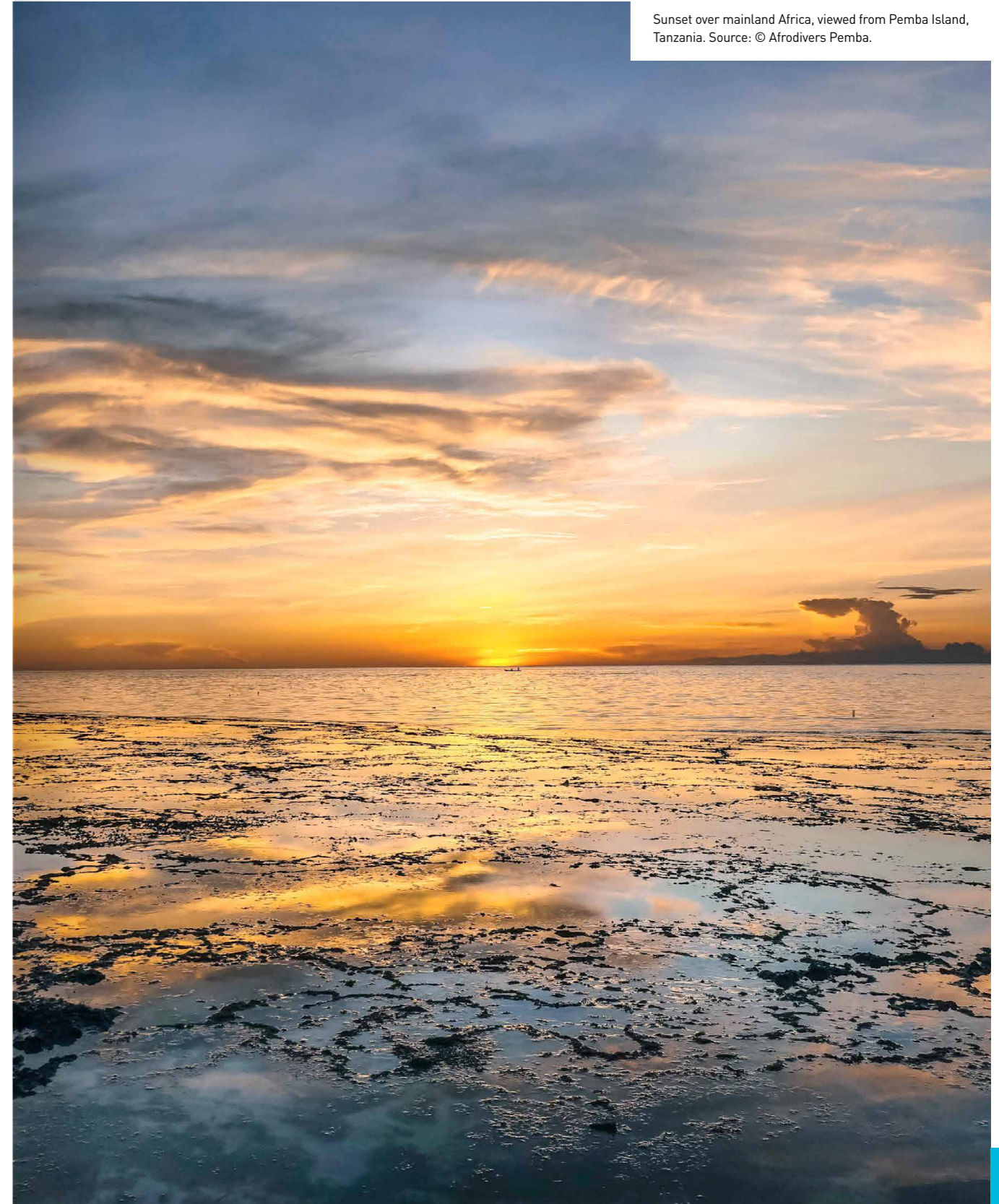

Achieving the 2030 Agenda

In summary, over the past decade, early career networks in Africa have demonstrated their involvement with ocean-related programmes and projects and have contributed to human development and the protection, sustainable use and health of our oceans. The African UN Decade presents a period for young scientists to connect and contribute to the UN Decade challenges outlined in this booklet. This provides an opportunity for creativity and innovative research, citizen science projects and goals that could be achieved by young Africans for Africa. Capacity building through workshops, training and events should be the core business and focus of many young people across Africa in order to achieve the UN theory of change[1] by 2030. Partnership is crucial for a causal effect to achieve the ocean we want. It's up to the youth of today to champion initiatives. With its young population, Africa has the time and skills across disciplines to tackle and engage with the ten UN Decade challenges that aim to provide evidence of change, with realistic goals for the next generation of ECOPs.

Sunset over mainland Africa, viewed from Pemba Island, Tanzania. Source: © Afrodivers Pemba.

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[1] A theory of change is a method that employs a causal analysis based on existing data to explain how a given intervention is likely to result in a specific development change. This theory must be supported by sound analyses, consultation with key stakeholders, and learning from the United Nations Development Assistance Framework and its partners' experiences on what works and what doesn't in different situations. As a result, it will aid in identifying solutions to effectively address the root causes of problems that impede progress, as well as guiding decisions on which approach to take, taking into account UN comparative advantages, effectiveness, feasibility, and the uncertainties inherent in any change process. Finally, it aids in the identification of underlying assumptions and risks that must be understood and revisited throughout the process.

Source: https://unsdg.un.org/sites/default/files/UNDG-UNDAF-Companion-Pieces-7-Theory-of-Change.pdf

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Appendix:
Examples of Endorsed Ocean Decade Actions for Africa

Fenoy-X: Data Domain System of Ocean Knowledge for the Future Prosperity of Ocean Resources in the Western Indian Ocean (Fenoy: Malagasy name for filling the gaps / X: the Decade)

Lead institution: Western Indian Ocean Early Career Scientists Network

Summary: Fenoy-X will identify knowledge gaps through datasets from past and current publications. An online interactive map will explore ocean-related themes, data and tools. Our map seeks to promote understanding of sciences from the Western Indian Ocean region. The online map is open, fair and provides accessible ocean data and information. Fenoy-X seeks to demonstrate and promote sustainable development and partnerships to advance knowledge. Training and development in protection and conservation of the Indian Ocean ecosystem services form part of the Fenoy-X library to promote new studies for the future.

Start date: 04/04/2021; end date: 04/04/2030

Ocean basins: Indian

Challenges addressed: 4, 9 and 10.

Enhancing Ocean Observing System within the Republic of Mauritius

Lead institution: Mauritius Meteorological Services

Summary: The Mauritius Meteorological Services (MMS) is a government institution under the Mauritius Meteorological services act of 2019 that is responsible for the provision of weather, climate services and warnings for hydro-meteorological hazards and tsunamis. The observation network for the ocean is a key activity of the MMS and currently there are four tidal gauges and two wave riders in operation. Moreover, the MMS contributes towards deployment of drifters and Argo floats under the Data Buoy Cooperation Panel. In the context of the UN Ocean Decade, the MMS is proposing to enhance its existing ocean networks by increasing the number of tidal gauges and wave riders. Moreover, the MMS is looking forward to improving staff capabilities by seeking opportunities for capacity building in the field of ocean observation and research. The development

of ocean services for fishers, especially for effective communication in the event of natural hazards, will be worked out. In collaboration with local partners, new tools and software for ocean observation and research will be developed.

Start date: 01/07/2021; end date: 31/12/2025

Ocean basins: Indian

Challenges addressed: 4, 6, 7, 8 and 9.

African Youths Sustainable Ocean Campaign (AYSOC)

Lead institution: Federal University of Technology Owerri

Summary: The African Youths Sustainable Ocean Campaign (AYSOC) is a multi-country initiative with the core mandate to mentor and raise the consciousness of African youth, especially those in the Gulf of Guinea region, on ocean literacy and the need for sustainable ocean economy development in relation to the SDGs through a participatory and inclusive process. This initiative will also highlight the impact of climate change on the ocean and the livelihoods of those living in the coastal regions, such as the oil-rich Niger Delta and Cabinda in Angola. It will establish ocean literacy and marine litter clean up clubs in secondary schools across the region.

Start date: 08/06/2021; end date: 01/01/2030

Ocean basins: Indian, North and South Atlantic

Challenges addressed: 2, 3, 4, 5 and 10.

Protecting the estuaries of the WIO region

Lead institution: School of Aquatic Sciences and Fisheries Technology, University of Dar es Salaam

Summary: Estuaries are important habitats that support the existence of ocean life. They are sometimes referred to as "a cradle of the sea" due to their role as nurseries to various ocean animals. They are amongst the most fragile of marine habitats due to their dependence on the salt–freshwater balance; any imbalances significantly affect the biodiversity and ecosystems services of estuaries.

During the Ocean Decade, the School of Aquatic Sciences and Fisheries Technology and its partners aim to study the extent to which estuaries of the Western Indian Ocean region have been affected by anthropogenic activities and climate change, with a view to coming up with feasible recommendations to protect them.

Start date: 01/01/2021; end date: 31/12/2030

Ocean basins: Indian

Challenges addressed: 1, 2 and 5.

Institutional Capacity Building towards the sustainability of Ocean Science in light of COVID-19 pandemic (ICB-Ocean Science for COVID-19)

Lead institution: Nipe Fagio

Summary: ICB-Ocean Science for COVID-19 aims to enhance the capacity of government bodies, communities and NGOs to monitor coastal areas effectively around the COVID-19 pandemic. Most marine litter that goes into the ocean is fed by inland water sources. Marine litter is a global challenge that needs to be addressed at the regional level, especially during this time when the world has been hit by the COVID-19 pandemic. To mitigate this challenge, ICB-Ocean Science for COVID-19 aims to improve litter management by developing a baseline that provides measurements of the amount of litter being produced within the United Republic of Tanzania.

Start date: 01/04/2021; end date: 31/03/2023

Ocean basins: Indian

Challenges addressed: 7, 9 and 10.

Low-cost real-time monitoring of pollutants and water quality along the coral reefs in the United Republic of Tanzania: Supporting effective ocean management

Lead institution: Aqua Farms Organization

Summary: The Reef Protect Project is a project that seeks to deploy water quality monitoring devices in eight coral reef sites along the coast of the United Republic of Tanzania. The devices will help to measure ocean temperature, dissolved oxygen and pH. The devices will

be able to log the collected information in real time and make it available publicly through a portal that is to be custom designed. This information will be collected for 10 years and used to inform policymakers on possible actions that can be taken to safeguard Tanzanian coral reefs and the impacts of climate change.

Details of the device development are available here: https://sustainenvironres.biomedcentral.com/articles/10.1186/s42834-019-0009-4

Start date: 07/06/2021; end date: 07/06/2030

Ocean basins: Indian

Challenges addressed: 1, 2, 3, 4, 5, 6, 7, 8 and 9.

Sustainable Ocean Management Education Programme Strengthening the Blue Economy (SOME Programme)

Lead institution: Department of Blue Economy, Ministry of Fisheries and Blue Economy, Seychelles

Summary: Seychelles aims to champion the development of this initiative which strives to engage learners to become ocean literate and develop the Blue Economy. The adverse effects of climate change and exploitation within the Indian Ocean and the African continent in general are issues that cannot be overlooked and need engagement of the upcoming generations to elicit the mindset change required to mitigate actions harmful to the oceans.

Start date: 01/01/2021; end date: 31/12/2031

Ocean basins: Indian

Challenges addressed: 3, 4, 5 ,9 and 10.

West African Science Service Centre on Climate Change and Adapted Land Use: Cabo Verde Graduate School on Climate Change and Marine Sciences (WASCAL-CV)

Lead institution: Institute of Engineering and Marine Sciences at the Atlantic Technical University

Summary: The Cabo Verde Graduate School on Climate Change and Marine Sciences is dedicated to training up to 20 West African students, per batch, at the level of master´s degree in Marine Sciences and Ocean

Management. Students will be exposed to interdisciplinary and transdisciplinary courses on oceanographic areas, marine ecology, fisheries, coastal management and planning. With theoretical understanding and applied skills, students will be able to develop solution-oriented projects in marine sciences and management in a climate change context. The WASCAL-CV is being implemented under the WASCAL (West African Science Service Centre on Climate Change and Adapted Land Use) framework.

Start date: 01/09/2019; end date: 31/12/2023

Ocean basins: North Atlantic

Challenges addressed: 4 and 9.

Ocean Literacy Educational Program (Ocean Health and Protection)

Lead institution: Private and public partnership working group under the lead of the Ministry of Maritime Economy, Cabo Verde

Summary: Creation of an educational system for ocean literacy through a public–private partnership, involving academia, civil society and religious institutions. Training will be offered to all levels of society.

Start date: 31/01/2021; end date: 31/01/2030

Ocean basins: North Atlantic

Challenges addressed: 4 and 10.

Enhancement of hydrographic and oceanographic observations in support of marine scientific research (Coastal and natural resources, deep and ultra deep seabed geoscientific mapping, etc.)

Lead institution: National Commission for Education, Sciences and Culture, Kingdom of Morocco (MarocNatCom)

Summary: The aim of this initiative is to raise the hydrographic and oceanographic knowledge on the Moroccan marine zone in the Atlantic Ocean and in the Mediterranean Sea through on-site measurements during sea surveys. This effort aims to raise the importance of the ocean in the context of climate change among the Moroccan public. The importance of the ocean to global climate cannot be underestimated. It absorbs a significant part of carbon and an overwhelming portion of the excess heat. Warmer atmosphere and increasing concentration

of greenhouse gases nevertheless exert an enormous pressure on the ocean's ability to regulate the climate. Laying the groundwork for efficient climate adaptation and mitigation strategies at national level, this effort will contribute to better understanding of our marine ecosystem, particularly on the most damaging impacts of climate change: ocean acidification, temperature increase, sea-level rise, deoxygenation, changes in marine biodiversity and the overall contribution of the ocean to achieving the SDGs on conserving the ocean and combating climate change. This initiative also contributes to the regional programme of oceanographic, hydrographic and marine cartography of the African region and to international oceanographic programmes.

Start date: 01/01/2021; end date: 31/12/2030

Ocean basins: North Atlantic

Challenges addressed: 4, 5, 7 and 9.