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THE SAPPHIRE PROJECT PRESENTS

DATA AND THE WESTERN INDIAN OCEAN

OVERVIEW OF OCEANOGRAPHIC DATA AND RESEARCH FOR IMPROVED OCEAN GOVERNANCE IN THE WESTERN INDIAN OCEAN REGION

Edited by the Nairobi Convention Secretariat (1)

The SAPPHIRE project and Nairobi Convention Secretariat would like to recognize the many partners who have contributed to the projects outlined in this publication: the Nairobi Convention Contracting Parties, the United Nations Environment Programme, the United Nations Development Programme (www.undp.org) and the Global Environment Facility (www.thegef.org) for their support and financial contribution to these projects.

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(1) This document was prepared by Dr. Kwame A. Koranteng. Dr. Koranteng is a fisheries scientist, statistician and marine ecosystems analyst and former staff of the Food and Agriculture Organization (FAO) of the United Nations (2008 – 2017). At World Wide Fund for Nature (WWF). Dr. Koranteng was the Eastern Africa Regional Representative (2004 – 2008). He was previously staff and later Director of the Marine Fisheries Research Division, Ministry of Food and Agriculture (Ghana) (1979 – 2004). He has also served as Chairman of the Global Ocean Observing System for Africa (GOOS-Africa) Coordinating Committee, Co-Chairman of the Global Marine Assessment Group of Experts, Vice-Chairman of the FAO Advisory Committee on Fishery Research. Currently, he is a member of the Board of the Ghana Fisheries Commission and a member of the Editorial Board of the IOC of UNESCO's Global Ocean Science Report.

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1. Introduction and Background

I. Introduction

Entire regions of the world's oceans, otherwise known as Large Marine Ecosystems (LMEs), are under threat from overfishing, pollution, invasive species, climate change and other human activities. Because LMEs are either shared by multiple countries or beyond any one country's national jurisdiction, fighting back against their degradation requires strong ocean governance.

The Nairobi Convention, whose ten member states[1] have come together to form a partnership to combat ocean degradation, is a natural platform through which cross-country governance issues can be addressed.

The SAPPHIRE [2] project (implemented by UNDP, executed by the Nairobi Convention) with funding support from the Global Environment Facility (GEF), promotes policy and institutional reform to help improve the management of the WIO LME. It will build capacity among governments, communities, partners, intergovernmental organizations and the private sector in sustainable resource management and ocean governance.

However, if we are to effectively govern the Western Indian Ocean (WIO), we must better understand it. Oceanographic data has the power to tell us which ecosystems are most in danger, what mitigation measures are most useful, and where we should direct our resources. Collecting, sharing, and using such information will be essential to creating science-based policies across the region—and ensuring that the Western Indian Ocean's countless resources and benefits are enjoyed by generations to come.

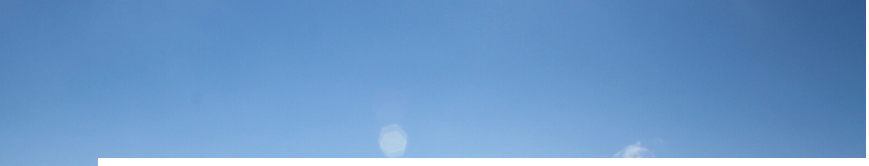
In recognition of the critical role data will play in effective LME management, the SAPPHIRE project will also support the collection of scientific and local data in the WIO region and ensure it is routinely archived in national data centres, where it can be retrieved for long-term environmental change studies. The work will build on the previous activities completed under the Agulhas and Somali Current Large Marine Ecosystems (ASCLME) project. This project established a data and information management system which ensured that project data was a) tracked and monitored until the publication stage of the report; and b) archived in national data centres for the ongoing benefit of countries.

II. Background and Purpose

The SAPPHIRE project held five meetings on oceanographic data and scientific research between March and June 2019 in order to build partnerships for oceanographic data and research management in the region. The sessions brought together scientists, policy makers, and partners to discuss the status of national data centres; identify priorities of countries in using, managing, and owning data findings; and agree on mechanisms and partnerships to improve data collection, sharing, and archiving, among others.

[1] Comoros, France (Réunion), Kenya, Madagascar, Mauritius, Mozambique, Seychelles, Somalia, South Africa, and Tanzania.

[2] Western Indian Ocean Large Marine Ecosystems Strategic Action Programme Policy Harmonization and Institutional Reforms Project, funded by the Global Environment Facility



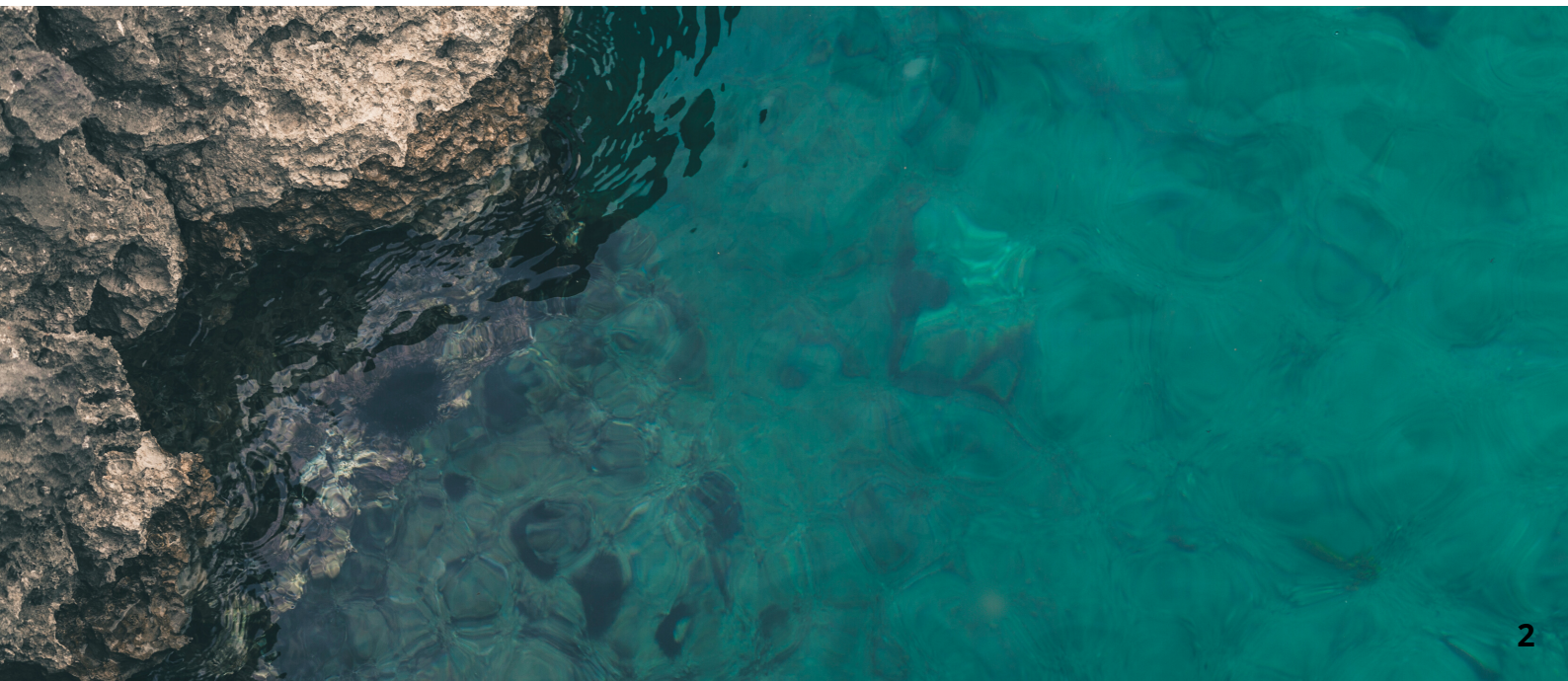
The SAPPHIRE project engaged Dr. Kwame Koranteng to prepare a working/background document before one such meeting, the Regional Stocktaking on Oceanographic Data and Scientific research in the WIO Region workshop held in Mauritius in 28 May 2019. At the Mauritius session, government representatives, experts, national data centre managers and partners provided feedback on the working document, also captured by Dr. Koranteng. Next, the author revised the background document by incorporating inputs and prepared a final set of "Guidelines to support countries in developing a roadmap for reviving the National Oceanographic Data Centres developed during the ASCLME project". Finally, the author prepared recommendations on collaborative arrangements with regional/national institutions engaged in ecosystem monitoring at the LME scale.

This publication highlights the author's assessment and an overview of the guidelines and recommendations. It is designed to provide a summary of the current state of affairs in the region concerning oceanographic data and research; highlights the recommended work to be done by the SAPPHIRE project in this area; and outlines possible future steps to be taken by Nairobi Convention Contracting Parties and the project to ensure long-term monitoring of natural resources.

Editor's Note: the following text has been excerpted from four documents submitted by Dr. Koranteng:

- Assessment of oceanographic data and scientific research in the Western Indian Ocean region
- Feedback on the Status of Oceanographic Data Centres in the Western Indian Ocean region
- Roadmap to Revive the National Oceanographic Data Centres Developed during the ASCLME project
- Collaborative arrangements with regional/national institutions engaged in ecosystem monitoring at the LME scale

Where appropriate, the text has been reordered, shortened, or omitted to avoid duplication and ensure cohesiveness.



2. **Assessment of oceanographic data and scientific research in the Western Indian Ocean region**

The focus of this section is on oceanographic data collection and management and covers:

- Inventory of initiatives (projects, programmes, etc.) and institutions that generate oceanographic data. If a basic inventory is found, then we will examine the best way for its expansion and make a provision for quality and availability index.
- Inventory of the available relevant datasets and management of the same.
- An assessment of access to and sharing of the data.
- Experience with development of information from the datasets as input for policy, decision making and management related to ocean governance and sustainable use of resources in the WIO region.

It provides input for discussion on a framework to guide the countries to revive the national data centres including modalities/framework/protocols for ensuring data ownership, access and quality control. It also looks at modalities for sharing and archiving of national and regional oceanographic data and information for improved ocean governance and sustainable use of resources in the WIO region. We take a broader look at, and consider several aspects of ocean science which “includes disciplines related to the study of the ocean - physical, biological, chemical, geological, hydrographic, etc. and multidisciplinary research on the relationship between humans and the ocean” (IOC-UNESCO, 2017). It is recognized that ocean observation and marine data are relevant for all categories of ocean science. The paper looks at the collection, management, dissemination and use of marine data and information, ocean-related databases, data reporting and management.

I. Ocean Science Research in the Western Indian Ocean Region

There are many institutions in the WIO region that carry out ocean science research, including those that collect oceanographic data and other information necessary for good governance (listed in Appendix I). These include government-funded research institutes, universities, non-profit and non-government organisations. As marine systems do not operate in isolation, most institutes do not focus on a single discipline but rather collect a multitude of data types in the conduct of their research.

The marine, fisheries and oceanographic research institutes work in the following major disciplines: fisheries science and management; oceanography; ecology; and primary production. A few also look at socio-economics, ocean governance, and more recently issues related to blue economy.

While some of the institutions participate in the collection of data for the region, it is more common for national institutions to collect data on a national or smaller scale. While this data collection meets immediate needs, there is also a need for longer term trend data for the region. At this stage, WIO countries do not collect data on the regional scale, meaning researchers and decision makers have to rely on external sources of data, such as from satellites operated by American and European space agencies or research vessels provided by France or the EAF-Nansen Project.

The ASCLME and Southwest Indian Ocean Fisheries Project (SWIOFP) were multi-national programmes that included most of the countries of the WIO. Somalia had observer status, due to the political situation in that country at the time, but all other countries were active participants. In some cases, such as with the Seychelles Fishing Authority and the Kenya Marine and Fisheries Research Institute, the institutes were the country representatives in both projects. However, more often there were different organisations from each
country participating in each project.

II. Inventory of Initiatives (Projects, Programmes, Etc.) And Institutions Generating Oceanographic Data

The collection of oceanographic data in the WIO region has been undertaken since the 1900s (SADCO, 2019) but collection methods have become more sophisticated over time. The expansion of technology has been accompanied by an increase in the number of institutions and initiatives collecting these data. For this work, we look at datasets collected nationally, regionally and globally that are relevant to the WIO region.

There are several institutions that collect oceanographic data on a global scale. Two which hold a substantial amount of data for the WIO region are the United States of America's National Oceanic and Atmospheric Administration (NOAA) and the National Aeronautics and Space Administration (NASA). NOAA and NASA collect data, mostly remotely, using satellite technology or buoys that are either moored or drifting. The data collection is automated and continuous.

There are also initiatives that work on regional scales; key among these in the context of ocean science are the EAF-Nansen Programme and the Institut Francais de Recherche pour l'Exploitation de la Mer (IFREMER) of France. Both initiatives include the use of research vessels in their data collection. The vessels are highly sophisticated and collect a multitude of data as they work in countries within the WIO. The EAF-Nansen Programme is a partnership between the Norwegian Agency for Development Cooperation (Norad), the Norwegian Institute of Marine Research (IMR) and the Food and Agriculture Organization of the United Nations (FAO). Other collaborative initiatives have collected data for a specific period and/or area. These are mostly projects such as the ASCLME project and the SWIOFP, both of which involved all the countries of the WIO and collected data were on regional and national scales.

In almost all countries of the WIO, there are national institutes that collect fisheries and oceanographic data in national waters. Notable among these are the Mauritius Oceanography Institute (MOI), the Seychelles Fishing Authority (SFA), the Kenya Marine and Fisheries Research Institute (KMFRI), the Tanzania Fisheries Research Institute (TAFIRI), the National Fisheries Research Institute (IIP) of Mozambique, and the Council for Scientific and Industrial Research and the Oceanographic Research Institute (ORI) in South Africa. There are also several university departments and schools in these countries, e.g. the Institut Halieutique et des Sciences Marines of the University of Toliara in Madagascar, which collect oceanographic, fisheries and marine information and data. Finally, some amount of oceanographic data is also collected for small areas as part of stand-alone projects or through consultancies.

The data collected and available in national, regional and international institutions cover many facets of oceanography. These include physical ocean data such as temperature, salinity, density, currents, chlorophyll, fluorescence, etc. as well as chemical ocean data, such as carbon, nitrogen, and phosphorus occurrence. Many of the institutes collecting oceanographic data collect additional types of data. These can include data on pollution (chemical contaminants, plastic, etc.) and biological ocean data (plankton distribution and biomass, marine species, etc.)

Appendix 1 provides an inventory of some of the initiatives and institutes that collect oceanographic data relevant to the WIO region. It also gives an indication of what data are collected and where and how they may be accessed. Modern datasets are mainly in electronic form but some older datasets may still be on hardcopy.

III. Platforms for Ocean Data Collection

Data collection platforms vary quite widely in their areas of operation, types of data collected and reporting mechanisms. A few of these are discussed here. Oceanographic data collection in the WIO is carried out on a diversity of platforms, including satellites and research vessels, and using instruments that range from ship board equipment through electronic sensors on automated vehicles to Niskin and Nansen reversing bottles, Secchi disks and other basic tools and implements. Some key Essential Ocean Variables (EOVs) to document ocean mean-state and variability as defined by the Global Ocean Observing System are in situ temperature, salinity, ocean currents, nutrients, dissolved inorganic and organic carbon, dissolved gases such as oxygen, plankton, etc. The various platforms are necessary to obtain the EOVs of relevance to the problems at hand.

IV. Research vessels

Over time, many surveys by many different nations have been conducted in the WIO by dedicated oceanographic and fisheries research vessels. While some of the vessels have conducted ad hoc surveys, others have been operating in the WIO for extended periods, collecting data and information using standardized methods.

A well-known research vessel name in the WIO region is the RV Dr Fridtjof Nansen, owned by Norad and presently operating within the EAF-Nansen Programme of FAO (Groeneveld & Koranteng, 2017). To date, there have been three vessels of this name. The R/V Dr Fridtjof Nansen undertook its first survey in the WIO in 1975, and the three vessels have undertaken over 30 surveys in the area since (Groeneveld & Koranteng, 2017). Beneficiaries of the surveys over the past four decades include the African mainland countries - Somalia, Kenya, Tanzania and Mozambique, and the island States – Seychelles, Comoros, Mauritius and Madagascar. The surveys are carried out with the participation of scientists and technicians from the region and have contributed immensely to the accumulated knowledge of the WIO, in diverse fields such as fisheries, biodiversity, ocean productivity, ecosystems and physical oceanography. According to Halo et al. (2017), the Nansen vessels have played an important role in describing the physical oceanographic processes of the WIO, often from the perspective of how they would affect fish distribution and abundance. Data from the R/V Dr Fridtjof Nansen surveys are maintained by the Institute of Marine Research in Bergen, Norway.

Similarly, the French vessels Marion Dufresne I and II worked in the WIO region over the same period. Information on these surveys is available on IFREMER's website (see Table 2). The R/V Marion Dufresne is capable of carrying out observations in all fields of ocean science - marine geosciences, marine biology, physical and chemical oceanography.

Regional projects and smaller projects have leased commercial vessels and installed scientific instrumentation for the duration of the project. The data from these surveys are not as readily available as those from the international operations. While research vessels are dedicated to operating in specific areas at specific times, oceanographic data has also been collected by ships of opportunity.

These commercial vessels collect data on dedicated instrumentation as they sail around the globe while undertaking their normal activities. Some of these data can be found online (see Table 2). In some instances, summaries of the results of the surveys are available online, but the data still need to be sourced from the host institutions.

Table 2: An exert from Appendix 1 of institutes that provide online searches for research vessel survey.

Institute/Initiative	Vessels represented	Website
IFREMER	French research vessels	https://campagnes.flotteoceanographique.fr/search
JCOMMOPS: Ship Observations Team	Voluntary observing ships and ships of opportunity operated through the Voluntary Observing Ship Scheme and Ship-of-Opportunity Implementation Panel	https://www.jcommops.org/board?t=sot
British Oceanographic Data Centre	British research vessels	https://www.bodc.ac.uk/resources/inventories/cruise_inventory/search/
Southern African Data Centre for Oceanography	Vessels that operated in Southern African waters	http://sadcoinv.ocean.gov.za/sadco1/SadInv

V. Remote sensing

In this paper, remote sensing is considered as the acquisition of information about an object without making physical contact with the object. Platforms and equipment for collecting remote sensing data from the oceans include echo sounders and Acoustic Doppler Current Profilers (ADCPs). The datasets from such sources include bathymetry (topography and substrate type). Many large oceanographic and fisheries research vessels have the necessary remote sensing equipment installed on-board while smaller vessels use towed equipment. Like echo sounders, ADCPs (which measure water current velocities over various depth ranges) are installed on research vessels but can also be moored.

Downloads of global bathymetry data are available from NOAA. Data is also available from other programmes, such as the EAF-Nansen Programme, and can be found either online or on request depending on the host institute.

Boats alongside the Kilifi coast in Kenya © Riccardo Zennaro

Other remote sensing data are from RADAR and LIDAR (Light Detection and Ranging) as well as aerial photographs and satellite imagery. Aerial photographs, RADAR and LIDAR datasets appear to be available mostly from the commercial sector at cost. There is, however, LIDAR data available for download without cost for Madagascar from the GEOSUD [3] website. Satellite imagery is widely available and, depending on the resolution, may be freely available or have an associated cost. Probably the most well-known dataset is from the NASA Landsat Program which has been running since 1972. All the Landsat data are available free of charge. NASA also provides ocean biology data at no cost through its Ocean Color Web. Data include chlorophyll, sea surface temperature and fluorescence, among others, collected from the MODIS platform. The MODIS instruments image the entire Earth every 1 to 2 days and are designed to provide measurements in large-scale global dynamics, including changes in Earth's cloud cover, radiation budget and processes occurring in oceans, on land, and in the lower atmosphere. MODIS data are available from 2002 to the present. There are other satellite data available from other sources, with the cost dependent on the resolution of the data requested. Table 3 gives the institutions that provide online searches for remotely-sensed data.

Table 3: An exert from Appendix 1 of institutes that provide online searches for remotely sensed data.

Institute/Initiative	Data type	Website
National Oceanic and Atmospheric Administration	Sonar – Bathymetry, bottom mapping	https://maps.ngdc.noaa.gov/viewers/bathymetry/
GEOSUD	LIDAR - Madagascar	http://ids.equipex-geosud.fr/web/guest/madagascar
National Aeronautics and Space Administration: Landsat Program	Satellite	https://landsatlook.usgs.gov/viewer.html
National Aeronautics and Space Administration: Ocean Colour	Satellite	https://oceancolor.gsfc.nasa.gov/l3/

VI. Deep sea observation techniques (moorings, drifters, ROVs and AUVs, etc.)

Satellites and research vessels are expensive operations and they are not always in the area of interest or there are issues with data collection, such as cloud cover, etc. A relatively affordable method of ocean data collection is through moorings and drifting buoys. Several varieties of buoys have been deployed and their data are available online. NOAA's Environmental Research Division's Data Access Program (ERDDAP) has 32 datasets available for download. These datasets are from buoys such as the generic and Argo drifting buoys, the Research Moored Array for African-Asian-Australian Monsoon Analysis and Prediction (RAMA) moored buoys and sea gliders. The datasets cover various atmospheric and oceanographic parameters. Some other autonomous underwater vehicle (AUV) data is available for download from the University of Washington's Seaglider® Project. Data collected by sea gliders are determined by which instruments are fitted to the gliders, so not every glider collects the same types of information. Data collected may include variables such as temperature, salinity, density, current strength, etc. Recent Seaglider® deployments have, however, been limited to South Africa. AUV and remotely operated underwater vehicle (ROV) data are generally project-based and not immediately available for general use outside of the project. After a specified exclusion time, raw data can be requested directly from the archiving institute. Argo buoy data (currents, temperature and salinity profiles) can also be accessed through the Joint Technical Commission for Oceanography and Marine Meteorology (JCOMM) website. While this is a global dataset, specific areas can be selected. JCOMM also provides sites of moored and other generic drifting buoys. Table 4 shows some of the institutes that provide online searches for buoy and autonomous underwater vehicle data.for remotely-sensed data.

Table 4: An exert from Appendix 1 of institutes that provide online searches for buoy and autonomous underwater vehicle data.

Institute/Initiative	Platforms	Website
National Oceanic and Atmospheric Administration: Environmental Research Division's Data Access Program (ERDDAP)	Drifting and moored buoys, sea gliders	http://osmc.noaa.gov/erddap/index.html
University of Washington: Seaglider® Project	Sea gliders	http://iop.apl.washington.edu/seaglider/index.php
Joint Technical Commission for Oceanography and Marine Meteorology: Argo	Argo and generic drifting buoys, moored buoys	https://www.jcommops.org/board?t=jcommops

VII. Regional and National Data Centres

Data Centres, essentially networks of connected servers, are very important facilities whose primary objectives are to secure, store and disseminate data. They ensure that the best available scientific data and local knowledge are shared and incorporated in planning and policy development at the national and regional level. This is particularly important for large datasets. These data centres are also expected to improve accessibility to data, thus allowing it to be used for scientific research and management of various ecosystems.

For oceanographic data, a key player is the International Oceanographic Data and Information Exchange (IODE) programme of the Intergovernmental Oceanographic Commission (IOC) of UNESCO. Its purpose is "to enhance marine research, exploitation and development by facilitating the exchange of oceanographic data and information between participating Member States and by meeting the needs of users for data and information products (GOSR, 2018). According to Garcia et al. (2018), the data centres have a mandate to manage all ocean-related data variables, including physical oceanography, chemical, biological, etc. The IODE has established a global network of National Oceanographic Data Centres (NODC) and all WIO countries are represented except for Yemen and Somalia. Certain organisations have been designated by the governments of the WIO Member States as the official oceanographic data centres for each country (Table 5). Also designated are personnel to manage the centres. The number of scientific personnel in the fields of oceanography and related disciplines in each country is also given through the related site https://www.oceanexpert.net. Through the IODE network, substantial amounts of ocean data and observations have been collected, archived and made available to Member States. Thus, the IODE Programme ensures accessibility to oceanographic data, metadata and information.

The IOC of UNESCO's Ocean Data and Information Network for Africa (ODINAFRICA) project brought together marine related institutions from African Member States with the aim of enabling them to a) get access to data available in other data centres and b) develop skills for the manipulation and presentation of data and information products. It also looked at the development of infrastructure for archival, analysis and dissemination of the data and information products (www.odinafrica.org). Each of the participating institutions developed a suite of data and information products that have been quality controlled, merged and made available through the project website. Examples are Directories of marine and freshwater professionals, Catalogues of marine related data sets, Marine Species databases, catalogue of marine related publications from/about Africa.

There are also other data centres that are not part of UNESCO-IODE list that also store and distribute WIO ocean-related data. These include the Southern African Data Centre for Oceanography (SADCO), the Partnership for Observation of the Global Oceans (POGO) and the Indian National Centre for Ocean Information Services (INCOS) which is a unit of the Earth System Science Organization (ESSO).

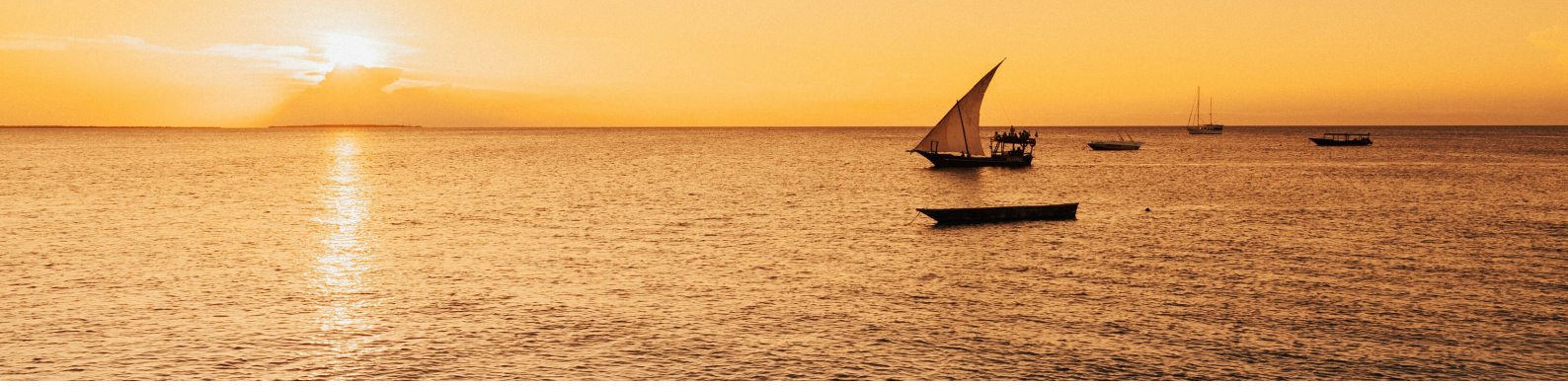
ESSO-INCOIS is mandated to provide the best possible ocean information and advisory services to society, industry, government agencies and the scientific community through sustained ocean observations and constant improvements through systematic and focused research.

The current functionality of other data centres created as part of projects is questionable. One of these is the African Coastal and Marine Atlas developed by ODINAFRICA III, in collaboration with the African Coelacanth Ecosystem Programme (ACEP) and the United Nations Environment Programme (UNEP). It does not work across all browsers (layers do not display in Chrome and Explorer) and the Open metadata and Download options do not work at all. The search functionality also appears to be compromised. When looking forward to re-establishing a data portal for the region, this atlas would be an ideal candidate for resurrection.

Another option that is already established is the Nairobi Convention Clearinghouse Mechanism (CHM). Incorporated in the ASCLME project's data policy was a provision that an inventory of new data would be lodged with the CHM and data archived at the SADCO and the World Data Centre for Oceanography (now named World Ocean Database). The CHM does not hold the ASCLME data inventory, SADCO has summaries from three RV Dr Fridtjof Nansen surveys co-sponsored by the ASCLME project, and the World Ocean Database (WOD) has no record of project data for the ASCLME project. This does not, however, exclude the possibility that the data were included, as they could have been included without a project name. A data centre was set up at KMFRI for all the data collected during the SWIOFP. Unfortunately, this digital library, as it was termed, is now only available to users who can access the server from the KMFRI premises in Mombasa, Kenya. These and additional data centres and portals are listed in Appendix 1.

Table 5: IODE list of WIO National Data Centres, National Coordinators and their contact details
(https://www.iode.org/index.php?option=com_content&view=article&id=61&Itemid=100057)

Country	Contact	Institute / Person	Email	Website
Comoros	Data Centre host	Centre National de Documentation et de Recherches Scientifiques	cndrs@comorestelecom.km	www.cndrs-comores.org
	National Coordinator	Ahmed ABDOULKARIM	a_abdoulkarim@yahoo.fr; cdo.cndrs@comores telecom.km	
Kenya	Data Centre host	Kenya Marine and Freshwater Fisheries	director@kmfri.co.ke	www.kmfri.co.ke
	National Coordinator	Mr. Harrison ONGANDA	honganda@kmfri.co.ke	
	IODE NC for information management	Mr Elijah MOKAYA	emokaya@kmfri.co.ke emokaya2001@yahoo.com	
Madagascar	Data centre host:	Institut Halieutique et des Sciences Marines	contact@ihsm.mg	www.ihsm.mg
	National Coordinator	Mr. John BEMIASA	j.bemiasa@ihsm.mg	
	IODE NC for information management	Dr. Tsarahevitra JARISOA	jers_jarisoa@hotmail.com; jarisoa@assocout.org	



Mauritius	Data Centre host:	Mauritius Meteorological Services	meteo@intnet.mu	metservice.intne.mu
	National Coordinator	Mr. Krisna BUCHA	krisnabucha@gmail.com	
Mozambique	Data Centre host	Insituto Nacional de Hidrografia e Navegaco	inahina@inahina.uem.mz	www.inahina.go.mz
	National Coordinator	Ms. Clousa MAUEUA	clousam@yahoo.com.br clousamaueua@gmail.com	
Seychelles	Data Centre host:	Seychelles Fishing Authority	management@sfa.sc	www.sfa.sc
	National Coordinator	Mr. Calvin GERRY	cgerry@sfa.sc calvingerry@gmail.com	
	IODE NC for information management	Ms. Denise MATHIOT	dmathiot@sfa.sc denise.mathiot@gmail.com	
South Africa	Data Centre host:	Department of Environmental Affairs		
	Council for Scientific and Industrial Research, Stellenbosch (African OBIS node)	Council for Scientific and Industrial Research, Stellenbosch		www.csir.co.za
Tanzania (United Republic of)	Data Centre host:	University of Dar es Salaam, Institute of Marine Sciences	director@ims.udsm.ac.tz	https://ims.udsm.ac.tz
	National Coordinator	Prof. Desiderius MASALU	masalu@ims.udsm.ac.tz d.masalu@odinafrica.net	
	IODE NC for information management	Ms. Fatma UKI	ukifatma@gmail.com	

VIII. Status of Data Centres Recognized/Established under the ASCLME Project

The ASCLME project recognized that the countries have institutions that have mandates for collection and management of certain marine related data. Consequently, member countries of the Project were identified as the primary custodians of datasets, hence the primary contact points and archive locations for ASCLME-generated data. Selected institutions in the countries were designated as National Data Centres and data and information coordinators were appointed from each country (Table 6). The ASCLME Project offered to provide appropriate support and training to the Data Centres to enable them function as required. The Project also offered to pursue and support the repatriation of data sets (e.g. from research cruises in Western Indian Ocean) to their source countries. The Data Centres were expected to use internationally accepted standards and best-practices for data collection and management and the ASCLME Project offered to support the coordination of effort across the region for the promotion of access to coastal and marine-related information in appropriate forms, to underpin informed ecosystem management decisions.

The SAPPHIRE project has initiated updating of existing national Marine Ecosystem Diagnostic Analyses (MEDAs), Transboundary Diagnosis Analyses (TDAs), developed under the ASCLME Project and South West Indian Ocean Fisheries Project (SWIOFP). The MEDAs will provide each country with an updated assessment of their ecosystems within their Exclusive Economic Zones (EEZ) and also provide them with a baseline document upon which they can base their National Action Plans (NAP) for the sustainable management of marine resources.

Moreover, the scope of the MEDAs will be expanded to include assessments of land-based sources of pollution--i.e. issues addressed by SAPPHIRE's sister project, WIOSAP --meaning that countries will have their first-ever "Ridge to Reef" assessment of their marine ecosystems. The findings will be fed into an expanded regional Transboundary Diagnostic Analysis and prioritize areas of concern that can be addressed through a merged Strategic Action Programme (SAP).

During the stocktaking workshop in Mauritius, some effort was therefore made to obtain information on the operational status of national data centres in the WIO region (Table 7). A representative of each country, except Comoros and Somalia, presented the state of their data centres that were identified or designated as oceanographic data centres under the ASCLME project (Table 6). Many had been established prior to the ASCLME project and are listed as NODCs under the IOC/UNESCO IODE programme.

The areas in the MEDAs, TDA and NAPs for which data are required for revision and regular updates are the marine environment, socio-economic status, policy and governance, and planning and management. There are also issues related to capacity development and community engagement. The types of data required for each is presented in Table 7.

As indicated in Table 7, the data required are available from numerous sources with varying levels of accessibility. Satellite imagery can in many cases be sourced without cost from organizations such as NOAA in the US. Other data may be publicly available from government organisations but would need to be requested. Data from surveys similarly need to be requested and may only be used with the consent of the country in which the survey was conducted. A list of data sources and their accessibility are available in Appendix 1. The consequence of the data requirements for the MEDAs and NAPs is that the configuration of the NODCs (or other institutions/organizations designated by the country to undertake the work) must allow for the capture, management and reporting of data and information for the various areas other than oceanography or the capability to import and/or utilize data from other data centres.

Table 6: National Data and Information Coordinators for the ASCLME project (2008-2013) (www.asclme.org)

Country	Institution	Official Representative	Alternate	Contact Details
Comoros	Ministry of Agriculture, Fisheries and the Environment (MAPE)	Mr. Farid Anasse	Yahaya Ibrahim	farid_anasse@yahoo.fr; yahayaim@yahoo.fr
Kenya	Kenya Marine and Fisheries Research Institute (KMFRI)	Mr. Harrison Onganda		honganda@kmfri.co.ke
Madagascar	Office National pour l'Environnement (ONE)	Mr. Jean-Roger Rakotoarijaona		jroger@pnae.mg; jr.rakotoarijaona@gmail.com
Mauritius	Mauritius Meteorological Services (MMS)	Mr. Mohamudally Beebeejaun	Renganaden Virasami	m.bbjohn@odinafrica.net; vganessen@yahoo.com
Mozambique	Instituto Nacional de Hidrografia e Navegação (INAHINA)	Ms. Clousa Maueua	Obadias Cossa	clousam@yahoo.com.br
Seychelles	Policy Planning and Services Division, Ministry of Environment, Natural Resources and Transport	Mr. Justin Prosper	Michelle Etienne	j.prosper@pps.gov.sc; justinpros@hotmail.com; m.etienne@scmrt-mpa.sc
South Africa	South African Environmental Observation Network (SAEON)	Dr. Juliet Hermes		juliet@saeon.ac.za
Somalia	Ministry of Fisheries	Mr. Ali Sabriye		ali.sabriye@gmail.com
Tanzania	Institute of Marine Sciences	Dr. Desiderius Masalu	Dr. M. Kyewalyanga	masalu@ims.udsm.ac.tz
France (Observer)	IRD-EME	Dr. Jean-Francois Ternon		Jean.Francois.Ternon@ifremer.fr

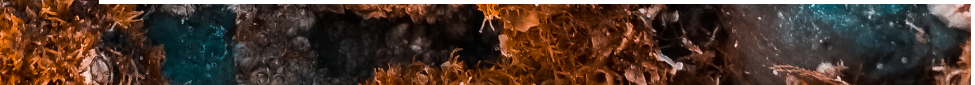


Table 7: Institutions that collect ocean related data in the WIO

Country	Institution	Area of research	Links
Comoros	Centre National de Documentation et de Recherches Scientifiques	Biodiversity	ASCLME, SWIOFISH
Kenya	Kenya Marine and Fisheries Research Institute	Fisheries, Oceanography, Ecology, Biodiversity	ASCLME, SWIOFP. KCDP, ODINAFRICA
	Kenya Wildlife Service	Fisheries, Oceanography, Ecology, Biodiversity, Socioeconomics	
	WWF Kenya	Fisheries, Oceanography, Ecology, Biodiversity, Socioeconomics	
Madagascar	National Office for the Environment	Fisheries, Oceanography, Ecology, Biodiversity, Socioeconomics	
	University of Toliara - Institut Halieutique et des Sciences Marines	Fisheries, Oceanography, Ecology, Biodiversity	ASCLME
	Ministère des Ressources Halieutiques et de la Pêche	Fisheries, Oceanography	SWIOFP
Mauritius	Albion Fisheries Research Centre	Fisheries, Oceanography, Ecology, Biodiversity	ASCLME, SWIOFP
	Mauritius Oceanography Institute	Oceanography, Ecology, Biodiversity	
	Mauritius Meteorological Services	Climatology	ASCLME
Mozambique	Instituto Nacional de Investigação Pesqueira	Fisheries, Oceanography, Ecology, Biodiversity	SWIOFP
	WWF Mozambique		
	National Institute of Hydrography and Navigation	Oceanography, Meteorology	ASCLME
	Universidade Eduardo Mondlane	Fisheries, Oceanography, Ecology, Biodiversity	
Seychelles	Seychelles Fishing Authority	Fisheries, Oceanography, Ecology, Biodiversity	ASCLME, SWIOFP
	Nature Seychelles	Fisheries, Oceanography, Ecology, Biodiversity	
South Africa	Department of Environmental Affairs	Oceanography, Primary production	ASCLME
	Department of Agriculture, Forestry and Fisheries	Fisheries, Oceanography, Ecology, Biodiversity	SWIOFP
	University of KwaZulu-Natal	Oceanography, Ecology, Biodiversity	
	University of Zululand	Oceanography, Ecology, Biodiversity	
	Council for Scientific and Industrial Research	Oceanography, Ecology, Biodiversity	
	Oceanographic Research Institute	Fisheries, Oceanography, Ecology, Biodiversity	ASCLME, SWIOFP
Tanzania	Tanzania Fisheries Research Institute	Fisheries, Oceanography, Ecology, Biodiversity	ASCLME, SWIOFP, SWIOFISH
	University of Dar es Salaam - Institute of Marine Science	Fisheries, Oceanography, Ecology, Biodiversity	ASCLME, SWIOFP

a) Kenya

The Kenya Marine and Fisheries Research Institute (KMFRI) was established as the Kenya National Oceanographic Data Centre in 1996 and it makes use of the IODE Ocean Data Portal and an institutional repository for the data collected by their researchers. KMFRI also holds the data from the SWIOFP. Those datasets should be available online to the wider science community, but this is not the case presently.

b) Madagascar

The Madagascar National Office for Environment has an online Environmental Dashboard that provides a suit of environmental indicators. It also hosts an environmental data atlas and numerous environmental databases.

c) Mauritius

The Mauritius Oceanography Institute (MOI), the national data centre for Mauritius, is operational and is collating data from several projects. Data collected include those on habitats, bathymetry, currents, water quality and biodiversity.

d) Mozambique

In Mozambique, the National Institute of Hydrography and Navigation was established as the National Oceanographic Data Centre in 1998. It has links with Universidade Eduardo Mondlane, Instituto Nacional de Investigação Pesqueira and the Meteorology Institute. It hosts survey data as well as data collected through various projects.

e) Seychelles

Though the Seychelles National Parks Authority (SNPA) was the focal point during the ASCLME project, the country did not establish a national data centre as the Ministry of Environment, Energy and Climate Change already had a data centre collecting and storing data for the SNPA. It includes a GEO-database, web portal (UNEP) and other data repositories for the Ministry. It has a vast databank of marine/biological oceanographic data and includes some geological oceanographic data.

f) South Africa

South Africa has the most advanced data centre in the region, with dedicated staff to maintain it. The Department of Environmental Affairs is the current custodian for ocean data. Its database, the Marine Information Management System (MIMS), is available online with free public access. It is a Tier 3 data centre that allows for any planned maintenance activity of power and cooling systems to take place without disrupting of the operation of computer hardware. It also has a safeguard to ensure that an uninterruptible power supply (UPS) system is in place so that the server is always available.

g) Tanzania

The Institute of Marine Science (IMS), based in Zanzibar, is the National Oceanographic Data Centre for Tanzania and currently operational. Data centre activities are coordinated through the National Oceanographic Committee. IMS is also the lead institute in Tanzania that conducts ocean science research.

Stakeholder Discussion on Revitalizing Data Centres

In the discussions that followed the national presentations at the stocktaking workshop in Mauritius, there was still the question of how moribund centres, particularly those established by ASCLME, WIO-LAB and SWIOFP could be revived and strengthened. It became evident that most data centres that were running during the ASCLME, WIO-LAB and SWIOFP are still operational, although several have some challenges that affect their performance and efficiency. Participants mentioned that the biggest challenges that their national data centres face are a lack of financial resources and adequate human capacity. Hardware is expensive, and personnel do not always have the necessary skills to set up and maintain the centre. It appears that data centre operations are not mainstreamed in work plans and budgets of the host institutions and therefore not seen as a priority to receive direct funding and staff support. It was emphasized that it is necessary to re-market the data centres as service providers, rather than only being data storage units.

The consensus of the panelists was that more emphasis should be placed on providing products that are useful to governance practitioners and processes. By placing emphasis on useable output rather than raw data, appreciation of the importance of data management and the longevity of data centres will follow. While infrastructure is a challenge in most countries, improvements can be made to each data centre, but they need not all be raised to the same level. Each centre needs to move to a level at which it can provide a service to its own data user community rather than trying to attain a level beyond its needs and means. Regional standards should be developed for data collection, storage and archiving to enable more fluid data exchange and use. The establishment of a regional meta-database and portal will greatly aid data sharing in the region. There are clear differences in the capacity of the various countries of the WIO and this can be addressed by establishing personnel exchanges between countries where countries that are more advanced provide hands-on training to personnel from countries that are not as advanced. It is also vital that personnel be dedicated solely to data management to ensure a high level of technical expertise and time allocation to the process.

IX. The Available Relevant Datasets and Their Management

Several relevant datasets are available to researchers in the WIO region (see Appendix 1). As noted, they differ in their scale, the collection platforms, the sensors used and the amount of post-collection processing performed. The datasets are generally large and complex, necessitating capital investment in their storage and distribution. Well-funded large institutes and multinational commissions, such as IFREMER, NASA, and NOAA tend to have the most accessible data. This does not, however, mean that all data for a particular country are stored on one server in one locality. Rather, many online data storage access points are portals that direct users to the appropriate server.

Data and samples from regional surveys may be kept or processed at several institutes. For example, for the survey on the Mascarene plateau (Saya de Malha and Nazareth Banks), carried out by the R/V Dr Fridtjof Nansen from 4th May to 3rd June 2018, the inventory of the data and post-survey processing were described in the post-survey meeting report (EAF-Nansen Programme Report, 2019) as follows:

Physical oceanography. The current data (ADCP) have been partially processed and the remaining data analyses are being pursued in co-operation with Institute of Marine Research in Bergen, Norway.

Geomorphology and benthic substrates. The grab samples are being processed at the Mauritius Oceanography Institute (MOI).

Chemical oceanography and phytoplankton. Analyses of nutrient samples have begun at the MOI. Work on alkalinity and pH have been completed either on the ship or at the University of Seychelles. Phytoplankton post-processing not done on-board has been completed at the University of Mauritius.

Zooplankton. The main set of samples will be processed in a master's project at the University of Seychelles. Samples of gelatinous plankton and the Manta trawl samples have been shipped to the University of Western Cape where they will be processed.

Pelagic and demersal fish. Data from the mid-water trawls, bottom trawls (Nazareth Bank only),

and the pot fishing have been recorded but need to be re-evaluated, and this work will be conducted in Mauritius by the Albion Fisheries Research Centre and the MOI. Identification/confirmation of a selection of species using genetic barcoding is underway at the MOI in collaboration with the Beijing Genomics Institute (BGI).

Benthos. Organisms in the grabs were extracted on the ship, and identification of the samples were either completed on-board or in Mauritian institutions.

Mammals, birds and turtles. The data on these taxa were fully processed on-board the ship.

Other observations (including litter and microplastics). The data on litter (mostly macroplastics) and microplastics from plankton samples with different gears were mostly processed on-board, but there is potential for further work on microplastics from CUFES-samples (pump samples from surface waters). The latter is being pursued by the MOI. The institute is also processing microplastics from sediment samples.

National datasets are not always readily available online and are generally scattered over more than one national institute. This makes it more challenging for users to access all the relevant data required. Unless specific institutional/project data policies are in place, data are not made easily discoverable. These data may be stored on local servers or desktop computers. This is particularly the case with smaller projects, whose collected data may be valuable but is unregistered on a meta-database or an archiving portal.

Appendix 1 provides some indication of the accessibility of the data collected by the listed institutes and initiatives, as well as hurdles that need to be overcome to gain access. As mentioned previously, the storage of the large datasets that accumulate from oceanographic sampling requires a substantial capital investment in servers and personnel to set up and maintain the servers and portals. Often there is an investment in these activities during projects, but the servers and portals are no longer maintained after the projects conclude. Therefore, a better option may be to incorporate data storage on servers and portals that have proven track records when it comes to longevity.

Additionally, there are meta-databases in place in the region that can be used to document data already in existence and/or to be collected in the future. For example, the Marine Spatial Atlas for the Western Indian Ocean (MASPAWIO - http://maspawio.net/) provides an open access geospatial data repository for the WIO. Shapefiles and metadata are available to users for download. Users are also able to create their own maps online with the content that is available. ODINAFRICA had a GeoNetwork meta database, but the search functions are no longer operational. ODINAFRICA III produced a data atlas that included many datasets, but the functions to open the full metadata records are not working.

An example of a functioning meta-database is that of the South African Environmental Observation Network (http://www.saeon.ac.za /data-portal-access). This data portal has “meta-data-driven search and discovery facilities and also serves as a repository for data contributed by stakeholders and providers”. It has the benefit of using multiple metadata standards that facilitate the uploading of metadata by data originators. It is, however, not regional.

The Food and Agriculture Organization of the United Nations (FAO) also has a GeoNetwork meta database which is global and has more than ocean data included. The benefit of using GeoNetwork is that it is freeware and can be used as a standalone installation which can be synchronized with a regional system, avoiding any manual uploading processes.

X. An Assessment of the Sharing and Accessibility of the Data

National and regional approaches for oceanographic data and information exchange

According to IOC, “the timely, free and unrestricted international exchange of oceanographic data is essential for the efficient acquisition, integration and use of ocean observations gathered by the countries of the world for a wide variety of purposes, including the prediction of weather and climate, the operational forecasting of the marine environment, the preservation of life, the mitigation of human-

induced changes in the marine and coastal environment, as well as for the advancement of scientific understanding that makes this possible". The IOC Oceanographic Data Exchange Policy stipulates that Member States shall provide timely, free and unrestricted access to all data, associated metadata and products generated under the auspices of IOC programmes. Member States are also "encouraged to provide timely, free and unrestricted access to relevant data and associated metadata from non-IOC programmes that are essential for application to the preservation of life, beneficial public use and protection of the ocean environment, the forecasting of weather, the operational forecasting of the marine environment, the monitoring and modelling of climate and sustainable development in the marine environment". Nevertheless, as previously noted, several national datasets are not always readily available online; scattered over more than one national institute; or stored on local servers or computers—making them difficult to access and find.

The main objectives of the UNESCO's IODE Programme are to: (i) facilitate and promote the discovery, exchange of, and access to, marine data and information, including metadata, products and information, through the use of international standards, and in compliance with the IOC Oceanographic Data Exchange Policy for the ocean research and observation community and other stakeholders; (ii) encourage the long-term archival, preservation, documentation, management and services of all marine data, data products, and information; (iii) develop or use existing best practices for the discovery, management, exchange of, and access to marine data and information, including international standards, quality control and appropriate information technology; (iv) assist Member States to acquire the necessary capacity to manage marine research and observation data and information and become partners in the IODE network; and (v) support international scientific and operational marine programmes, including the Framework for Ocean Observing for the benefit of a wide range of users.

Institutional/National/Regional Data Policies

With the exception of the IOC Oceanographic Data Exchange Policy and others for the EAF-Nansen Programme and the ASCLME project, we did not come across any modalities/framework/protocols for ensuring data ownership, access and quality control of national and regional oceanographic data and information.

Policy on access and use of data collected in R/V Dr Fridtjof Nansen surveys (Nansen Data Policy)

The Nansen Data Policy (EAF-Nansen Project, 2015) is intended primarily to guide and regulate access to the data collected during the R/V Dr Fridtjof Nansen surveys, their distribution (especially to third parties) and the use of such data for the good of the beneficiary countries and regions. The Policy also looks at management of the data, especially from cooperative surveys carried out with partner institutions. The Nansen Data Policy is intended to facilitate and encourage extensive use of the data collected in the surveys as well as to produce accurate insights from the data for management purposes and for scientific publications. It also encourages the establishment of strong linkages between the use of the data and capacity development of scientists and technicians from developing countries where the surveys were conducted.

Under the EAF-Nansen Programme, all data collected through the surveys within national EEZs are owned by the respective countries. Each country receiving the services of the R/V Dr Fridtjof Nansen is expected to specify which institution will be the main partner in carrying out the survey, have the responsibility for receiving the data collected, and represent the country as its "data owner". Data collected in international waters are owned by the Regional Fisheries Management Organization (RFMO) or Regional Fisheries Body (RFB) that manages or oversees the resources in the particular region, and the countries that are members of the RFMO of RFB. Data obtained from surveys that are co-funded by partner projects (like the LME projects that act on behalf of the countries participating in the project) must also be supplied to the partner projects. The subsequent distribution and use of data and all publications that use the data are also to be guided by the data policies of the partners. No data and information obtained from the R/V Dr Fridtjof Nansen surveys may be traded or used for commercial gain.

Unless restrictions are stipulated by the data owner, environmental data (temperature, salinity, oxygen, plankton) can be made publicly available immediately after the survey. Fish abundance data older than 5 years, from the date of collection, are to become publicly available, unless restrictions are specified by the data owner for reasons of confidentiality.

Data management agreement for cruises undertaken under the ASCLME project

The ASCLME Data Management Agreement (ASCLME, 2008) outlines the principles and guidelines for ASCLME data and information management to facilitate the effective collection, use and dissemination of information in support of TDA/SAP development in the short term and the ecosystem approach in the long term. The Agreement was intended to govern the collection, storage and access to data on the ASCLME 2008 Cruises and to clarify and protect the interests of all scientists and countries. National Data and Information Coordinators in particular have a responsibility for developing mechanisms for reliable long-term storage and use of information collected under the ASCLME project.

There is understanding in the agreement that data collected was to be shared freely between the ASCLME project and the SWIOFP, bearing in mind that access to new data, associated metadata, information collection activities and resulting products funded by the ASCLME project would be free and unrestricted. The primary custodians of data sets would be the ASCLME project and the member-countries of the ASCLME project. The primary contact points and archive locations for ASCLME-generated data would be at nationally appointed data centres as well as through the ASCLME project Coordination Unit. The intellectual property of new data, associated metadata, information collection activities and resulting products funded by the ASCLME project resided with the principal investigator (in the case of a scientific investigation), the institution to which the scientist belongs, the participating country and the ASCLME project.

3. Considerations for National and Regional Data Ownership, Access, Sharing, and Collaboration

XI. Modalities/frameworks/protocol for ensuring data ownership, access and quality control

The main objective of data management is to ensure the safe and long-term storage of data and metadata so that present and future users can access it over time. Delivery of data and metadata is, therefore, a vital step.

An archive must be able to respond, in a timely way, to requests for the data and information it holds, and to deliver these to a user in a way that is suitable for their purposes. The user community of an archive is not solely the same people who provide data; rather, it may include a diverse range of other actors from the public (e.g. policy-makers) and private sectors. It is important that data managers also include information about how and when the data were collected, the instruments used, including the precision of the instrumentation, and the collection procedures. The inclusion of this metadata in data management procedures is crucial.

Modalities, frameworks and/or protocols need to be developed to ensure that the storage and archiving of data are done in such a way as to provide the most benefit to the oceanographic data user community while at the same time ensuring that the original stipulations for use and dissemination of the data are honoured. Since the data are of a geographic nature, it would be best to record the metadata for each dataset in one of the recognized geographic metadata standards. These standards allow for the recording of aspects such as ownership of the data; access and use constraints; geographic positions; data collection dates, etc. The meta-database would provide a portal to either the data servers, if the data are publicly accessible, or to the contact person should there be restrictions placed on its access and use.

Data centres need to meet the following six characteristics to ensure that data are of good quality (KCP, 2010):

- Accuracy - data should be sufficiently accurate for their intended purpose. Any limitations should be made clear to the users.
- Validity – data should be collected in accordance with standardized methodologies.
- Reliability – data should reflect stable and consistent data collection processes.
- Timeliness – data should be made available as quickly as possible after collection within reasonable time periods, or periods stipulated by the data collector.
- Relevance – the data should be relevant to the field of oceanography.
- Completeness – data should reflect the entire collection without any omissions

KCP (2010) also outlines principles that would be beneficial to include in the protocols for the national and regional data centres. These fall under three larger headings of Awareness, Collecting and Recording, and Evaluating. The below have been adapted from the original document:

AWARENESS

- Responsibility for data quality is clearly assigned and everyone understands their role.
- Members at all levels recognize why data quality is important and see it as part of their work.
- Third parties which provide data are made aware of the value placed on data quality and set high standards.

COLLECTING AND RECORDING

- Indicator definitions and associated guidance are readily available and understood.
- Systems and processes are fit for purpose and operate efficiently.
- Procedure notes, guidelines and training are used to ensure members/staff have the skills and knowledge to correctly collect, store and archive data.
- Data is held securely and used and shared in compliance with all requirements as stipulated by the data originator/owner.

EVALUATING

- Data are subject to proportionate verification to check accuracy, validity, relevance and completeness.
- Arrangements for providing data are evaluated proactively and any deficiencies reported and remedied. There is a region-wide approach to data quality which is reviewed regularly.

XII. Protocols for Data Sharing

Data sharing of existing data is dependent on the limitations/restrictions placed on the data by the data originators. It therefore necessitates that protocols need to be developed with those institutions that would contribute to the data centre. This contribution might only be a metadata entry with a link to their own data portal, or it may involve the storage of their data at the regional/national data centre. These conditions will be captured in the meta-database. Any data collected under the SAPPHIRE project must be subject to the data sharing policies of the project, something that needs to be discussed and finalized with the partner countries and others. Typically, these policies allow for data sharing among project members during the project lifespan, as well as for a limited period after the project (e.g. 3 – 5 years), after which the data become more accessible to the wider community.

Under the ASCLME project, protocols and mechanisms for data exchange, sharing and access were put in place and internationally-recommended standards for data description were promoted. According to Scott (pers. comm), metadata formats used by the project were to comply with Open Geospatial Consortium (OGC) and ISO standards.

It was agreed that data obtained from other projects or sources must be attributed with comprehensive metadata, copyright, and use restrictions. Data provided by National Institutions were deemed to be national contributions to the ASCLME project and would remain the intellectual property of those institutions while also being used by countries in the development of their own National and Regional TDAs and SAPs (Scott pers. Comm.)

The project resolved to ensure interoperability with existing African and international marine and coastal information networks. It was recommended that public domain data should be contributed to appropriate international databases and international information networks including SADCO, the World Ocean Database, the Ocean Biogeographic Information System, the African Marine Atlas, the Nairobi Convention CHM, the Global Ocean Observing System, among others. Mechanisms of data exchange were to be determined by the Data and Information working group under the ASCLME project.

Among WIO stakeholders, there appears to be an apparent lack of trust in the data sharing process. Such sentiments can be overcome by developing clearly-defined policies and protocols for data management and sharing. These policies and procedures should protect the data originators and the data centres from misuse and abuse of data and provide an element of confidence in the rights and abilities of those involved. Scientists should also be encouraged to share their data so that greater benefits can be derived from the data than what could be obtained from a single project/product.

XIII. Collaborative arrangements with regional/national institutions engaged in ecosystem monitoring at the LME scale

The types and sources of data required for such monitoring, together with the institutions engaged in such monitoring, have been described above. This section will therefore consider the collaborative agreements necessary to achieve long-term monitoring of the WIO marine environment.

Generally, agreements exist to protect the organisations involved in data and information gathering and sharing and aim to regulate the relationships between the parties. These agreements spell out the responsibilities of both parties, particularly with regard to allocation of responsibilities, financial implications and exploitation of products or data required for use/storage. The agreements are intended to avoid potential uncertainties between parties and they clarify the nature and scope of the relationships.

a) Types of collaboration with regards to long-term data

Monitoring of ecosystem processes is reliant on the availability of data; therefore, it is necessary to set up agreements with various organisations and institutions in the WIO region to facilitate data availability for this task. Collaboration in terms of data may take one of two forms:

1. Collection of metadata records;
2. Collection of metadata records and data for download.

The first option provides descriptions of the data, who collected it and how users can access the data. This option requires a collaborative agreement that will encourage institutions and organisations to submit metadata records to be included in a regional meta-database where other users can locate relevant data. While the second option functions the same way as the first option, it also provides the opportunity to download the data. Here an agreement needs to cover the submission of metadata records as well as the data. In this case the agreement needs to cover the terms of data storage, dissemination and use.

For some data sets, metadata are available and may be investigated online with data acquisition being on request per survey or area of interest with conditions attached. In most cases, repatriation of entire datasets without specific use objectives will not be supported. Metadata for data collected by ships of opportunity are available online e.g. http://www.jcommops.org/board?t=sot. And while most products developed from ship data are not freely available, there are some exceptions. One example is the Southwest Indian Ocean Bathymetric Compilation (swIOBC) which can be downloaded from: https://doi.pangaea.de/10.1594/PANGAEA.880618?format=html#download.

Similarly, metadata of data collected by buoys is available online. This metadata informs the user whether downloads of data are immediately available or if requests need to be made. The data may be freely available or have a purchase cost.

b) Institutions and organizations with which UNEP/Nairobi Convention Secretariat could discuss collaborative agreements

The institutions and organisations working in the WIO region that collect data and information necessary for ecosystem monitoring include government-funded research institutes, universities, non-governmental organisations, and regional programs and projects. Many of these have already been profiled in this text. The involvement of these entities in long-term monitoring of the LMEs needs to be formalized through specific funding and collaborative agreements. The type of agreement depends on the nature of the entity and the data and information required.

Relevant Regional Economic Commissions are the East African Community (EAC), and the Indian Ocean Commission (IOC). These bodies have long-term health of marine ecosystems as an objective. One of the objectives of the EAC, for example, is “managing and sustaining the ecosystems and natural resources of the Community by preventing, arresting and reversing the effects of environmental degradation as well as management and the sustainable utilization of natural resources”.

Relevant regional technical or subject-matter entities are the Indian Ocean Tuna Commission (IOTC), Southern Indian Ocean Fisheries Agreement (SIOFA), and the South West Indian Ocean Fisheries Commission (SWIOFC).

A formal collaboration agreement with each institution/organization will contribute enormously towards setting up long-term ecosystem monitoring in the western Indian Ocean. This task will be impossible without reliable and relevant data so the provision of a central metadata and database is vital. Institutions and organisations will be more willing to contribute to this initiative if the terms of their engagement are clearly set out.

XIV. Conclusion

Several challenges were highlighted during the Nairobi Convention Science to Policy Workshop and stocktaking exercise held in Mauritius in May 2019, but there were also positive activities and experiences shared by the stakeholders. Generally, the participants showed enthusiasm for the revival of the data centres and expressed that this is a vital activity that will benefit the region. The revitalization of the Data Centres could provide enormous benefits to the greater WIO community of governments and scientists working in the region. It will add substantially to the development of practices that will lead to greater sustainability of ecosystems and their functioning in the region. Concretely, and for immediate need, the National Oceanographic Data Centres will provide enormous and much needed support for the updating of the MEDAs, TDAs and NAPs.

Appendix 1: Inventory of some of the initiatives and institutes that collect oceanographic data relevant to the WIO region

Responsible Institute	Country	Initiative	Platform/Data type	URL	Dataset	Period	Coverage	Access
Consortium	KEN, TAN, MOZ, RSA, SEY, MAU, MAD, COM	South West Indian Ocean Fisheries Project	Fisheries, oceanography	Currently not available	Various surveys, rapid assessments and data collation exercises	2009-2013	KEN, TAN, MOZ, RSA, SEY, MAU, MAD, COM	Data are stored on servers at KMFRI, need to clarify access rights
Department of Environmental Affairs: Oceans and Coasts (DEA: OC)	RSA	Southern African Data Centre for Oceanography	Multi-disciplinary marine information	http://sadco.ocean.gov.za/	Various	1920 - 2019	KEN, TAN, MOZ, RSA, SEY, MAU, MAD, COM	Public
ESSO - Indian National Centre for Ocean Information Services	IND		Location, temperature, salinity, density from Argo Buoys	https://incois.gov.in/argo/ADV.jsp	18 databases and one nc file	2001 - 2017	IO	Public
Food and Agriculture Organization of the United Nations	ITA	GeoNetwork	Applied Ecology, Base Maps, Remote Sensing, Biological and Ecological Resources, Climate, Fisheries and Aquaculture, Hydrology	http://www.fao.org/geonetwork/srv/en/main.home	Only 15 files available for download from the WIO, not very useful	1978 - 2009	WIO	Public
Remote Sensing Centre (AgroParisTech, CIRAD, IRD and Irstea)	FRA	GEOSUD	LIDAR data	http://ids.equipex-geosud.fr/web/guest/madagascar	1 zip file with sharefiles, text and jpeg files	Unknown	MAD	Public

Responsible Institute	Country	Initiative	Platform/Data type	URL	Dataset	Period	Coverage	Access
IFREMER	FRA	Marine Data Portal	Oceanography, Fisheries	http://data.ifremer.fr/			FRA, ATF, WIO	Public
Institute of Marine Research/Food and Agriculture Organization of the United Nations	NOR / ITA	EAF-Nansen Programme	Oceanography, Fisheries, Pollution	http://www.fao.org/in-action/eaf-nansen/en/	RV Dr Fridtjof Nansen	1975 – 2018 (not continuous)	KEN, TAN, MOZ, RSA, SEY, MAU, MAD, COM	Country permission required for data more recent than 5 years
Joint Technical Commission for Oceanography and Marine Meteorology	FRA	Ocean Data Portal	Physical and chemical oceanography – mostly metadata Argo, drifting and moored buoys	http://www.oceandataportal.net/portal https://www.jcommops.org/board?t=jcommops,	351 datasets	1889 – 2019	Global	Public
Joint Technical Commission for Oceanography and Marine Meteorology	FRA	Voluntary observing ships and ships of opportunity operated through the Voluntary Observing Ship Scheme and Ship-of-Opportunity Implementation Panel	Surface meteorological observations, plus sub-sets for upper air meteorological and upper ocean physical data	https://www.jcommops.org/board?t=sot	88 cruises in Indian Ocean	1987 – 2019	Global	Public
Kenya Marine and Fisheries Research Institute	KEN	Surveys on R/V *Mtafiti*	Oceanography, macrobenthos, sediments				KEN	Unknown

Responsible Institute	Country	Initiative	Platform/Data type	URL	Dataset	Period	Coverage	Access
Mauritius Oceanography Institute	MAU	Oceanographic Data Mapping	Oceanography, Genetics, Biology, Aquaculture	http://moi.govmu.org/online-databases			MAU	On request
Nairobi Convention		Nairobi Convention Clearinghouse mechanism	Sustainable 'data shop', providing accurate and relevant data and information for improved management and protection of the coastal and marine environment in the in the Western Indian Ocean region	http://staging1.unep.org/emunyao/ncchm/discover-data	12 records	2001 - 2017	WIO	Public
National Aeronautics and Space Administration	USA	LANDSAT	Satellite	https://landsat.gsfc.nasa.gov/data/where-to-get-data/	Raster images	1972 - 2109	Global	Public
National Aeronautics and Space Administration	USA	OceanColor Web	Satellite	https://oceancolor.gsfc.nasa.gov/data/overview/	Raster images	2002 - 2019	Global	Public
National Oceanic and Atmospheric Administration	USA	Bathymetry Data Viewer	Single beam sonar	https://maps.ngdc.noaa.gov/viewers/bathymetry/	233 cruises	1956 - 2016	Global	Public

Responsible Institute	Country	Initiative	Platform/Data type	URL	Dataset	Period	Coverage	Access
National Oceanic and Atmospheric Administration	USA	ERDDAP	Oceanographic data from satellites and buoys	http://osmc.noaa.gov/erddap/index.html	31 datasets	1970 - 2019	Global	Public
National Oceanic and Atmospheric Administration	USA	Global Ocean Heat and Salt Content	Temperature, sea level and salinity	https://www.nodc.noaa.gov/OC5/3M_HEAT_CONTENT/	Distribution figures	1960 - 2019	Global	Public
National Oceanic and Atmospheric Administration	USA	TAO Project - Global Tropical Moored Buoy Array	Position and sea surface temperature data along with other meteorological data	https://www.pmel.noaa.gov/tao/drupal/disdel/	Data from 4 moored buoys in the WIO off the east coast of Madagascar	2000 - 2019	Global	Public
National Oceanic and Atmospheric Administration	USA	Temperature, Nutrients, Plankton, Salinity, Oxygen, Coral Reef, Ocean Currents, Chlorophyll, Sea Level, Waves, pH	All data products available	https://www.nodc.noaa.gov/archivesearch/catalog/search/browse/browse.page	netCDF files	1800 - 2019	Global	Public
National Oceanic and Atmospheric Administration	USA	World Ocean Database	Oceanography	https://www.nodc.noaa.gov/OC5/WOD/pr_wod.html https://www.nodc.noaa.gov/OC5/SELECT/dbsearch/dbsearch.html	Large set of data that can be refined on locality, datatype and date	1800 - 2018	Global	Public

Responsible Institute	Country	Initiative	Platform/Data type	URL	Dataset	Period	Coverage	Access
National Oceanography Centre	U.K.	British Oceanographic Data Centre	Research vessels	https://www.bodc.ac.uk/resources/inventories/cruise_inventory/search/	6 cruises	1975 - 2006	MOZ Channel	Public
ODINAFRICA	Online	Ocean Data Collections and Catalogues	Metadata for ocean station data, satellite analyses, ocean climatology, weather climatology, geology, base mapping, ecology, fisheries.	http://geonetwork.iode.org/geonetworkAMA/srv/en/main.home	A catalogue of datasets but the search page does not work.	1989 - 2014	WIO	Public
ODINAFRICA III, in collaboration with the African Coelacanth Ecosystem Programme (ACEP) and the United Nations Environment Programme (UNEP)	Online	African Coastal and Marine Atlas	Phytoplankton, Chlorophyll/pigments Zooplankton, Etc.	http://www.africanmarineatlas.org/	Over 800 downloadable spatial data products	Various	MAD, MAU, MOZ, SEY, TAN	Public

Responsible Institute	Country	Initiative	Platform/Data type	URL	Dataset	Period	Coverage	Access
SeaDataNet: National Oceanographic Data Centres (NODCs) from 35 countries	USA	Partnership for Observation of the Global Oceans (POGO)	Physical and chemical oceanography, Contamination, Biology and Fisheries, Meteorology, Geology and geophysics	http://seadata.bsh.de/csr/retrieve/pogo_index.html	284 cruise summaries from the Indian Ocean	1978 - 2019	Global	Public
University of Washington	USA	Seaglider Project	Autonomous underwater vehicles - gliders	http://www.apl.washington.edu/project/project.php?id=seaglider http://iop.apl.washington.edu/seaglider/index.php	Variable	2017 - 2019	Various, most recently RSA	Public
South African Environmental Observation Network	RSA	SAEON Data Portal	Oceanography.	http://www.saeon.ac.za/data-portal-ac	Not of relevance to the WIO. It is a good example of a functioning metadatabase from which data can be downloaded	1950 - 2019	RSA	Public

List of Acronyms and Abbreviations

ACEP	African Coelacanth Ecosystem Programme
ADCPs	Acoustic Doppler Current Profilers
ASCLME	Agulhas and Somali Current Large Marine Ecosystems
AUV	Autonomous Underwater Vehicle
CHM	Clearinghouse Mechanism
EAC	East African Community
EEZ	Exclusive Economic Zones
EOVs	Essential Ocean Variables
ERDDAP	Environmental Research Division's Data Access Program
ESSO	Earth System Science Organization
FAO	Food and Agriculture Organization of the United Nations
IFREMER	Institut Francais de Recherche pour l'Exploitation de la Mer
IIP	National Fisheries Research Institute of Mozambique
IMR	Norwegian Institute of Marine Research
IMS	Institute of Marine Science (Zanzibar)
INCOS	Indian National Centre for Ocean Information
IOC	Indian Ocean Commission
IOC-UNESCO	Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific and Cultural Organization
IODE	International Oceanographic Data and Information Exchange
IOTC	Indian Ocean Tuna Commission
JCOMM	Joint Technical Commission for Oceanography and Marine Meteorology
KMFRI	Kenya Marine and Fisheries Research Institute
MEDA	Marine Ecosystem Diagnostic Analysis
MIMS	Marine Information Management System (South Africa)
MOI	Mauritius Oceanography Institute
NAPs	National Action Plans
NASA	National Aeronautics and Space Administration
NOAA	National Oceanic and Atmospheric Administration
NODCs	National Oceanographic Data Centres
NORAD	Norwegian Agency for Development Cooperation
ODINAFRICA	Ocean Data and Information Network for Africa
ORI	Oceanographic Research Institute of South Africa
POGO	Partnership for Observation of the Global Oceans
RAMA	Research Moored Array for African-Asian-Australian Monsoon Analysis and Prediction
RECs	Regional Economic Commissions
RFB	Regional Fisheries Body
RFMO	Regional Fisheries Management Organization
SADCO	Southern African Data Centre for Oceanography
SAP	Strategic Action Programme
SAPPHIRE	Western Indian Ocean Large Marine Ecosystems Strategic Action Programme Policy Harmonization and Institutional Reforms Project, funded by the Global Environment Facility
SFA	Seychelles Fishing Authority
SIOFA	Southern Indian Ocean Fisheries Agreement
SNPA	Seychelles National Parks Authority
SWIOBC	Southwest Indian Ocean Bathymetric Compilation

List of Acronyms and Abbreviations *continued*

SWIOFC	South West Indian Ocean Fisheries Commission
SWIOFP	Southwest Indian Ocean Fisheries Project
TAFIRI	Tanzania Fisheries Research Institute
TDA	Transboundary Diagnostic Analysis
UNEP	UN Environment Programme
WIO-LAB	Addressing Land-based Activities in the Western Indian Ocean Project
WIOSAP	Implementation of the Strategic Action Programme for the Protection of the Western Indian Ocean from Land-Based Sources and Activities
WOD	World Ocean Database

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About the partners

The United Nations Environment Programme (UNEP) is the leading global environmental authority that sets the global environmental agenda, promotes the coherent implementation of the environmental dimension of sustainable development within the United Nations system, and serves as an authoritative advocate for the global environment.

The Nairobi Convention, signed by Comoros, France, Kenya, Madagascar, Mauritius, Mozambique, Seychelles, Somalia, South Africa, and Tanzania, aims to promote a prosperous Western Indian Ocean region with healthy rivers, coasts, and oceans. It provides a platform for governments, civil society, and the private sector to work together for the sustainable management and use of the marine and coastal environment.

The United Nations Development Programme (UNDP) partners with people at all levels of society to help build nations that can withstand crisis, and drive and sustain the kind of growth that improves the quality of life for everyone. On the ground in nearly 170 countries and territories, we offer global perspective and local insight to help empower lives and build resilient nations.

The Global Environment Facility (GEF) was established on the eve of the 1992 Rio Earth Summit to help tackle our planet's most pressing environmental problems. Since then, the GEF has provided close to $20 billion in grants and mobilized an additional $107 billion in co-financing for more than 4,700 projects in 170 countries. Through its Small Grants Programme, the GEF has provided support to nearly 24,000 civil society and community initiatives in 128 countries.

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