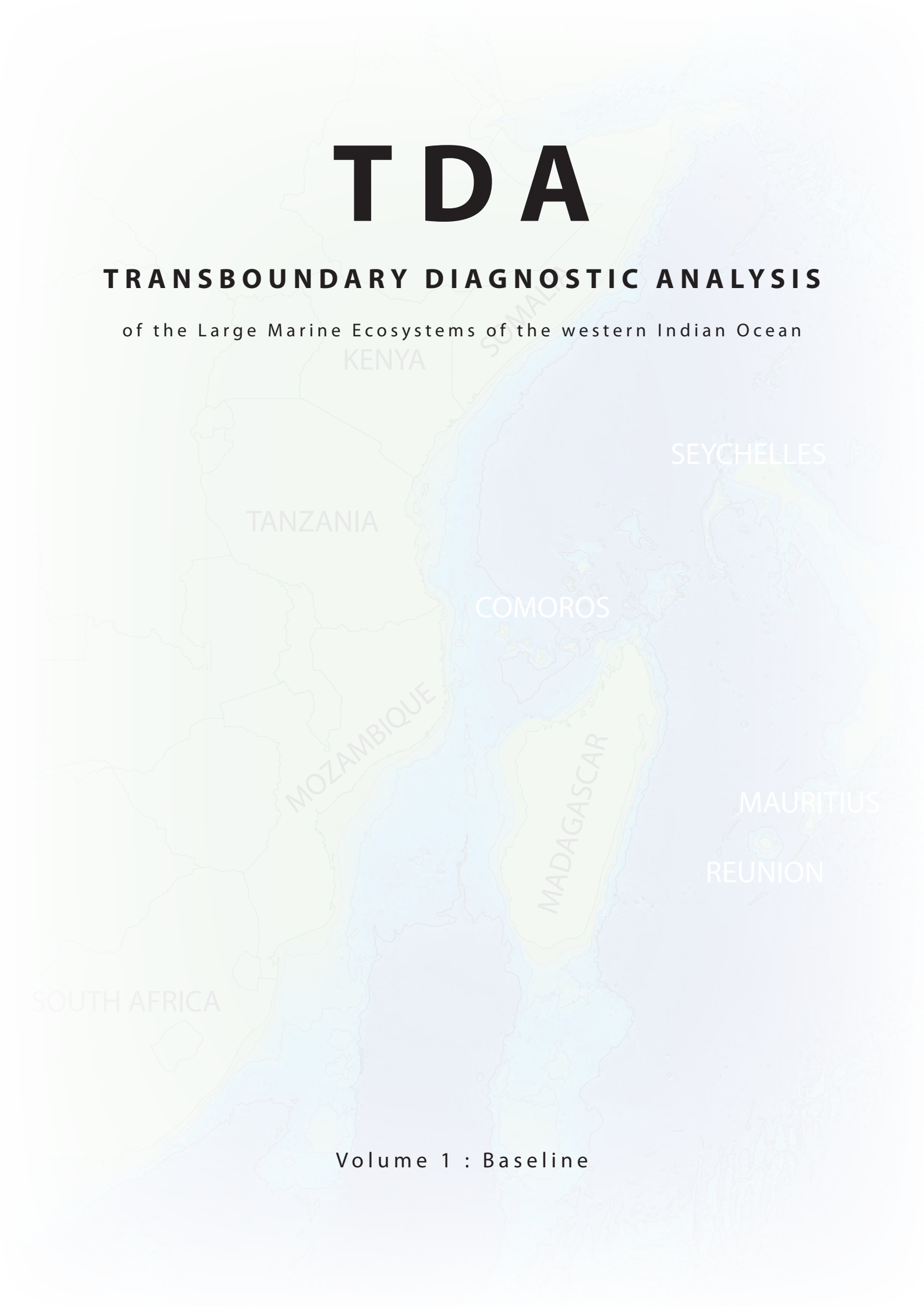
TDA

TRANSBOUNDARY DIAGNOSTIC ANALYSIS

of the Large Marine Ecosystems of the western Indian Ocean



Volume 1 : Baseline

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Foreword

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Appendices are available in digital form from the ASCLME and SWIOFP websites and will also be available at OceanDocs.org.

Note

Volume 1 *of the TDA contains the Biophysical and Socio-Economic review;* ***Volume 2*** *contains a discussion of Areas of Concern, and the Causal Chain Analysis.*

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List of Acronyms and Abbreviations

ACEP	African Coelacanth Ecosystem Programme
ACLME	Agulhas Current Large Marine Ecosystem
AMESD	African Monitoring of the Environment for Sustainable Development
ASCLME	Agulhas and Somali Current Large Marine Ecosystems Project
AU	African Union
CBD	Convention on Biological Diversity
CB&T	Capacity Building and Training
CBOs	Community-based Organisations
CCA	Causal Chain Analysis
CCRF	Code of Conduct for Responsible Fisheries
COI	Indian Ocean Commission
CORDIO	Coastal Ocean Research and Development in the Indian Ocean
DEAT	Department of Environmental Affairs and Tourism (South Africa)
D&I	Data and Information
DLIST	Distance Learning and Information Sharing Tool
DSS	Decision Support System
EAC	East African Community
EAME	East African Marine Ecoregion
EIA	Environmental Impact Assessment
ENSO	El Niño Southern Oscillation
EU	The European Union
FAD	Fish Aggregating Device
FAO	Food and Agricultural Organization
GCRMN	Global Coral Reef Monitoring Network
GEF	Global Environment Facility
GEMPA-EA	Group of Experts in Marine Protected Areas for Eastern Africa
GIS	Geographic Information System
GIWA	Global International Waters Assessment
GOOS	Global Ocean Observing System
GPA	Global Programme of Action for the Protection of the Marine Environment from Land-based Activities
ICRAN	International Coral Reef Action Network
ICRI	International Coral Reef Initiative
ICZM	Integrated Coastal Zone Management
IFREMER	Institut Français pour la Recherche et l'Exploitation de la Mer
IMS	Institute of Marine Sciences, University of Dar es Salaam, Tanzania
IOC-UNESCO	Intergovernmental Oceanographic Commission of UNESCO
IOD	Indian Ocean Dipole
IOTC	Indian Ocean Tuna Commission
IUCN	The World Conservation Union
IW	International Waters
IW: LEARN	International Waters Learning Exchange and Resource Network
KMFRI	Kenya Marine and Fisheries Research Institute
KWS	Kenya Wildlife Service
LME	Large Marine Ecosystem
MDGs	Millennium Development Goals
MEDA	National Marine Ecosystem Diagnostic Analysis
M&E	Monitoring and Evaluation
MPA	Marine Protected Area
MPRU	Marine Parks and Reserves Unit (Tanzania)
NBSAP	National Biodiversity Strategy and Action Plan
NEAP	National Environmental Action Plan
NEMA	National Environment Management Authority (Kenya)

NEMC	National Environment Management Council (Tanzania)
NEPAD	The New Partnership for Africa's Development
NFP	National Focal Point
NGFPA	National Government Focal Point Agencies
NGO	Non-Governmental Organization
NOAA	National Oceanographic and Atmospheric Administration (USA)
NORAD	Norwegian Agency for Development Cooperation
OAU	Organization for African Unity (now AU)
ODINAfrica	Ocean Data and Information Network for Africa
ORI	Oceanographic Research Institute (South Africa)
PAC	Policy Advisory Committee
PCU	Project Coordination Unit (ASCLME)
PM	Project Manager
PIR	Project Implementation Review
POPs	Persistent Organic Pollutants
PPER	Project Performance and Evaluation Review
PSC	Project Steering Committee
QA	Quality Assurance
QC	Quality Control
RMU	Regional Management Unit (SWIOFP)
SADC	Southern Africa Development Community
SAP	Strategic Action Programme
SCLME	Somali Current Large Marine Ecosystem
SeaWiFS	Sea-viewing Wide Field-of-view Sensor
SEC	South Equatorial Current
SIDS	Small Island Developing States
STAP	Science and Technical Advisory Panel of the GEF
SWIOFC	Southwest Indian Ocean Fisheries Commission
SWIOFP	Southwest Indian Ocean Fisheries Project
TAFIRI	Tanzania Fisheries Research Institute
TDA	Transboundary Diagnostic Analysis
TOR	Terms of References
TPR	Tri-Partite Review
UNCLOS	United Nations Convention on the Law of the Sea
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNOPS	United Nations Office for Project Services
WB	World Bank
WCS	Wildlife Conservation Society
WIO	Western Indian Ocean
WIO-LaB	UNEP GEF Project addressing land-based activities in the Western Indian Ocean
WIOMSA	Western Indian Ocean Marine Science Association
WWF	World Wide Fund for Nature

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Executive Summary

The Agulhas and Somali Current Large Marine Ecosystems (ASCLME) Project and the South West Indian Ocean Fisheries Project (SWIOFP) are part of a multi-project and multi-agency undertaking to institutionalize cooperative and adaptive management of the Agulhas and Somali LMEs. South Africa, Mozambique, Tanzania, Kenya, Comoros, Seychelles, Madagascar and Mauritius are full participants in both Project activities while Somalia has observer status. France is a full participant in the SWIOF Project and an active partner in the ASCLME Project. This Transboundary Diagnostic Analysis (TDA) has been developed jointly by the ASCLME and SWIOF Projects and is the regional synthesis report on the current status of the Agulhas and Somali Current Large Marine Ecosystems. It presents an analysis of the ecosystem status and the threats to the long term sustainability of coastal and marine processes and resources in the region. The relative importance of the immediate and root sources and causes of the problems are assessed with a view to identifying potential preventive and remedial actions. As such, the TDA provides the technical basis for development of a Strategic Action Programme (SAP) for the region. The TDA is based on the outcomes of a four-year process of data collection, regional reviews and assessments, and engagement with stakeholders in the ASCLME countries from community to ministerial level. The input to the Analysis comes from the National Marine Ecosystem Diagnostic Analyses (MEDAs) together with a total of 56 reports and studies resulting from detailed specialist studies undertaken by the projects.

In order to achieve effective ecosystem management and governance in the region, it was necessary to agree on the management boundaries. Suitable boundaries are considered in Chapter 2 and the following were recommended:

- the western boundary should be the mainland African coastline, taking note of land-based influences currently being addressed by the WIO-LaB project;
- the eastern boundary should be approximately 67 degrees East to include the EEZs of all the major western Indian Ocean island states, the South Equatorial Current and the Central Indian Ridge;
- the southern boundary should be approximately 42 degrees South and, recognizing that it overlaps with the eastern boundary of the BCLME, approximately 20 degrees East to include the Agulhas Current region and the Agulhas Return Current; and
- the northern boundary should be 10 degrees North, to include the Somali current, offshore upwelling and great whirl.

The Agulhas and Somali Current and Mascarene region are three Large Marine Ecosystems (LMEs) situated off the east coast of Africa. Chapter 3 of this report provides a baseline description of their environmental status. These LMEs and their adjacent seas are very closely linked ecologically and culturally, and are referred to collectively as the western Indian Ocean (WIO) region. The region covers approximately 22.3 million square kilometres and is floored by deep abyssal plains and bounded to the west by non-volcanic continental shelves. The Mascarene Plateau is the most prominent bathymetric feature of the Indian Ocean and extends as a submerged part-continental and part-volcanic plateau for over 1 500km. The width of the continental shelf of the ASCLME region tends to increase southwards from the Somali coast in the north and extends to 150m depth on average. Approximately 700 seamounts have been identified in the WIO region and are known to be hotspots of biodiversity and marine biomass in the pelagic ecosystem. The coastline of the Agulhas and Somali LMEs countries, including mainland and island states, is over 15,000 km long. It includes a wide diversity of coastal habitats including rocky shores, sandy beaches, coral reefs, mangrove systems, seagrass beds and estuaries which, in combination, supply a wealth of ecosystem services to the human populations along the coast. However, coastal habitats tend to be at high risk because of their proximity to land and marine based impacts and because they are typically easily accessible from land and vulnerable to overexploitation if not managed properly.

The oceanography of the WIO is influenced by the seafloor bathymetry, continental masses, input of water from surrounding oceans, and interaction with the atmosphere. Steady warming has been observed in both the Agulhas and Somali Current LMEs with warming of 0.68 ° C having been observed since 1957 in the former.

Section 3.3 of Chapter 3 deals with fisheries. The WIO generates a catch of more than 4 million tonnes of fish per year, produced by fisheries ranging from traditional subsistence and artisanal activities using a wide variety of different gears, to large-scale industrial operations fishing mainly with longlines, purse seines and trawling. The best available estimates are that one third of stocks in the region are now either overfished or depleted. The most important underlying causes of declines in fish catches and resources, and recommendations for addressing them were obtained through a series of retrospective analyses. Retrospective analyses were done on the Crustacean Trawl Fisheries (Shallow), Crustacean Trawl Fisheries (Deep), Crustacean Trap Fisheries (Deep), Demersal Fisheries and Pelagic Fisheries, as well as on Biodiversity in Fisheries Management. An important common underlying cause identified from the analyses was a lack of adequate and appropriate data on the priority species for effective management of the fisheries in the SWIOFP region. This should be addressed by implementation of sampling and monitoring programmes in accordance with the specific features of each fishery. A second underlying factor was a generally limited understanding of the linkages between fisheries and biodiversity, including vulnerable species, bycatch and fishing impacts on target and non-target stocks, the ecological impacts of trawling and other interactions. The TDA also notes that many of the national fisheries laws in the region do not adequately incorporate the binding obligations of international fisheries instruments and do not always reflect currently accepted "best practices" in fisheries legislation. Other concerns included the absence of regional management strategies for shared and transboundary stocks in the demersal and crustacean fisheries, overcapacity from rapidly increasing coastal populations together with high levels of unemployment and poverty, inadequate monitoring, control and surveillance, and the need to increase awareness about environmental and fisheries-related issues amongst the fisher communities to encourage sustainable behaviours in the future.

A high diversity of species and communities exists in the waters of the Agulhas and Somali LMEs. By 2005, 11,257 marine species had been recorded from the western Indian Ocean region including island states but this is estimated to be less than 50% of the marine species that are actually present. Most of the ASCLME region falls into the Tropical Western Indian Ocean biogeographical region and is characterised by Indo-Pacific biota but the subtropical East Coast Province starts in southern Mozambique and extends to the Eastern Cape of South Africa. The biodiversity includes a total of 37 marine mammal species recorded in the WIO region while five species of sea turtle are known to occur in the South West Indian Ocean (SWIO). Eleven seabird families occur as breeding species within the geographical scope of the western Indian Ocean.

Less than 200 cartilaginous fishes have been recorded in the SWIO and, except for South Africa, little effort seems to have been made to assess the status of sharks and rays in the region. This limited knowledge is of concern given that sharks and rays are likely to be heavily impacted by fisheries and other activities. Approximately 2,200 species of teleost fish have been recorded, consisting of 270 families. Many of these species are transboundary and shared between the SWIOFP countries. The fishes of the WIO region are subjected to a number of negative impacts which place them at differing levels of risk. The impacts arise from factors including ecosystem and habitat destruction, climate change and fishing, including targeted fishing or as bycatch. Fishing is also impacting on the species' environment in some instances.

Coral reefs, mangroves and seagrass beds are critically important tropical habitats in the region. They provide habitat and other services for coastal species and for coastal human populations which depend on them for food, livelihoods and other ecosystem services. These habitats are under threat from a range of human impacts including pollution, sedimentation, physical removal, human settlement and the damaging effects of fishing. One hundred and four introduced or alien species and 45 cryptogenic species have been identified within the region of which only 5 are considered to be invasive. However, the data available were very limited and may be incomplete

Chapter 4 reports on the socio-economics and coastal livelihoods of the region. Over 160 million people reside in the ASCLME countries and approximately 55 million of them live on the coast. Although variable from place to place, there is a high reliance by these people on coastal and marine resources for food security and livelihoods in general. Because of their high dependence and limited resilience or adaptive capacity, environmental variability and extreme events have a disproportionately severe effect on the communities. Further, coastal cities and settlements are growing and developing at a rapid rate. Tourism, fisheries, coastal agriculture, mining, mariculture, and ports and coastal transport provide the main coastal livelihoods in the WIO region. The

relative contribution of each of these sectors and their specific characteristics vary from country to country but there are important similarities and common themes across the region. Notwithstanding constraints, there are a number of opportunities for sustainable development of the coastal areas in the western Indian Ocean. Regional initiatives are required to bring together and assist the various stakeholders to discuss how best to develop these opportunities.

Challenges to sustaining and developing coastal livelihoods and opportunities vary between countries and sectors. One of the common challenges is revenue leakage, which means that only small proportions of the revenues received remain in the countries and even smaller proportions trickle down to communities. This problem is particularly serious in the tourism sector. Weak infrastructure and facilities is another problem constraining development in, for example, tourism, small-scale fisheries, mariculture and ports and coastal transport. It is generally linked to another common problem which is a lack of access to finance and capital for development. This ranges from lack of access to credit for small-scale fishers to the problems associated with insufficient development capital for ports and transport. It is a problem that impacts on the fisheries, mariculture, and ports and coastal transport sectors amongst others. Environmental degradation and environmental impacts are also important constraints across all sectors. Over-exploitation of resources is common in fisheries, agriculture and forestry and is frequently linked to poverty and over-dependence on the resources. Alternative livelihoods and livelihood diversification are urgently required to ameliorate these problems. The environmental impacts of tourism, fisheries, mariculture, forestry and agriculture, energy and coastal mining are already a serious concern and development of these sectors must be done in a way that minimises such impacts and does not cause irreversible damage. Limited and often inadequate human capacity is also common to nearly all of the sectors and encompasses, for example, inadequate governance capacity, research capacity and capacity for fulfilling financial, operational and human resource functions. Security concerns, political instability, weak service delivery, conflicts between sectors and centralised control and over-regulation were also identified as problems in some sectors and countries.

Notwithstanding the challenges, there are many examples of progress being made. For example, ecotourism in Kenya is providing incentives to protect the environment and enables the inclusion and employment of local communities in the sector. In Mauritius and Seychelles, the need to support small-scale fishers through soft-term loans and duty concessions from the government has been recognized, while in Comoros the government is helping to support development in the small-scale sector with revenues gained from the large-scale industrial fisheries. Also in fisheries, progress towards decentralized and participatory management is being made in Mozambique, Tanzania and South Africa, for example, while Kenya, Tanzania and South Africa are making progress in promotion of participatory management of forests. Good examples of responsible development can be seen in the mariculture sector where prawn farming in Madagascar and abalone farming in South Africa could serve as models for the region. Examples of promotion of alternative sources of income can be seen in the development of bee keeping, honey production and tree nursery management as means of reducing the pressure on coastal resources in Tanzania. Pottery, horticulture, and small-scale cashew nut and coconut collection are fulfilling the same role in Mozambique. Positive engagement in local development by the private sector can be found in both the energy and coastal mining sectors. Oil and gas companies have engaged in wide variety of social development activities in Madagascar and all the mainland countries such as construction of community clinics, rehabilitation of roads and community buildings, and support to cyclone-affected populations. Similar contributions have been made by companies engaged in coastal mining.

A comprehensive cost-benefit analysis, presented in Chapter 5, estimated that almost US$22.4 billion a year is derived from the coastal and marine resources of the ASCLME. Coastal tourism was found to make the largest contribution to GDP at over USD 11 billion a year, equivalent to 40% of the total from marine and coastal resources. Agriculture and forestry were next at 20% of the combined contribution, followed by mining and energy at 15% and fisheries at 11%. The fisheries of the ASCLME region generate a resource rent estimated at approximately USD 68 million per year, of which about USD 59 million are generated by ASCLME countries and the remainder by countries outside of the region. The study estimated that effective management of the fisheries and rebuilding of stocks of the ASCLME could result in an additional USD 221 million in annual economic rent. Most of the economic benefits from the coastal and marine resources of the ASCLME remain in the countries of the region. In the fisheries sector, the workers, for example the fishers, receive an estimated USD 365.69 million per year in wages compared to earnings of USD 60.16 million by the fishing enterprises

that employ them.

Chapter 6 describes deterioration in the quality of the coastal waters of the ASCLME region that is a significant threat to public health and to the well-being of the living marine resources and ecosystems. The sources of pollution include land-based, marine and maritime related activities. The land-based activities are addressed in the separate WIO-LaB project and this TDA focusses on marine sources including dumping, shipping, ports, and oil and gas activities. Addressing the threats requires an effective legal regime covering national, regional and international levels. The majority of ASCLME countries are parties to most of the relevant international conventions but a number of gaps and inconsistencies need to be addressed, especially in the national legal and institutional frameworks. Examples include: overlapping jurisdictions and a lack of communication across sectors; failure to include the provisions of international conventions in domestic laws and regulations; weak implementation; surveillance activities split amongst various institutions; and some unresolved maritime borders between some of the countries. There is also a need to introduce or strengthen legislation on dredging, environmental impacts of offshore oil and gas activities, liability and compensation related to offshore activities, and monitoring and standards. Considerable progress in meeting these needs can be achieved through collaborating with existing programmes and organisational partners that are already active in the region.

Chapter 7 provides a baseline description of management, policy and governance in the region, at both national and regional levels. The styles of marine and coastal governance vary from country to country, reflecting their individual histories and cultural backgrounds. The styles have also been influenced by relevant regional and international agreements. The differences between countries occur in their systems of governmental organisation, processes and priorities, the levels of economic development, scientific capacity and incorporation of science into policy processes, patterns of social organization, culture and values, and in their political relations. Similarly, there are differences in the governance of the major sectors related to sustainable use of marine and coastal resources. Inadequacies and gaps exist in the application of the existing legislation to ecosystem based management, also varying from country to country. A number of regional agreements and bodies are in place in the ASCLME region including, for example, the Nairobi Convention (Convention on the Protection, Management and Development of the Marine and Coastal Environment of the Eastern African Region) and the South Western Indian Ocean Fisheries Commission (SWIOFC). There are also the wider regional agreements such as the Indian Ocean Tuna Commission (IOTC) and several Regional Economic Commissions and the African Union's New Economic Partnership for African Development (NEPAD) also play a role in the region. The countries are also parties to the most important relevant international agreements including the 1982 United Nations Convention on the Law of the Sea (UNCLOS). Notwithstanding this existing framework, there is currently no single mechanism that could implement an integrated region-wide approach to the governance of marine and coastal resources in the ASCLME region, but the countries have agreed that one is needed.

In the absence of an integrated regional approach, the countries are not obtaining the optimal benefits from the marine and coastal resources. The TDA examined four regional ecosystem based governance options to fulfil this role. They were: i) business as usual; ii) enhancement of an existing institution with new powers; iii) establishment of a new institution; and iv) an informal collaboration mechanism. After analysis of the options and formal discussion at the regional level, it has been concluded that an informal collaboration mechanism would be the most appropriate for the ASCLME region. The countries and their partner agencies have endorsed the need to develop and implement a "Western Indian Ocean Sustainable Ecosystem Alliance" (WIOSEA) to serve as an effective regional management and governance system. It has also been recommended that the regional mechanisms of the Alliance should be replicated at the national level. The establishment of the Alliance is one of the major recommendations from the TDA for future action.

Chapters 8 and 9 present the agreed priorities for the main transboundary areas of concern, together with a regional summary of proximal and root causes. Through a thorough process of validation and prioritisation at national and regional levels, the 21 top priority transboundary issues for inclusion in the Strategic Action Programme (SAP) were identified. These issues were categorised into four Main Areas of Concern (MACs): MAC01: Water quality degradation, MAC02: Habitat and community modification, MAC03: Declines in living marine resources, and MAC04: Unpredictable Environmental Variability and Extreme Events. Examples

from the 21 issues include: 1.1 Alteration of natural river flow and changes in freshwater input and sediment load and 1.3.5 Solid wastes/marine debris from shipping and land-based-sources (both from MAC01); 2.1.Shoreline change, due to modification, land reclamation and coastal erosion and 2.2.6 Disturbance, damage and loss of mangrove habitats (from MAC02); 3.2.2 Decline in populations of large pelagics and 3.4 Excessive bycatch and discards (from MAC03); and 4.1 Climate hazards and extreme weather events and 4.2 Sea level change (from MAC04).

Chapter 9 reports on the results of two complementary analyses of the priority issues: the construction of the impact chains and the causal chains. Impact chain analysis includes identification of the environmental impacts arising from each issue and the impacts on the ecosystem services provided. Ecosystem services are categorised as Provision Services, Cultural and Amenity Services, Supporting / Habitat Services and Regulating Services. The socio-economic impacts of the issue were also examined, covering consequences such as reductions in opportunities for tourism and leisure; loss of fisheries resources and revenue; loss of income generating livelihoods from tourism; increased unemployment; threats to public health; reduction of foreign income and revenues; loss of national revenues; reduced resilience; increasing poverty; and others.

Construction of the causal chains required identification of the direct or immediate causes of each issue, the sectors and resource use practices that contributed to the direct causes, the underlying legal, social, economic and political causes and then finally the root causes. The 9 common root causes identified through the analyses were:

- Inappropriate governance arising from problems such as inappropriate and outdated legislation, deficiencies in enforcement and compliance, and lack of management and institutional capacity;
- Economic drivers including high international and local market demand for resources, inappropriate subsidies and incentives, and lack of alternative opportunities;
- Inadequate financial resources resulting from the low GDPs of most countries in the region as well as inadequate mechanisms for leveraging additional finances;
- Inadequate knowledge and awareness arising from factors such as lack of or inadequate regulations, lack of legal expertise, limited or lack of education, and others;
- Cultural traditions that can stem from a legacy of decades of poor environmental management in some countries, as well as traditional practices that may no longer be sustainable;
- Population pressure and demographics as a result of population growth over the last century exacerbated by large scale migration to the coast driven by a number of pressures;
- Poverty and inequality, which can lead to an increased dependency on the exploitation of natural resources and subsistence living;
- Climate change and natural processes;
- Personal attitudes such as a culture of entitlement in some fisher communities and a tendency to shift blame other stakeholder. Bribery, greed and corruption were also identified as problems.

1. Introduction

The ASCLME and SWIOF Projects

The Agulhas and Somali Current Large Marine Ecosystems (ASCLME) Project and the South West Indian Ocean Fisheries Project (SWIOFP) were part of a multi-agency undertaking to institutionalize cooperative and adaptive management of the Agulhas and Somali Currents LMEs and to confirm the presence of a possible Mascarene Plateau LME. The two projects were funded by the Global Environment Facility (GEF). The ASCLME Project was implemented by the United Nations Development Programme (UNDP) with the United Nations Office for Project Services (UNOPS) serving as the executing agency. The South West Indian Ocean Fisheries Project was implemented by the World Bank. The countries of South Africa, Mozambique, Tanzania, Kenya, Comoros, Seychelles, Madagascar and Mauritius participated in the implementation of both Projects. Somalia had the status of an observer and was actively involved in the ASCLME Project. France participated in the implementation of the SWIOF Project through the co-financing of the Fond Français pour l'Environnement Mondial (FFEM), and was also an active partner in the ASCLME Project (Figure 1).

In addition to these two projects, the GEF also supported the UNEP-implemented Project (WIO-LaB) through which a TDA and SAP were developed focused on the land-based sources of pollution in the Western Indian Ocean.

A phased approach was adopted for the three projects that progressively built the knowledge base and strengthened technical and management capabilities at the regional scale to address transboundary environmental concerns within the Western Indian Ocean (WIO). The projects also built political will to undertake threat abatement activities and leverage finances proportionate to management needs in the participating countries.

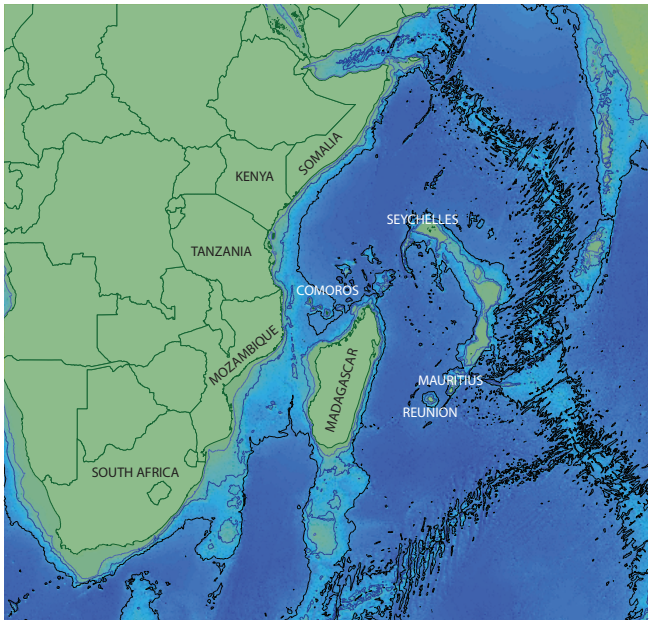


Figure 1: Countries participating in the ASCLME and SWIOF Projects

Objectives of the Transboundary Diagnostic Analysis (TDA)

The Transboundary Diagnostic Analysis (TDA) is the regional scientific and technical synthesis report for the current status of the Agulhas and Somali Current Large Marine Ecosystem. Developed by the ASCLME and SWIOF Projects together, it presents an analysis of ecosystem status and threats to the long term sustainability of coastal and marine processes.

As defined by GEF International Waters: "The purpose of conducting a TDA is to scale the relative importance of sources and causes, both immediate and root, of transboundary 'waters' problems, and to identify potential preventive and remedial actions. The TDA provides the technical basis for development of a Strategic Action Programme (SAP) in the area of international waters of the GEF." (IW resources guide, terms and definitions).

The synthesis presented in this TDA will be used to develop a Strategic Action Programme (SAP) to address the problems of greatest concern that are facing the marine and coastal ecosystems of the WIO region today. The joint ASCLME-SWIOFP TDA and SAP are intended to be complementary to the TDA and SAP for land based sources of pollution produced by the WIO-LaB project Addressing Land Based Sources of Pollution in the Western Indian Ocean (UNEP/Nairobi Convention Secretariat 2009).

A preliminary TDA for the WIO region was prepared under the auspices of the Nairobi Convention by the Institute of Marine Sciences (IMS) of the University of Dar es Salaam in 1998, prior to project development (see Annex 9 to UNDP 2005). The main perceived problems or issues were identified as:

I. Shortage and contamination of fresh water
II. Decline in harvests of marine and coastal living resources
III. Degradation of coastal habitats (mangroves, seagrass beds, and coral reefs), loss of biodiversity.
IV. Overall water quality decline. Contamination of coastal waters, beaches and living resources.

The preliminary TDA was based on the limited data and information available in the WIO Region at that time, and mainly identified perceived issues and problems that formed the basis for the preparation of the three GEF financed projects (WIO-LaB, ASCLME and SWIOFP). It was intended that the three GEF projects would generate more data and information and prepare a more comprehensive TDA with the full involvement of countries and stakeholders for the entire WIO region, including high seas.

MEDA-TDA-SAP approach and country engagement

The ASCLME TDA is an outcome of a four-year process of data collection, regional reviews and assessments, and engagement with a wide range of stakeholders in the participating WIO countries. An early decision was made through the Steering Committee to initiate the TDA process at the country level by starting with national Marine Ecosystem Diagnostic Analyses. These would effectively provide an up-to-date status report from each country on their marine and coastal environment, potential and actual impacts and threats, root causes of these impacts, threats, and possible mitigating actions or solutions.

Establishment of SWIOFP components / working groups

Each of the SWIOFP participating country were supported by a National Management Unit (NMU) lead by a National Focal Point and assisted by National Component Coordinators (NCCs) who are responsible to coordinate all the national activities: Each country has the following NCCs:

- A Data and Information National Component Coordinator (NCC1)
- A Crustacean Fisheries National Component Coordinator (NCC2)
- A Demersal Fisheries National Component Coordinator (NCC3)
- A Pelagic Fisheries National Component Coordinator (NCC4)
- A Non Consumptive Resources National Component Coordinator (NCC5)
- A Fisheries Management National Component Coordinator (NCC6)

Apart from the National Component Coordinators attached to the NMUs (responsible for coordinating all projects within a component within a country), the NMU also host a Regional Component Coordinator (RCC) with the broader responsibility of coordinating a specific component across all SWIOFP countries. The six RCCs (one per component) were designated to the following NMUs:

- Component 1 (Data and Information) - Kenya
- Component 2 (Crustacean resources) – South Africa
- Component 3 (Demersal resources) – Tanzania
- Component 4 (Pelagic resources) – Seychelles
- Component 5 (Non-consumptive resources) – Mauritius
- Component 6 (Strengthening management) – Kenya (Regional Management Unit)
- Sectoral Specialists to contribute to the technical reports

The countries have participated actively in the review the status of the fisheries and associated ecosystem through the South West Indian Ocean Fisheries Commission Scientific and Commission meeting as well as the relevant technical working groups, which has resulted in the preparation of the Retrospective Analysis reports that give the baseline on the status of the major fisheries in the region.

Establishment of national technical groups for the ASCLME Project

Each participating country established a National Technical Coordination Group (COG) under the leadership of the National Focal Point. Each COG consisted of the following;

- A Data and Information Coordinator, responsible for archiving of cruise data at national level, driving data policy, coordinating MEDA development and specialist input for the TDA.
- A Capacity Building and Training Coordinator, responsible for coordinating a national Capacity Building and Training (CB&T) review and providing input to the development of a regional training plan.
- A Cruise Coordinator, responsible for coordinating national participation in cruises.
- Sectoral specialists to contribute to technical documents.

Each participating country actively participated in the national review of the status of their marine and coastal ecosystems, culminating in the production of a national Marine Ecosystem Diagnostic Analysis (MEDA) report.

In preparation for TDA development, the ASCLME Project therefore supported participating countries to develop national Marine Ecosystem Diagnostic Analyses (MEDAs). Listed on page iii (this report), these are national reports combining information on the status of the coastal and marine environment, socio-economics, legislation and threats to coastal and marine ecosystems.

The MEDAs also captured essential information related to the dynamic biophysical processes that define the LMEs, and identified areas of concern that fed into the Transboundary Diagnostic Analyses (TDAs), and the Strategic Action Programme (SAP).

Whilst the TDA/SAP process was effective at the regional level, each MEDA provided data and information relevant to the management of the coastal and marine ecosystem in each of the participating countries. MEDAs added a new dimension to the management of LMEs by providing a better understanding of the overall state of the environment within each of the participating countries. The information presented in each national MEDA, when combined with those from neighbouring countries, revealed pertinent transboundary issues that would not have been apparent had the process solely adopted a regional approach. Furthermore, a healthy, well-understood and well-managed national marine ecosystem will inevitably have positive impacts at the regional scale. During the implementation phase of the SAP, the MEDAs should be used to develop National Action Plans in support of SAP implementation.

The MEDA reports, together with other detailed specialist studies including those on invasive species, marine pollution, coastal livelihoods, commercial fisheries and cost benefit analyses (a total of 58 reports and studies listed on page iii form the factual basis of this TDA.

Issues of concern identified by the countries in the MEDAs have been taken through a prioritisation and detailed causal chain analysis process at both national and regional level which was used to identify transboundary issues of greatest concern to the participating countries. The process also identified proximal and root causes as well as direct and indirect consequences to coastal and marine ecosystems (including human populations). These issues included those related to Fisheries, with ASCLME and SWIOFP representatives involved in the process.

Detailed methods as well as the results of the causal chain meetings are summarised in Chapters 8 and 9 (in Volume 2 of this report).

TDA and SAP development

The process of TDA development commenced formally in 2010, and concluded with the fourth and final TDA Working Group meeting in July 2012. Key findings from the MEDAs, the Retrospective Analysis and other baseline reports are presented in this report, as well as the results from the Causal Chain Analysis meetings.

Guided by the Project Steering Committees, Joint Policy Advisory Committee and Strategic Action Programme development team, the key findings of the TDA were used in the development of the ASCLME SAP. The

ASCLME SAP will be focussed mainly on reforms and investments required to address various problems/ issues identified in the TDA (Figure 2).

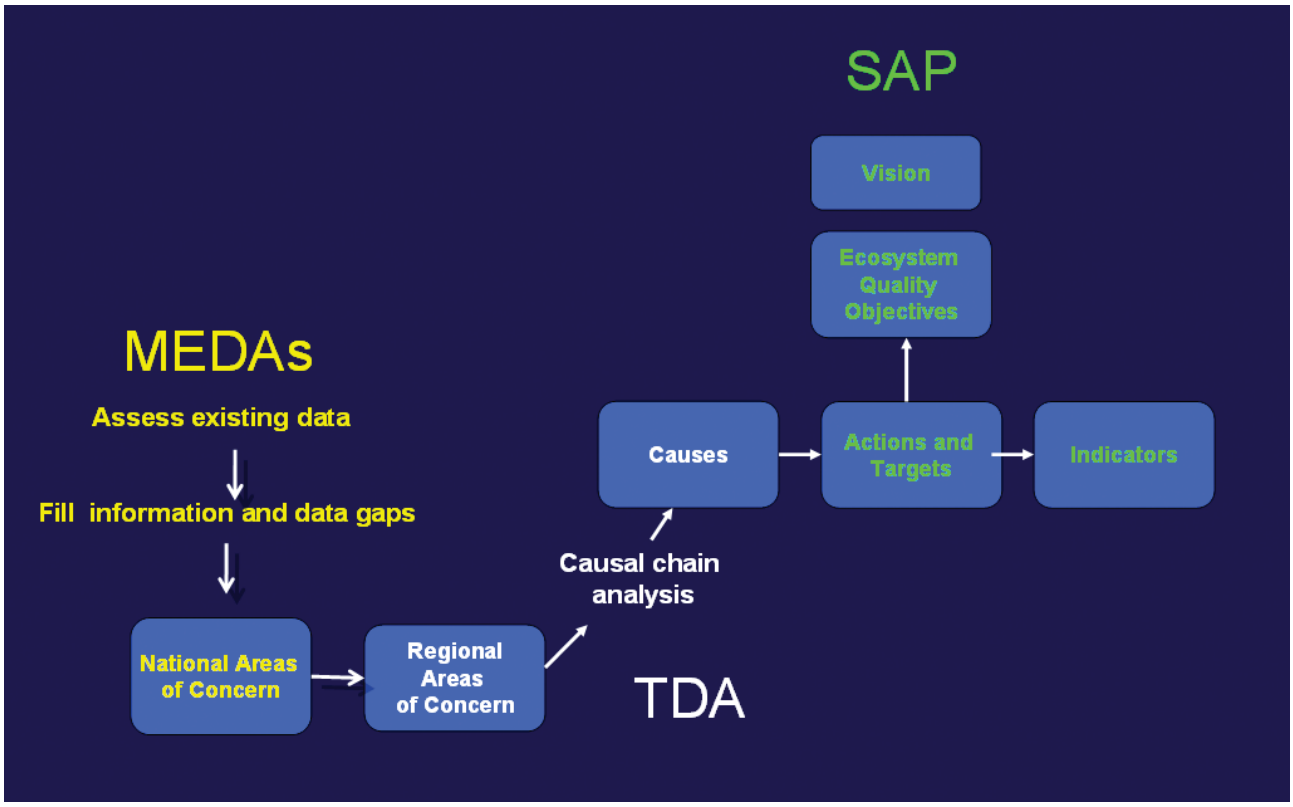


Figure 2: The process of MEDA-TDA-SAP development

Building the knowledge base

The ASCLME and SWIOF Projects commenced at a time when there was a low baseline of existing knowledge for the Western Indian Ocean region. Results from scientific studies were not easily accessible, often being published in institutional reports and scattered in national facilities, NGOs and project archives. Data and information from international studies were not routinely repatriated to host countries, leading to local loss, or at least reduced benefit of international investment in marine science in the region (UNDP 2005). Efforts from many agencies have served to address these problems. Within the region, networks such as WIOMSA have funded and promoted the development of marine science programmes, projects such as ODINAFRICA have supported the development of national information networks and the repatriation of data. The ASCLME and SWIOF Projects have encouraged these efforts as well as supported dedicated studies to fill information and capacity gaps identified in the ASCLME and SWIOF Projects documents.

The existence of baseline data and key partners for TDA and SAP development were identified at several meetings, notably:

1. Towards a Framework for Information Sharing Between Programmes and Countries in the Western Indian Ocean Region (20-22 October 2004; Grahamstown, South Africa)
2. ASCLME Regional Project Coordination Forum (2-4 October 2008; Balaclava, Mauritius).

Partnerships with projects and agencies represented at these meetings have been built over the subsequent five years, and it is expected that these partnerships will be carried forward into the implementation of the SAP.

Communications and Stakeholder Participation

The ASCLME Project has carried out several activities aimed at ensuring broad communications and stakeholder participation throughout the ASCLME region.

DLIST

The Distance Learning and Information Sharing Tool (DLIST; www.dlist-asclme.org) developed and implemented by EcoAfrica provided community-level input and engagement with the ASCLME Project. A similar approach and toolset was previously adopted and deployed by the neighbouring BCLME through a GEF MSP grant.

The DLIST "platform" comprises an electronic Community of Practice with discussion lists, an online document and image repository and e-learning courses. There are approximately 400 registered users in the WIO region, with DLIST e-newsletters distributed to around 2,000 recipients. Recognising the difficulty in accessing such content in rural areas, by communities with low literacy levels and in order to surmount language barriers, nine demonstration site communities were selected in consultation with National Focal Points, one in each ASCLME country, with two in Tanzania (one mainland site and one on Pemba). Due to the security situation, no community was selected in Somalia.

Inputs to the TDA/SAP process were primarily through a MEDA input report, which was included in each country's MEDA Annexes (with the exception of Somalia) along with other DLIST reports and Local Economic Development (LED) plans for each community. These provide a snapshot of community concerns, and whilst limited in scope (a single community per country) the themes in each are similar enough, both between each community and within the broader developing world situation, that one can assume they are broadly applicable throughout the region - even if local solutions to challenges may be unique.

DLIST reports reflect numerous cross-cutting issues related to poverty, environmental degradation, resource overexploitation and development (or lack thereof), with LED plans aiming to guide development activity in each community, dependent on external financial assistance to do so. Solutions and activities are presented to address various shortcomings in education, healthcare, sanitation, water/electricity supply, alternative livelihoods and so on. Many reports expose challenges in the enforcement of existing regulations and laws, gaps in communication between local communities and governance structures and considerable inter-sectoral resource use conflicts. These in particular deserve attention in the SAP.

Website

The ASCLME Project website serves as an internationally accessible resource for Project information, with comprehensive background information about the Project and its activities and periodic updates covering ongoing actions. A popular feature has been the cruise blog, which serves as a slightly less formal window into the Project's activities, showcasing Project scientific activities as and when they happen. Over 60,000 visitors have seen the site, with over 124,000 pageviews. Websites are a relatively low-cost but very flexible method of making Project information available to large audiences. The website also occasionally elicits direct questions from the public via e-mail, which are answered as quickly as possible.

Films

The ASCLME Project has produced two films, a 26 minute documentary-style "education" film, produced in conjunction with WIO-LaB entitled *Rivers of Life, Oceans of Plenty* and a shorter 10 minute film, aimed at policy-makers with an emphasis on climate change and its impacts on marine and coastal resources, entitled *Planning for Change*. The films were distributed as DVDs and are available electronically.

Education

In addition to the films above, the ASCLME Project has partnered with the African Coelacanth Ecosystem Programme (ACEP) to continue development and deployment of a series of educational materials, based around workbooks and video-based lessons, which cover environmental issues and the impacts of human activities from the water cycle, down rivers, through estuaries and into the sea. Completed modules include the water cycle, rivers and estuaries (temperate), with modules on the coastal environment, shallow water ecosystems and the broader ocean in development. This activity will allow the Project and its Partners to inject lively, relevant and engaging educational content which is not only of use to present curricula, but also serves to introduce important ideas and concepts with a focus on marine and coastal issues which are not necessarily included in current educational curricula. A key concept of this series is that the materials are not simply dumped on educators, but are instead introduced through workshops, which enable deeper understanding and

familiarity with the materials, and making the information more locally relevant by choosing and incorporating local case studies and assisting educators with effectively utilising the materials. "Mainstreaming" (marine) science, marine and coastal livelihood issues and sustainable development in national curricula would be a very useful target for SAP implementation. The development of the material is ongoing.

Newsletters
The ASCLME Project, latterly in conjunction with SWIOFP, has produced annual printed newsletters in 3 languages, covering project activities and achievements throughout the region and serving as a useful and engaging summary of activities of the Projects and their various partners. These are also available electronically. The first newsletter also included a large poster showcasing the Project and region.

Media Engagement
The Project has also engaged with the mass media, particularly in print, with focal activities such as ship port visits and large meetings serving as useful "hooks" to engage media interest in the Project and its activities.

Ad hoc
The Project continuously communicates with stakeholders through meetings, both regionally and internationally and will often produce event-specific communications materials targeted at specific events or audiences. Ship port visits have enabled some public participation activities such as ship visits, which serve as a useful opportunity to showcase marine research and the broader issues which the Project aims to tackle. Networking with other LME practitioners and marine researchers in general has been facilitated through active participation in various conferences. Publication of peer reviewed scientific papers and contributions to academic books are also vital parts of the Project's communication activities.

Regional Training Priorities

A meeting of the national Capacity Building and Training Coordinators was held in the Seychelles on the 6 and 7 August 2012, with a view to presenting the National Training Plans (Annexes to the MEDAs), and developing a regional strategy, to be incorporated into the Strategic Action Program. The results of this Workshop are summarized below.

Key Regional Issues
1. Lack of infrastructure and equipment
2. Lack of schools
3. Lack of basic marine education in schools curricula
4. Lack of capacity at all levels including but not limited to fishers, processors, marketers, investment agencies, biological research, stock assessment, oceanographers, marine geographers, aqua culturists, marine engineers, economists, monitoring, surveillance and compliance, governance experts, socio economists, marine lawyers, marine meteorologists and health and tourism planning.
5. Middle and senior managers often lack background and training in the marine field
6. Lack of incentives for Government service, particularly salaries
7. Choice of candidates for training often not taken strategically
8. Lack of implementation of training received
9. Language barriers
10. Communication challenges at all levels both within and between governments and private and business sector - local, national, regional
11. Writing of proposals for study – scientific writing in general
12. Other than South Africa, lack of access to the offshore environment
13. Training by NGOs not sustained
14. Lack of mentors and mentorship
15. Private-public collaboration requires substantial expandsion for maritime studies

Specific interventions suggested
To form a CBT alliance of regional partners to facilitate training in the region

Through this alliance:

- To identify, encourage and build on regional centers of excellence for future training, and develop new centers of excellence
- To play a coordination role where appropriate, through identifying and expanding on key courses and training activities across the region, recognizing and resolving both communication issues within country and regional, and language barriers

1. For the ASCLME/SWIOF Strategic Action Program project to successfully implement the key regional training objectives as identified through the TDA
2. For the ASCLME/SWIOF Strategic Action Program undertake specific interventions for key priority training as identified through the CBT coordinators and specialists, in National Training Plans, and are listed below:
3. In conjunction with Alliance partners provide selected short courses and individual training in as many aspects as are possible of training required in the National Training Plans, and those of Alliance partners. Recognizing that the first courses should include Ocean Governance, oceanographic instrumentation, taxonomy and curatorship, environmental monitoring and use of hydrodynamic modeling in oceanography and climate change.
4. To develop capacity in socio-economic assessments (fisheries, tourism, ecosystems, value chain analysis, ecosystem services).
5. To promote capacity for scientific research/proposal writing and coaching.
6. To provide support to selected training institutions – e.g. CEPAM
7. To source training platforms (ships, infrastructure) for offshore research and training and provide training
8. To provide opportunities for twinning exercises and provide mentors for extended periods throughout the region
9. To investigate and provide support for school curricula : primary and secondary schools
10. To successfully introduce at least one new course in a tertiary institution in the region identified as a major gap by the nine countries in the first phase of the project.
11. To set up and undertake at least one on-going Public Private Sector sponsored Training course
12. To provide courses in all aspects of the ecosystem approach to management of LME's.
13. To provide broad basic training on data collection and data management strategies
14. To source and provide training in selected key areas in both French and English, and Portuguese where required

Data and information management

ASCLME Project

Substantial amounts of data collected by government and donor-funded marine scientists around the world are not routinely archived in data centres. Even if published, the original data are irretrievably lost to studies of long-term (environmental) change (SCOR/IODE 2008) over time. The ASCLME Project developed a data & information management policy (Appendix I) and a regional data & information management plan (Appendix II), which was subsequently interpreted by each of the participating countries in an integrated national data and information management plan (Annexed to each of the MEDAs). The regional plan has been peer reviewed (by the IOC/UNESCO, UNEP & Nansen Projects).

The purpose of the plan is to ensure that data collected during the duration of the ASCLME Project, and thereafter, are not only tracked and monitored to the stage of publication, but that data sets are also archived in national data centres for the ongoing benefit of countries, and to build country ownership of the TDA/SAP process. International best practices and standards for data management were followed in all cases (eg. JCOMM 2008). Together with capacity building interventions, this approach aimed to support the goal of supporting sustainable national data archives that countries can use in the support of ecosystem monitoring and management in the long term.

A brief summary is provided below, and Appendices should be referenced for full details.

Collection of new data
New data generated by the ASCLME Project will be placed in the public domain as soon as possible; in most cases immediately after collection. A limit to the distribution of raw data may be placed for up to two years (following ICSU recommendations) to allow for publication.

Publications
Nationals for participating countries will be encouraged to use ASCLME data to generate publications, even if they were not able to participate in research activities themselves.

D&I coordination
At the start of the ASCLME Project, each country nominated a data and Infornmation Coordinator to lead the D&I management activities in their country, to participate in the development of regional policy, a national D&I plan (covering analysis, storage, access, data management and dissemination) and to ensure that new data were safely archived.

Archiving of new data
Complete copies of raw and processed data are housed on an FTP site, to which all participating scientists and countries have access.

Data collected by the ASCLME Project have been archived in each of the participating countries, in nationally appointed National Oceanographic Data Centres fo the long term benefit of participating countries and their scientists (see National D&I plans for country-specific details). For long-term security purposes, copies of data have been submitted to regional and international data centres.

Literature management
Literature (bibliographic) information from all sub-contracts was entered into an Endnote database. Where available, full text PDFs were linked to records.

Building capacity
Data management training, covering oceanographic data collection, modelling, coast GIS and many other subjects has been supported by the ASCLME Project in cooperation with ODINAFRICA (IOC/UNESCO), the Nairobi Convention, EU-JRC, University of Cape Town, Rhodes University, Ma-Re (UCT), and the Data Buoy Cooperation Panel of JCOMM.

Financial, software and logistical support was given to existing national facilities to allow them to meet their data management tasks for the project.

Assessment of capacity
The ASCLME Project and ODINAFRICA (IOC/UNESCO) jointly funded a new assessment of national capacity for long term oceanographic and coastal data management in each of the ASCLME countries. This was complemented by a subsequent study of oceanographic and meteorological capacity originating from DBCP III.

Archives and dissemination
Dissemination of data and information takes place in several ways:
- Through the national MEDAs and the TDA (this document)
- Directly from national participating institutions in nine countries
- Through the main FTP server
- Through the Nairobi Convention Clearinghouse Mechanism
- Through the African Marine Atlas
- Via a portal on the ASCLME website (http://bit.ly/ASCLMEDnI)
- Via near-real time data streams from project partners (such as RAMA and the Argo Project).

SWIOF Project
The SWIOF Project has a dedicated component, led by Kenya, addressing Data Gap Analysis, Data Archiving

and Information Technology. This component established a regional data management system to underpin information needed to ensure management of regional fisheries and to undertake a gap analysis to identify the specific research activities to be supported by the project. A data policy agreement was also developed by the SWIOF Project. The regional database was created during the first year of the Project and continues to operate and service the participating and observer countries in SWIOFP, expanding the database with new information from the SWIOFP research cruises and other relevant data input from projects in the SWIO. The project database includes fields for existing data describing by-catch, and provision for adding information from Project-leased and commercial vessels (that have Project observers onboard). The gap analysis relies on the development of a data atlas of historic data describing offshore fisheries of the WIO. A single regional fisheries database will be created using the data atlas, which reflects published information, along with repatriated and consolidated data from various sources. National fisheries related IT and communications infrastructure have been procured or upgraded for each of the nine countries along with training in data handling and reporting.

Joint ASCLME – SWIOFP data management activities

- Joint data collection cruises have been carried out between the projects
- Joint training activities have been supported by both projects
- The ASCLME and SWIOF Projects share the use of the Project FTP site for the uploading of data sets and the exchange of data between the PCU/RCU and participating countries.
- Both projects are using the same literature management software (Endnote) to facilitate better data exchange.
- Both projects are using Geonetwork for the description of metadata, to facilitate data exchange as well as to allow cooperation with the African Marine Atlas Project and the Nairobi Convention Clearinghouse Mechanism.
- Both projects are active participants in the African Marine Atlas Project for the dissemination of data.

2. Defining the Management Boundary

For the purposes of effective ecosystem management and governance of any natural system, certain management boundaries must be agreed. The objective of the definition of a boundary is to motivate for the management of a whole system using an ecosystem approach. In the case of a relatively open ocean system, these boundaries can be defined on the basis of bathymetric features, patterns of biodiversity, patterns of ocean currents and productivity, temperature of chlorophyll fronts, movement and dependencies of migratory species, or socio-economic, governance or cultural features of the human population.

The original definition of the Agulhas and Somali Current LMEs only considered coastal currents and areas within Exclusive Economic Zones (EEZs); see Figure 3 for example.

However, it has long been recognised that the Mascarene plateau region must be included in the LME approach for the Western Indian Ocean region due to the connectivity of the Western Indian Ocean islands and the mainland countries, driven largely by the South Equatorial Current and connected by sub-regional eddy, coastal current, counter-current and upwelling systems. The region also has a shared historical, cultural, political and biological (indo-pacific) history as the Western Indian Ocean which extends from the South-East of South Africa up to the horn of Africa and includes the Western Indian Ocean island states. Figure 4 presents the results of a study demonstrating the connectivity between the reefs of the WIO region, and also demonstrates the close links with the Mascarene Islands.

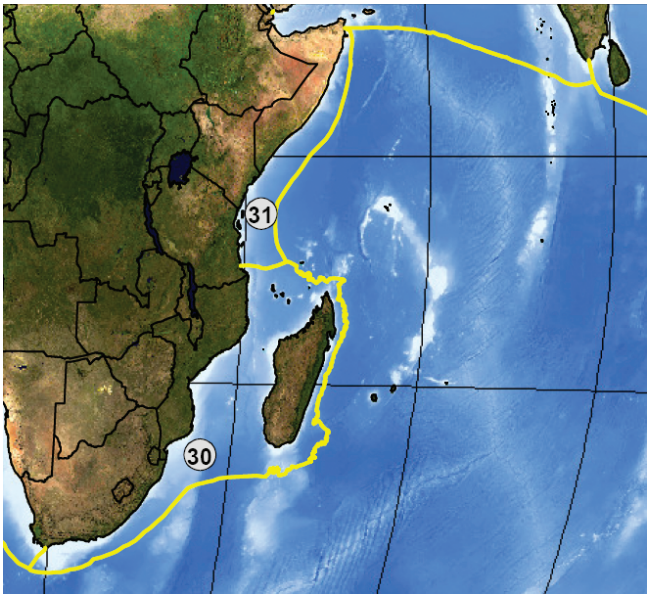


Figure 3: Large Marine Ecosystems of the World; 30 – Agulhas Current; 31 – Somali Current (http://www.lme.noaa.gov accessed 01-2011).

In 1998, in a publication on the LMEs of the Indian Ocean, Nguta proposed that three large hydrographic zones be considered; the Somali upwelling zone (Somalia), the monsoon currents zone (Tanzania, Kenya and the Seychelles), and the Agulhas and Mozambique Currents zone (Mauritius, Madagascar, Comoros, and Mozambique). Although this is not being proposed here, it does demonstrate how the close links between the Mascarene Islands and the Agulhas Current have been appreciated for some time.

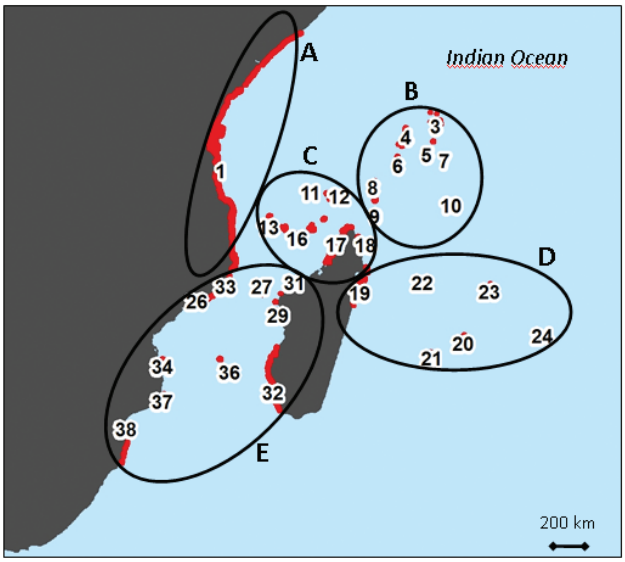


Figure 4: Reef connectivity in the WIO region; letters indicate groups of closely related reefs. Results of an ASCLME-commissioned study (Crochelet 2012)

Since at least 2008, the source region of the Agulhas current, including the islands of Mauritius, La Reunion (France), Seychelles and Comoros, has been included in the greater Agulhas Current LME (Heileman *et al.* 2008). Even so, this boundary is not discrete, with the seasonal South Equatorial Counter Current introducing connectivity from mainland East Africa and the Somali Current LME to the Seychelles Islands.

The boundaries of current governance structures in place for the management of the oceans and associated living marine resources, including the

Nairobi Convention, IOTC, SWIOFC and SIOFA must also be taken into account. LMEs are traditionally defined biophysically, but people must be included as part of the ecosystem, and thus existing management and governance boundaries should be acknowledged.

LME definition

Large Marine Ecosystems (LMEs) are relatively large areas of ocean space of approximately 200,000 km² or greater, adjacent to the continents in coastal waters, with unique bathymetry, hydrography, productivity, and trophic relationships. Based on these criteria, 64 LMEs have been identified in the coastal waters of the Indian, Pacific and Atlantic Oceans.

http://1.usa.gov/XSfhQE

In this TDA, and in the subsequent SAP development, the area under consideration will be as shown in Figure 5 to include the original boundary of the Agulhas and Somali Current LMEs as well as the Western Indian Ocean region, to include:

1) The major surface currents directly associated with the Agulhas and Somali Currents,

2) The defining bathymetric features (ocean basins) of the region, bounded by the Carlsberg Ridge, Central Indian Ridge and Southwest Indian Ridge, and

3) The culturally diverse yet historically connected peoples of southern and East Africa as well as the Indian Ocean Islands.

Landward (western) boundary:
Discharges from major rivers do have an impact on the ASCLME region, and particularly on the quality of its inshore waters. Major cities, especially on mainland Africa have a significant polluting effect in the coastal zone. With this in mind, land-based influences have been considered in this TDA and in the SAP in order to ensure a comprehensive ecosystem approach to problem analysis, but it is acknowledged that land-based issues are being addressed by the WIO-LaB TDA and SAP, so information provided in this document will be used to validate / complement the WIO-LaB products and the LBSA Protocol.

Eastern boundary
Approximately 67 degrees East to include the EEZs of all the major Western Indian Ocean island states, the South Equatorial Current and the Central Indian Ridge.

Southern boundary
Approximately 42 degrees South and approximately 20 degrees East to include the Agulhas Current region, as well as the Agulhas Return Current. The important seamounts of the SWIO are included, but not the EEZs of South Africa and France in the Southern Ocean.

Northern Boundary
10 degrees North, to include the Somali current, offshore upwelling and great whirl, but excludes the EEZ of Yemen.

The southern boundary is dynamic, changing with the Agulhas retroflection and leakage of Indian Ocean water into the South Atlantic. 27 degrees East was taken as the BCLME boundary, and although there is an overlap with the stated ASCLME boundary here, this is to be expected given the exchange of water and biota between the systems.

Although these boundaries are chosen to facilitate a pragmatic ecosystem approach to management in the region, connections in surface and deep ocean circulation exist to the East, with the eastern Indian Ocean, to the southwest with the Atlantic Ocean (BCLME), to the North with the Arabian Sea and to the north-east with the Bay of Bengal (BOBLME).

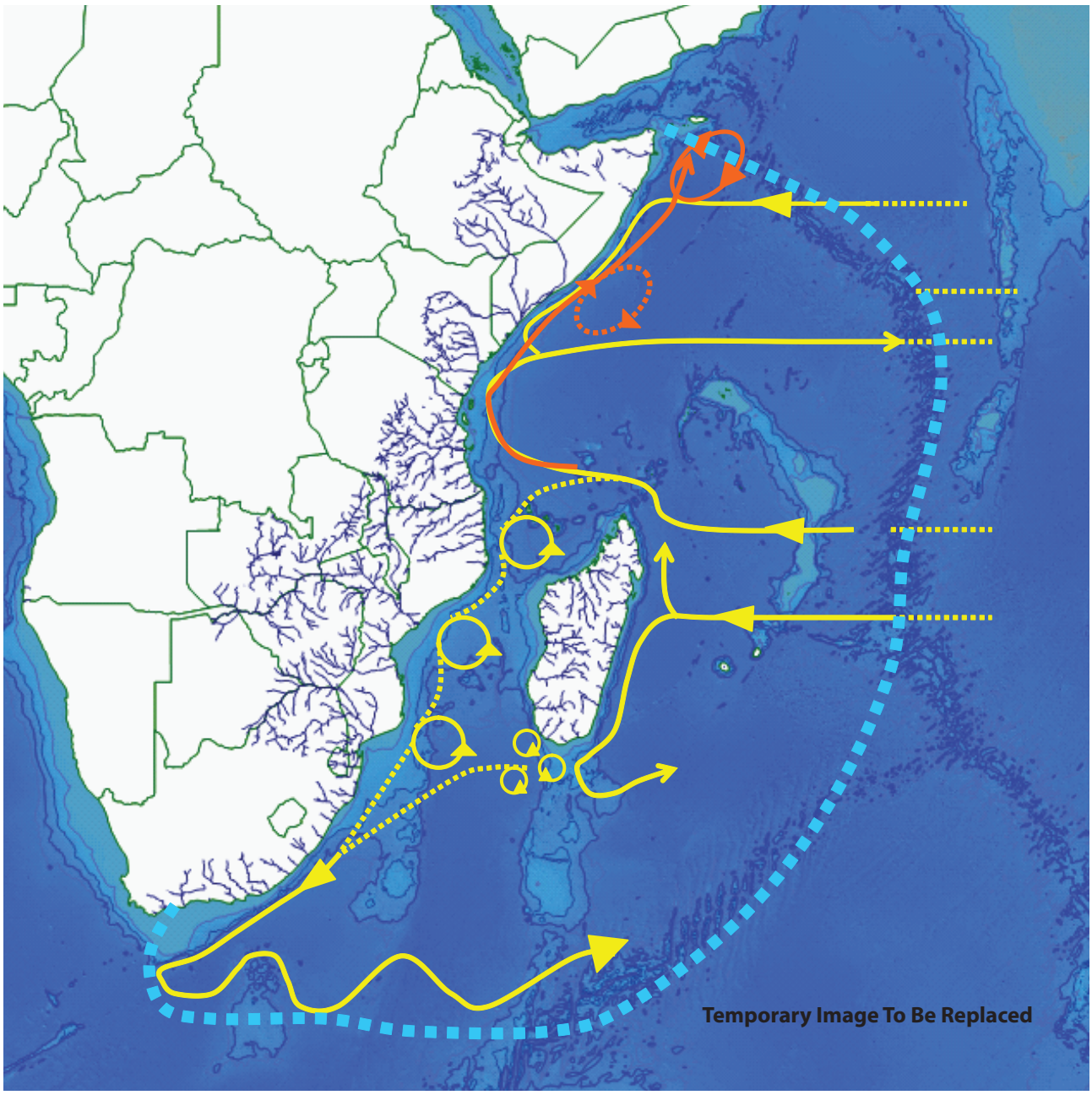


Figure 5: The provisional management boundary for the WIO region. A detailed discussion of ocean currents is presented in Chapter 3.

3. Baseline Environmental Status

3.1 Coastal zone, continental shelf and features of the deep ocean

The Western Indian Ocean (WIO) is one of the most geologically diverse of the world's oceans, containing active and fossil plate boundaries, fracture zones, complex mid-ocean ridge configurations and some of the thickest known sedimentary sequences (Parson and Evans 2005). The topography of the sea floor has a significant influence on the oceanographic environment, water flow and marine biophysical processes.

The WIO covers approximately 22.3 million square kilometers, is floored by deep abyssal plains and bounded to the west by non-volcanic continental shelves (Parson and Evans 2005). This ocean was formed by the break-up of Gondwanaland over 160 million years ago (Ma), which saw India, Madagascar and Antarctica break away from the African continent. India and Madagascar separated from Antarctica approximately 120-130Ma, and subsequently from each other ca. 85Ma, with India continuing to move northwards. The movement of plates northward over the stationary La Reunion hotspot formed the Maldive and Laccadive islands, Chagos bank, and the volcanic ridge underlying much of the Mascarene Plateau, as well as the Mauritius-Reunion island chain (Duncan and Hargreaves 1990, Muller *et al.* 1993, Parson and Evans 2005).

A **hotspot** is a near-stationary, surface expression of a deep mantle plume. Plate motion over these hot-spots has been shown to form volcanic islands and aseismic ridges. Iceland, Hawaii and the Galapagos Islands are examples of other islands formed by hot-spots. The stresses induced by rising material, on continental plates, are sufficiently large to influence plate motion significantly (Morgan 1972).

Three major features dominate the seafloor topography of the WIO; the Chagos-Laccadive Ridge, the Indian Ocean mid-ocean ridge, and the most prominent bathymetric feature of the Indian Ocean, the Mascarene Plateau, which extends as a vast submerged part-continental and part-volcanic plateau for over 1,500 km (Figure 6). The Mascarene plateau is made up of the Seychelles Plateau, the Ritchie Bank, the Saya de Malha Bank, the Nazareth Bank and the St Brandon shoals to the south (Parson and Evans 2005). Between these features, islands and continental shelves, four basins formed by complex spreading patterns make up the deepest parts of the WIO; the Central Indian Basin, the Madagascar Basin, the Somali Basin, the Mozambique Basin, and the Mascarene Basin (Mart 1988, Parson and Evans 2005).

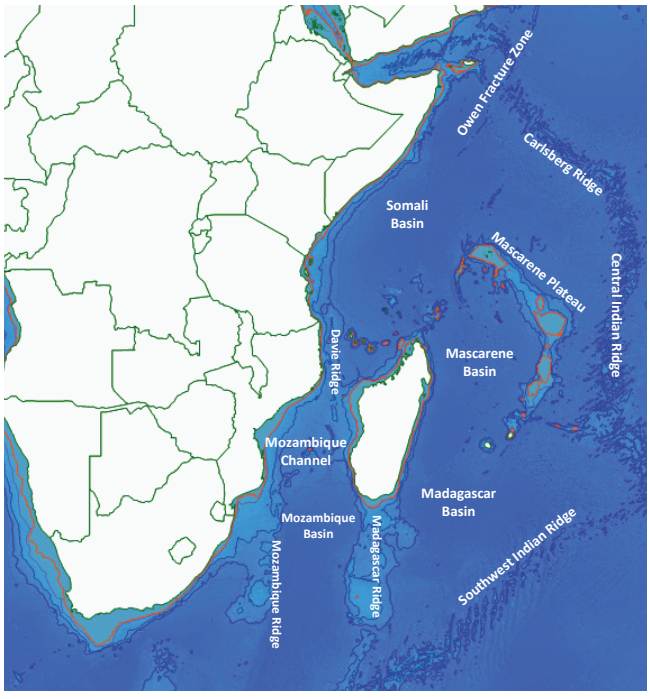


Figure 6: Bathymetry and geological features of the Western Indian Ocean, the 200m isobath is shown in red (Parson and Evans 2005)

The continental shelf is the flooded margin of a continent, extending from the shoreline to a point of increasing slope; the shelf break. The continental shelf of the ASCLME region tends to be narrow in the North, off the Somali coast, gradually widening to the South, and extending to 150m depth on average. Features of the offshore coastal zone and continental shelves have a significant effect on ocean current flow, and thus on the biophysical characteristics of the region. The widening of the continental shelf in the vicinity of St Lucia and the Agulhas Banks, for example, has been shown to drive local upwelling (Lutjeharms *et al.* 1999).

The mainland WIO continental shelf, particularly in northern South Africa and northern Mozambique, is incised by canyons up to 1.5 km long and 750 m deep, extending from the continental shelf to the abyssal plain (Figure 7) (Harris and Whiteway 2011, Ramsay 1994). Modification of ocean currents, local upwelling and mixing in the vicinity of canyons can have extremely important effects on

local oceanography and physical processes (Harris 2011). Aggregations of commercially important pelagic and demersal fish species have been associated with canyons, as have species of conservation importance such as the coelacanth, *Latimeria chalumnae* (Nulens *et al.* 2011). Canyons may also act as conduits for the transport of sediments and nutrients from the continental shelf to the deep sea. Relative pressure on sensitive canyon ecosystems is higher in the island states in the WIO, than the mainland states (Harris and Whiteway 2011).

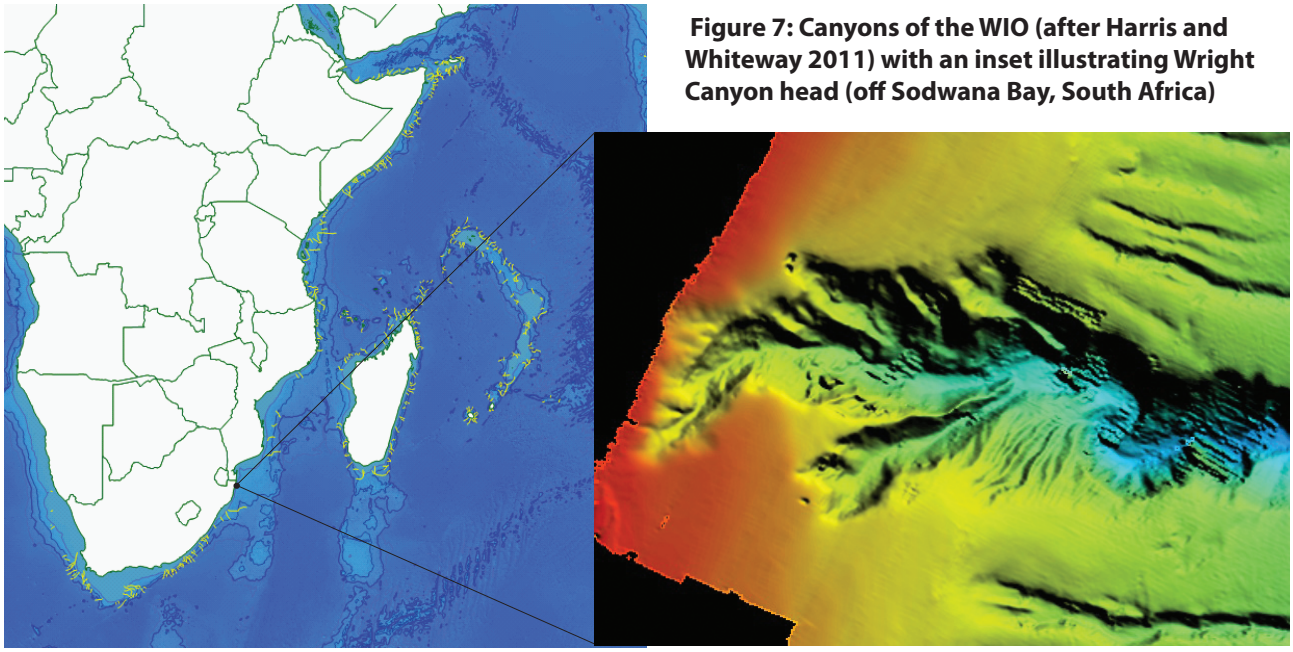


Figure 7: Canyons of the WIO (after Harris and Whiteway 2011) with an inset illustrating Wright Canyon head (off Sodwana Bay, South Africa)

Approximately 700 seamounts have been identified in the WIO region from global studies of bathymetry (Figure 8). Being raised from the ocean floor, and often with exposure to more light because of their lesser depths, seamounts are well known to be hotspots of biodiversity and marine biomass in the pelagic ecosystem. As such, they are often targeted by fishing vessels. Closed circulation cells may form around seamounts, trapping nutrients, inducing upwelling and enhancing primary productivity (Harris 2011, Keating *et al.* 1987). Enhanced primary productivity attracts seabirds, marine predators and attracts a range of pelagic species, and makes them favoured breeding and feeding grounds for demersal species (some of commercial importance e.g. the orange roughy). Global knowledge of seamounts has been improving as access to bathymetry data improves, and a recent estimate put the global total at 14,287 (Kitchingman and Lai 2004). Seamounts are now recognised as being globally important with recent estimates supporting a cover of 59 million km^2 (~16.3% of the ocean floor). This compares to 24 million km^2 of shelf and 10 million km^2 of tropical humid forest (Yesson *et al.* 2011). Being isolated habitats, seamounts are characterized by a high degree of endemism (Rogers *et al.* 2009). Seamounts in the Indian Ocean are of relatively medium size on a global scale and show little variation in size save for the large seamounts of the Cosmoledo group to the North of Madagascar (Craig and Sandwell 1988).

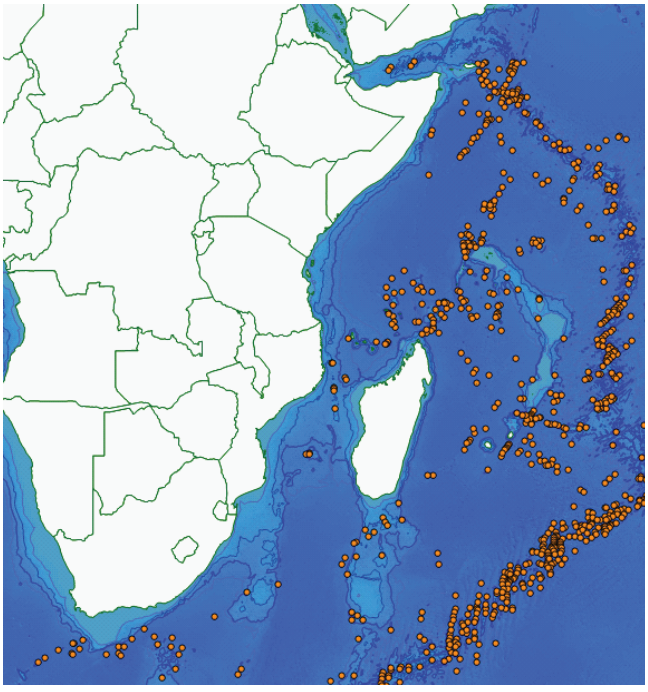


Figure 8: Seamounts in the Western Indian Ocean (Kitchingman and Lai 2004).

A joint ASCLME-IUCN research cruise in 2009 explored five seamounts distributed along the South West Indian Ocean Ridge including Atlantis Bank (a Benthic Protected Area or BPA), Sapmer Seamount, Middle of What Seamount, Melville Bank and Coral Seamount (BPA) and led to an

improved understanding of the biology and ecology of these important areas (Rogers *et al.* 2009).

The coastline of the Agulhas and Somali LMEs countries, extending for over 15,000 km (including mainland and island states), is characterized by a wide diversity of coastal habitats including rocky shores, sandy beaches, coral reefs, mangrove systems, seagrass beds and estuaries (Richmond 2002). This diversity of habitats provides a variety of ecosystem services to the human populations along the coast as well as to pelagic and deep sea organisms. Coral reefs, seagrass and mangrove ecosystems are highly productive and support a huge diversity of organisms as well as provide critical coastal protection and ecosystem maintenance services. Inshore habitats are also those under greatest threat as they are vulnerable to land based impacts, marine based impacts as well as, because of their proximity to the land, vulnerability to overexploitation if not managed correctly.

3.2 Oceanography and productivity

The general oceanography of the Western Indian Ocean, illustrated in Figures 9 and 10, is driven by the various influences of the seafloor bathymetry, continental masses, input of water from surrounding oceans, and interaction with the atmosphere.

The South Equatorial Current (SEC) strongly influences the near-surface circulation of the Western Indian Ocean. The SEC flows westward across the Mascarene Plateau, after which it divides north and south to form components of the Somali and Agulhas currents respectively. To the south, it flows down the east coast of Madagascar as the South East Madagascar Current (SEMC). To the north it forms the North East Madagascar Current (NEMC) and across the northern tip of Madagascar to contribute to the southward transport and circulation of the Mozambique Channel, as well as feeding into the northward-flowing East Africa Coastal Current (Schott and McCreary 2001). Low-salinity Indonesian Throughflow (ITF) thermocline water forms a component of the SEC, and has a significant influence on the heat and freshwater budgets of the Indian Ocean (Song *et al.* 2004, Song and Gordon 2004).

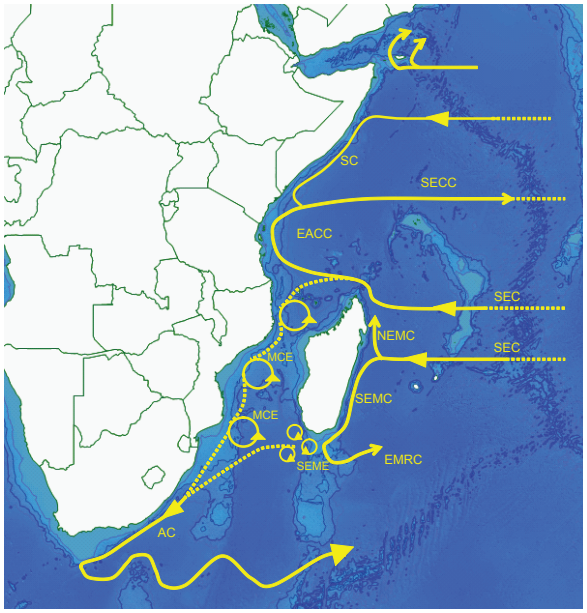


Figure 9: A schematic of the near-surface ocean currents of the western Indian Ocean during the North-east monsoon (Jan/Feb).

Indicated are the:
South Equatorial Current (SEC),
South Equatorial countercurrent (SECC), Northeast Madagascar Current (NEMC), Southeast Madagascar Current (SEMC), East African Coastal Current (EACC), Somali Current (SC),
Agulhas Current (AC),
Mesoscale Eddies (ME) and
South east Madagascar dipole eddies (SEME).

Dotted lines indicate direction of transport, not boundary currents. Adapted from Schott and McCreary (2001), Schouten *et al.* (2003), De Ruijter *et al.* (2005), Lutjeharms (2004), and Tew-Kai and Marsac (2009).

The Mascarene plateau

As the South Equatorial Current (SEC) flows over the Mascarene plateau, its waters are channeled by the shallow banks which have an influence on water transport and productivity. New *et al.* (2005) estimates that 23Sv of the total 56Sv of the SEC is channeled between the Saya de Malha and Nazareth banks. The remainder is diverted around the north of the Saya de Malha bank and southwestwards, between the Cargados Carajos Bank and Mauritius. Preliminary in-situ ADCP data from the ASCLME research cruise confirmed this finding (Stromme *et al.* 2008) and are shown in Figures 11 and 12. Upwelling in the open ocean between 5 and 10 ° South in the Central and Western Indian Ocean is indicated by mesozooplanton and biochemistry, but although there is some evidence for topographically induced upwelling on the lee side of the Mascarene Plateau, this is highly variable and has not been consistently or conclusively established (Gallienne and Smythe-

Wright 2005).

Preliminary results from the ASCLME cruise in 2008 showed no indication of upwelling, nutrient enrichment or enhanced primary production along the leeward edge of the plateau (Stromme *et al.* 2008).

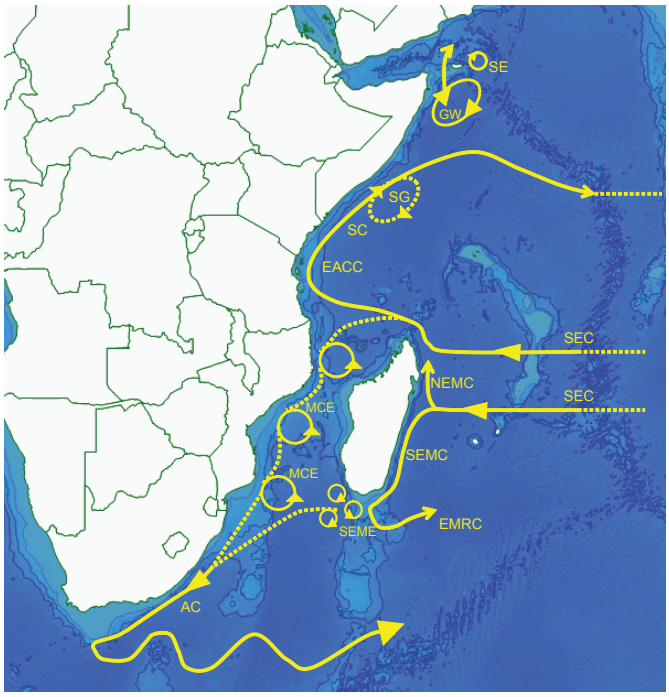


Figure 10: A schematic of the near-surface ocean currents of the western Indian Ocean during the South-west monsoon (July/Aug).

Indicated are the:
South Equatorial Current (SEC),
South Equatorial countercurrent (SECC), Northeast Madagascar Current (NEMC), Southeast Madagascar Current (SEMC), East African Coastal Current (EACC),
Somali Current (SC),
Southern Gyre (SG),
Great Whirl (GW),
Agulhas Current (AC),
Socotra Eddy (SE),
Mesoscale Eddies (ME) and
South east Madagascar dipole eddies (SEME).

Dotted lines indicate direction of transport, not boundary currents. Adapted from Schott and McCreary (2001), De Ruijter *et al.* (2005), Schouten *et al.* (2003), Lutjeharms (2004), and Tew-Kai and Marsac (2009).

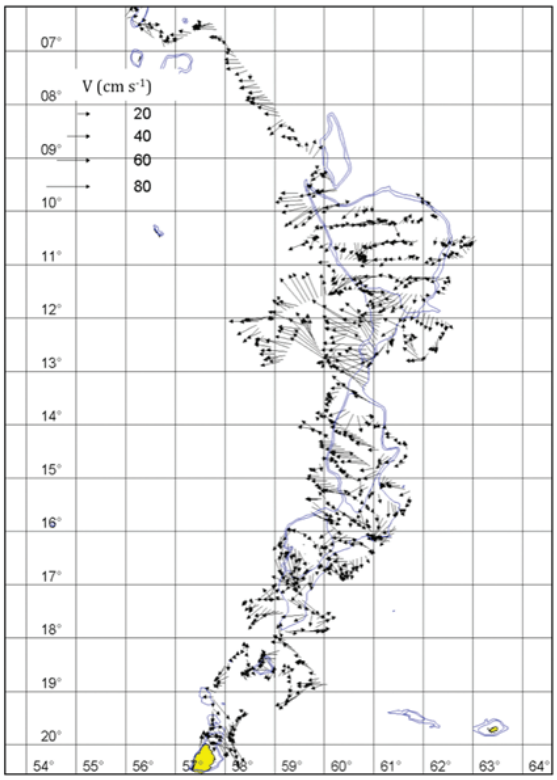


Figure 12: Map of geostrophic velocities derived from in-situ ADCP data during the ASCLME survey number 3 (2008). Increased flow between the Saya de Malha and Nazareth banks is evident as is the current reversal over the Seychelles banks associated with the SECC (Stromme *et al.* 2008).

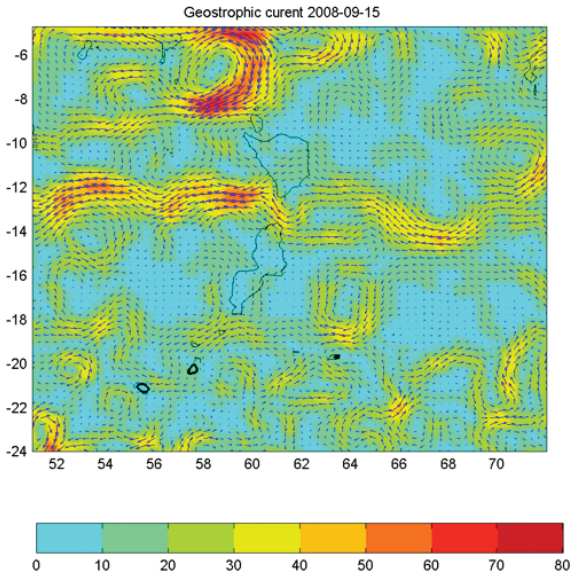


Figure 11: Geostrophic current as resolved from altimetry data in the Mascarene region. Increased flow between the Saya de Malha and Nazareth banks is evident (Stromme *et al.* 2008).

The Agulhas Current LME

The Agulhas Current LME is considered to be a Class II, moderately productive ecosystem, with an average productivity of 150-300gCm^{-2}.year (Heileman *et al.* 2008). It is a relatively oligotrophic system with localized upwelling driven by eddies, or nearshore currents influenced by seafloor topography.

The southward flowing East Madagascar Current (EMC) has been recorded over 11 months at 23° S to have a mean near-surface current of 0.7m.s^{-1} with variations throughout the year. Two to three cyclonic eddies move southwards in the current per year. The EMC causes coastal upwelling, evident in a clear chlorophyll boundary parallel to the coast. Some cyclonic eddies lead to the advection of chlorophyll more than 200km from the coast (Quartly *et al.* 2005). The East Madagascar Current has been observed to retroflect, but this is not a persistent phenomenon (Quartly and Srokosz 2004).

The Mozambique Channel is characterized by a high levels of mesoscale variability dominated by large anticyclonic eddies. In the North, Rossby forcing drives the generation of approximately seven eddies per year which are formed at the narrows of the channel, at 16-17 ° S. Eddies move steadily southward and the frequency slows to five per year. In the South, Mozambique Channel eddies merge with cyclonic and anti-cyclonic contra-rotating eddy pairs or dipole eddies formed to the south of Madagascar which move south-west to feed into the Agulhas Current (Ridderinkhof and De Ruitjer 2003, Schouten *et al.* 2003, Quartly and Srotskz 2004, Tew-Kai and Marsac 2009). Cyclonic eddies are characterized by divergent flow at their centre, upwelling of cold nutrient-rich water, and thus by higher primary production (McGillicuddy and Robinson 1997, Tew-Kai and Marsac 2009). Anticyclones tend to have low-nutrient water at their centre due to convergent flow and downwelling, which also promotes retention of passive organisms, but enrichment has been noted at their periphery (Mizobata *et al.* 2002). At a depth of 100m, distinct hydrographic differences have been noted between these mesoscale features, with cyclonic eddies characterized by Subtropical Surface Water, and anti-cyclonic eddies containing Tropical Surface Water (Lamont *et al.* 2012). In the Mozambique Channel during a recent ASCLME survey, total chlorophyll a (TChla) concentrations were found to be greater in cyclonic eddies than anticyclonic eddies, at the surface. TChla in regions of divergence, and on shelf zones, were found to be similar to cyclonic eddies, whereas values in frontal zones were slightly lower (Barlow *et al.* 2011). Interannual variabilities in sea level anomaly, indicating presence of eddies, may be related to climate forcing IOD/SOI, which may have an effect on the flow of water into the Mozambique Channel and hence on eddy generation (Tew-Kai and Marsac 2009).

Chlorophyll variability is mostly driven by seasonal wind-induced turbulence, coastal upwelling and river runoff in the North (10-16°S) and South (24-30°S) of the Mozambique Channel. In the centre (16-24°S), seasonality has less of an influence, and chlorophyll distribution is more dependent on mesoscale dynamics (eddies and filaments). In this part of the channel, interaction between cyclonic and anticyclonic eddies generates complex multiple fronts which can lead to entrainment of chlorophyll from the coast to the open ocean. This enrichment process, if persistent, leads to favourable foraging areas for top predators (Quartly and Srokosz 2004, Tew-Kai and Marsac 2009).

Top marine predators, such as great frigatebirds (*Fregata minor*), have been observed to feed at the edges of anticyclones or at the boundary area between eddies where geostrophic currents are stronger (Weimerskirch *et al.* 2004). Hyrenbach *et al.* (2006) observed that tropical oceanic terns and shearwaters are common at the region of convergence upstream of the interface of two paired eddies. Another recent study found that sooty terns fed predominantly in cyclonic eddies (where surface tuna schools are common), frigatebirds in frontal zones (characterized by high geostrophic currents and high biomass of nekton) and red-footed boobies in divergence zones, rich in many seabird species. Other seabird species did not show a clear preference in foraging behavior, save that they actively avoided anticyclonic eddies (Jacquemet *et al.* 2012).

Frequent upwelling on the Mozambican continental shelf between Praia do Tofo and Bazaruto also appears to be driven by the interaction of poleward moving mesoscale eddies and the narrow continental shelf, together with divergent upwelling driven by water flow following its path along the shelf edge as it diverges from the coastline, drives high productivity. This region supports one of the highest, non-migrating hotspots of whale sharks (*Rhincodon typus*) in the WIO at Praia do Tofo (Rohner *et al.* 2012). Ecologically, other species are also

associated with this highly productive region and economically, this has important consequences for tourism in the area.

Figure 13 illustrates geostrophic currents derived from satellite altimetry data together with ADCP data collected on the ASCLME Mozambique channel survey (Kaehler *et al.* 2008).

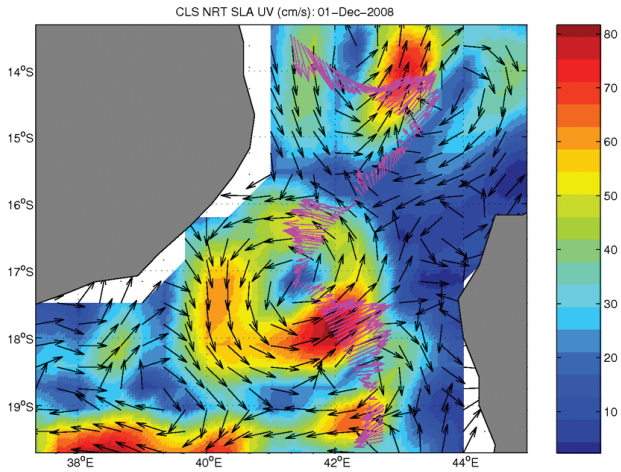


Figure 13: Geostrophic currents derived from satellite altimetry data together with ADCP data collected on the ASCLME Mozambique Channel survey (Kaehler *et al.* 2008).

The Agulhas current is the largest western boundary current in all the world's oceans (Bryden *et al.* 2005). Source water for the current derives from the East Madagascar current and the Mozambique Channel eddies (Biastoch and Krauss 1999, De Ruijter *et al.* 2005, Heileman *et al.* 2008). The current flows southwards along the East coast of South Africa, following the shelf edge closely; usually within 31km of the coast and no more than 203km offshore. Total transport is always poleward, varying from -121 Sv to -9 Sv, with an average of -69.7 Sv (Bryden *et al.* 2005).

Triggered by eddies and interaction with the Natal Bight, large solitary cyclonic meanders (Natal pulses) intermittently interrupt the stability of the current, and their passing causes a reversal of shelf currents – possibly leading to upstream transport of biota for short periods of time (Lutjeharms *et al.* 2000, 2003, de Ruijter *et al.* 2005). South of the Agulhas Bank, meanders in the current increase, producing shear eddies and warm plumes on the shoreward side. At approximately 40°S, the Agulhas current retroflects and Agulhas rings are shed, to spin off to the west into the Atlantic Ocean. The retroflection is unstable and intermittent; the retroflection loop has been observed to appear 4-5 times per year though it has not been established whether each loop formation generates a ring shedding event. The majority of the Agulhas current volume travels eastwards in the Agulhas Return Current which is also the region of highest variability in the southwest Indian Ocean (de Ruijter *et al.* 2005)

The inter-ocean movement of warm (salty) water from the Indian Ocean to the Atlantic Ocean is likely to have a significant effect on global climate (De Ruijter *et al.* 2005) as it is the primary source of warm, salty water carried towards the sub-polar north Atlantic in the Meridional Overturning Circulation (Biastoch *et al.* 2008). The inter-ocean water movement is also critically important to some fisheries in the Benguela Current Large Marine Ecosystem (BCLME) as pelagic species that spawn on the Agulhas Bank are carried to the West coast of southern Africa via these Agulhas rings (Heileman *et al.* 2008).

The variability of the southwest Indian Ocean is connected to global circulation. At 12°S and 25°S, bands of enhanced sea surface height variability stretch East of Madagascar. These anomalies propagate westward as baroclinic Rossby waves, influencing the water flows to the North and South of Madagascar and driving eddy development in the Mozambique Channel and South of Madagascar respectively. Interannual variability of forcing (IOD/ENSO) propagates along these pathways with consequent changes in eddy formation, Agulhas ring shedding and thus in water transport to the South Atlantic (de Ruijter *et al.* 2005).

In contrast to the circulation patterns near the surface of the ocean, deep ocean transport demonstrates quite different patterns. For example, a deep water Agulhas Undercurrent flows northwards up the East Coast of southern Africa below the Agulhas Current (Beal and Bryden 1997). Deep water current patterns are illustrated in Figure 14.

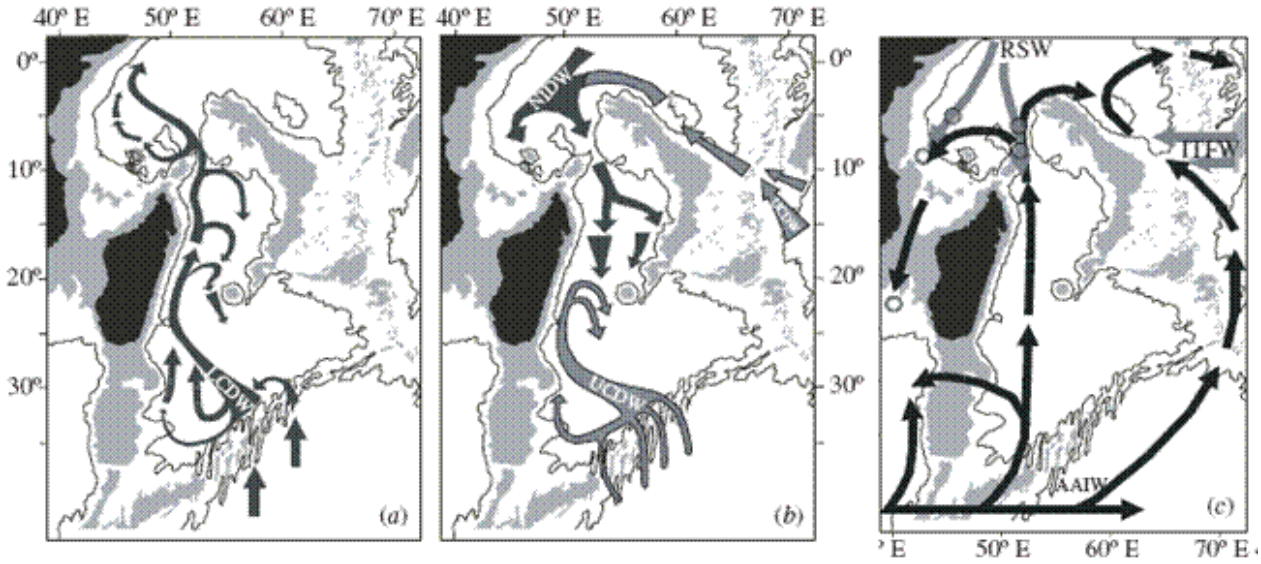


Figure 14: General circulation patterns at a) -3800m, b) -3700 to -2000m, and c) -1500m to -500m, (McCave *et al.* 2005)

The Somali Current LME

The Somali Current LME is also considered to be a Class II, moderately productive ecosystem, with an average of 150-300gCm^{-2}.year (Heileman and Scott 2008). In contrast to the Agulhas current where productivity is driven by Mozambique Channel eddies, and localized eddy or topography-driven upwelling, primary productivity of the Somali current is strongly influenced by persistent, monsoon-driven upwelling. Productivity is highest during the south-west monsoon which drives an upwelling cell off the continental shelf (Okemwa 1998).

The Somali Current is the western boundary current of the north-western Indian Ocean. It is strongly influenced by the two monsoon seasons of East Africa. During the north-east monsoon the Somali current flows towards the south-west to meet the northward-flowing East African Coastal Current, and then eastward at 0-2°N in the South Equatorial Counter Current (SECC). As the season changes and the south-west monsoon strengthens, the EACC strengthens and the Somali current changes direction to flow towards the north-east. At this transition, an intense jet (the Indian Equatorial Jet) develops that may reach speeds of 3.5 m.s^{-1}. The jet, appearing between April and June for short, one-month periods, is not well understood, but it has been shown to drive a strong offshore upwelling cell known as the Great Whirl (Schott and McCreary 2001). By August, the East African Coastal Current and the Somali Current form a continuous north-eastward flowing current to the East Arabian Current (Heileman and Scott 2008) (Figures 9 and 10).

Mozambique Channel circulation is also affected by the monsoon regime, with the southwest monsoon associated with strong winds and high volume transport through the Mozambique Channel, while the northeast monsoon is associated with low winds and very low levels of transport through the channel (Biastoch and Krauss 1999). North-East monsoon winds have also been correlated with upwelling off the coast of Mozambique, particularly in the vicinity of Angoche, which has important consequences for local productivity and nutrient availability to the economically important prawn stocks of the Sofala Bank (Maluaene *et al.* 2012).

Fronts

Oceanic fronts may be seasonal or persistent and can occur at a variety of scales from < 1km to thousands of kilometres. They indicate the boundary between two water masses, and are often associated with zones of increased productivity. A study of oceanic fronts in the World's LMEs by Belkin and Cornillon (2007) shows the Agulhas Current Front (ACF), the clearly distinguishable inshore boundary of the Agulhas current. Other more ephemeral currents that have been mapped include the East Madagascar Current Front (EMCF), and Glorioso Islands front (GIF). During the south-west monsoon, a sharp front separates the warm salty Somali Current water from the offshore upwelling.

Ocean temperature

Steady warming has been observed in both the Agulhas and Somali Current LMEs. In the Agulhas Current region, warming of 0.68°C has been recorded since 1957 (Heileman *et al.* 2008). Post 1982, the warming of the Agulhas current has been non-uniform, with warming of up to 1° C recorded for the Agulhas Current Retroflection. The all-time warmest year was in 1998 for both LMEs, as it was for much of the Indian Ocean (Annamalai and Murtugudde 2004, Reynolds and Smith 1994).

Primary productivity

Understanding the primary production in the upper ocean is of fundamental importance for two main reasons. Firstly, primary productivity sets a first-order constraint on the energy available to sustain oceanic ecosystems. Secondly, fixation and subsequent sinking of organic particles removes carbon from the surface ocean (the so-called biological pump), which plays a key role in the partitioning of carbon dioxide between the ocean and atmosphere.

The mean chl-a biomass across the Mascarene Plateau during a recent ASCLME survey (Stromme 2008) was 0.476 ± 1.562 µg/l. Microplankton (> 20 µm) formed the largest component of the phytoplankton with nano (20 µm - 2 µm) and picoplankton (2 µm - 0.7 µm) biomass rarely exceeding 1 µg/l. Surface biomass was generally < 0.5 µg/l and the fluorescence maximum varied in depth between 30m and 100m depending on the depth of the seafloor. No indication of upwelling was discovered. Total Surf Chl-a = 0.26 ± 0.01 µg/l whereas the total chl-a for the Deep Chlorophyll Maximum (DCM) were significantly higher at 0.96 ± 0.26 µg/l. Low chl-a biomass was associated with the low salinity Tropical Surface Water situated between 4° and 20°S. While the South Equatorial Current dominates the general circulation in the vicinity of the Mascarene Plateau, the higher chl-a biomass over the Seychelles Bank and Amirante Shelf was associated with Arabian Sea High Salinity Water under the influence of the warmer eastward flowing South Equatorial Counter Current. Except for the Amirante basin where chl-a biomass exceeded 30 µg/l, the highest phytoplankton biomass between Mauritius and Seychelles was recorded on the Saya da Malha Bank (Figure 15).

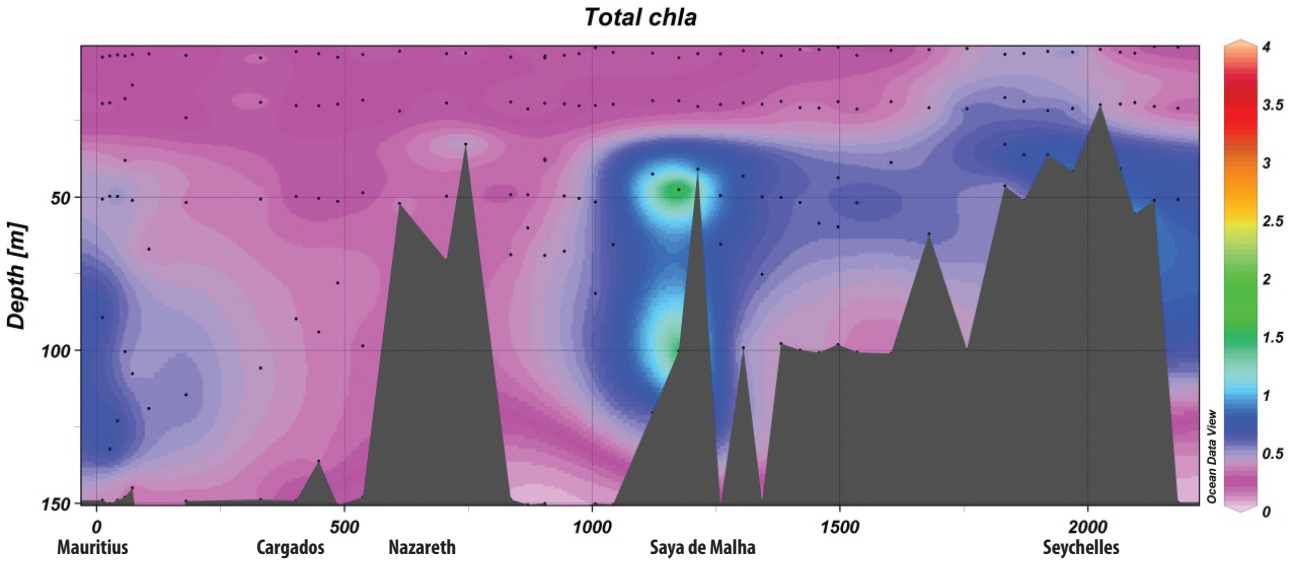


Figure 15. Cross section from Mauritius to Seychelles showing the phytoplankton biomass distribution down to 150 m.

Secondary productivity

In the Somali Current LME, Euphausiids have been documented to make up 25% of total zooplankton biomass and copepods the remainder. Within the upwelling zone, copepods *Calanoides carinatus* and *Eucalanus elongatus* dominated the upwelling zone (Okemwa 1998).

Mesoscale eddies in the Mozambique Channel play a very important role in the distribution of zooplankton communities. In situ studies over four years (2007-2010 inclusive) demonstrated that cyclonic eddies (with

characteristic cool water 20˚C at 100m, negative sea level anomalies) exhibited moderate to high levels of zooplankton (0.3-0.7ml.m^{-3}) and anticyclonic eddies (with characteristically warm temperatures – 23˚ C at 100m, and positive sea level anomalies) exhibited low concentrations (<0.2 m^{-3}) of zooplankton (Huggett 2012). Taken together, divergences and fronts tend to reflect more species than cyclonic and anticyclonic eddies (Potier *et al.* 2012).

Ocean-atmosphere interactions

Understanding ocean-atmosphere processes is important to understand the drivers controlling weather and particularly rainfall over land, which has a profound effect on health and food security, through its influence on agriculture, fisheries and fresh water resources (Conway *et al.* 2005). The complex interactions between the atmosphere and ocean are becoming better understood with recent studies over longer time scales and the employment of new techniques. The Western Indian Ocean plays a key role in influencing the rainfall of South and East Africa (Slingo *et al.* 2005).

The prevailing wind regimes that dominate the Somali and Agulhas Current LMEs are the monsoon regime in the north and the sub-tropical high pressure system in the South (Schott and McCreary 2001, UNDP 2005). The monsoon regime is characterized by north-easterly winds from December to April (moderate winds, dry terrestrially derived air), and stronger south-easterly winds from June to October. Rainfall over much of East Africa is bimodal, with rainy seasons in March to May and October to December. This regime changes to a single season rainfall regime with increasing distance from the equator (Conway *et al.* 2005, Schott and McCreary 2001). Between November and April, wind movement and air pressure disturbance cause cyclones, which tend to originate between 10 and 20˚S over the Central Indian Ocean, and move westwards affecting Mauritius, Madagascar and Mozambique, sometimes with devastating consequences.

The El Niño Southern Oscillation (ENSO) forms an important component of the forecasting of the rainfall over southern Africa. ENSO controls approximately 25% of wet season (January – March) rainfall variability. In ENSO-neutral seasons, rainfall anomalies have been positively correlated with SST anomalies at 80˚E and 25˚S in the Indian Ocean. Wet (dry) rainfall anomalies are enhanced by cold (warm) SST anomalies (Lizcano and Todd 2005). ENSO has also been shown to correlate with drought events in Madagascar. Over inter-annual time scales (1982-1999) the normalized difference vegetation index (NDVI) has a strong negative correlation with El Niño events, which is attributed to drought events and wild fires. Long term environmental change is predicted to increase the frequency of these events, with severe consequences for Madagascar (Ingram and Dawson 2005). El Niño events been shown to bring drought to South Africa, but more rain to equatorial East Africa.

The Indian Ocean Dipole is an inter-annual mode of variability in Indian Ocean SST (Saji *et al.* 1999). The strength of the dipole is measured by the Dipole Mode Index (DMI) defined as the difference in SST anomaly between the East and West Indian Ocean. The DMI varies from -1 to 1.5˚C with both a mean and standard deviation of 0.3. Black (2005) showed that East African inter-annual rainfall variability is not directly linked to SST anomalies in the Indian or Pacific Oceans, but rather to a positive dipole event (Saji *et al.* 1999). In fact, the observed link between East African rainfall and ENSO is likely a manifestation of the link between ENSO and the IOD. However, strong El Niño forcing in boreal autumn may cause cooling in the WIO, trigger an IOD and thus cause rainfall in coastal equatorial East Africa (Black 2005).

3.3 Fisheries

It has been estimated that 65 million people live within 10km of the coast in the wider Indian Ocean region (Burke *et al.* 2011) and for many of these people seafood represents an important source of food and employment. While large industrial fisheries, such as those targeting tuna and crustaceans, supply the world's markets, most developing countries of the South West Indian Ocean (SWIO) have important artisanal fisheries that contribute towards local food security and the local economy (van der Elst 2012).

The Western Indian Ocean (WIO) generates about 5% of the global industrialised fish catch, equivalent to more than 4 million tonnes of fish per year (FAO 2012a). Fisheries within the region range from traditional

subsistence and artisanal activities to large-scale industrial operations. Artisanal fisheries use a wide variety of different gears including hand-lines, traps, nets (seine, cast, gill nets), small trawls and harpoons and target demersal and small pelagic fish species as well as sea cucumbers, lobsters, crabs, prawns, bivalves and octopus. Industrial fishing consists mainly of longlining and purse seining for tuna and large pelagics as well as trawling for prawns, langoustines, lobsters and crabs.

History of Fisheries in the Western Indian Ocean

In the last half century, the production of fish and fish products in the wider Indian Ocean region increased significantly, from 0.861 million tonnes in 1950 to 11.2 million tonnes in 2010, as a result of improvements in fish capture technology and in response to a rising demand both from within the region and globally. Since 1999, although total catches have increased, annual catches have remained stable at around 4 million tonnes (FAO 2012a, van der Elst *et al.* 2005).

The coastal regions of the WIO have a long tradition of exploiting their coastal marine resources. The fisheries that developed historically are, in principle, the same as the "artisanal" or "traditional" coastal fisheries of the present day. These fisheries provide a livelihood for several million people and characteristically employ a diverse range of fishing gear types and target many different species (Samoilys *et al.* 2011, WIOFish 2011). They are often important for food security. A number of different factors have constrained the further development of the artisanal fisheries in the WIO (e.g. lack of infrastructure and access to finance to upgrade boats and equipment). Despite this there has been a significant increase in fishing effort in the last few decades as coastal populations have continued to expand and demands for fish and fish products have increased within the region and internationally. The industrialisation of the offshore fisheries was perhaps the most significant recent development in the WIO (Cochrane and Japp 2012), particularly the targeting of tuna and other large pelagic resources by Distant Water Fleets (DWF) from the European Union, Japan, South Korea and Taiwan.

DWF nations began longlining for tuna in the WIO in the early 1950s, initiated by the Japanese and soon followed by the Taiwanese (1954) and South Koreans (1960). Since then, the presence of Asiatic longliners in the Indian Ocean increased significantly; until recently when the numbers of active Japanese and Korean longliners diminished because of declining profitability. Large-scale purse seine fishing for tuna began in 1983, when French and Spanish fleets moved into the WIO, fishing under access right agreements (Kimani *et al.* 2009). Catches of tuna and tuna-like species in the WIO increased from 0.5 million tonnes in 1987 to 1.1 million tonnes in 2003 (Anon 1998, 2006).

The fisheries sector currently employs 2.7 million people, full and part time, generating wages of about US$366 million per year. The fisheries have also diversified and the number of species recorded in landings has increased from 85 in 1971 to 152 in 2000 (van der Elst *et al.* 2005). According to the Southwest Indian Ocean Fisheries Committee (SWIOFC), one third of stocks in the region are now considered to be either 'Overfished' or 'Depleted' (FAO-SWIOFC 2011) (Figure 16). Although there is some contention about the reliability of these estimates, the general overarching impression is one of overexploitation. There is now a growing demand for new resources that has led to increased exploration and exploitation of deepwater fisheries. Due to the overfishing of coastal stocks, many countries are now planning to expand their semi-industrial and industrial national fleets to new fishing grounds in their EEZs (Michel *et al.* 2012). Some countries have developed their own semi-industrial fishery, but in most countries there is still a huge disparity between the capacities of the artisanal fisheries and the industrial offshore fisheries that has yet to be resolved.

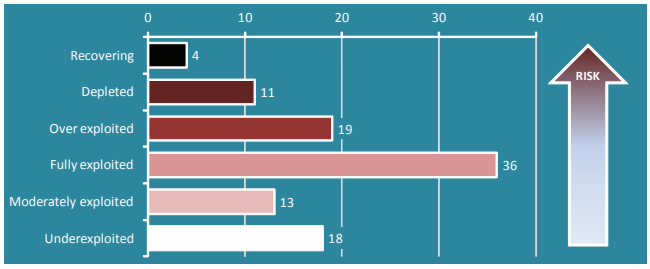


Figure 16: Status of stocks in the SWIO in 2009 (SWIOFC 2011)

Due to limitations of traditional boats, equipment and safety concerns, the majority of artisanal fishers in the WIO have had to concentrate their activities on the near-shore reefs and drop-offs on the shelf edge. Although some will migrate, the majority of artisanal fishers are not equipped to be able to go offshore. Rapidly increasing coastal populations, coupled with high levels of unemployment and poverty, has thus resulted in overcapacity within artisanal sector in most countries in the SWIO. As

the resources are often open access, and many of the coastal fisheries require minimal skills and investment, there has been increasing pressure on near-shore environments and resources. Environmental conditions, especially the monsoon winds (either south east or north east) and tidal ranges also further limit effort. Meanwhile the lack of infrastructure and inadequate post-harvest storage and processing facilities have prevented the fishers from accessing larger more lucrative international markets to obtain the maximum value from the catches. Although some countries have adequate storage facilities many do not and this continues to result in extensive post-harvest losses. Limited access to finance has prevented many fishers within the region from upgrading equipment and increasing production. Some countries are now trying to address these issues and have implemented microfinance and duty concessions to give the sector the opportunity to become more competitive internationally. Other countries have also implemented schemes where the local fisheries benefit from the money raised through providing licences to international vessels.

Overview of Fisheries in the Western Indian Ocean

In the development of the South West Indian Ocean Fisheries Project (SWIOFP), it was recognised that there was a large quantity of fisheries information available, in the form of data collected by government fisheries monitoring programmes, past fisheries surveys, research projects, observer- and port-based sampling data and published studies. These data were not however, consolidated data at the national or regional level as would be required for the effective management of fisheries in the SWIO region. In response to this, SWIOFP recognised that it would be prudent to evaluate these data so that specific gaps in information could be identified at the regional level and ultimately form the basis of the SWIOFP work programme. As a first step towards this effort, each SWIOFP country undertook its own national data inventory and gap-analysis of existing information for the four SWIOFP Components dealing with crustaceans, demersal fishes, pelagic fishes and biodiversity issues. These data activities were supported by Component 1 of SWIOFP (Data and IT), which was responsible for developing regional data management capacity.

Each of the four relevant components developed a meta-database describing existing pertinent datasets, a literature catalogue of relevant published articles and reports, as well as a gap-analysis document. The gap analysis documents included an analysis of existing information to identify key issues and species relevant to SWIOFP. Also included were proposals for additional information and research required to support fisheries management and an assessment of each country's needs in terms of the scientific capacity required to perform SWIOFP activities over a long term. The national data gap-analyses were performed by experts in each country, under the leadership of the National Country Coordinators (NCCs) for each of the components.

Once the gap analyses were completed SWIOFP then contracted the Oceanographic Research Institute (ORI) in South Africa to undertake a series of retrospective analyses to examine existing information and databases and to assess the state of priority species within the region. ORI assembled a team of experts to focus on distinct topics and groups that had been identified through the gap analysis for each Component. The following retrospective analyses were undertaken:

- Crustacean Fisheries (Fennessy 2012, Groeneveld 2012a, b)
- Demersal Fisheries (Heileman 2012)
- Pelagic Fisheries (Cochrane and Japp 2012)
- Biodiversity in Fisheries Management (van der Elst 2012)

The gap analyses and retrospective analyses together with the information presented in the national MEDA documents prepared under the ASCLME project provided the basis for the contents of this chapter. Other outputs from SWIOFP, from Component 6 for example (e.g. Swan 2012), which focused on the legal requirements needed to strengthen regional and national fisheries management, are also included in this chapter.

Crustacean Fisheries

Fisheries for prawns (shrimps), lobsters and crabs are very common along the coastal edges of the SWIO region, and are exploited at both the artisanal and industrial scale. Reported landings for nine (of the ten) countries in the WIO are approximately 35,000 tonnes per year (van der Elst *et al.* 2009), and the largest contributors are the shallow-water penaeid prawn fisheries of Mozambique and Madagascar. Several species of tropical

spiny lobsters and crabs (e.g. mangrove- and swimming crabs) are targeted in shallow waters by artisanal and recreational fishers, and caught by simple gears operated from the shore or from small boats. According to the Scientific Committee of the South West Indian Ocean Fisheries Commission (SWIOFC), most of the crustacean stocks in the region are fully or overexploited (Table 1) although there is some disagreement about the status of shallow water prawns in South Africa and deepwater prawns (and langoustines) in Mozambique and South Africa. The deep-water crustaceans in the SWIO region (i.e. deep-water prawns, langoustines, several deep-water spiny lobster species and deep-sea crabs) are only accessible to industrialised trap and trawl fisheries and therefore the extent and fisheries potential of deep-water stocks are not as well known as for shallower-water species (Groeneveld *et al.* 2009).

Table 1: The status of crustacean stocks in the 9 ASCLME countries as agreed during the 5th session of the Scientific Committee of the SWIOFC (FAO-SWIOFC 2012)

Country	Species/Complexes/Groups	Stock Status
Comoros	Crustaceans (prawns, langoustines, crabs)	Under Exploited
Kenya	Spiny and rock lobster	Overexploited
	Shallow-water prawns (commercial)	Fully Exploited
	Shallow-water prawns (artisanal)	Unknown
	Crabs	Fully Exploited
Madagascar	Langoustines	Fully Exploited
	Prawns	Fully Exploited
	Crabs	Fully Exploited
Mauritius	Deep-water prawns (*Heterocarpus laevigatus*)	Under Exploited
Mozambique	Spiny and rock lobster (*Palinurus delagoae*)	Depleted
	Shallow-water prawns (*P. indicus* & *M. monoceros*) (industrial)	Fully Exploited
	Shallow-water prawns (semi-industrial & artisanal)	Fully Exploited
	Deep-water prawns (*Haliporoides triarthus* & *Aristeomorpha foliacea*)	Moderately Exploited
Seychelles	Spiny and rock lobster (*P. longipes, P. versicolor, P. penicillatus, P. ornatus*)	Recovering
	Spanner crab (*Ranina ranina*)	Under Exploited
Somalia	Spiny and rock lobster	Overexploited
South Africa	Spiny and rock lobster (*P. gilchristi, P. delagoae & P. homarus*)	Fully Exploited
	Crustaceans (deep & shallow-water prawns, langoustines, scyllarids)	Overexploited
Tanzania	Spiny and rock lobster	Fully Exploited
	Shallow-water prawns	Depleted

Industrial Trawl Fisheries (Shallow)

Apart from the tuna fisheries, trawling for shallow water penaeid prawns is the most prevalent, coastal, industrial fishery in the SWIO region. All of the east African mainland countries (South Africa, Mozambique, Tanzania, Kenya and Somalia) as well as Madagascar use this fishery method. The main target species are *Fenneropenaeus indicus* (*Penaeus indicus*) and *Metapenaeus monoceros* which together contribute around 90 % of landed shallow water trawled prawn catches. Other commercially-valuable shallow prawn species (*Penaeus monodon*, *P. semisulcatus*, *P. latisulcatus* and *P. japonicus*) are also caught, but in a much lower abundances. The vessels and gear used for trawling are broadly similar in all of the different countries, with increased levels of sophistication in parts of the fleets in Mozambique and Madagascar. Steel, motorised vessels of up to 40m in length are equipped with refrigeration methods to preserve the catch, allowing them to stay at sea for up to 1 month. Demersal otter trawls are used with up to 4 trawls on outrigger booms. With the exception of South Africa, trawled catches of prawns are exported and represent a valuable source of foreign currency, particularly in Mozambique and Madagascar. Mozambique, Tanzania, Kenya, Somalia and Madagascar have substantial small-scale (traditional) fisheries which appear to be growing and increasingly targeting prawns, leading to user-conflicts with the trawl sector. In Kenya, the trawl fishery was intermittently closed in 2000 and 2001, and again in 2006 due to clashes with artisanal fishers (Ochiewo 2004, Munga *et al.* 2012). After re-opening in 2007, it was closed again in 2008-2010; currently (2011) only 3 vessels are licensed of which 2 fished in 2011 and 2012 (Fennessy 2012).

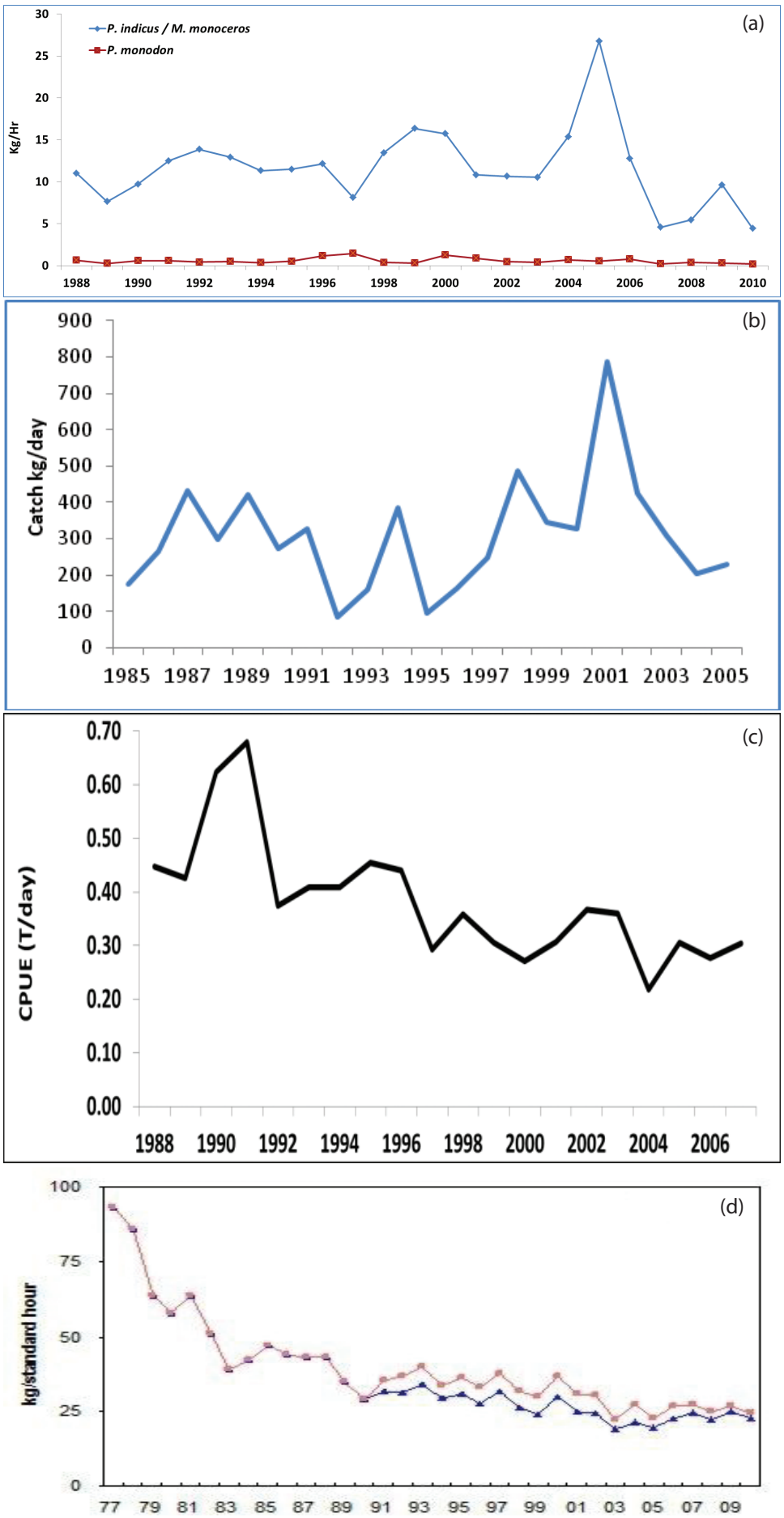


Figure 17: Trends in CPUE for the shallow water prawn trawl fisheries in (a) South Africa, (b) Ungwana Bay, Kenya, (c) Tanzania and (d) Sofala Bank, Mozambique by day (blue) and day and night combined (red) (Fennessy 2012). NB. Charts show different time scales and measures of CPUE.

According to the Scientific Committee of the SWIOFC, penaeid prawns in the region are fully exploited (FAO-SWIOFC 2011). In Kenya, CPUE declined from 2001 onwards; in Mozambique, CPUE declined sharply from the late 1970s to the late 1980s, then declined more slowly to 2004, after which it remained steady; and in Tanzania, catches declined sharply from the mid- 2000s. The fishery has been closed since 2008 in order to allow stock recovery (Figure 17) (Fennessy 2012).

While there are management measures in place for the shallow water prawn trawl sector in each country, there are not always clearly quantified objectives, and ensuring compliance with some measures is difficult to achieve. This may have resulted in the declining CPUE observed in Tanzania and Mozambique, although in South Africa declines in prawn catches occurred as a result of the closure of the large St Lucia estuary in 2001, from which about half of the prawns recruit (Fennessy 2012). There are currently no Ecosystem Approach to Fisheries (EAF) management plans developed for the crustacean fisheries in the SWIO, although these have been proposed for the artisanal and commercial fisheries in Kenya, Tanzania and Madagascar (FAO-SWIOFC 2012). In the small-scale sector there is currently no effort limitation, few management measures and low compliance and in Madagascar artisanal catches have declined from 750t in 2003 to just over 100t in 2009. The fisheries are all managed at a national level, with no regional management strategy. There is however no genetic evidence at this stage to indicate that the priority shallow water prawn species are shared and thus it is appropriate that the stocks in each country continue to be managed separately for the time being (Fennessy 2012).

Industrial Trawl Fisheries (Deep)

Industrial deep-water bottom trawl fisheries for crustaceans in the SWIO operate at depths of 100 - 600m (sometimes to 800m) and catch a mixture of high value crustacean species. Deep-water crustacean trawl fisheries in the SWIO are far less common than shallow-water prawn trawl fisheries, and known fishing grounds are restricted to eastern South Africa, Mozambique, Madagascar, Tanzania and Kenya. Long term deep-water trawl fisheries exist only in Mozambique and South Africa; in Madagascar, Kenya and Tanzania trawling appears to be occasional, limited to a few vessels, and usually short-lived (Groeneveld 2012a).

The fisheries target a variety of crustacean species depending on the depth and area being trawled, but catches are generally composed of deep-water knife (or pink) prawns (*Haliporoides triarthrus*), several other deep-water prawns (*Aristeus virilis*, *Aristeus antennatus*, *Aristaeomorpha foliacea*, *Plesiopenaeus* and *Heterocarpus* spp.), langoustines (*Metanephrops mozambicus*), deep-water lobsters (*Palinurus delagoae*) and red crabs (*Chaceon macphersoni*). Other species of crustaceans are caught in smaller numbers. In addition to crustaceans, the trawlers also catch large quantities of bony fishes and elasmobranchs, which are retained if they can be sold, or discarded if their commercial value is considered to be low (Groeneveld 2012a).

Trends from Mozambique show a long-term decline in fishing effort and catches, with the number of vessels having declined from 45 in 1990 to approximately 15 in 2010. There has been an increase in nominal CPUE since 2004 (Figure 18); it is unclear however whether this is a result of stock recovery, or as a result of increased fishing power of vessels, or reduced competition for trawling space, with fewer vessels competing, or even improved data collection. Fishing effort in the South African fishery declined from 8 vessels in 2001 to 3 vessels in 2008 - 2009 and 4 vessels in 2010. Catches have remained relatively stable, and nominal CPUE has increased since 2004. As in Mozambique, the reason for the CPUE increase is presently unclear. No conclusions can be drawn from the limited data of the Madagascar and Tanzania deep-water trawl fisheries. In Mozambique, numerous surveys of deep-water trawl grounds have been undertaken using research vessels and wet-leased trawlers. Most of these surveys were for stock assessment and fisheries development purposes, and information from the surveys is incorporated into fisheries management decisions. In South Africa, data are collected based on skipper logbooks, landing weights, and information gathered by fisheries observers. No stock assessments are undertaken by the national fisheries department and the relatively small fishery is managed through effort restrictions on the number of rights holders and fisheries permits. All management strategies for this fishery are currently at national level, despite the apparent transboundary distributions of fished stocks (Groeneveld 2012a).

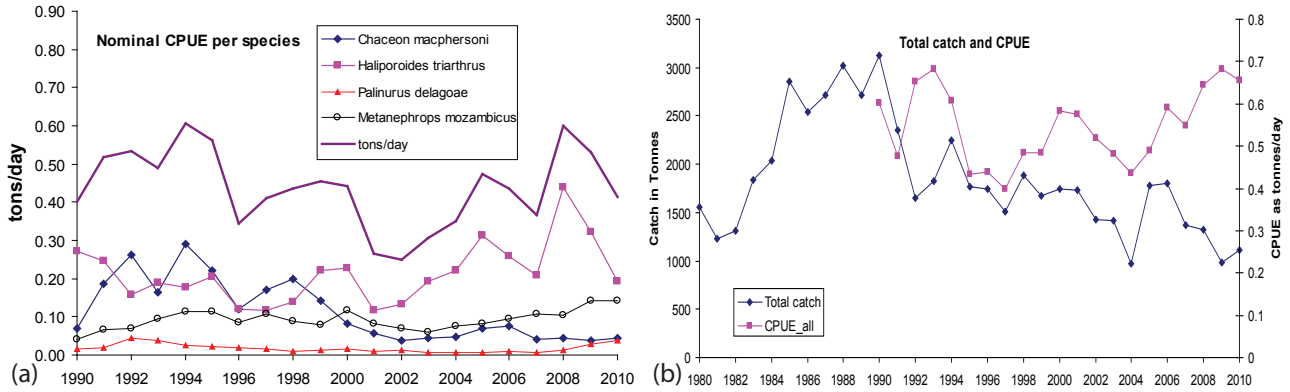


Figure 18: Status of deepwater prawn stocks in (a) South Africa (nominal CPUE per species) and (b) Mozambique (Total catch and CPUE combined) (Groeneveld 2012a).

Industrial Trap Fisheries (Deep)

Deep-water trap-fisheries for spiny lobsters and crabs are industrial, utilising large ocean-going fishing boats that are able to deploy hundreds of baited traps along anchored bottom longlines. The trap-fisheries mainly target high-value *Palinurus* spiny lobsters (several species) for export markets. Slipper lobster (*Scyllarides elisabethae*) and deep-sea red crab (*C. macphersoni*) make up substantial retained bycatches of the trap-fisheries in eastern South Africa and in Mozambique. *Octopus magnificus* is a retained bycatch in traps set for *Palinurus gilchristi* off southern South Africa (Groeneveld 2012b).

Four distinct deep-water trap-fishing sectors have been identified in the SWIO: (i) Industrial trap-fishery for *P. gilchristi* (southern South Africa); (ii) Experimental trap-fishery for *P. delagoae* (eastern South Africa); (iii) Industrial trap-fishery for *P. delagoae* (Mozambique); (iv) Exploratory trapping for spiny lobsters, crabs and deep water shrimps in other countries (Madagascar, Mozambique, Kenya, Mauritius and Seychelles) and on high-seas seamounts (Groeneveld 2012b). Only the trap-fishery for *P. gilchristi* off southern South Africa is presently active as a stable and well-managed fishery. Long-term spatially explicit databases of fishing effort and catches (logbooks) and high resolution catch rate and biological data collected by fisheries observers at sea support annual stock assessments which inform a robust management strategy with good enforcement. The two fisheries for *P. delagoae* are less stable, and are presently inactive. An experimental fishery for *C. macphersoni* off Mozambique has however recently started (2009). In international waters, exploratory trapping was undertaken for spiny lobsters (*Palinurus barbarae* and *Jasus paulensis*) on seamounts of the Madagascar Ridge (Walters Shoals) and the Southwest Indian Ridge by Soviet and Ukranian vessels (1970s-2000), and more recently by EU and South African vessels in 2010 and 2011 (Groeneveld 2012b). The actual numbers of vessels working in this area, frequency of trips, and quantities of lobsters caught by traps are unknown (Groeneveld 2012b). Trap-fisheries operating within the Exclusive Economic Zones (EEZs) (200NM) of countries in the SWIO are controlled according to national management strategies. No regional management strategies exist, even where stocks are apparently transboundary (Groeneveld 2012b). The South Indian Ocean Fisheries Agreement (SIOFA), which came into force in 2012, does however aim to ensure sustainable use of fishery resources (other than tuna) in areas that fall outside of national jurisdictions.

Artisanal / Small-scale Crustacean Fisheries

Shallow-water prawns are targeted in the artisanal fisheries of Kenya, Madagascar, Mozambique, Tanzania and Somalia using gill and seine nets as well as fence traps ('valakira') in Madagascar (WIOFish 2011). Catches from the artisanal fishery in Tanzania are nearly equal to landings from trawlers (Tanzania MEDA 2012) and inshore populations of prawns are declining in Somalia (Somalia MEDA 2012). The artisanal fisheries also target spiny lobsters, using tangle nets, traps, spearguns or reef gleaning methods using snorkelling or SCUBA diving. This is a valuable fishery but monitoring is limited and information on stocks is insufficient, although the status is thought to be mainly fully-fished to depleted (FAO-SWIOFC 2011). The exploitation of crabs is common in several countries in the WIO region. The main target species include the mangrove swamp crab, *Scylla serrata*, and swimming crabs; coconut crabs are exploited in Comoros and ghost crabs are caught in the artisanal and recreational fisheries of South Africa (WIOFish 2011).

Demersal Fisheries

All countries in the SWIO have demersal fisheries, with demersal fish species (and an inseparable component of small pelagic species) constituting the largest category of reported landings by SWIO countries (~200,000 tonnes; FAO data for "Other marine fishes" for 2003) (Fennessy 2009). The demersal fisheries are predominantly artisanal in nature, except in Madagascar, Mozambique, South Africa, and Seychelles, which also have industrial and semi-industrial sectors that target demersal fish (line fish). Information on catches made by artisanal fishers is often sparse, and official estimates grossly under-represent actual catches. These fisheries are generally multi-gear and multispecies, with catches comprising of almost 600 species, although certain species might be dominant, depending on season and area, or targeted by some sectors (e.g. line fishing) (Heileman 2012).

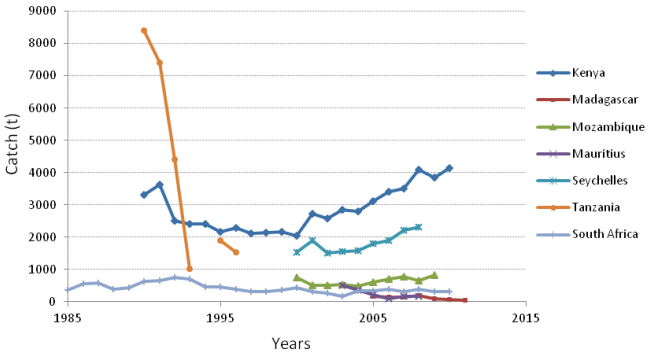


Figure 19: Trends in annual catch of demersal fish in SWIOFP member countries (Statbase data) (Heileman 2012)

Seven distinct demersal fishery sectors have been identified in the SWIO: (i) Drop-line conducted on offshore banks and drop-offs (Mauritius and Seychelles); (ii) Crustacean trawl for shallow-water prawns and deep-water crustaceans (mainland African countries and Madagascar); (iii) Line fishing conducted either using hand-line or rod and reel, generally on reefs in shallow water; (iv) Small-scale fishing using a wide variety of fishing gear, including traps, hook and line, seine nets, gill nets and small trawls, using motorised or non-motorised boats; (v) Longline targeting hake in South Africa and sharks in Tanzania; (vi) Fish trawl targeting hake (South Africa); (vii) Experimental trap (Mozambique) (Fennessy 2009).

The region's demersal stocks, especially in nearshore areas, have experienced heavy fishing pressure over the past decades (Table 2). Most of the priority species for which stock assessments have been carried out were found to be either overexploited or fully exploited. Annual catches of 12 species showed a general decline over the period for which data were available. Catches that increased in more recent years did so following a decline and did not return to previous levels. In some countries, total annual catch (all species) was stable or increased, which could be attributed to a shift to other fishing grounds following localised stock depletion (Figure 19) (Heileman 2012).

Table 2: The status of demersal fish stocks in the 9 ASCLME countries as agreed during the 5th session of the Scientific Committee of the SWIOFC (FAO-SWIOFC 2012).

Country	Species/Complexes/Groups	Stock Status
Comoros	Slope-water snapper	Fully Exploited
Kenya	Demersals (mixed)	Fully Exploited
Madagascar	Snapper	Moderately Exploited
Mauritius	Coastal fisheries (demersal)	Recovering
	Slope-water snapper	Moderately Exploited
	Lethrinids (shelf)	Moderately – Overexploited
Seychelles	Slope-water snapper	Recovering
	Demersal line fish stocks	Fully to Overexploited
Somalia	Demersals (groupers, snapper)	Moderately Exploited
South Africa	Handline fishery (mixed)	Overexploited - Depleted
Tanzania	Reef fish	Fully Exploited
	Demersal fish	Moderately – Fully Exploited

Most of the countries have limited knowledge of the status of the stocks of priority species. Similarly, comprehensive stock assessments have been sporadic, with only two countries (Mozambique and South Africa) conducting regular assessments and the others "one off" assessments. Few priority species are explicitly covered in national fisheries management plans, or have established biological reference points, and even these are

limited to sparids in Mozambique (considered overexploited South of 21˚S and moderately exploited North of 21˚S) and South Africa and *Pristipomoides filamentosus* (Lutjanidae) in Seychelles. Where management exists (e.g. license fees, limited entry, catch quotas, size and gear restrictions), it is at the national level only. Several of the priority species including *Lethrinus nebulosus*, *Lutjanus bohar*, *Epinephelus chlorostigma*, *Lethrinus mahsena*, *P. filamentosus*, *Etelis coruscans* and *Johnius fuscolineatus* are widely distributed in the SWIO region and could be shared or transboundary. There is however, little or no information on the identity and spatial and temporal distribution of the stocks (Heileman 2012).

Drop-line Fisheries

In Mauritius, vertical longlines (drop-lines) are used to target snapper and grouper species on the drop-offs of the Nazareth and Saya de Malha Banks at depths of 100 – 300 m. In Seychelles, drop-lines are deployed from schooners. The drop-line consists of a very long mainline with a buoy at one end and a weight at the other end. The mainline extends from the surface to the seabed, with a series of baited hooks attached at approximately 1 m intervals by snoods. The fishery targets red snapper, groupers and jobfish at depths of up to 350 m on the Mahé Plateau (WIOFish 2011).

Line Fisheries

The Mauritian banks fishery is a mothership-dory fishing operation, which has been operated by a single licensed fishing company since the 1950s. This fishery operates on the banks of the Mascarene Plateau and the Chagos Archipelago and targets *Lethrinus mahsena* which constitutes 80–90 % of the annual catch (Mauritius MEDA 2012). Management measures include a licensing system for all fishing vessels operating on the banks since 1992 and a quota allocation system since 1994. Data for the last ten years show that the stocks have been moderately fished at about two thirds of the total MSY (Munbodh 2012). In Seychelles, the two main fishing grounds for the demersal hand-line fishery are the Mahé Plateau and the Amirantes Plateau at depths from 25 - 70 m. Other fishing areas include the offshore banks and around the southern group of coralline islands. Important demersal species include red snappers, groupers, job fish, and emperors (Seychelles MEDA 2012). The semi-industrial and industrial line fisheries in Mozambique are multispecies hook and line fisheries, comprising more than 200 species, and are conducted over a wide area and mostly at a depth of 30-200m. It takes place mainly on rocky bottoms that are not suitable for trawling. Some linefish species are also targeted by sport fishers. Linefish resources are subject to a high level of exploitation with a recorded 50% increase in effort from 2008 to 2010 (*República de Moçambique Ministério das Pescas* 2012).

Small-scale Coastal Fisheries

The small-scale and artisanal fisheries are an important sector in the WIO region providing food and income to coastal communities. Rising coastal populations and the open-access nature of the fisheries has meant that reef and nearshore demersal fish are heavily exploited throughout the WIO region. The artisanal / traditional fisheries use many different gear types including harpoons, spears, hook and lines, traps and nets (e.g. cast nets, gill nets, seine nets) and target a wide range of reef and demersal species. Many of the preferred food fishes such as jacks, groupers, snappers, emperors and parrotfishes are becoming increasingly rare throughout the region, and some species are now recognised as being of international concern for conservation, including some groupers (Serranidae), the humphead wrasse, *Cheilinus undulatus* (Labridae) and the double-headed parrotfish *Bolbometopon muricatum* (Scaridae). As resources become more depleted there has been an increase in the use of more destructive and non-selective fishing methods, including the use of dynamite, plant derived poisons or smaller mesh size nets, such as mosquito nets.

Longline Fisheries

Longlines are traditionally set on or close to the bottom and the length of main line varies in extent. The longline fishery in South Africa is hake-directed and is relatively selective compared to the trawl fishery. Over-harvesting of deepwater stocks is however a concern as the deep-water hake stock levels are estimated to be <30% of BMSY (the biomass that can support the Maximum Sustainable Yield, MSY). There is little information readily available on the longline fisheries in Tanzania and Kenya, although the former appears to be directed at sharks (Heileman 2012).

Hake Trawl Fishery

South Africa is the only country that targets deep-water and shallow-water hake. This fishery also has quite a substantial bycatch and many other fish species such as kingklip, horse mackerel, angelfish, snoek and monk are caught. The trend in the hake-directed offshore trawling, particularly on the South and East coasts, towards deeper fishing (> 600 m) has resulted in the exploitation of a new "deepwater" species regime with a unique set of biodiversity impacts linked to the continental shelf break (500 – 2000m water depth) (Heileman 2012).

Deep water Trawl Fishery

Deep-sea trawl fishing started several decades ago in the high seas of the South West Indian Ocean region, with exploratory surveys by vessels from the former USSR beginning in the 1970s.

Former USSR vessels conducted periodic deep-sea trawl research cruises on a commercial scale throughout the 1980s and 1990s, and deep-sea trawlers from both New Zealand and Australia were reportedly also fishing in the region during the 1990s. In the period 1999 – 2001 there was a major increase in deep-sea trawling on the high seas with the discovery of orange roughy (*Hoplostethus atlanticus*) stocks by vessels from New Zealand. The dominant bottom fishery in the high seas of the South West Indian Ocean over the past several years has been the mid-water and bottom trawl fishery on and around seamounts for alfonsino (*Beryx splendens*) and orange roughy (*Hoplostethus atlanticus*). In addition to the trawl fishery, a deep-sea longline fishery on the high seas developed over the past several years targeting primarily deepwater longtail red snapper (*Etelis coruscans*).

Exploratory fisheries surveys around the Madagascar shelf and slope in the 1970s and 1980s discovered >50 species (FAO 1998). A relatively new short-lived industrial fishery launched in 2007 by a South African company used deepwater trawling techniques to target alfonsino (*Beryx splendens*). The fishing grounds included seamounts to the south of Madagascar, and there is concern about the impact of the deepwater gear on these habitats (Madagascar MEDA 2012).

Pelagic Fisheries

FISHSTAT data suggest that large pelagics make up nearly 50% of marine fishery catches in the WIO. The national industrial fleets are evenly matched by the foreign fleets as they account for 55% of large pelagic catches in the national EEZs. National catch projections (excluding foreign fleet data per EEZ) show a boom in large pelagic catches over the last decade (four-fold increase between 1995 and 2005). The Seychelles is the only country to have shown a marked interest in large pelagics in the last few years, gradually adding new vessels to the national fleet since 1995 while setting up joint ventures to supply the tuna cannery in Port Victoria (Seychelles MEDA 2012). The development of a semi-industrial fleet in Madagascar since the end of the 1980s boosted production from 5,000 t to 25,000 tonnes today. In the other countries there has been no significant increase in catches of large pelagic (Failler *et al.* 2011).

There are numerous other coastal net-based fisheries targeting small to medium pelagics, the majority of which are data deficient (Cochrane and Japp 2012). Medium pelagics mostly include large mackerels including the kingfishes (*Caranx*), dolphin fish (*Coryphaena hippurus*) and the larger spanish mackerel (*Scomberomorus commerson*) and the wahoo (*Acanthocybium solandri*). The taxonomic groups supporting the highest catches of small pelagics include Carangidae, *Scomber japonicus* (Scombridae) and Scombridae nei, and *Trachurus delagoa* (Carangidae) and *Rastrelliger kanagurta* (Scombridae). These small pelagic fisheries commonly operate at night with purse nets and gill nets. In most cases these smaller pelagic fish provide are a staple food source and may also be used for animal feed. These species are also the primary source of bait for many fisheries, in particular live bait for the large pelagic tuna pole and line fisheries.

As part of its management process, the member States of the Indian Ocean Tuna Commission (IOTC) collect information on the fisheries and the biology of tuna and tuna-like species that is submitted for stock assessment analyses. For three of the main tuna species, the data available for analyses have been reinforced by the results of a large-scale tuna tagging programme, tagging more than 200,000 fish in recent years. There is, however, the need for further studies and better data collection in the SWIO region. As the range of these stocks extends beyond the SWIO, management strategies are discussed in the context of the IOTC for the overall Indian Ocean. Advice from the IOTC Scientific Committee on the status of the stocks relative to biological reference points is taken into account for the adoption of management by the IOTC countries. Several of the target or

bycatch species of the region have high commercial value and are heavily fished by foreign fleets and on a more localised coastal scale by artisanal fishers (Lucas *et al.* 2009). National assessments suggest that many stocks are fully or overexploited (Table 3a), however regional assessments conducted by the IOTC suggest that for the species were sufficient data are available, stocks are not currently overfished (Table 3b).

Table 3a: The status of pelagic fish stocks in the 9 ASCLME countries as agreed during the 5th session of the Scientific Committee of the SWIOFC (FAO-SWIOFC 2012)

Country	Species/Complexes/Groups	Stock Status
Comoros	Coastal tunas and related species	Fully Exploited
	Medium pelagics	Fully Exploited
	Small pelagics	Moderately Exploited
	Sharks and rays	Fully Exploited
Kenya	Small pelagics	Fully Exploited
	Sharks and rays	Fully Exploited
Madagascar	Coastal tunas and related species	Unknown
	Sharks	Overexploited
Mauritius	Coastal tunas and related species	Moderately Exploited
	Offshore tunas and swordfish	Moderately Exploited
	Small pelagics	Under Exploited
Mozambique	Medium pelagics	Fully Exploited (Mozambique states the status is unknown)
	Small pelagics	Moderately Exploited
Seychelles	Offshore tunas	Fully - Overexploited
	Sharks (inshore)	Depleted
	Sharks (offshore)	Overexploited
	Medium pelagics	Moderately exploited
Somalia	Coastal tunas and related species	Unknown
	Sharks and rays	Overexploited
	Small pelagics	Moderately exploited
South Africa	Coastal tunas and related species	Under exploited
	Sharks	Unknown
Tanzania	Coastal tunas and related species	Under exploited
	Sharks	Moderately exploited
	Small pelagics	Moderately exploited

Table 3b: The status of priority large and medium pelagic fish stocks in the Indian Ocean as reported by the IOTC Scientific Committee (IOTC 2011)

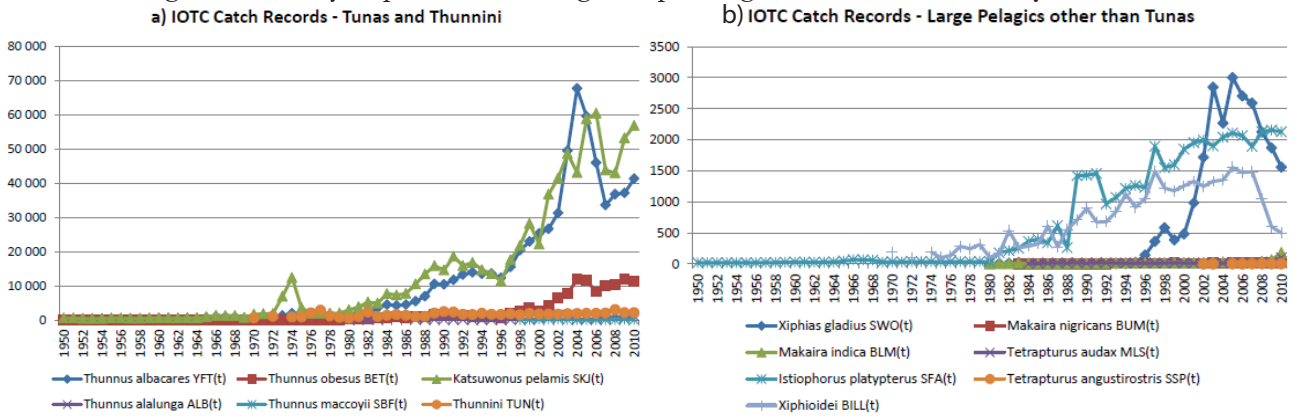
Species	Status	Date
Thunnus albacares	Stock not overfished; Stock not subject to overfishing	2009
Thunnus obesus	Stock not overfished; Stock not subject to overfishing	2009
Katsuwonus pelamis	Stock not overfished; Stock not subject to overfishing	2009
Xiphias gladius	Stock not overfished; Stock not subject to overfishing	2009
Thunnus alalunga	Stock not overfished; Stock subject to overfishing	2010
Thunnus tonggol	Uncertain	2010
Istiophorus platypterus	Uncertain	2010
Makaira indica	Uncertain	2010
Makaira mazara	Uncertain	2010
Tetrapturus audax	Uncertain	2010
Euthynnus affinis	Uncertain	2010
Scomberomorus commerson	Uncertain	2010
Auxis thazard	Uncertain	2010

Tuna catches are largely made up of skipjack (*Katsuwonus pelamis*) and yellowfin tuna (*Thunnus albacares*), followed by bigeye tuna (*T. obesus*). Catches of large pelagics other than tunas are much lower than for the main tuna species and consist mainly of swordfish (*Xiphias gladius*) and the Indo-Pacific sailfish, (*Istiophorus platypterus*) (Cochrane and Japp 2012). Catches of bigeye, skipjack and yellowfin tuna have all declined in recent years (Figure 20) although this may be related to the expansion of piracy in the WIO and the resulting drop in fishing effort. The swordfish stock in the south west Indian Ocean has been overfished in the past decade and biomass in the SWIO remains below the level that would produce MSY (BMSY). The abundance of silky sharks (*Carcharhinus falciformis*) has also declined significantly in recent decades and other shark species are vulnerable to overfishing due to their life history characteristics (IOTC-SC14 2011).

Figure 20: Catches of SWIOFP priority large pelagic species reported to IOTC (a) tuna species and Thonnini and (b) other large pelagic species (Cochrane and Japp 2012)

Longline Fisheries

Industrial longliners are very important in the region, operating in the EEZs of virtually all countries, as well



as on the high seas (Lucas *et al.* 2009). The fishery is dominated by fleets from countries in Asia (Taiwan, Japan and China) targeting bigeye, yellowfin and albacore tuna (*Thunnus alalunga*); the European and Taiwanese longliners also target swordfish (WIOFISH 2011) with a bycatch of pelagic sharks, tuna-like species and billfishes. A semi-industrial longline fishery was established in Seychelles in 1995 targeting yellowfin tuna, bigeye tuna and swordfish with a bycatch of sharks (Lucas *et al.* 2009); a semi-industrial fishery for sharks was also started in 2003, but this ceased to operate in 2010/2011. Artisanal longline fisheries also take place in Kenya, Madagascar, Mozambique, Seychelles and Tanzania targeting sharks, billfish and medium pelagic species (WIOFish 2011).

Vertical Line Fisheries

Fisheries using vertical lines are generally of a coastal nature, and dominated by artisanal and recreational (or sport) fisheries, either around anchored FADs or without FADs (i.e. 'free'). These fisheries target a larger range of pelagic species than longline fisheries, extending from small to medium and large pelagic species (Lucas *et al.* 2009).

The deployment of FADs in countries of the SWIO in the early 1980s (Comoros, Madagascar, Mauritius and the Seychelles) and more recently in Tanzania (2005) clearly shows that while small-scale fishing catches have subsequently increased (doubled in the Comoros; 15 to 20% increase for Mauritius; very localised and overall less successful results in Madagascar and in the Seychelles), this is largely dependent on the level of technological development of the fisheries when the FADs were installed and on the absorption capacity of the pelagic fish markets. Fishing techniques around FADs include handlines used by setting boats adrift or trolling a line back and forth around the FADs with motorised or non-motorised (sailing or oar) boats; this is supplemented by a mid-water longline to catch fish below 50m (Failler *et al.* 2011). It is important that the influence of FADs on the amount and species and size composition of catches must be included in the assessments and management plans for IOTC to avoid increasing the risk of over-exploitation (Cochrane and Japp 2012).

Artisanal line fisheries are particularly important in Comoros where large pelagic fish account for approximately 75% of the fish consumption. There are two main pelagic fisheries: an artisanal fishery for tuna, swordfish

and sharks concentrated around FADs and a traditional fishery for small pelagics: clupeids, small carangids, scombrids and half beaks (Lucas *et al.* 2009). In Mauritius, over 20 FADs have been deployed in water depths of 250 – 3,500m and fishers target tuna and medium pelagic species. Free vertical line fishing in Kenya, Madagascar, Mozambique, Seychelles and Tanzania targets sharks as well as large and medium pelagics.

Recreational fisheries, usually aimed at local and international tourists, operate in the mainland African countries as well as Mauritius and Seychelles targeting billfish, tuna and medium pelagic species (WIOFish 2011). These fisheries are becoming an increasingly popular tourist attraction in some countries (Mauritius MEDA 2012). Landings are often not recorded as the fishery may be licensed under a different ministry.

Purse Seine Fisheries

Two types of purse-seine fisheries operate in the region for small pelagics (scads, sardines, small mackerels) and for tuna and tuna-like species (Lucas *et al.* 2009). The purse-seine fisheries for tunas and tuna-like species are generally operated by foreign fleets under license. The European fleet (Spain, France and Italy) has the highest landings in the region and skipjack tuna and yellowfin tuna are the main species caught. Seychelles has the largest purse-seine fleet in the region. The potential for purse-seine fisheries for small pelagics is generally unknown in the region.

Artisanal / Small-scale Coastal Net Fisheries

Coastal net fisheries (beach seine, small purse-seines, cast nets, ring nets) are of an artisanal nature and target small and medium pelagic fish species for own consumption and local sale in all countries within the SWIO region (Lucas *et al.* 2009).

The annual catches of medium pelagics recorded on WIOFish range from 0t in four of the countries to 8,165t in South Africa. Mozambique and Seychelles reported values of between 500 and 600t. Catches are composed of seventeen species or species groups but no catch estimates are provided for 11 of those taxonomic groups (Cochrane and Japp 2012).

Artisanal fisheries in Madagascar use cast nets and gill nets to catch medium and small pelagic fish species. The most affected species by traditional and artisanal fisheries are small Scombridae, such as the eastern little tuna, *Euthynnus affinis*, the wahoo, *Acanthocybium solandri*, the narrow-barred Spanish mackerel, *Scomberomorus commerson*, the Indian mackerel, *Rastrelliger kanagurta* and *Auxis* spp., Sphyraenidae, Carangidae, sardines (Clupeidae), anchovies (Engraulidae), Hemiramphidae, Belonidae and others (Madagascar MEDA 2012).

An artisanal purse seine fishery operates in Tanzania; the main species caught are sardine and anchovy, which together form 30-50% of total fish landings. Bottom-set gillnets, are also used to target sharks and rays, and these vary in length up to 450m, with mesh sizes ranging from 20-40cm (Tanzania MEDA 2012). In Kenya, gill nets are used to target sharks and tuna, whilst ring nets, cast nets and seine nets are used to catch medium and small pelagic species (Maina 2012).

Other Coastal Fisheries

High coastal population densities within the countries of the SWIO results in intense exploitation of various other nearshore resources by recreational and subsistence fishers. Many coastal invertebrate stocks are overexploited as a result (Table 4), with significant impacts on both target and non-target species having been recorded. In addition, Mozambique records stock status of Cephalopods offshore- under exploited; Bivalves inshore - Moderately exploited; sea cucumber – overexploited; Octopus offshore- under exploited; and Cephalopods inshore: Under exploited.

Table 4: The status of invertebrate stocks in the 9 ASCLME countries as agreed during the 5th session of the Scientific Committee of the SWIOFC (FAO-SWIOFC 2012)

Country	Species/Complexes/Groups	Stock Status
Comoros	Cephalopods	Under Exploited
	Bivalves	Under Exploited
Kenya	Octopus	Fully Exploited
	Sea cucumbers	Overexploited
	Bivalves	Fully Exploited
Madagascar	Octopus	Fully Exploited
	Sea cucumbers	Overexploited
	Bivalves	Fully Exploited
Mauritius	Octopus (St Brandon)	Moderately Exploited
	Sea cucumbers	Depleted
Seychelles	Sea cucumbers	Overexploited
South Africa	Octopus	Under exploited
	Bivalves	Fully – Overexploited
Tanzania	Octopus	Overexploited
	Cuttlefish and Squid	Fully Exploited
	Sea cucumbers	Overexploited
	Bivalves	Overexploited

Bivalves and gastropods

Mollusc resources are exploited in nearshore habitats, most often by reef walking or snorkelling. Molluscs are often collected opportunistically as additional catch alongside other fishing methods. The main molluscs targeted are the edible and ornamental species such as oysters, clams, whelks and mussels. Most of the shells collected for the curio trade are threatened species (Tanzania MEDA 2012, Somalia MEDA 2012) and their stock status ranges from fully to overexploited (FAO-SWIOFC 2011).

Cephalopods

There are fisheries targeting squid, cuttlefish and octopus within the region, the most widespread of which is the artisanal octopus fishery which occurs in every country in the SWIO region. Declines in octopus fisheries landings were reported by several countries due mainly to overexploitation but also often associated with habitat damage. The South West Indian Ocean Fisheries Commission (SWIOFC) has classified the octopus fishery as overfished in the SWIO region. Octopus fishing is usually undertaken by walking on the reef flat at low tide. The most common fishing technique employed throughout the region is to use a long metal spike, or harpoon to lure the octopus from its den in the reef rock. The squid-jigging fishery in South Africa is an important commercial fishery targeting spawning aggregations of chokka squid (*Loligo vulgaris reynaudii*) in sheltered bays on the south coast (South Africa MEDA 2012).

Bêche-de-mer

Sea cucumber (also known as bêche-de-mer when semi-processed) fishing is not a traditional fishery within the SWIO, but it has rapidly and significantly increased in importance due to the high export value of the product. Sea cucumbers are typically targeted by fishers using a mask and snorkel or SCUBA equipment or collected as bycatch by spear fishermen and other gleaners. Fishers typically target the six highest value species (*Holothuria nobilis*, *H. fuscogilva*, *H. scabra*, *Thelenota ananas* and *Actinopyga mauritiana*). Sea cucumber resources in all countries in the SWIO are largely over-exploited (FAO-SWIOFC 2011). Management regulations to control the fishery and processing were implemented in Seychelles in 1999 (Seychelles MEDA 2012). Sea cucumber fishing in Comoros has been banned since 2004 (FAO-SWIOFC 2012) and in Mauritius, a two-year moratorium period was implemented from 1st October 2009 to 30th September 2011; this has now been extended until February 2016 (WIOFish 2011).

Biodiversity

The SWIO sustains significant fisheries in a region of high biodiversity, endowed with vulnerable and iconic species. New fisheries opportunities therefore need to be environmentally sustainable, including their relationship with vulnerable species and the biodiversity of the region (van der Elst 2012).

Vulnerable Species

The incidental catch of marine megafauna, including marine mammals, sea turtles and elasmobranchs, poses one of the main threats to these species at the global scale. These taxa are particularly vulnerable for biological reasons, such as late maturity and low reproduction rates (Kiszka 2012).

In contrast to other regions of the world, WIO industrial fisheries, including the WIO oceanic purse seine fisheries, do not catch quantities of marine mammals. Dugong populations in Mozambique, Tanzania, Madagascar and Comoros continue to decline through incidental and targeted artisanal gill netting. The population now remaining is estimated to be composed of less than 500 animals, the majority of which are found in Mozambique, in particular in the Bazaruto Archipelago (van der Elst 2012). Recent surveys have also found potentially significant populations in northwest Madagascar (Ridoux *et al.* 2010), and Mayotte (Kiszka *et al.* 2007) but the viability of these populations remains uncertain. The capture of delphinids in artisanal gillnet fisheries in Zanzibar and several other locations in Tanzania as well as Madagascar, may be high enough to negatively impact local populations. In particular, dolphins that are opportunistically hunted by fishermen in Madagascar are under threat (van der Elst 2012).

Among the 1,160 species of cartilaginous fishes known from around the world, 200 of which have been recorded in the SWIO, including iconic species such as whale sharks and the critically endangered sawfish. Declared landings of elasmobranchs (sharks and rays) in the SWIO peaked at 180,000Mt in 1996, which was due partly to increased effort targeting tuna which has since subsided (Smale 2008). Landings of elasmobranchs have halved since then and are currently reported to be. Few if any shark management plans are in place. High levels of bycatch are frequently associated with longline, trawl and line fisheries. Specific issues of concern are the mortalities associated with shark netting on the KwaZulu-Natal coast, artisanal harvesting of reef manta rays in Mozambique and uncontrolled catches made in shrimp trawl fisheries (van der Elst 2012). IOTC member States have agreed to ban the practice of finning sharks, as well as banning the landing of thresher sharks from their fisheries.

Threats to the five main WIO sea turtle species are imposed by both artisanal and industrial fisheries including a large turtle bycatch in the South African pelagic longline fishery. While most of the turtles are caught on the Walvis Ridge by this fishery, there will undoubtedly also be impacts on SWIO turtle populations considering the high incidence of loggerheads which nest on the KwaZulu-Natal coast. Industrial inshore prawn trawl fisheries in all countries capture sea turtles; however, the use of turtle excluder devices (TEDS) is progressively reducing the problem, especially in Madagascar. In South Africa protective shark nets in KwaZulu-Natal impact sea turtles as well as sharks, while artisanal gill nets in Zanzibar, Tanzania Somalia, Mozambique and Madagascar take both a directed and bycatch of sea turtles. Madagascar in particular, has a long history of fishers taking sea turtles for meat while eggs are commonly collected for human consumption. Annual turtle catch in one province alone has been estimated to be between 10,000 and 16,000 individuals (van der Elst 2012). IOTC has adopted measures to reduce the impact of interactions between marine turtles and fisheries for tuna and tuna-like species.

Fisheries impacts on seabird populations include incidental capture or entanglement with gear, (longline, trawl and gillnet fisheries), loss of foraging opportunities due to depleted fish stocks and direct competition with fisheries targeting low trophic level fish. Direct seabird mortality mostly affects long lived more temperate species, such as albatrosses, which are under extreme pressure. The rich and abundant seabird assemblages in tropical waters of the WIO are however largely immune to direct, incidental mortality from fishing as their foraging strategy is different from the more temperate seabirds (van der Elst 2012). IOTC has adopted measures to mitigate the incidental mortality of seabirds in the fisheries of its member States.

The Indo-West Pacific region has the greatest diversity of fishes of all the oceans' eight biogeographic regions with about 2,200 species found in the WIO, representing some 83% of all the fish families known. Included are

many iconic fishes, ranging from the world's "oldest" fish, the coelacanth (*Latimeria chalumnae*), to the world's largest, the whale shark (*Rhincodon typus*). A high level of endemism is found: for example southern Mozambique and South Africa have 227 endemic fishes. Several fisheries report capture of vulnerable species included in the IUCN Red List, especially artisanal and recreational fisheries. Linefishing often targets serranidae and labridae including the red-flagged species, which are often slow growing, and therefore vulnerable to overexploitation. Some fisheries target spawning aggregations, with the potential to rapidly deplete fish stocks (van der Elst 2012).

Bycatch

There is a consensus that the issue of bycatch is an important matter in the context of an ecosystem approach to fisheries and hence ultimately for environmental sustainability (van der Elst *et al.* 2010). However, bycatch is a complex issue and the definition of bycatch is not straightforward, particularly in artisanal and other less-sophisticated fisheries. The bycatch can be split into retained and discarded components, and the proportion of each is similarly variable depending on numerous factors. Artisanal fisheries will often have negligible discards (van der Elst 2012). There is little formally published information on bycatch or discards in the WIO. Levels of bycatch were found to be particularly high for the prawn trawl fishery followed by the pelagic longline and purse seine fisheries (van der Elst 2012). Trawl fisheries have a variable level of bycatch, only a proportion of which is discarded. There is however very limited information about the species composition of the bycatch. Similarly, there is a lack of information relating to the incidence of bycatch within the longline fishery, although in South Africa, sea turtle bycatch, mostly comprising leatherback turtles, is of concern (van der Elst *et al.* 2010). Bycatch has been particularly poorly documented within the artisanal fisheries in the region. A recent study revealed the high extent of large marine vertebrate bycatch in artisanal fisheries, especially in drift, bottom-set gillnets and beach seines (Kiszka 2012).

At least 59 species were identified as bycatch and by-product species, including five species of sea turtles, eight species of marine mammals and 46 species of elasmobranchs. The study highlighted that gillnet fisheries (both drift and bottom-set) have the highest impacts, especially for marine mammals but also for sea turtles. Beach seines were also noted for high impact on sea turtles, especially the green turtle.

Trawling Impacts

A further topic of concern is the effect of uncontrolled trawling on the seabed through removal of non-target species and its impacts on seabed habitat ecology and the ability of the ecosystem to support the resources being trawled. Almost no attention has been given to this potentially deleterious practice in the WIO, despite the fact that it is well documented from other seas (Fennessy 2012). There is a pressing need to develop an understanding of this problem and to improve environmental management of trawl fisheries to prevent further habitat degradation and loss of biodiversity (van der Elst 2012).

Critical Habitats

The SWIO is a zone of high biodiversity and a diversity of ecosystems. As the region is largely oligotrophic, there is heightened reliance on the productivity generated by these diverse ecosystems and habitats. Critical ecosystems in the region include coral reefs, mangrove forests, seagrass meadows, rich offshore banks, scattered islands and deep sea habitats. Areas such as mangroves, seagrasses and other critical habitats are also known to play a pivotal role as nurseries for many of the key fisheries resources (van der Elst 2012) but are under threat from a range of human impacts. Protection of these critical ecosystem and habitats requires a wide range of actions, including integrated coastal zone management, pollution control, waste management and minimising the impact of fisheries. At present there is no uniform approach to protecting critical ecosystems between the countries and even less so at the regional level (van der Elst *et al.* 2010).

Deep-sea habitats are now also recognised as having unique abiotic and biological characteristics (Ramirez-Llodra *et al.* 2011). Some progress has been made in managing the impacts of deep-sea fisheries, for example through the establishment of benthic protected areas (BPA) where bottom trawling, mid-water trawling and dredging is forbidden (van der Elst 2012). Nevertheless, management of deep-sea fisheries remains complicated and faces several challenges (Clark *et al.* 2006). Anecdotal information also suggests that several vessels may be fishing on these types of habitats in international water with deep-sea gillnets for deep-sea sharks around Walters Shoal (seamounts on the SW Indian Ocean Ridge). While long-line fishing may have less direct

impact than bottom trawling, the line weights and the line itself can cause damage to benthic fauna, especially erect sponges and corals.

Modern approaches to resource management include the ecosystem approach (EAF) promoted by the FAO (van der Elst 2012) which recognises the need to take foodweb interactions into account in fisheries management. Since 2010, considerable progress has been made by SWIO countries in the process of development of National Fisheries Management Plans following the EAF methodology. Additionally, a regional EAF implementation baseline report has been prepared for the South West Indian Ocean Fisheries Commission. Mozambique, Seychelles and Tanzania started the development of fisheries management plans with EAF methodologies in 2010, followed by Comoros, Kenya, Madagascar and Mauritius in 2011 (FAO-SWIOFC 2012). The IOTC also routinely reviews ecosystem issues in its Working Party on Ecosystems and Bycatch, which meets annually and recommends measures to mitigate ecosystem impacts by tuna fisheries.

Legal Arrangements

International Fisheries Instruments

Several international fisheries instruments provide a governance framework for fisheries in the WIO region. Key legally binding instruments include the 1982 UN Convention on the Law of the Sea (the 1982 Convention), the 1995 United Nations Fish Stocks Agreement and the 2009 FAO Agreement on Port State Measures (not yet in force) (Table 5) (Swan 2012). A leading voluntary instrument is the 1995 FAO Code of Conduct for Responsible Fisheries and the international plans of action, elaborated under its provisions, on seabirds, sharks, fishing capacity and illegal, unreported and unregulated (IUU) fishing.

Other voluntary instruments include the:

- 2003 FAO Technical Guidelines on the Ecosystem Approach to Fisheries
- 2008 FAO International Guidelines for the Management of Deep-sea Fisheries in the High Seas
- 2010 FAO International Guidelines on Bycatch Management and Reduction of Discards

All countries in the SWIO region have signed and ratified UNCLOS, which forms the foundation for the other instruments. It sets the standards for management of fisheries, including straddling fish stocks and highly migratory species. Four countries in the region are parties to the UN Fish Stocks Agreement (Kenya, Mauritius, Mozambique, Seychelles, and South Africa). Key areas of this Agreement include the requirements for compatibility of measures inside and beyond areas under national jurisdiction, an ecosystem approach to management of stocks and associated and dependent species throughout their range, functions of regional fisheries bodies or arrangements, information provision and exchange, flag state duties, port state measures and MCS provisions including procedures for boarding and inspection on the high seas (Swan 2012). Although the FAO Agreement on Port State Measures has not yet entered into force, Kenya has already ratified it and Mozambique has signed. In this context, countries should not do anything to defeat the object and purpose of the Agreement. In addition, the members of IOTC have adopted a legally binding resolution, Resolution 10/11, which is almost identical to the Agreement.

Regional Organisations

The Indian Ocean Tuna Commission (IOTC), established in 1996, has a mandate for the management of tuna and tuna-like species included in its constitutive Agreement. Its area of competence includes high seas and areas under national jurisdiction in the Indian Ocean. It seeks "to promote cooperation among its Members with a view to ensuring, through appropriate management, the conservation and optimum utilisation of stocks" and by "encouraging sustainable development of fisheries based on such stocks". It has a management mandate and takes legally binding decisions (Swan 2012). Membership is open to Members and Associate Members of FAO that accept the IOTC Agreement and are coastal States or Associate Members situated wholly or partly within the Area, States or Associate Members whose vessels engage in fishing in the Area for stocks covered by the Agreement, or regional economic integration organisations to which the foregoing states have transferred appropriate competence. IOTC currently has 31 Contracting Parties (IOTC 2001-2009). All of the 9 ASCLME countries are full Contracting Parties to IOTC with the exception of South Africa, which is a Cooperating non-Contracting Party (Table 5) (Swan 2012).

The South West Indian Ocean Fisheries Commission (SWIOFC), established in 2004, has an advisory mandate over all living marine resources within the national jurisdiction, without prejudice to the management responsibilities and authority of other competent fisheries and other living marine resources management. This effectively recognises the mandate of IOTC within national waters over the tuna and tuna-like species set out in the IOTC Agreement, so there is no overlap with IOTC. Its main objectives are to promote the sustainable utilisation of the living marine resources of the region through management and development and to address common problems of fisheries management and development faced by the Members of the Commission (Swan 2012). Comoros, France, Kenya, Madagascar, Mauritius, Mozambique, the Seychelles, Somalia, and Tanzania are all members of the Commission (FAO 2012b).

The South Indian Ocean Fisheries Agreement (SIOFA) entered into force in 2012, and its area of competence falls within the high seas of the South Indian Ocean. It has competence over high seas fisheries resources, other than sedentary species on countries' continental shelves beyond the exclusive economic zone and, in order not to overlap with IOTC, highly migratory species. It has a management mandate and takes legally binding decisions (Swan 2012). Comoros, Kenya, Madagascar and Mozambique have signed the SIOFA and Mauritius and Seychelles have ratified the Agreement (FAO 2012b).

The Southern African Development Community (SADC), of which Madagascar, Mauritius, Mozambique, Seychelles, South Africa, and Tanzania are members, has a long experience of cooperation in fisheries. The 2001 SADC Protocol on Fisheries aims to promote responsible and sustainable use of the living aquatic resources and aquatic ecosystems of interest to State Parties, and it contains Articles in relation to, *inter alia*, the management of shared resources, harmonisation of legislation, law enforcement, access agreements and protection of the aquatic environment. It allows for States to establish instruments for co-ordination, co-operation, or integration of management of shared resources (Swan 2012).

The East African Community (EAC) is a regional intergovernmental organisation which includes Kenya and Tanzania as members. The EAC seeks to promote the co-management of natural resources, harmonise policies, laws and strategies for both the sustainable use of coastal and marine resources and fisheries, fisheries laws, policies and strategies and address a range of issues including reduction and prevention of pollution, introduction of alien species and monitoring, evaluation and control (Swan, 2012). The EAC adopted a Protocol on Environment and Natural Resources in 2005, which aims to promote and enhance cooperation amongst Partner States in the conservation and management of environmental and natural resources, adopt a common vision in addressing challenges of sustainable development, make concerted efforts to prevent and control environmental degradation and includes fisheries as one of its focal areas (East African Community Portal 2012).

The Indian Ocean Commission (COI-IOC) has a strong focus on fisheries and has several management programmes for fisheries resources and the protection of the marine environment. The Regional Fisheries Surveillance Plan Project (PRSP), which has been active since 2007 aims to eliminate illegal, unregulated and unreported (IUU) fishing in the exclusive economic zones of its Member States. It also contributes to the sustainable management of fisheries resources in the Indian Ocean and to the promotion of responsible fishing. In 2009, the IOC decided to develop a regional strategy for fisheries and aquaculture to ensure a greater coherence among all these initiatives and to encourage the efficient and sustainable management of these shared fisheries resources. The SmartFish Programme, which was officially launched in 2011, aims to contribute to an increased level of social, economic and environmental development and deeper regional integration in the Eastern and Southern Africa and the Indian Ocean (ESA-IO) region through improved capacities for the sustainable exploitation of fisheries resources. The Programme aims to achieve five main results which relate to fisheries development and management; fisheries governance; monitoring, control and surveillance; fish trade and food security (IOC 2011).

The New Partnership for Africa's Development (NEPAD) is a programme of the African Union (AU) adopted in 2001 which aims to enhance Africa's growth, development and participation in the global economy. NEPAD has developed the Partnership for African Fisheries which is working to improve the sustainability of Africa's fisheries and improve the returns provided by this sector by defining processes that will strengthen the region's

capacity to implement policy reforms in fisheries governance and trade. Working groups have been established in 5 key areas: good governance; illegal fishing; trade and access to markets; aquaculture; and finance and investment in fisheries and aquaculture (NEPAD 2010-2012).

The African Union-Interafrican Bureau for Animal Resources (AU-IBAR) has included fisheries issues in its Strategic Plan 2010-2014 and supports regional fisheries organisations and member states to sustainably manage marine and inland capture fisheries based on international best practices. The Strategic Partnership for Sustainable Fisheries Investment Fund Project aims to promote sustainable use of fisheries resources and the management of marine ecosystems that support them with the overall aim of poverty eradication and enhancement of sustainable income growth of the fishing communities of Sub-Saharan Africa (AU-IBAR 2004-2012).

Table 5: International, regional, sub-regional instruments and organizations (shaded areas indicate States that are members or parties to the instrument/organization. Light shading indicates signature only of the instrument) (Swan 2012).

Country	International Instruments			RFBS			Regional Organisations			
	1982 UN Law of the Sea Convention	1995 UN Fish Stocks Agreement	2009 FAO Port State Measures Agreement	IOTC	SIOFA	SWIOFC	ASCLME	COI-IOC	EAC	SADC
Comoros	■			■	■	■	■	■		
Kenya	■	■	■	■	■	■	■		■	
Madagascar	■			■		■	■	■		■
Mauritius	■	■		■	■	■	■	■		■
Mozambique	■	■		■	■	■	■			■
Seychelles	■	■		■	■	■	■	■		■
South Africa	■	■		[1]		■	■			■
Tanzania, U.R. of	■			■		■	■		■	■

[1] Cooperating non-Contracting Party.

National Legislation

All countries within the SWIO region have national fisheries laws and five of these countries (Kenya, Madagascar, Mauritius, Mozambique and Seychelles) have recently prepared, or are in the course of developing, revised fisheries legislation (Swan 2012). However, many laws do not fully implement the binding obligations of international fisheries instruments or regional organisations, nor do they reflect up to date "best practices" of fisheries legislation. In addition, they do not provide a harmonised basis for fisheries conservation, management and development, including in related areas such as monitoring, control and surveillance, information requirements, jurisdiction and application, international cooperation, evidence and fines, penalties and other determinations.

Trade

Fish is the most internationally traded food commodity at the global level. In the region, industrial fishing activities provide an important source of employment, foreign exchange revenue and food security. World exports of fish and fishery products reached 56 million tonnes with a value of US$96 billion in 2009 which showed a significant increase from 2000 (FAO 2012a). Growing exports can be attributed to the increase in consumption not only in the European Union (EU) and the United States of America, but also in other regions of the world such as in Asia. The development of processing, packaging, handling and transportation of fish and fish products, as well as the growth of international distribution channels, are all factors that contributed to the increase of fish exports (Tsamenyi and McIlgorm 2010). In 2009, fish exports were more than 30% of the value of agricultural exports in Madagascar, Mauritius and the Seychelles (Table 6). In the Seychelles, over 50% of all exports are fish and fish products (FAO 2012a). Fish exports from the region primarily include unprocessed fresh or frozen whole tuna, canned tuna, small pelagic species such as mackerels and sardines, and crustaceans (mainly shrimp and rock lobsters) and molluscs. In the Seychelles, the fisheries sector is the main source of foreign exchange, and the country contains the most important tuna port in the world (Port Victoria). The Seychelles has the second largest tuna processing factory in the world, with canned tuna exports representing

87% of the country's foreign exports; it handles 88% of the total tuna catch in the WIO fleet (Kimani *et al.* 2009).

Table 6: The value of fishery exports to the economics of 8 countries within the SWIO

Country	GDP (million US$) (2009)[1]	Exports (million US$)[2]	Imports (million US$)[2]	Fishery exports (% of agricultural exports)[2]	Fishery exports (% of total merchandise exports)[2]
Comoros	530	Not available	2.52	4.6	1.5
Kenya	29,412	57.11	6.58	2.3	1.3
Madagascar	8,790	115.19	18.00	38.1	10.9
Mauritius	8,668	284.53	235.46	48.1	14.7
Mozambique	9,579	66.41	39.82	17.7	3.1
Seychelles	788	210.20	87.45	97.8	53.2
South Africa	285,983	441.78	260.65	7.5	0.7
Tanzania	22,351	145.52	4.00	15.0	5.0

[1] UNdata (2012) [2] FAO (2012a)

Countries in the SWIO have benefited from the trade preference provided under the non-reciprocal Lomé/ Cotonou arrangement between the African, Caribbean and Pacific (ACP) countries and the EU. This agreement has led to a considerable export market in the EU for ACP produced fish and fish products, with the EU receiving 68.8% of total ACP exports by value. There have, however, been recent developments in the international trade arena which will impact this situation. With the advent of Economic Partnership Agreements (EPAs) and Fishery Partnership Agreements (FPA), the relationship between ACP and the EU is changing (Tsamenyi and McIlgorm 2010). EPAs are a key element of the Cotonou Agreement and aim to provide a broad range of measures to support the gradual integration of ACP countries into the world economy. ACP countries are encouraged to enter into the EPAs in regional groupings and countries within the SWIO are members of the different regional trade groups: Eastern and Southern Africa (Comoros, Mauritius, Madagascar, Seychelles and Somalia), East African Community (Kenya and Tanzania) and the Southern African Development Community (Mozambique and South Africa). Madagascar, Mauritius, Mozambique, Kenya, Seychelles and Tanzania all signed interim Economic Partnership Agreements with the EU between 2007 and 2009 (European Union 1995-2012).

In the past, the preferential access to EU markets for fish and fish products produced in ACP countries was a fundamental and important competitive advantage given to ACP producers. However, as a result of a general liberalisation of trade in non-agricultural products, including fish and fish products, average import duties on fish have come down substantially. This enables non-ACP producers to gain access to the EU markets at lower rates than previously applied. Other developments such as the establishment of Free Trade Agreements between the EU and Thailand, Philippines and Indonesia, the Everything but Arms concessions by the EU to the Least Developed Countries, and concessions accorded to Central American countries under the anti-drug concessions programmes have, cumulatively reduced considerably the preference accorded to ACP producers of processed fish (mainly tuna) for the EU market. As a result, fish exporting ACP member countries must now explore other potential opportunities such as market diversification and the expansion of intra-ACP fish trade is a potential opportunity for ACP member countries (Tsamenyi and McIlgorm 2010).

Piracy

Piracy stemming from Somalia has increased significantly over the last 5 years and now threatens maritime users in the Gulf of Aden and across large parts of the Indian Ocean. Pirate attacks went up 11% in 2011, with the highest incidence being in West and East Africa. Piracy poses a serious challenge to fisheries and has had a major impact on countries which rely on the fishing industry for economic revenue. In the Seychelles for example, it has been estimated that piracy has resulted in a 4% decline in GDP. This in turn poses a serious development challenge, affecting employment and income and leading to increased poverty. Piracy has resulted in a shift of fishing effort in the Indian Ocean, with the Asian longline fleets particularly displaced to the east and southeast. The purse seine fleet suffered an eastward displacement in 2009, but has since partially adjusted to

the threat due to the security arrangements for the vessels. Catches of swordfish and bigeye and yellowfin tuna have declined since 2008 in parallel with decreased longline fishing effort, whereas slight declines in skipjack tuna have occurred. While piracy has undoubtedly changed the level of fishing capacity and distribution of fishing effort, the long-term implication for stocks are not fully understood (EBCD 2012).

Conclusions

The findings from the SWIOFP Gap Analyses and Retrospective Analyses indicate that all three of the main fisheries types (crustacean, demersal and pelagics) as well as other fisheries, currently lack the appropriate data on the priority species required for effective management of the fisheries in the region (Fennessy 2012, Groeneveld 2012a,b, Heileman 2012, Cochrane and Japp 2012). Where data do exist, they have not been fully analysed to increase the knowledge and understanding about the priority species (Heileman 2012). There is a recognised need to harmonise sampling strategies across the region with particular recommendations to improve the sampling methods for the small and medium pelagic fishes (Cochrane and Japp 2012, Lucas *et al.* 2009) and to improve collection of catch and fishing effort data for the demersal fisheries (Heileman 2012).

For the industrial fisheries, scientific observer programmes should be expanded and regular training provided to observers, data collectors and other relevant persons (fisheries researchers and officers) in species identification and sampling methods, and collection of biological data (Heileman 2012). Additional surveys are also required to incrementally strengthen the IOTC's Tuna Tagging Programme, particularly for bigeye tuna and swordfish and the linkages between pelagic fisheries information and environmental information (integration of ASCLME with SWIOFP) should also be strengthened (Lucas 2009). For the artisanal fisheries, countries need to take urgent steps to ensure that at least the minimum monitoring and data analysis necessary for responsible management is routinely carried out. In pursuing these goals, the WIO countries need to identify and implement cost-effective methods for monitoring and assessing small-scale and multispecies fisheries, such as rapid appraisal methodologies and participatory processes (Cochrane and Japp 2012, Cochrane *et al.* 2011).

A significant regional effort also needs to be undertaken to identify areas of special interest for marine mammals, sea turtles and elasmobranchs, including more in-depth studies of their critical habitats, movements patterns and population structure of the most vulnerable species. It is recommended that a regional scientific observer programme should be initiated for all sizeable fisheries to collect reliable information about fishing impacts on target and non-target stocks. There is a particular lack of quantitative data regarding elasmobranchs, turtle and marine mammal bycatch and therefore this should be addressed at all levels (van der Elst 2012). There is however also a general perception that there is negligible bycatch in artisanal and subsistence fisheries, probably because of the impoverished nature of these fishers which means that all of the catch has some value. So there is a need for the monitoring of bycatch in the WIO region to include the recording of the fate of bycatch (i.e. discarded or used as bait).

All of the countries in the SWIO region have planned or existing fisheries management plans, and fisheries regulations and measures for their fisheries in general or for certain sectors. A review of national fisheries legislation in the SWIO region has shown however that fisheries related legislation in the SWIO region is generally outdated and weak (Swan 2012). Although all countries within the SWIO region have national fisheries laws, many of these laws do not fully implement the binding obligations of international fisheries instruments or regional organisations, nor do they reflect up to date "best practices" of fisheries legislation (Swan 2012). Furthermore, few priority species are explicitly covered in the existing or planned fisheries management plans, or have established biological reference points (Heileman 2012). A further review of national legislation should therefore be considered and management plans should be revised to incorporate stock assessment information and to explicitly consider the priority species and the major fisheries that target them.

3.4 Biodiversity

The coastal zone and marine waters of the Agulhas and Somali LMEs host a high diversity of species and communities, the distribution of which is determined by physical-chemical conditions (water temperature, currents, nutrient regimes and substrate) and biological interactions. Oceanographic characteristics already discussed, particularly the predominant currents, eddies and upwelling cells have an influence on the distribution of species.

Richmond (2001) presents a comprehensive inventory of the known biodiversity of the Western Indian Ocean; from which some statistics are presented in Table 7.

Table 7: Summary of the minimum estimated species number for major macroflora and macrofauna taxa from littoral and shallow sublittoral waters of the western Indian Ocean. Data from Richmond (1997) unless indicated.

Taxa	Minimum No. of Species		Taxa	Minimum No. of Species
Mangroves	10		Caridea	150
Seagrasses	12		Palinura	20
Macroalgae[1]	1011		Thalassinidea	20
Porifera[2]	200		Anomura	50
Ctenophora	20		Brachyura	100
Scyphozoa[3]	30		Scaphopoda	10
Hydrozoa	100		Polyplacophora[4]	39
Octocorallia	300		Prosobranchia[4]	2550
Ceriantharia	20		Opisthobranchia[5]	400
Actinaria	30		Pulmonata	20
Corallimorpharia	10		Bivalvia[4]	667
Zoanthidea	5		Cephalopoda	20
Scleractinia	200		Echinoidea	62
Antipatharia	10		Holothuroidea	148
Platyhelminthes	100		Asteroidea	58
Echiura	22		Ophiuroidea	132
Sipuncula	50		Crinoidea	19
Polychaeta[4]	300		Phoronida	5
Oligochaeta	10		Brachiopoda	5
Cirripedia	30		Bryozoa	500
Nemertea	59		Hemichordata	20
Amphipoda	300		Chaetognatha	50
Isopoda	100		Thaliacea	30
Stomatopoda	30		Ascidiacea[6]	100
Dendrobranchiata	10		Pisces	2000
Total				**10,627**

[1]Silva et al. (1996) (excluding South Africa); [2] van Soest, 1994 (including Red Sea and Arabian Sea); [3]Cornelius (pers. commun.); [4]Richmond (1999); [5]Yonow (pers. commun.); [6]Monniot (pers. commun. estimate for Mozambique).

By 2005, Griffiths notes that although no species lists exist for individual countries of tropical Africa, 11,257 marine species have been recorded from the Western Indian Ocean region (including island states). This, however, is estimated to be less than 50% of the marine species actually present (Griffiths 2005). Charismatic species such as turtles, dugongs, coelacanths and cetaceans, as well of those of commercial importance tend to be better studied, while the microfauna and meiofauna, although highly diverse, tend to be poorly studied worldwide (Gage 1996). Existing species lists are based largely on shallow water surveys, and the fauna of deeper waters, abyssal plains and seamounts are less well known (Griffiths 2005). Research surveys by the ASCLME Project and partners have led to the discovery of new species (e.g. Randall and King 2009).

Each of the national Marine Ecosystem Diagnostic Analyses presents an overview of species groups per country and the status of species of concern. The SWIOFP Biodiversity report contains a comprehensive overview of biodiversity of the WIO (SWIOFP 2012). Figure 21 illustrates areas recently identified to be of particular ecosystem importance, after: a) The SWIOFP Biodiversity Retrospective Analysis: Hotpots of biodiversity importance (SWIOFP 2012); b) The WWF East African Marine Ecoregion Vision (WWF 2004); c) The WWF Western Indian Ocean Marine Ecoregion Report (WWF 2010).

Biogeographically, most of the ASCLME region falls into the Tropical Western Indian Ocean region, characterised by Indo-Pacific biota. The dominant coastal habitats are mangrove forests, seagrass beds, and coral reefs, interspersed with estuarine and lagoon systems, sandy beaches, and rocky shores. The subtropical East Coast Province starts in southern Mozambique and extends to the Eastern Cape of South Africa, where the warm-temperate South Coast or Agulhas Province starts (Griffiths 2005).

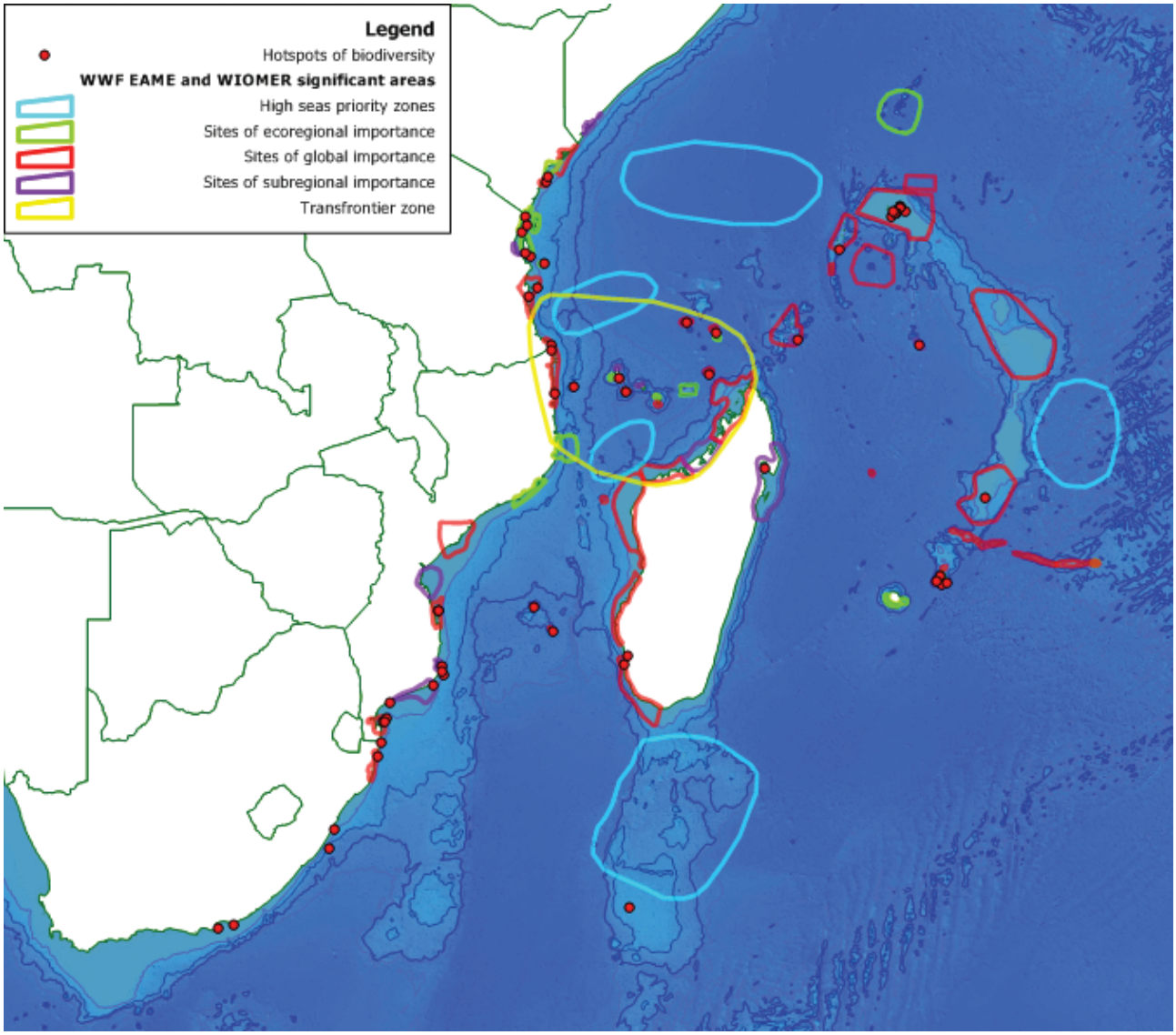


Figure 21. Map of the WIO region showing areas recently identified to be of particular ecosystem importance, after: a) The SWIOFP Biodiversity Retrospective Analysis: Hotpots of biodiversity importance (SWIOFP 2012); b) The WWF East African Marine Ecoregion Vision (WWF 2004); c) The WWF Western Indian Ocean Marine Ecoregion Report (WWF 2010)

3.4.1 Marine mammals

Within the SWIO, a total number of 37 marine mammal species have been recorded (authenticated records, including sightings and/or strandings), including 32 cetaceans, 1 sirenian (the dugong) and 4 pinnipeds. Only one species of sirenian occurs in the region, the dugong (*Dugong dugon*). Extralimital records of pinnipeds have also been recorded on various tropical islands, such as Madagascar (Garrigue and Ross 1996) and the Comoros (David *et al.* 1993). However, pinnipeds are not regularly present in the region. The South African fur seal (*Arctocephalus pusillus*) is found along the south and southwest coasts of South Africa (Best 2007).

Among baleen whales, there are still several taxonomic uncertainties. However, there are currently nine species that are known to occur in the WIO region. Within the blue whale group, two subspecies possibly co-occur: the Antarctic blue whale (*Balaenoptera musculus intermedia*) and the pygmy blue whale (*B. m. brevicauda*). Concerning the toothed whales, some uncertainties exist regarding the range of several species, especially among beaked whales (Ziphiidae). For example, there are a number of unpublished records mentioning sightings of antitropical species, such as True's beaked whale (*Mesoplodon mirus*) and Shepherd's beaked whale (*Tasmacetus shepherdi*) (V. Vely, personal communication; G. Doremus, personal communication). Unconfirmed records of ginkgo-toothed beaked whale (*Mesoplodon ginkgodens*) also exist from Mayotte (Kiszka *et al.* 2007a) and eastern Madagascar (Ballance and Pitman 1998).

Marine mammal mortality through fisheries interactions in the SWIO, while not exhaustively studied, are generally low and certainly lower than many other regions of the world. While this is primarily true for offshore regions, there is greater concern for coastal species and fisheries. It is suggested that three coastal marine mammal species are particularly affected by human activities, including fisheries, and are consequently highly vulnerable:

- *Dugong dugon* (classified as Vulnerable by IUCN)
- *Sousa chinensis* (classified as Near Threatened by IUCN)
- *Tursiops aduncus*

The dugong is probably the most endangered and threatened marine mammal in the WIO, despite available knowledge on this species, most is empirical and anecdotal (WWF EAME 2004, Muir and Kiszka 2011). Dugongs have progressively declined in most SWIO countries, and the only known viable population is located in the Bazaruto Archipelago, in Mozambique (Cockroft *et al.* 2008, Findlay *et al.* 2011). Along the northwest coast of Madagascar, recent aerial surveys highlighted the existence of a potentially important aggregation of dugong (Ridoux *et al.* 2010), while populations in Mayotte are of uncertain viability (Kiszka *et al.* 2007b).

In Zanzibar, Madagascar and South Africa, coastal dolphin bycatch and direct hunting is threatening several species (including those previously cited), and potentially others such as the spinner dolphin. The three vulnerable species are patchily distributed in the SWIO region, and that critical attention should be given to the following areas:

- Bazaruto Archipelago (critical area for dugongs in the SWIO, *T. aduncus* and *S. chinensis*)
- Northwest coast of Madagascar (important area for *T. aduncus*, *S. chinensis* and potentially a critical habitat for *D. dugon*, as underlined by a preliminary survey in 2010 (Ridoux *et al.* 2010)
- South coast of Zanzibar (critical habitat for both *T. aduncus* and *S. chinensis*, with high bycatch level)

These areas may be considered as hotspots, as they are critical habitat for at least two of the three most vulnerable marine mammal species in the SWIO. It is clear that other areas are also potentially important for these species (for example off the coast of Kenya), but need to be further identified in the future. A clear priority should be given to the study and conservation of these three species. For management purposes, stock boundaries should be further investigated, as management of marine mammal population is clearly transboundary. Fisheries development in these sensitive areas needs to be carefully controlled if not restricted.

3.4.2 Turtles

Sea turtles are highly vulnerable reptiles that have been subjected to direct exploitation for centuries, resulting in severely depleted populations in many cases. As the awareness of their plight and threatened status grew, so too has the advent of their protection in many regions, including the WIO. Whilst this protection has been successful in many cases, the threat to sea turtles remains high because of inadequate compliance with regulations and especially indirect mortality posed by fisheries. The region has over the past few decades seen a huge increase in fishing diversity and effort, invariably resulting in higher turtle mortalities as a bycatch.

The South West Indian Ocean is known to host five species of sea turtle (Marquez 1990, Ratsimbazafy 2003, Seminoff 2004). Of these, the green turtle (*Chelonia mydas*) and hawksbill (*Eretmochelys imbricata*) are the most widely distributed and abundant in this region, with the green turtle being by far the most numerous. These two species have also been the most severely impacted by directed exploitation (Hughes 1974a, b, Frazier 1980, 1982). Loggerheads (*Caretta caretta*) and leatherbacks (*Dermochelys coriacea*) are most common in South African waters, but less common in the rest of the region, and have little importance in relation to commercial and directed exploitation (Hughes, 1974a, b, Hughes 2010). Relatively little has been documented on the olive ridley (*Lepidochelys olivacea*) and this species is not considered to be much more that a vagrant to the region.

3.4.3 Seabirds

Eleven seabird families occur within the geographical scope of the Western Indian Ocean as breeding species. They are typically referred to as penguins (Spheniscidae), albatrosses (Diomedeidae), petrels and allies (Procellariidae), storm-petrels (Hydrobatidae), diving-petrels (Pelecanoididae), tropicbirds (Phaethonidae), gannets and boobies (Sulidae), cormorants (Phalacrocoracidae), frigatebirds (Fregatidae), skuas (Stercorariidae), gulls and terns (Laridae).

Most of the seabirds found in the WIO region fall broadly into three categories: Indo-Pacific or pan-tropical, highly migratory Procellariiformes from high southern latitudes, or predominantly Atlantic species with distributions that are relatively marginal to the WIO. Consequently, levels of endemism are relatively low compared with other regions. There are, however, at least nine extant, breeding endemics (Table 8) of which five are listed as globally threatened, including two critically endangered species (BirdLife International 2008). Half of these are from Subantarctic islands, two from Reunion Island and two from the Arabian seas.

In addition to some endemic and very range-restricted species, the WIO region is host to globally important numbers of more widespread seabird species. The Seychelles and French islands together hold significant proportions of tropical seabird populations, some of which have huge numbers of breeding species. The region has 25% of the world's Sooty Terns *Sterna fuscata*, with prodigious colonies at Juan de Nova, French Mozambique Channel (2 million pairs), Cosmoledo Atoll, Seychelles (1.8 million), Bird Island, Seychelles (1 million) and Europa Island, French Mozambique Channel (1 million) (Le Corre and Jaquemet 2005, BirdLife South Africa unpubl data). Aride Island, Seychelles, has >10% of the world's Tropical Shearwaters (*Puffinus bailloni*) and Lesser Noddies *Anous tenuirostris*, and Seychelles holds roughly 15% of the global population of the latter (Fishpool and Evans 2001, BirdLife International 2012). Aldabra Atoll has the world's second-largest frigatebird colony, estimated to be 10,000 pairs in 2000, and is the only oceanic breeding site for the Caspian Tern *Sterna caspia* (Fishpool and Evans 2001). For two of the southern African endemic seabirds, the Nelson Mandela Bay area (where the city of Port Elizabeth is located, southeastern South Africa) has always been important for seabirds. Subsequent to the implosion of African Penguin (*Spheniscus demersus*) numbers at Atlantic colonies, the WIO island of St Croix now hosts the largest colony (>8,000 pairs in 2011) and hosts approximately 50% of the global population (Crawford *et al.* 2011). Similarly, the near-total collapse of Namibia's Cape Gannet *Morus capensis* colonies has resulted in Bird Island, next to St Croix Island, now hosting 65% of the global population (~90,000 out of ~120,000 pairs in 2005/06) (Crawford *et al.* 2007). For species breeding in the Sub Antarctic, the WIO holds significant numbers of several Procellariforms: Wandering Albatross (*D. exulans* – 74% global breeding pairs), Sooty Albatross (*Phoebetria fusca* – 39% global breeding pairs), Light-mantled Albatross (*P. palpebrata* – 32% global breeding pairs), Grey-Headed Albatross (*T. chrysotoma* – 20% global breeding pairs) and Southern and Northern Giant-Petrels (*Macronectes giganteus* and *M. halli*– 30% and

26% global breeding pairs, respectively) (ACAP 2010). Tropical WIO waters are dominated numerically by the tropicbirds (two species), boobies (three species), frigatebirds (two species) and terns (>10 species), with *Puffinus* shearwaters also common, but less abundant and usually less visible than the other groups. None has substantial ranges during breeding. However, because there is not the marked seasonality in the tropics as there is further south, there tends to be less rigid periodicity to the breeding cycles, with some species' breeding cycles being less than 12 months, and it is usual to find seabirds present at breeding colonies year-round (Le Corre 2001). The main breeding grounds are the islands off Arabia and the Socotra Archipelago, Seychelles, the Mascarenes and the Mozambique Channel.

Table 8: Endemic seabirds of the WIO region and their status on the IUCN-Red List. CR = Critically endangered; EN = Endangered; VU = Vulnerable; NT= Near threatened; LC= Least concern; ? indicates no threat assessment due to taxonomic uncertainty.

Species	IUCN Status	Breeding Islands
Amsterdam Albatross *Diomedea amsterdamensis*	CR	Amsterdam
Indian Yellow-nosed Albatross *Thalassarche carter*	EN	Amsterdam, St Paul, Prince Edward Crozet and Kerguelen archipelagos
Barau's Petrel *Pterodroma baraui*	EN	La Réunion
Jouanin's Petrel *Bulweria fallax*	NT	Socotra Archipelago and islands off Oman
Reunion/Mascarene Petrel *Pseudobulweria aterrima*	CR	La Réunion
Salvin's Prion *Pachyptilia salvini*	LC	Prince Edward, Marion, and Crozet Archipelago
Persian Shearwater *Puffinus* [*bailloni*] *persicus*	?	Islands off Arabian peninsula
Socotra Cormorant *Phalacrocorax nigrogularis*	VU	Islands in Persian Gulf and Arabian Sea
Kerguelen Tern *Sterna virgate*	NT	Prince Edward, Marion, Crozet and Kerguelen archipelagos

Migration patterns are not well understood for most tropical seabird species. With few exceptions, tropical seabirds associate very strongly with tuna, and feed in association with them (Le Corre 2001). As a consequence, their post-breeding dispersal is likely to be linked to broad-scale oceanic features (such as productive upwelling or mixing areas) to which forage fish, and consequently tunas, are attracted. Recent work using tracking technologies to identify foraging ranges of seabirds in Reunion, Seychelles and other Southern Hemisphere tropical sites has identified five large-scale IBAs in the WIO (Le Corre *et al.* in press). A sixth important site is located in the central Indian Ocean. The WIO sites include 1) the Seychelles basin (east of the granitic Seychelles), 2) the pelagic waters encompassing the Aldabra Group northwards and west of the Seychelles Basin, 3) from Reunion southwards, 4) the area south of Madagascar and 5) the southern third of the Mozambique Channel and southwards to ~30°S. The principal species for which these areas are important are Wedge-tailed Shearwater (1), Greater Frigatebird (2, 5), Red-tailed Tropicbird *Phaethon rubricauda* (5) and Barau's Petrel (3-5).

Temperate and sub-antarctic pelagic waters, Subantarctic and cool-temperate islands and the highly productive South African continental shelf waters are dominated by the procellariiform seabirds (albatrosses, petrels and allies, storm-petrels and diving-petrels) and a cameo role from the Subantarctic Skua *Catharacta antarctica*. In addition, several species of near-shore-foraging Larids and cormorants breed here, with only one breeding species (Antarctic Tern *Sterna vittata*) migrating northwards during the austral winter.

Of the eight SWIOFP countries, three hold exceptional diversity of breeding species. These are the French islands, Seychelles and South Africa. Between them they have all the major breeding sites in the WIO, and all the endemic species of the WIO aside from the two species from the islands of the far northwestern Indian Ocean. Nevertheless, all eight countries have sites that BirdLife International has identified as of global importance for seabirds, hosting >1% of the global population of at least one species, or congregations of

>20,000 individuals (Fishpool and Evans 2001).

As tracking technology continues to miniaturise, and thereby bringing the technology within reach of researchers interested in smaller, tropical seabirds, we may well discover more pelagic sites that are globally significant. Climate change, and with it the profound, but as yet unpredictable consequences for the marine environment, may also add or subtract breeding and visiting species from the SWIOFP countries' national lists.

Le Corre *et al.* (in press) has summarized current understanding of migratory behaviour of birds in the tropical WIO. Frigatebirds from Aldabra and Europa range widely, primarily northwards, and into the Maldives area. White-tailed tropicbirds also range extremely widely outside the breeding season, with a hotspot that overlaps with the non-breeding distribution of Barau's Petrel, in the central tropical Indian Ocean. None of the typical tropical species is currently of global conservation concern. However, the two Reunion-endemic petrel species are of high conservation concern, as are most of the larger procellariiform seabirds that breed in or visit the WIO. The African Penguin and Cape Gannet are the most threatened coastal South African species in the WIO region.

Most conservation efforts for seabirds relating to mitigating impacts from fisheries will require concerted and coordinated approaches. Seabirds are the most international of all birds, spending more time than any other bird group in international waters, which are by definition beyond national jurisdictions. Most species within the WIO are migratory or dispersive outside the breeding season to some extent, and can be expected to cross national boundaries and enter into international waters.

The meta-population dynamics of the more widespread and commoner seabirds in the WIO region are poorly understood, and losses of breeding colonies or subpopulations in one area cannot necessarily be compensated for by healthy colonies or subpopulations elsewhere. Fortunately, seabirds are the most conspicuous components of above-water marine biodiversity, making them easier to monitor than virtually any other group of marine animals. Secondly, they are obligate terrestrial breeders, returning predictably to colonies to lay eggs and raise their young, which facilitates more accurate counting and estimation of productivity.

3.4.4 Elasmobranchs

Among the 1,160 species of cartilaginous fishes known, less than 200 have been recorded in the southwest Indian Ocean region (SWIO). Except for South Africa (especially the coast of KwaZulu-Natal province), little effort seems to have been made to assess the status of sharks and rays in the WIO, although some species have been more investigated than others in the region, notably the larger and emblematic species. This is despite the fact that sharks and rays seem to be heavily impacted by fisheries, and probably other activities in the region. Based on voluntary declared FAO records there is evidence that shark catches in the WIO have more than halved after reaching a peak of 180,000Mt in 1996.

Generally, information on elasmobranchs is poor in most areas, except for the east coast of South Africa, where research was stimulated largely in response to a spate of shark attacks on bathers in the region. In other countries of the region, knowledge is confined to fishery data or specific research projects that have focused on large and emblematic species such as the whale shark (*Rhyncodon typus*) or the reef Manta ray (*Manta alfredi*). Knowledge on the ecology, biology and fisheries of elasmobranchs is highly fragmentary. Credible information from KwaZulu Natal (KZN) shark nets is one of few useful data sets that provide scientific knowledge on elasmobranchs. However, there is an increase in research activities on open ocean sharks and the development of new initiatives in the region, especially under the auspices of the Indian Ocean Tuna Commission (IOTC) and its Working Party on Ecosystems and Bycatch (WPEB). Overall, research on sharks and rays has been limited to large and emblematic species, ignoring the assessments of smaller, less charismatic but equally threatened species.

The highest elasmobranch diversity in the WIO region has been recorded from Mozambique waters, with 108 species (73 sharks and 35 rays. Around 30 species of elasmobranch spend much of their life away from land masses in oceanic waters. The most abundant pelagic shark families in the South West Indian Ocean (SWIO)

are Lamnidae, Carcharhinidae and Alopiidae. Among Lamnidae, great white sharks are mostly confined to southern Africa but occasionally make incursions in tropical waters. Large adults have also been recorded in the tropical Western Indian Ocean, including Zanzibar, northern Madagascar, Mauritius, Kenya (Cliff *et al.* 2000) and on several occasions around Mayotte (Jamon *et al.* 2010). The short-fin mako shark (*Isurus oxyrynchus*) is the most abundant mackerel shark in the SWIO, and this area takes the highest catch rate for this species in the Indian Ocean (Smale 2008). This species is rarely seen on the continental shelf. Between 1978 and 2003, annual catches of this species in KZN Sharks Board nets were low (mean=13.4; SD=4.5 sharks), and no trend in catch rate or size of sharks has been detected over the period (Dudley and Simpfendorfer 2006). In the Carcharhinidae, silky and blue sharks are the most abundant species. Silky sharks are found near the surface in open waters, from 50 to 3,000m (Compagno 1984). Blue sharks occur in deeper waters and are probably one of the most prolific shark species in the world. However, they are less abundant in equatorial waters and their abundance tends to increase with latitude, including in the SWIO (Nakano and Stevens 2008). All three species of thresher sharks occur in the SWIO, but are far less abundant (Romanov *et al.* 2010).

3.4.5 Teleost fishes

The Indo-West Pacific region has the greatest diversity of fishes of all the oceans' eight biogeographic regions. Embedded in this is the West Indian Ocean (WIO) with some 2,200 species, about 14% of the global total of marine fishes (Smith and Heemstra 1986, Nelson 2006). The fish species found in the WIO can be grouped into 270 families, representing some 83% of all the fish families known. This richness is due to the large variety of habitats and oceanographic conditions of the region (van der Elst *et al.* 2005, UNEP 2009b). On a national scale, the diversity of fishes is also considerable. For example, the Tanzanian national fish species list may reach 1,000 species (Benbow 1976), that of the Seychelles over 1,000 species, and, at a smaller scale, 552 species of fish for the Grand Reef at Toliara alone in south-west Madagascar (Gaudian *et al.* 2003). Mozambique has several thousand species of marine fish with at least 307 species of linefish, La Réunion boasts 885 species (Letounreur *et al.* 2004) while the South African list is also around 2,500 species. Many of these species are transboundary and shared between the SWIOFP countries. The West Indian Ocean marine fish assemblage includes many remarkable and iconic fishes, ranging from the world's "oldest" fish the coelacanth *Latimeria chalumnae* to the world's largest, the whale shark *Rhincodon typus*. The origin of the region's ichthyofauna is diverse, with about ½ considered to be Indo-Pacific (Smith and Heemstra 1986), about 13% endemic to the WIO and the rest made up of species that are global or original migrants from different regions as shown in Table 9.

Table 9: Origin of fish species found in the Western Indian Ocean region (Smith and Heemstra 1986).

Origin	Percent
Indo-Pacific	50
Atlantic	3-4
Southern Ocean	<1
Global deel sea	29
Cosmopolitan	4
Endemic	13

The distribution of this diversity of fishes in the western half of the Indian Ocean is not necessarily uniform. There are regions of higher diversity, such as the East African coast, Madagascar and India and also regions of relatively low diversity, such as the Arabian Gulf, with its shallow seas, high salinity and temperature fluctuation from 10°C to 35°C (Cohen 1973, Randall 1995). Significantly, there are also regions of high endemism. The Red Sea and Arabian Gulf, with their restricted opening and relative isolation from other seas have levels of endemism around 15%. Endemic species have also been recorded from several islands, especially belonging to the butterfly (Chaetodontidae), damsel (Pomacentridae) and angelfish (Pomacanthidae) families.

A surprisingly high level of endemism is also found off southern Mozambique and South Africa, the latter country with 227 endemic species (i.e 13% of its marine ichthyofauna) (Smith and Heemstra 1986). This endemism is largely due to five key families.

The reason for this high level of endemism in South Africa can be attributed to the unique environment of the southern tip of continental Africa. This is the only coastal region in the Western Indian Ocean that has a temperate climate with distinctly different environmental conditions in association with the Agulhas large marine ecosystem (Beckley *et al.* 2002). Some of the endemics in the WIO may be glacial relics, meaning that they were once more widespread during the Pleistocene (Randall 1995). In some cases, upwelling systems may have contributed to their isolation, such as off South Africa, Oman and Somalia. There is also evidence of disjunct distribution of fishes, such as the croaker, *Argyrosomus hololepidotus* (Griffiths and Heemstra 1995). Surveys have suggested antitropical distribution of several inshore species that have been found off Puntland in Somalia and KwaZulu-Natal in South Africa, but not in between these latitudes. Examples of this are the elf *Pomatomus saltatrix*, the blackail *Diplodus sargus*, the Cape fur seal *Arctocephalus pusillus* and the Natal rock lobster *Panulirus homarus* (Mann and Fielding 2000).

Despite the extensive fish collections made, and the major studies undertaken in the WIO over the years, the ichthyofauna remains poorly understood. Very few countries of the region have national collections, most specimens are housed in northern hemisphere museums and the institutional support for ichthyology and taxonomy has declined. A notable exception is the South African Institute for Aquatic Biodiversity which hosts the largest fish collection in Africa, including collections from many of the WIO countries. The precise numbers of species found in the region and the levels of endemism will continue to vary as new species are added, synonyms recognised and errors corrected. Most of the large and comprehensive ichthyofaunal surveys were published before the 1960s and the more recent studies have been focussed on individual families or specific sites, such as those in Mozambique (Gell and Whittington 2002), Kenya (Mwatha *et al.* 1998, McClanahan and Obura 1996). There are, however, two notable exceptions, namely the five-volume FAO species guide to the Western Indian Ocean (Fischer and Bianchi 1984) and the comprehensive Smith's Sea Fishes, edited by Smith and Heemstra (1986). A further major contribution is imminent when "Fishes of the West Indian Ocean" is published later in 2012 by Heemstra and Heemstra.

Species under threat

Fishes of the WIO region are variably at risk. These risks may be attributed to causes that include ecosystem and/or habitat destruction, climate change and fishing. In the case of fisheries, the risks imposed can be either as a result of directly targeting or incidental as a bycatch or impact on the species' environment. Whatever the case, some species are more vulnerable than others and these require identification and protection. The identification of such species at risk can be done on the basis of several different criteria. Included are issues such as declining populations, limited distributions, endemism, slow turn-over life cycles, reduced distribution range, high mortality rates, etc. While traditional fish stock assessments should be able to deal with harvested fish stocks, it is often the less common but vulnerable species that require special attention. There are several approaches, including the IUCN Red List system as well as national conservation programmes.

Based on the IUCN red data listing for marine fishes there are presently a total of 738 marine fish species listed on the Red List for the WIO. Of these, 237 (32%) are elasmobranchs and 492 (68%) teleost fishes. Amongst the latter are 83 families dominated by coral reef species as shown below in Figure 22.

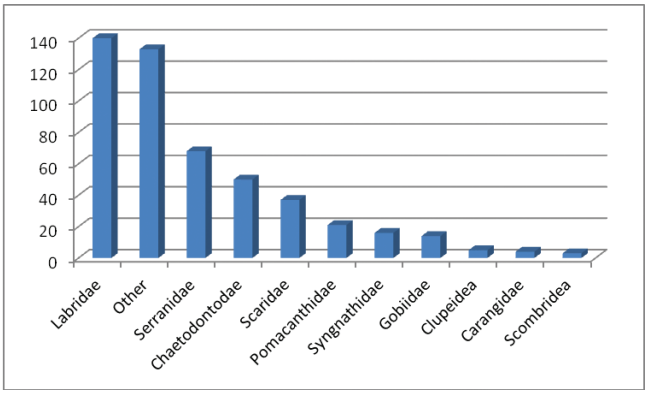


Figure 22: Distribution of the number of species listed on IUCN Red List for the main WIO teleost fish families (IUCN).

The IUCN Red List includes a total of 17 species (3.4%) that are listed as either Critically Endangered (2 species); Endangered (3) or Vulnerable (12). Of these, six are shallow water species and not threatened directly by commercial fisheries, while the remaining 11 are variably taken in fisheries in the South Western Indian Ocean region, mostly by line. In contrast, there are 57 species of elasmobranch listed (24% of total) as either Critically Endangered (8 species); Endangered (8) or Vulnerable (41). The higher proportion of elasmobranchs listed signifies the higher levels of risk associated as well as the greater effort and progress made by the respective specialist group. One further species that is red-

listed as Critically Endangered is the coelacanth *Latimeria chalumnae*, belonging to the class Sarcopterygii.

Table 10: The twelve non-elasmobranch species in the WIO included on the IUCN Red List as 'Threatened' (van der Elst 2012).

Species	Common Name	Status
Latimeria chalumnae	Coelacanth	CR
Thunnus maccoyii	Southern bluefin tuna	CR
Argyrosomus hololepidotus	Madagascar kob/croaker	EN
Cheilinus undulatus	Humphead wrasse	EN
Epinephelus marginatus	Dusky grouper	EN
Bolbometopon muricatum	Bumphead parrotfish	VU
Epinephelus albomarginatus	Captain fine	VU
Epinephelus gabriellae	Gabriella's grouper	VU
Epinephelus lanceolatus	Brindle bass	VU
Plectropomus areolatus	Spotted coral trout	VU
Plectropomus laevis	Black-saddled coral grouper	VU
Thunnus obesus	Big eye tuna	VU

In most cases the capture of IUCN Red-Listed species is not seen as a matter of concern by management agencies, except perhaps the coelacanth, for which a marine park was recently declared in Tanzania. Similarly, the capture of elasmobranchs is not generally viewed in the light of their status.

In addition to the IUCN Red Listed species, individual countries have also identified species in their ichthyofauna that require special protection. While some of these species are endemic and may apply to one country only, others are transboundary and shared by more than one country. In some cases species are partially protected by marine protected areas while in others they are fully protected and may not be landed at all. The table reflects that aside from the coelacanth there is considerable room for improved regional collaboration in the protection of IUCN Red Listed non-elasmobranch fishes. In most cases the IUCN Red Listed species are not even listed in national management regulations.

3.4.6 Critical habitats

Coral reefs, mangroves and seagrass beds are critically important habitats that jointly support a large proportion of coastal species and human populations which are reliant on them for a range of food sources, livelihoods and other ecosystem services. Although each is characterized by certain species assemblages, many coastal species are reliant on more than one habitat for certain life stages or activities. Some pelagic species are also reliant on these coastal habitats for early life stages. All of these habitat types also provide an important protective function to the coastline by way of dissipation of wave energy and consolidation of otherwise mobile sediments.

Coral Reefs

Coral reefs extend through most of the region from southern Somalia to the coast of KwaZulu-Natal, South Africa. Fringing reefs are the most common, but barrier reefs (Madagascar, Mayotte), atolls (Seychelles) and patch reefs (South Africa) are also found. Coral reefs provide important habitat for many tropical species, including fishes of commercial and subsistence importance, they are a major drawcard for tourism, and they provide many materials for commercial and non-commercial value such as shells for sale and coral rock for building. As a result, many coral reefs around the Western Indian Ocean are under threat from over-utilization as well less direct anthropogenic effects of pollution, sedimentation, nitrification and the damaging effects of fishing or poling. Activities such as dynamite fishing can have devastating consequences for the habitat and its sustainability into the future.

Kenya

Fringing coral reefs occur along much of the 500 km Kenyan coastline, except in areas under influence of rivers such as the Tana and the Shebella in southern Somalia (Obura *et al.* 2000, Spalding 2001, WWF-EAME 2004). The coastal areas are densely populated in places and there are extensive artisanal fisheries. Industrial fishing is confined to shrimp trawling off Malindi. Damage to reefs by fishing gear and poor fishing methods are a major threat to the Kenyan coral reef habitat, despite a ban on all forms of destructive fishing (Wilkinson 2008). Beach seines and other types of drag-nets are the most common form of destructive fishing gear that cause significant damage to reef habitats, juvenile fish populations and vulnerable species (Obura 2005). The use of banned seine nets continues as a result of inadequate enforcement of regulations (Muthiga *et al.* 2008). Small-scale commercial octopus collecting using spearguns damages coral. Shore gathering of ornamental shells also causes habitat destruction by walking on fragile coral reefs and the extraction of shells from crevices or underneath rock breaks corals. The removal of shells also may have ecological consequences. Collection of shells is totally illegal within the marine protected areas (MPAs) (WIOFish 2011).

Tanzania

Much of the 3,580km^2 reef area in Tanzania consists of fringing reef systems that run along most of the main coastline except around some of the larger bays and estuaries, such as the Rufiji and Ruvuma deltas (Spalding 2001). There are three main offshore islands (Pemba, Zanzibar and Mafia) as well as numerous smaller islands and islets. Tanzania has a large and growing coastal population that is characterized by high levels of poverty and high dependence on fishing as a major source of protein and income (Spalding 2001, Muthiga 2008). Overfishing is a major problem, which has been exacerbated by destructive fishing practices such as industrial trawling, beach seine-netting, fish-trapping and dynamite fishing. Although dynamite fishing has always been problem in Tanzania, it has become a persistent and significant threat to many coastal ecosystems, particularly coral reefs, since 2003 (Wells 2009).

Mozambique

The 3,000km Mozambique coastline can broadly be divided into three major zones: the northern coral coast, the middle swamp coast and the southern parabolic dune coast (WWF-EAME 2004) Fringing reefs are extensive along the northern coral coastline except in proximity to rivers which have deposited deltaic sediments. There are several offshore island groups which sustain coral reefs including the Quirimba Archipelago near the Tanzanian border, the Primeiro and Secundo island chain near Angoche, the Bazaruto Archipelago in the central coast and Inhaca Island in the south. There are 70,000 artisanal fishers in Mozambique with a high proportion dependent on the coral reef environment. (Muthiga *et al.* 2008, UNEP/Nairobi Convention 2009a). While coral cover is high on most reefs, reef fish populations have been heavily impacted and as a result abundances are low and dominated by small size classes (Muthiga *et al.* 2008, Floros 2010). Threats to coral reef fisheries are due to inadequate fisheries management and control over fishing effort, destructive fishing methods and overexploitation of species. Subsistence fishing, hook and line fishing and semi-industrial fishing all damage reefs. Similarly, with anchors and fishing tackle that is discarded and entangled on the reef (WIOFish 2011). Tourism has been developing at a rapid rate and certain activities such as recreational fishing may be unsustainable and detrimental to the reefs and surrounding communities (Spalding 2001, Fennessy *et al.* 2012). Recreational fishing, including spearfishing, removes the largest resident predators and targets species which affects the ecology of coral reef ecosystem.

South Africa

The South African coral reefs are situated within two connected MPAs, which form part of the iSimangaliso Wetland Park. The reefs total an area of about 50km^2 along a 120 km stretch of coast. Although modest in size, the fact that these reefs are the southernmost coral reefs in the WIO region bestows on these habitats importance in range extensions for more tropical species. There are no commercial fisheries within the MPAs and human activities are strictly zoned with only recreational fishing and SCUBA diving permitted on certain reefs. While pelagic fishes may be caught by linefishers, no demersal reef species have allowed to be taken for the past two decades. This has resulted in a remarkable recovery of several previously depleted species including the speckled snapper Lutjanus rivulatus (Mann *pers comm*). Similarly, studies on deeper and more temperate reefs south of KwaZulu-Natal have revealed recovery of species including the IUCN Red listed grouper *E. marginatus* (Maggs 2011). In such cases the recovered species represent a potential reservoir of spawning stock enhancing fisheries in open fished areas.

Madagascar

The coral reef area of Madagascar covers approximately 2,200km^2 (Spalding 2001). The most extensive reefs are found along the north-east, north-west, and south-west coasts, and have the highest richness of coral species in the central and Western Indian Ocean (Ahamada *et al.* 2008). Artisanal fishing is a very important activity, accounting for approximately 70,000t, equal to 1/3 of total fish production in Madagascar (FAO 2011). Almost half of this artisanal harvest comprises reef-associated species (Spalding 2001). The greatest threat to reefs and their associated fisheries is hyper-sedimentation due to improper land-use such as poor agrcultural practices and excessive deforestation (Spalding 2001, Ahamada *et al.* 2008). This is exacerbated around coastal urban areas where waste management is poorly controlled. Overfishing is a significant problem and fishing effort has increased considerably over the past decade due to rapidly expanding commercial demand from fisheries enterprises (Ahamada *et al.* 2008). Excessive removal of herbivorous fish on many reefs has led to a phase-shift from coral to algae-dominated communities (Ahamada *et al.* 2008).

Comoros

The three islands that make up the Republic of Comoros are volcanic with steep slopes and as such have little shelf region and thus not much coral reef. However, the islands are edged by a narrow fringe of coral while Moheli has more extensive coral reefs, making a total area of 430km^2 (Spalding 2001). The Comoros is one of the world's poorest countries (UNDP 2011) and the reliance on fisheries is high. Some 8,000 artisanal fishers are registered, harvesting especially oceanic species such as Carangidae, Gempylidae and Scombridae from traditional boats in deep but near-shore waters (Spalding 2001; UNEP/Nairobi Convention 2009). As reefs are limited, overfishing is a serious problem on reefs, with predator species abundance recorded as low or absent (Quod *et al.* 2000). Destructive fishing methods such as dynamite and poison fishing threaten coral reefs by indiscriminatingly killing corals, fish and invertebrates (WIOFish 2011). Reef trampling by fishers to collect octopus also contributes to degradation of reef flats and fragile corals (Spalding 2001).

Seychelles

The Seychelles Archipelago, which consists of 115 named islands and atolls, constitutes approximately 13% of the total coral area in the SWIO (1,690km^2) (Spalding 2001). Most of the population lives on the three inner islands, which have only 40km^2 of coral reef and where both industrial and artisanal fishing are important economic activities. Despite their great distance, fishing pressure on the outer granitic islands is also heavy. Artisanal fisheries involve 1,000 fishers on 400 vessels, mostly smaller pirogues that operate in inshore areas, with hand-line, traps and nets while larger fully decked inboard vessels ('schooners') operate on offshore banks and ledges of the Mahé Plateau. The total catch from the artisanal sector has remained fairly constant in recent years with landings ranging between 4,000 and 5,000 tons per year, including reef associated species such as Lutjanidae (*Pristipomoides* and *Aprion* spp., and *Lutjanus sebae*), Siganidae, Carangidae and Serranidae. However, a long-term historic downward trend in abundance has been observed in several of the main target fish such as Holocentridae, Lethrinidae, Lutjanidae and Serranidae. Notwithstanding the fact that landings have been reasonably constant recently, there was an exception in 2009/10 when lower effort reduced catches (FAO-SWIOFC 2011). Primary threats to coral reefs include dredging and reclamation, sedimentation, excessive fishing pressure, coral diseases, invasive species and climate change associated with global warming (Ahamada *et al.* 2008).

Mauritius

This small island has a huge EEZ covering some 1.9 million km^2 including Rodrigues, St Brandon Shoals, Cargados, Agalega, the Chagos Archipelago and extensive areas of the Mascarene Plateau. It follows that Mauritius is custodian of considerable fishery resources, including so-called distant bank (reef) fisheries that comprise Lutjanidae, Lethrinidae and Sparidae, and including a new fishery for *Polysteganus baissaci*. The island of Mauritius is almost completely encircled by fringing coral reefs, with substantial lagoon and reef development on the east and southwest coasts (Spalding 2001). The coral reefs are important for tourism and fishing. Traditionally fishing has been done in the reef lagoons using basket traps and handlines but severe depletion has resulted in fishers being "bought out" by their government and directed to offshore FAD-aggregated resources instead. In effect, most reefs around Mauritius have been degraded by human activities (Spalding 2001), although the island of Rodrigues remains relatively less impacted (Turner and Klaus 2005).

Reunion

Being a volcanic island with steep slopes and great depths, Reunion has only a few fringing reefs (<50km^2) which are restricted to the leeward western shores (Spalding 2001). Reunion has a large coastal population and overexploitation of coastal fishes has been occurring for a long time (Spalding 2001). The artisanal fishery comprises some 500 fishers operating from small outboard-powered boats using handlines, driftlines and trolling. Collectively they take 300-800mt of linefish around the main island annually, mainly Scombridae as well as Carangidae (eg. *Selar crumenophtalmus*), Clupeidae (eg. *Sardinella* sp.), Mullidae, Serranidae and Lutjanidae. Catches have declined in recent years suggesting that levels of exploitation may have exceeded sustainability. On outer islands and reefs within the large EEZ of Reunion, larger mother ships with attendant dories harvest reef fish using handlines to catch mainly Lethrinidae, especially *Lethrinus mahsena* and *L. variegatus* (van der Elst 2012) The combined effects of overfishing, coastal development and poor waste management has resulted in 81 % of reefs at risk (Spalding 2001).

Hotspots

The coral triangle between East Africa, the northern tip of Madagascar and the associated islands constitutes a high biodiversity region which merits greater conservation and resource-use management, especially as it has proven vulnerable to elevated SST-related coral bleaching due to climate change (Sheppard 2003, Obura 2005).

Seagrasses

Seagrasses, which are one of the most productive aquatic ecosystems on earth, extend from southern Somalia to the north coast of South Africa, and are widely distributed throughout the WIO region mainland and island states. 12 species are recorded from the WIO region, distributed from the intertidal zone down to about 40m. Seagrass beds are often found in close proximity to coral reefs and mangrove forests, are characterized by very high productivity, and support a wide variety of species. Molluscs and fish of commercial importance (including fishes of the families Apogonidae, Blenniidae, Centriscidae, Gerreidae, Gobiidae, Labridae, Lethrinidae Lutjanidae, Monacanthidae, Scaridae, Scorpaenidae, Siganidae, Syngnathidae and Teraponidae) use seagrass beds to forage and for shelter during their juvenile stages (Gullstrom *et al.* 2002).

It is clear that seagrass beds are extremely important nationally, regionally and globally, for the health and sustainability of marine living resources of the WIO region, but also for the global sequestration of carbon. Little quantitiative research has been carried out on the ecological role of seagrasses in the WIO, but it is known that these critically important ecosystems are under increasing pressure from human disturbance (sedimentation, pollution, physical removal, damage during fishing activities). Burnett *et al.* (2001) notes that preliminary data from the Shoals of Capricorn Programme indicate extensive, uncharted seagrass beds on the Mascarene plateau.

Kenya

Seagrass beds are one of the most conspicuous ecosystems types along the Kenyan coast, especially located inside the coral fringed coastal lagoons (Wakibya 1995). They function as nursery, breeding and feeding grounds for a number of targeted fish species; particularly lethrinids, lutjanids, siganids, scarids and spiny lobster. Threats to seagrass habitat include dredging for coastal development, pollution from sewage and heavy metals, mariculture, artisanal harvesting and clearing of seagrass for seaweed farming (Green and Short 2003).

Tanzania

The most extensive seagrass meadows occur in back-reef lagoons, which are found between the beaches or cliffs and the adjacent fringing reefs (Green and Short 2003). The fish and shrimp communities associated with seagrass beds are important to both the artisanal and industrial fishery (Ngusaru *et al.* 2001). Semi-industrial, small-scale commercial and industrial trawling for inshore crustaceans causes direct damage to seagrass habitat (WIOFfish 2011) and is indiscriminate (Green and Short 2003). In addition, illegal trawling continues throughout the closed season. Collecting and digging of invertebrates for food, waste disposal, unsuitable farming practices and coastal development threaten seagrasses in Tanzania (Gullström *et al.* 2002).

Mozambique

In Mozambique, seagrass beds are most extensive in the sandy (south) and limestone (north) areas of the coastline (Green and Short 2003). Extensive seagrass beds are found in the Bazaruto Archipelago and around Inhaca Island. Fisheries on seagrass beds include semi-industrial shrimp trawlers (WIOFish 2011) and artisanal beach-seine netting. Both methods contribute significantly to the destruction of sea grass beds. Seagrass beds in the Bazaruto Archipelago are heavily fished using beach-seine netting, despite it being banned since 2001 (WIOFish 2011). These beds have diminished in extent due to heavy exploitation of sea cucumbers and the oyster Pinctada margaritifera. The high by-catch of non-target and juvenile species associated with shrimp trawling and beach-seine netting is also a serious threat to seagrass ecosystems. Trampling and the heavy concentration of fishing and tourist activities directly disturb seagrass meadows at Inhaca Island and has already caused a disappearance of *Zostera capensis* from the bay in front of Inhaca's main village (Green and Short 2003). The digging of *Zostera capensis* and related seagrass beds to collect bivalves for food has dramatically depleted the seagrass cover at Bairro dos Pescadores near Maputo from a cover of around 60% or more to 10% or less in the last ten years (Green and Short 2003). The current levels are unsustainable and are expected to completely destroy the *Zostera capensis* beds, which will threaten the food security of the local population.

South Africa

Seagrass beds are confined to estuarine waters from KwaZulu-Natal to the Western Cape region (Green and Short 2003). Once abundant in KwaZulu-Natal estuaries, seagrass beds have been largely lost as a consequence of port development and declining water quality including salinity and siltation (Fiona Mackay, pers. comm). Little information is available on the historical decline; however, its absence has been suggested to be a limiting factor to fish diversity and abundance, especially for seabream (Sparidae) species and some haemulids (Weerts and Cyrus 2002).

Madagascar

Seagrass species diversity, distribution, abundance and status in Madagascar are largely unknown. Seagrass beds are generally well developed in reef lagoons (Cooke *et al.* 2000). Threats include destructive fishing gear such as the artisanal and industrial nets used to harvest inshore shrimps (WIOFish 2011). Linkages with fisheries remain to be fully investigated but are certain to be considerable.

Comoros

Little is known about the seagrass meadows of Comoros. The relative close proximity to the coastline of Mozambique (less than 400 km) and sharing a similar climate, Comoros may have similar meadows to northern Mozambique (Green and Short 2003). The main threats to seagrass beds are over-fishing and sedimentation from soil erosion (Ahamada *et al.* 2008).

Seychelles

Seagrass beds in the Seychelles are extensive in Platte, Coetivy, Amirante Banks and Aldabra. Little information on seagrass based fisheries has been documented. Land reclamation, dredging, untreated sewerage outlets resulting from urban expansion, and soil run-off due to deforestation, are threatening many of the shallow coastal environments including seagrass beds (Hughes Dit Ciles 2002).

Mauritius

Extensive and important seagrass beds in lagoons surrounding Mauritius were reported prior to 1980 (Montaggioni and Faure 1980); however, current data on the status of seagrass habitats is lacking and their status is assumed to be declining (Turner and Klaus 2005). Harvesting of sea cucumbers for foreign export is an important artisanal fishery, but the method of gathering of sea cucumbers causes trampling and destruction of seagrass habitat (WIOFish 2011). Seagrasses are also threatened by the high use of fertilizers in sugar cane agriculture, and specifically by the eutrophication of coastal lagoons that is caused nutrients leach into these shallow areas (Green and Short 2003). In addition, seagrass beds are being dredged and destroyed to provide bathing and other tourist facilities (Turner and Klaus 2005).

Reunion

The seagrass habitat in Reunion is monospecific *Syringodium isoetifolium* and found in the reefal lagoon (Naim *et al.* 2000). It is considered rare and poor in comparison to those of the other Mascarene Islands (Turner *et al.*

2000c). Few other data are available.

Seagrass hotspots

- The highest seagrass biomass in the WIO region has been recorded at Inhaca Island (Gullström *et al.* 2002). Nine of the 12 seagrass species occurring in Mozambique occur around Inhaca Island (Bandeira and Gell 2003), which also constitutes 16% of the world's seagrass species. This is high diversity considering the small size of the island.
- The seagrass beds in the Bazaruto Archipelago in Mozambique support the one of remaining viable dugong population in the WIO. Protection of this valuable habitat is critical for the survival of the species.
- Extensive seagrass beds offshore of Rufiji Delta in Tanzania and Lamu Archipelago in Kenya provide habitat for one of East Africa's few remaining dugong populations in the WIO (Spalding *et al.* 2010).

Mangroves

Mangroves extend from southern Somalia to the Eastern Cape coast of South Africa. Salt-tolerant evergreen trees, mangroves are often found in dense stands or forests near estuaries and river deltas. Ten mangrove species occur in the ASCLME region, all of which are tolerant of immersion in salt water, but with different salinity tolerances (Shunula and Semesi 2002). Mangrove habitats are critical for fish spawning and nurseries, as well as providing timber for construction, firewood, and services such as coastal protection. Other threats to mangroves are posed by clearing for salt production, aquaculture and human settlement.

Kenya

Mangroves are found along most of Kenya's coastline, but the most extensive mangroves are found in the north in the Lamu Archipelago and adjacent mainland (Spalding *et al.* 2010). Kenya has specific fisheries that are dependent on estuarine mangrove systems. Notable amongst these are the shrimp fisheries of Malindi-Ungwana Bay, which have up to four trawlers harvesting up to 650 tons of shrimp and fish annually (Fulanda *et al.* 2011, Kimani *et al.* 2009). Mangrove wood gathering for traps, timber and fuel wood is the biggest threat to mangrove ecosystems in Kenya (WIOFish 2011) because the cutting and clearing of trees reduces their nursery function (Spalding *et al.* 2010). It also reduces habitat for important commercial species and affects the productivity of adjacent marine ecosystems. The decline of fisheries resources in the Lamu district has been associated with the loss of mangroves (Tiensongrusmee 1991) and it is likely that further destruction of the mangrove systems will compromise other valuable fisheries.

Tanzania

Mangroves are the dominant coastal ecosystem in Tanzania and provide income for approximately 150,000 people (Taylor *et al.* 2003). In recognition of their national importance, mangrove areas have been designated as forest reserves since 1928-1932. The most extensive mangroves are found in the Rufiji Delta where they cover 480km^2 along 70km of coast; the largest contiguous mangrove area in the Western Indian Ocean (Wang *et al.* 2003). Fisheries are the major source of income in the coastal areas, which include crab, mollusc and finfish fisheries from the mangrove channels (Spalding *et al.* 2010). Shrimp trawling is very important in Tanzania and most of the artisanal trawl operations are conducted in mangrove-lined estuaries. Offshore there are industrial shrimp trawlers that in 2002 contributed US$ 6.6 million in revenue through export royalties (URT 2009). The Mangrove Management Plan, initiated in 1988, has been responsible for improved mangrove protection and reduced illegal harvesting. However, threats to mangroves in Tanzania still exist and are due to overexploitation (timber and animals), deforestation for development, and increasing water pollution that poisons invertebrate and fish larvae (Taylor *et al.* 2003).

Mozambique

Mozambique's coastline has extensive mangrove areas, particularly along the central coast which has 19,000km^2 of mangroves – one of the largest in the region (Spalding *et al.* 2010). Mangroves in Mozambique are important for timber and fisheries (fish and crustacean) as well as providing environmental benefits (Barbosa *et al.* 2001). Mangrove related fisheries, namely shrimp fisheries, have in the past been estimated to contribute 40% to the country's GNP (Fatoyinbo *et al.* 2008). The most important industrial shallow-water shrimp fishery is located at Sofala Bank. It has an annual average catch of 8,600t and is valued at about US$80 million. Mangrove cover has reduced at a rate of 18.2km^2/year over the past few decades largely due to urbanisation, tourism and

industrial development (Taylor *et al.* 2003). Conversion of mangroves to rice paddies and saltpans has also occurred (Spalding *et al.* 2010). Pollution from oil spills in Maputo Bay is a frequent threat as are spills from the heavy shipping traffic in the Mozambique Channel (Barbosa *et al.* 2001).

South Africa

Mangroves in South Africa are modest in comparison and concentrated along the east coast, particularly in the north where the largest mangrove areas are found in the Mhlathuze/Richards Bay and St Lucia estuaries (Taylor *et al.* 2003). While harbour development has significantly reduced Durban's once rich mangrove forests, the opposite has occurred in Richards Bay where stands of white mangroves have increase enormously under the protection of a sanctuary (Berjak *et al.* 2011). These mangrove habitats, especially in the St Lucia estuary and at Richards Bay, provide critical nursery grounds for commercially exploited penaeid shrimp (Cyrus and Fomes 1996). The most southerly trawling grounds for shallow water shrimp in the WIO are located on the Tugela Banks off the east coast of South Africa, directly associated with these mangrove systems (Fennessy and Groeneveld 1997). Clear evidence of this was provided through mark and recapture of shrimp tagged in the estuarine nurseries being recaptured in the industrial fisheries offshore (Forbes *et al.* 1994). The biggest threats to local mangroves are illegal harvesting, development and reduction of freshwater inputs into estuaries causing river mouths to close and mangroves to flood (Taylor *et al.* 2003). Mangroves are exploited to make fish traps because the wood is more robust in salt water than other types of wood. The traps called *kraals* are used by artisanal and subsistence fisherman. Shore gathering of sesarmid crabs is another threat (WIOFish 2011) because these herbivores form an important link between producers and primary predators as their consumption of leaf litter prevents loss of nutrients from the ecosystem (Berjak *et al.* 2011). Removal of the crabs in large quantities can seriously impact on ecosystem function within mangrove forests. In addition, the harvesting method is destructive when the harvesters hack through the mangrove trees' roots (WIOFish 2011). Mangroves in South Africa grow at a slower rate than those in the tropics so that felling mangrove trees may have implications over a longer period of time in comparison to other WIO countries (Taylor *et al.* 2003).

Madagascar

Mangroves are widespread along the entire west coast of Madagascar with the largest formations found along the north-west coast (Spalding *et al.* 2010). Small dense mangrove stands exist on the east coast along the Masoala Peninsula (Taylor *et al.* 2003). Mangroves in Madagascar are known to functions as important nursery grounds for 60 species of juvenile fish, including 44 commercial species (Taylor *et al.* 2003) as well as crustaceans. The fisheries industry is one of the highest generators of foreign revenue in Madagascar and further employs 14% of the workforce (Taylor *et al.* 2003). Shrimp is the main product with an annual catch of some 13,000t. Exploitation of mangroves is highest in the vicinity of large coastal cities and considerable degradation has resulted from excessive collection of mangrove wood for a variety of uses including fuelwood to smoke fish and boil sea cucumber, extraction of polewood for construction, and deforestation for shrimp pond aquaculture (Rajonson 1993, WIOFish 2011).

Comoros

Mangroves in the volcanic Comoros Archipelago are largely restricted to one of the four islands Moheli, where they cover an area of approximately 90ha (Spalding *et al.* 2010). Despite the presence of an MPA on Moheli and the requirement for a permit to exploit mangroves, losses have still occurred mainly due to deforestation for firewood and building materials, including boat construction. While Comoros has mainly artisanal fisheries, involving 8,000 fishermen and 4,000 traditional boats, these operations are largely oceanic because of the very narrow shelf zone on these volcanic islands. Consequently, the link between the mangroves and fisheries in this country is considered to be small (Ahamada *et al.* 2008).

Seychelles

Mangroves are widespread on the granitic islands of the Seychelles and are notable on Mahé, Praslin and La Digue. The most important area is around Port Launay on the east of Mahé where all nine regional species of mangrove are found in only 20ha and on Aldabra, which has the most extensive mangrove area (2,000ha) in the Seychelles island group (Spalding *et al.* 2010). Unlike many other countries in the WIO, mangroves do not seem to be in direct use in the Seychelles. Nevertheless, they have been progressively destroyed by urban expansion, tourism and coastal development, and water pollution (Taylor *et al.* 2003). Aldabra and Port Launay are protected as UNESCO World Heritage and Ramsar Sites, respectively.

Mauritius

Mangroves in Mauritius play an important role in the coastal ecosystem by providing habitats and nursery grounds for crabs, shrimp and juvenile fish, as well as providing substrata for fixation of oyster spat (Appadoo 2003). Few studies have been published documenting the fauna and flora inhabiting mangrove ecosystems. Mangroves were once abundant on the shoreline of Mauritius (Turner *et al.* 2000), but large areas have been lost, with a 30% reduction between 1987 and 1994. This has been linked to overharvesting for timber, firewood and for tourism development (Spalding *et al.* 2010). Any links between fisheries and mangroves have not yet been clearly established.

3.4.7 Invasive species

Invasive alien species (IAS) are now generally recognised as one of the greatest threats to global biodiversity. They also have serious economic, environmental and health impacts and, as a result, can place major constraints on development and natural resource use. In the marine realm there are examples of invasive species from all different taxonomic groups, ranging from plants, to vertebrates and microbes.

Globally, the incidence of species invasion is increasing drastically, as ongoing development leads to growth in maritime and shipping sectors, and also other human-mediated activities involving species translocation, such as aquaculture. The impacts of invasions are similarly increasing as marine ecosystems weaken under the combined stresses of overfishing, pollution and coastal development.

There are several significant vectors of transfer for marine organisms, including intentional introduction (e.g. for fisheries or aquaculture) and unintentional means, such as biofouling on ocean-going vessels, accidental release from aquariums, and discharge of ships ballast water, which is thought to be the most serious modern vector. Almost any type of organism can be transferred in situations where water is transported from one ecosystem to another, due to the planktonic life stages that most marine species undergo. Ballast water is taken on by ships in order to stabilise them at sea when they are not fully loaded with cargo. Large vessels can carry over 150,000 tons of ballast water on one voyage. It is estimated that upwards of 10 million tons of ballast water are transferred around the worlds oceans each year, containing up to 7,000 species of aquatic organisms at any given time.

The International Maritime Organization (IMO) has developed the *International Convention for the Control and Management of Ships' Ballast Water and Sediments*, adopted by member states in 2004, which remains the most pertinent of international legal instruments in the fight against marine IAS. The Convention on Biological Diversity (CBD) (1992) provides a comprehensive basis for protection of biodiversity from IAS generally, and the FAO has developed framework for the management of species deliberately introduced for fisheries and aquaculture purposes. Efforts to implement the provisions of these instruments are being made at local and regional levels. The ASCLME programme is aiming to help facilitate this process, and function as a medium for a collaborative partnership approach to building the appropriate capacity and networks to reduce the risk of serious impacts to the region's marine biodiversity and resources.

There is an important distinction to be made between the words 'invasive' and 'alien' especially in consideration of reports of species presence in regional habitats. Several non-native or alien species may be present as the result of intentional or unintentional introductions. Examples of intentional introductions may include marine aquaculture or fisheries purposes. Escapement of aquaculture species into the wild may not be an intended outcome of such introduction, but is often likely for types of species grown in coastal environments. A more serious concern however is the possibility of the introduction of pathogens or parasites through the stock of farmed organisms.

Invasive species are the alien species that are able to spread and have an impact on the local environment. It is not always possible to determine if/when an established alien species will become invasive, and for this reason the precautionary principle must always be used for management decisions.

The review conducted as part of this study captures species records for both invasive and alien species in

the WIO region, recognizing that these labels may change over time as new information becomes available. The data available in terms of species lists was very sparse, especially outside of South Africa and may be incomplete. Efforts to build upon the species list must be included in ongoing best management practices for coastal biodiversity authorities, and promoted from within the ASCLME project. Appendix III contains a list of known invasive species in the region.

The list of current invasive and alien species in the WIO region is presented in the full report on Invasive species. The list is categorized by country and species type, and reflects the information provided by the specialists contacted and literature available. The strong bias in species number in South Africa does not necessarily reflect a higher number of invasive and alien species in SA, but rather increased sampling and research effort over time. The biogeographic heterogeneity of SA also contributes to the higher number of species observed in the study, as the west coast temperate environments differ greatly to the range of tropical and sub-tropical environments found on the East Coast of SA and the rest of the WIO region. Most of the available data on marine IAS species records came from reports of surveys or research specifically targeting these types of organisms. For the majority of the countries in the region there have been no investigations of this nature conducted and therefore little to no data was obtained or available for some countries. This is unlikely a representation of the actual current state, and it is therefore recommended that such surveys be supported and carried out where possible to fill in the existing information gaps and generate adequate baseline data to support ongoing management for marine IAS.

A total of 104 introduced or alien species and 45 cryptogenic species are listed within the WIO region. Of these only 5 are considered to be invasive. As some species have only recently been 'upgraded' to the status of invasive (e.g. *Crassostrea gigas* in South Africa) it is imperative that all species on this list are considered as potentially harmful or disruptive to native biodiversity and ecosystems.

Harmful Algal blooms

Harmful Algal Blooms (HABs) have received much attention due to the acute impacts some may have on coastal systems, local populations of fish and invertebrates, and human health. These microscopic species are particularly vulnerable to transport in ships' ballast water, both in planktonic and cyst resting stages in the ballast sediments. Developments in ballast water treatment technologies must take mico-algal species of this nature (including the robust resting cyst stages) into account, as dictated by the D-2 standard of the IMO BWM Convention. This standard details the level of organism removal necessary for ballast water treatment technology approvals, which has thereby increased and focused international research on micro-algal and HAB forming species. The biogeography of these species is not always well understood, with many HAB species categorized as cryptogenic or pan-global, however it is clear that preventing further introductions of HABs has become a priority concern of the global marine IAS management community.

The algal species that form blooms may be dinoflagellates, diatoms, cyanobacteria or other types of mico-algae, and the blooms themselves may take various forms and colors, and cause impacts due to toxicity or other mechanisms such as localized oxygen depletion. The west coast of South Africa is well known for recurrent red tides and other HAB events, many of which are naturally occurring and others are likely to have been introduced. The East coast of Africa is less nutrient rich, and therefore experiences far fewer phenomena of this nature. There have however been some recorded events, with impacts on a relatively large scale. Regular monitoring in Réunion Island has shown cases of ciguatera fish poisoning (amongst other HAB species impacts/records) to be relatively common, likely throughout the region. Despite the potential acute threats to fisheries and other human interests, the only ongoing monitoring for HABs is occurring in isolated areas of the South African west coast and in Réunion Island.

Although there have been hundreds of micro-algal species recorded within the WIO region, significant HAB events in the region have only been reported from Kenya, Mauritius (including Rodrigues), Somalia, South Africa and Tanzania. This is likely a reflection of the monitoring and assessment capacity in these locations, as it is generally understood that red tides and other HAB events occur occasionally throughout the region, usually associated with the beginning of the North-east monsoon season in East Africa. Coastal upwelling associated with offshore winds brings cold nutrient rich waters to the surface forming ideal conditions for

blooming species to proliferate. Impacts of these events have been documented in all recorded locations, most commonly causing mass mortalities of fish or invertebrate species. While events along the West Coast of South Africa tend to recur with some regularity, the HAB records in the western Indian Ocean areas tend to be isolated events that are tied to less common weather or oceanographic phenomena.

Between 1998 and 2000, the UNESCO-IOC HAB programme coordinated a preliminary survey of the Western Indian Ocean region, as part of the WIOHAB programme. Study sites for the survey were located in Kenya, Zanzibar, Reunion, Mauritius and Madagascar (Ste Marie Island). A total of 60 potentially harmful species, representing 4 different classes, were recorded from the region during the survey. A list of the potentially harmful species found and an indication of the risks posed, as well as a guide to their sampling, handling and identification, was produced as the main publication of the programme. The publication can be downloaded from the UNESCO-IOC HAB programme website (http://ioc-unesco.org/hab/), and remains a very useful tool for researchers or those interested in HAB issues in this region.

4. Socio-economics and coastal livelihoods

Over 160 million people reside in the WIO region, of which approximately 55 million people live within the coastal zone. Some of the poorest countries in the world are found in this region, and there is a variable but high reliance on coastal and marine resources for sustenance and livelihoods in general. Coastal cities and settlements are growing and developing at a rapid rate. Environmental variability and extreme events have a disproportionately severe effect on communities with little resilience and resources to move away or adapt to the changing natural conditions.

The WIO supports regionally important fisheries, with industrial landings recorded at 280,000 metric tons per annum in 2002. The fisheries chapter (Chapter 3.3) provides a detailed analysis of commercial fisheries, and the coastal livelihoods chapter on small scale fisheries (Chapter 4.2) provides detailed information on the small scale and artisanal fisheries.

Tourism, fisheries, coastal agriculture, mining, mariculture, and ports and coastal transport are the main coastal livelihoods in the WIO region. These seven key coastal sectors have been addressed in some detail for each country in the Coastal Livelihoods Assessment (CLA) below. While many of these sectors contain characteristics that are intrinsic to particular countries, several issues highlighted across countries are, in fact, very similar and subsequently comparable.

A summary of socio-economic statistics for the region is presented in Tables 11-13 below.

Table 11: Population and Area data for the WIO states

Country	Popn (million)	% Coastal	Coastal Popn (million)	Terrestrial Area (000 km²)	EEZ Area (000 km²)	Coastline (km)
Comoros	0.737	100	0.737	2.235	164.691	340
Kenya	43.013	7.5	3.269	580.367	111.999	536
Madagascar	22.568	55.1	12.445	587.041	1,198.722	4,828
Mauritius	1.313	100	1.313	2.040	1,272.787	117
Mozambique	23.516	59	13.874	799.380	571.995	2,470
Seychelles	0.090	100	0.080	0.455	1,332.031	491
Somalia	10.086	54.8	5.527	637.657	830.389	3,025
South Africa	48.810	38.9	18.987	1,219.090	1,066.655	2,798
Tanzania	43.602	21.1	9.200	947.300	241.541	1,424
TOTAL	**193.75**	**59.61**	**65.44**	**4,775.565**	**6,790.770**	**16,089.00**

Country	Fisheries (million USD)	Coastal Tourism (million USD)	Coastal Agriculture & Forestry (million USD)	Mariculture (million USD)	Mining & Energy (Coastal) (million USD)	Ports & Coastal Transport (million USD)	Total Coastal Economy (million USD)	Coastal Domestic Product per capita	TCE / Coastline (million USD / km)
Comoros	45.2	16.7	0.86	7.6	-	24	94.36	127.99	0.28
Kenya	4.6	4,153	-	0.8	179	100	4,437.50	1,357.41	8.28
Madagascar	586.6	308.2	20.5	6.7	85	36	1,043.00	83.81	0.22
Mauritius	208.1	1,190	11	0.3	-	52	1,461.40	1,112.94	8.26
Mozambique	356	145	526.5	-	82.5	60	1,170.00	84.33	0.47
Seychelles	313.7	247	5.33	9.6	-	6	581.63	6,460.83	1.18
Somalia	36.9	0	729.6	4.3	-	24	794.80	143.80	0.26
South Africa	769.3	1,743	264	7.6	1,450	1,500	5,733.90	301.99	2.05
Tanzania	31	4,008	2,097	0.8	932	30	7,098.80	771.61	4.99
TOTAL	**2,351.40**	**11,810.90**	**3,654.79**	**37.70**	**2,728.50**	**1,832.00**	**22,415.29**	**1,160.52**	**2.89**

Table 12a: Economic data for the WIO region (from the ASCLME Cost Benefit Analysis)

Table 12b: Economic data for the WIO region continued

Country	GDP (PPP) (billion USD)	GDP Per Capita (USD)	Gini Coefficient	Urbanization (%)
Comoros	0.816	1,200	-	28.0
Kenya	70.580	1,700	42.500	22.0
Madagascar	20.600	900	47.500	30.0
Mauritius	19.280	15,000	39.000	42.0
Mozambique	23.870	1,100	45.600	38.0
Seychelles	2.244	24,700	-	55.0
Somalia	5.896	600	-	37.0
South Africa	554.600	11,000	65.000	62.0
Tanzania	63.440	1,500	37.600	26.0

Table 13: Socio-economic statistics for the WIO region

Country	Popn growth rate (%)	Literacy (total %)	Education Expenditure (%GDP)	Popn below poverty line (%)	Unemployment (%)	Life Expectancy at Birth
Comoros	2.063	56.6	7.6	60	20	62.7
Kenya	2.444	85.1	7.0	50	40	63.07
Madagascar	2.952	68.9	3.0	50	20	64
Mauritius	0.705	84.4	3.2	8	7.8	74.71
Mozambique	2.442	47.8	5.0	54	21	52
Seychelles	0.920	91.8	5.0	-	2	73.77
Somalia	1.596	37.8	-	-	-	50.8
South Africa	-0.410	86.4	5.4	50	24.9	49.41
Tanzania	1.960	69.4	6.8	36	-	53.14

Notes on data presented above:
NB this excludes French territorial areas of Mayotte and Réunion and other French Indian Ocean Islands.
EEZ Area from Sea Around Us; retrieved 19 June 2012 http://www.seaaroundus.org/eez/
Sectoral Economic Values from Cost-Benefit Analysis
Popn, area, coastline from CIA world factbook; accessed 19 June 2011
% coastal from Table 2, pg 15, Burke L, Kura Y, Kassem K, Revenga C, Spalding M, McAllister D (2001) Pilot Analysis of Global Ecosystems : Coastal Ecosystems. World Resources Institute, Washington DC. 93pp
Coastal popn = popn * coastal %
Terrestrial area includes inland water

4.1 Tourism

Tourism is one of the most important economic sectors in the Western Indian Ocean, not only making a substantial contribution to GDP and total foreign exchange earnings, but also a vital sector through which to create less resource-intensive streams of income and subsequently reduce the pressure being placed on coastal resources (Andrew *et al.* 2011).

The contribution of tourism must however be viewed in the light of extensive revenue leakages prevalent in the region. For example, in Kenya, it is estimated that only between 2% and 5% of tourism receipts actually trickle down to local communities (Sinclair 1990). Similarly, in Tanzania, it is estimated that between 75% and 90% of funds paid for vacations in Tanzania are actually collected by outbound operators, source country airlines and other imports from the visitor's country of origin (Chambua 2005). It is also estimated that leakages in the tourism sector in Africa's least developed countries is upwards of 85%. Such leakages are often a result of the fact that companies from industrialized countries tend to dominate the market through control of knowledge about the market and control of the means of distribution, which results, in many cases, in the host country only providing the infrastructure and social foundation in the sector. This reduces both the amount of revenue and employment that could have otherwise been gained by the host country.

Common throughout the region is weak infrastructure and facilities. For example, in Madagascar, poor infrastructure has inflated costs for visitors, which inevitably makes the country less competitive. In Kenya, deteriorating infrastructure has also been cited as a key weakness, while a lack of appropriate facilities for international clients has been constrained growth in Tanzania (Tuda 2011, Masekesa 2011). Weak service-delivery at the local level was also highlighted as a weakness in Mozambique. A lack of accommodation facilities was highlighted as a constraint in Comoros. In many cases, hotel facilities, in particular, are major sources of employment, thus, any facility upgrades have the potential to not only increase employment in the sector, but could also increase the attractiveness of the overall tourism product (Andrew *et al.* 2011).

There appears to be a great dependence on the European market throughout the region. For example, Europe accounts for over 76% of total visitors to Seychelles, while 31.6% of all arrivals to Mauritius in 2009 came from France alone (NSB 2010, Picard 2011). Similarly, in Madagascar, France represents nearly 70% of total arrivals, while Europe accounted for over R16.7 billion of total tourism revenue in 2008 in South Africa (Rajeriarison and Picard 2011, SATOUR 2008). While Europe will likely remain an important tourism market for the region, expanding into emerging markets is clearly one way to diversify the sector. Mauritius, for example, has announced plans to reduce the sector's over-exposure to the European market by expanding into India and China. Thus, if this expansion generates success, it is likely that other countries in the region could develop similar strategies.

Security and stability are challenges to the sector in the region. For example, crime has been cited as a crucial weakness in South Africa, while political instability continues to obstruct business expansion and sectoral growth in Comoros. Likewise, insecurity continues to leave tourism in Somalia untapped, while terrorism, and the resulting negative travel advisories, remains a threat to tourism in Kenya. It is also likely that any perpetuation of political conflict in Madagascar will have a negative impact on arrivals. The importance of security and stability for tourism is most evident in the case of South Africa. Upon establishing democracy in 1994, arrivals have grown 7.8% annually, the sector has nearly doubled in its contribution to GDP and it is now the fastest growing sector in the country's economy (DEAT 1999). Thus, the benefits of establishing security and stability cannot be underestimated.

Environmental degradation has been highlighted as a key issue in the sector throughout the region. Most tourist activity is directly dependent on the natural beauty of the respective countries, thus, degradation of the environment will have a negative impact on the sector. In response, ecotourism has become a means through which to not only enhance and diversify the product, but also facilitate the protection of the region's environmental assets. Ecotourism often includes a more authentic, community-oriented tourism experience, making it a beneficial means through which to incorporate and employ local communities in the sector. Kenya appears to be the most successful example in the region. For example, local boat operators near the Kisite Marine Park in Kenya earned an estimated $1.6 million USD in 1999 (Emerson and Tessema 2001), highlighting the benefits that can accrue to adjacent local communities who are included in the sector, particularly around valuable natural assets. Similar successes have been reported in the Arabuko butterfly project (Kipepeo 2006). Both projects were supported by the Tourism Trust Fund, which aims to support local entrepreneurs in ecotourism projects. Thus, Kenya's method of supporting ecotourism could potentially be replicated by other countries in the region. For the sector as a whole in the region, good integrated coastal zone management and planning is also required to ensure that tourism develops responsibly, safeguarding the natural and cultural assets on which the industry relies. Here there is an opportunity to follow up the work done through the ReCoMaP program. Another GEF funded project presently active in the region is the Collaborative Actions for Sustainable Tourism (COAST) Project (http://coast.iwlearn.org/), which is expected to generate additional information in many ASCLME countries.

4.2 Small Scale Fisheries

Approximately 2.7 million people are engaged in full and part-time employment in the fisheries sector of the WIO region (Teh and Sumaila 2011), generating wages in the region of US$ 366 million (Sumaila 2011). Although there are several opportunities for expansion and modernization in the small-scale fisheries throughout the Western Indian Ocean region, many of which could have a significant impact on livelihoods and poverty in

coastal areas, there are also many common constraints throughout the sector that require intervention.

All counties identified overexploitation as a threat to both the sector and the livelihoods that depend on it. Increasing pressure is being placed upon fisheries resources in the region, with a lack of alternative income generating activities, destructive fishing techniques, weak law enforcement capacity and population growth all being contributing factors. Many coastal communities also rely on the sector for food security, which again facilitates an overdependence on fisheries resources. Catch and effort information for the region is limited, and where information does exist, such as for Kenya and Mauritius, catch rates show significant declines (Kaunda-Arara *et al.* 2003, Ochiewo 2011, Soondron 2011). Weak governance capacity has not only made regulation and law-enforcement difficult, but it has resulted in a lack of data being produced around the sector, particularly in Madagascar, Mozambique, Somalia and Kenya. Without such data and law enforcement, it is not only extremely difficult to measure and mitigate overfishing, but it makes policy implementation an impossible challenge. Recent work, notably by the Sea Around Us project at the University of British Columbia, has attempted to more accurately reflect historical catches in the absence of detailed and complete historical records, for example that of Le Manach *et al.* (2011) and Jacquet *et al.* (2010), and in general indicates severe under-reporting in official statistics and often surprisingly large catches by small-scale fishers.

A lack of infrastructure has also resulted in negative impacts on the sector in the region. For example, poor storage facilities continues to result in extensive post-harvest losses in Madagascar and Tanzania, while weak post-harvest and processing activities has been highlighted as a constraint to the sector in South Africa, Mozambique, Tanzania and Somalia. Poor infrastructure has also hindered the marketability and commercialization of products from the sector, particularly prevalent in Seychelles and Mozambique.

Access to finance also constrains development of the sector. For example, lack of access to credit and capital has held back commercial development in Tanzania, Mozambique, Mauritius, Madagascar and Comoros (Sobo 2011, Pereira 2011, Soondron 2011, Andrianaivojaona 2011, Youssouf 2011). High investment costs were also cited as being problematic in the sector in Seychelles, while a dependence on external finance has been identified as a weakness in Tanzania. Many countries have, however, taken steps to mitigate these financial obstacles. For example, in Kenya, not only have private-sector investments in processing opened up opportunities for small-scale fishers to venture into non-traditional fishing grounds and strengthen value chain links, but a local bank has developed a loan program for the sector, which should allow fishers to upgrade equipment. Likewise, in Mauritius and Seychelles, the provision of soft-term loans and duty concessions from the government have been identified as having the potential to increase productivity in the sector and allow small-scale fishers to upgrade equipment and even access new fishing grounds (Soondron 2011, Lucas 2011). In Comoros, the government has reinvested revenue accrued from the large-scale industrial sector into the small-scale sector, which has not only facilitated the development of a cold chain and fisher training programs, but has allowed the sector to indirectly grow and benefit from the industrial fishery (Youssouf 2011). Thus, in many cases, the provision of microfinance and duty concessions has been identified as being helpful, as it has not only allowed the sector to upgrade equipment and potentially increase production, but it has also given the sector the opportunity to become more competitive internationally.

The advancement of co-management systems across the region is also a positive initiative in the region. For example, in Kenya, the government's Oceans and Fisheries Policy, along with its new co-management programs, have led to improved compliance in licensing requirements in coastal communities (Ochiewo 2011). In Mozambique, co-management committees have integrated local chiefs from fishing villages into the administrative process as a means to sustain traditional management techniques, while oversight and planning is gradually being decentralized to the community level through Beach Management Units (BMUs) and Collaborative Fisheries Management Areas (CFMAs) in Tanzania (Afonso 2006, Sobo 2004). One of the success stories in fisheries co-management can be found in the province of KwaZulu Natal in South Africa, and lessons from this and other successful initiatives need to be analyzed and used to inform best practice for the region (Napier *et al.* 2005). Nevertheless, it is clear that any co-management system requires advancements in capacity at the local level, which is lacking in many of the countries in the region. The building of this capacity requires serious commitment and allocation of resources from government and civil society.

There are a number of opportunities that can be tackled regionally. For example, increased international

demand for fishery products, as well as the presence of untapped niche markets, should incentivize production, investment and exports in the sector. Similarly, opportunities for value-addition have been emphasized throughout the sector, which, if promoted in conjunction with stronger marketing strategies, could be beneficial for the livelihoods that depend on it, without further endangering the resource. Increased returns from small-scale fisheries do not necessary imply increasing production, but rather on the more effective use of existing catches. Promoting alternative streams of income, such as mariculture, could also be fruitful not only in terms of providing employment and reducing poverty, but also as a means to reduce overfishing in coastal communities. Thus, while obstacles are clearly prevalent in the sector throughout the region, there are a number of opportunities to mitigate many of the challenges highlighted.

4.3 Mariculture

Mariculture clearly has great potential throughout the Western Indian Ocean and has been widely embraced as a possible means of creating alternative income streams and reducing pressure on the coastal zone. Nevertheless, constraints, such as weak infrastructure, limited research capacity and a lack of finance and environmental degradation need to be overcome to ensure further development in the sector. Limited research capacity has been a sectoral constraint across many countries in the region. In Mauritius, limited research capacity at the University of Mauritius, along with the poor status of funding at the Albion Research Center, have both been highlighted as weaknesses (Rotsaert and Sauer 2011). In Madagascar, improvements in research and development capabilities have been cited as an imperative to future sectoral development, while limited research and development infrastructure in Mozambique has constrained technological growth for farmers. Likewise, in Seychelles, weaknesses in research capacity have also been identified in the Department of the Environment and the Seychelles Fishing Authority, while the Tanzanian Fisheries Research Institute, like the Albion Research Center, is under-resourced. Weak research capacity has also been identified throughout Comoros.

Finance, and in some cases private-sector involvement, has also been problematic in the sector. For example, further development of mariculture in Madagascar is now contingent on increased access to finance, while finance has also been highlighted as a major issue around aquaculture policy in Tanzania. Likewise, both finfish production in Kenya and small-scale prawn farming in Madagascar have both been constrained by a lack of long term financial support, which appears to be a trend in the region with most projects being initiated by international donors. Private-sector involvement is also lacking in the sector in Tanzania, as well as in the small-scale sub-sector in South Africa. Cases of weak private-sector participation are also often simply associated with high costs, evident in prawn culture activity in Mauritius and the small-scale sub-sector in South Africa. Nevertheless, the importance of private-sector activity is most evident in Mozambique, where operations funded by private-investors have allowed mariculture operations to be sustained over the long term, which is often not the case in donor-initiated operations. Thus, developing sustainable and financially stable mariculture operations in the region, as made evident in Mozambique, may require a shift away from the donor-oriented paradigm that is currently prevalent in the sector.

Environmental issues, particularly with regard to sustainability and biosecurity, have also been raised around the sector throughout the region (Andrew *et al.* 2011). In Kenya, prawn farming has resulted in the destruction of mangrove habitats, while juvenile crabs (Scylla serrata) are being harvested with little regard for the future status of the wild crab resource. In Madagascar, prawn farming has the potential to result in the destruction of mangroves if not sensitively sited, while the sustainability of juvenile crab supplies, as well as juvenile harvesting, have also become issues in the farming of mud crab. Similarly, in Tanzania, issues around the sustainability of juvenile crab supplies, as well as long term issues around prawn bio-security, have also been raised. Nevertheless, there are examples of responsible management in the sector, particularly in prawn farming in Madagascar and in the abalone industry in South Africa, both of which could potentially be emulated in the region (Shipton 2011c, d).

Despite some of the issues aforementioned, there is great potential for sustainable expansion in the sector throughout the region. For example, there is potential for sea cucumber and crustacean farming in Seychelles, while in Comoros, the areas adjacent to the Parc Marin de Moheli provide an ideal environment for cage culture to be developed. Similarly, extensive lagoon areas in Rodrigues have the potential to be harnessed for the

farming of seaweed and sea cucumber, while there are opportunities for sea-cucumber ranching in Madagascar. In Mozambique, there are also opportunities to further develop an industrialised prawn and marine finfish culture sub-sector, while community-based fin-fish production holds some promise in South Africa.

Governments throughout the region appear to be committed to developing the sector as a means of promoting alternative streams of income. For example, in Kenya, a development mandate for the sector has been produced by the Coastal Development Authority (CDA 2008, Kenya MEDA 2012), while the Tanzanian government has developed a Seaweed Development Strategic Plan, as well as an Aquaculture Development Strategy (SDSP 2005, National Aquaculture Development Strategy 2008). In South Africa, the government has recognized the economic importance of mariculture, particularly for the coastal zone, and continues to actively promote private-sector involvement in the sector. Similarly, in Mauritius, mariculture continues to receive support from the Bureau of Investments, while the Seychelles government has recently commissioned a development plan for the sector with funding from the African Development Bank (Shipton 2011a, b).

Overall, the Western Indian Ocean region clearly has the natural assets with which to pursue mariculture development further. Growth in the sector will, however, require upgrades in capacity, including infrastructure, research, finance and governance, and a sensitivity to environmental impacts. These improvements are likely to be worthwhile, considering the impact the sector could have in terms of mitigating the over-exploitation of coastal resources and providing coastal communities with employment opportunities. Thus, while a dependence on international donors and NGOs for technical and financial support is not necessarily sustainable in the long-term, with backing from the private sector, it is possible for mariculture to further develop throughout the region in the future.

4.4 Agriculture and Forestry

Agriculture and forestry is one of the largest economic sectors in the Western Indian Ocean region, with most countries and coastal communities exhibiting some degree of dependence on production from these sources for both subsistence and commercial purposes (Andrew *et al.* 2011). It is also clear that livelihoods in the coastal zone usually comprise multiple activities, often determined by seasonal climatic patterns. Despite this dependence on the sector, the degradation of natural resources in the coastal zone has been highlighted as a problem throughout the region. Improved management, alternative streams of income, and less resource-intensive employment opportunities have all been cited as options to mitigate overexploitation and sustain the region's resources into the future.

Overdependence on the agricultural sub-sector in particular is clearly a trend throughout the region. In Kenya, the sub-sector employs 70% of the total work force (Daley 2011a), while agriculture and forestry combined employs 82% of the work force in Tanzania (Daley 2011b). In Madagascar, 75% of the population depends on agriculture and forestry for employment and/or subsistence (Daley 2011c), while between 70% and 80% of the population in Comoros is employed in the sector (Daley 2011d). This overdependence is recognized as one of the central factors motivating the overexploitation of resources in the region.

The overexploitation of resources has also been attributed to a number of other factors. For example, in Kenya, the depletion of coastal and mangrove forests, as well as the destruction of sea grass beds, has been attributed to high poverty rates, population growth, urban migration, inadequate property rights and poor planning (Kenya MEDA 2012). In Tanzania, poverty has been cited as a key factor leading to overexploitation (Daley 2011b), while the strain being placed on coastal forests has been partly attributed to the country's dependence on fuelwood for energy. In Mozambique, mangrove forests have also been over-exploited and converted into other land uses that generate higher returns, such as real estate and even garbage dumps, while illicit logging and slash and burn agriculture has been highly detrimental to forests in Madagascar (Daley 2011c). Similarly, in Mauritius, development in the coastal zone has in some cases been undertaken without adequate planning, facilitating coastal erosion and the degradation of lagoon water quality (Ministry of Environment and NDU, 2007).

In most cases, mitigating this overexploitation appears to be directly contingent on the development of

alternative streams of income and the reduction of poverty. In Tanzania, bee keeping, honey production and tree nursery management have all been developed as substitute sectors to reduce the pressure being placed on coastal resources (Jumaa *et al.* no date), while tourism and mariculture could also be promoted as potential substitute sectors throughout the region. In Mozambique, pottery, horticulture, as well as small-scale cashew nut and coconut collection, have also been reported as activities intended to stimulate alternative income streams in the coastal region (Ireland *et al.* 2004). Evaluations of the impacts of these activities throughout the region are, however, minimal.

Numerous countries have also implemented, or made commitments to, participatory management and decentralization in the sector. For example, in Kenya, a UNDP-funded forest landscape restoration initiative has included local communities throughout the program, while 10.8% of total forest area in Tanzania is now included under a participatory forest management scheme (MNRT 2006). Participatory forest management was also a central facet of South Africa's 2003 vision for forestry (DWAF 2004), while the Second Environment Management Plan (2000-2010) in the Seychelles has highlighted the necessity of building partnerships with communities as a means to strengthen capacity (EMPS 2000). Strengthening capacity at the community level, as highlighted in Seychelles, is a particularly significant venture, as weak capacity at the local level is often a characteristic that immobilizes policy implementation and regulation in many sectors. Nevertheless, other than the successes reported around the forest restoration initiative in Kenya, the results of many of these programs do remain vague. It is therefore important that more empirical evidence is collected to accurately assess the strengths and weaknesses of participatory management in the sector throughout the region.

As a whole, while the regional dependence on agriculture and forestry is not likely to diminish in the immediate future, there is clearly recognition by most countries that the current rates of exploitation are unsustainable. Natural assets in the region also have the potential to be productive in other forms, particularly through tourism, which again should incentivize a responsible approach to policy and management in the sector. Decentralization is also a positive feature prevalent in the sector, as responsibility is now being shifted to the very communities that depend on the resources for employment and subsistence, which should also incentivize more responsible management in the sector. Nevertheless, the cyclical relationship between poverty and the overexploitation of natural resources still appears to be prevalent in these sectors, thus, breaking this cycle through the generation of less resource-intensive activities should be encouraged.

4.5 Energy (Oil, Gas and Biofuels)

There is much potential for further development in the energy sector throughout the Western Indian Ocean region, which is very promising considering the global and regional projections for energy demand in the future. There are also numerous opportunities for biofuels development across many countries, which could allow the region to take great steps towards becoming a leader in clean energy production. There are, however, constraints in the sector, such as political instability, weak capacity, as well as the threat of oil spills, and the ongoing debate on the use of productive land for food security rather than biofuels, all which could constrict development in the future.

Many countries, including Tanzania, Mozambique, and South Africa, are currently producing natural gas, while deposits of gas have also been found in Somalia and Kenya (Kenya MEDA 2012, Somalia MEDA 2012). While South Africa is the only country currently producing oil, unconventional oil reserves have been found throughout Madagascar, there are prospective oil fields in northern Somalia, and oil exploration is currently ongoing in Kenya and Tanzania (Busson 2011a, b, c, d, e). Biofuels development is also generating much interest in the region, with Mozambique, Tanzania, South Africa, Madagascar and Mauritius all currently planning or initiating projects (Busson 2011a, b, e, f, g). Mozambique, in particular, reportedly has the greatest biofuels potential in all of Africa. However, to date, Mauritius, Tanzania and Madagascar appear to be the only countries that have initiated commercial production in the sub-sector (Busson 2001b, e, g). Nevertheless, there is clearly great regional potential in upstream oil and gas activities, as well as in biofuels.

A case study in Tanzania highlights the fact that biofuels investors often target the most fertile lands with optimal water access, with an intention to export the product (Mkindee 2007). This model not only demands a

degree of efficiency which small-scale farmers are not able to provide, but it also could lead to the displacement of small-scale food crop producers. Thus, it is likely that the interests of large-scale biofuels producers could conflict with the interests small-scale food crop producers, which is clearly a hypothesis that requires attention within the region.

Political instability has also been identified as a problem in the energy sector. For example, in Madagascar, not only has the recent political crisis led to the suspension of a large number of biofuels projects, but it will also inevitably lead to a lack of confidence from foreign investors. In Somalia, political instability and conflict has led to the collapse of upstream activity in 1991, and has in addition produced a great degree of uncertainty around current exploration rights and resource ownership. Similarly, in Comoros, not only has political instability reduced private-sector confidence, but it has been suggested that any future discoveries of oil will likely induce further political instability (Busson 2011h). Establishing political certainty in the business environment, particularly around capital-intensive upstream activities, should, thus, be seen as a prerequisite to developing the sector.

Weak capacity has also constrained development in the sector. For example, in Kenya, limited handling capacity at the Mombasa port continues to limit the amount of oil imported, while the refinery currently produces 1.6 million tonnes below its actual installed capacity of 3.2 million tones (Busson 2011d). Similarly, weak financial, operational and human resources capacity has made sectoral management difficult in Tanzania, while a lack of capacity at the Temane processing plant has limited gas export expansion in Mozambique (Busson 2011e, f). A lack of governance capacity in Madagascar has also led to weak enforcement and monitoring around the EIA process, while the lack of data and records around the sector in Comoros has severely constrained planning and management. Weak EIA capacity was reported in Seychelles (Busson 2011i, King and Walmsley 2003). The lack of capacity around EIAs is particularly significant, as oil and gas exploration and accidents could be highly detrimental to adjacent communities and ecosystems.

Activity in the sector has, however, facilitated a strong degree of corporate social responsibility from operating companies. For example, Kenya Petroleum Refineries Limited has actively promoted health in adjacent communities, which includes donations to community clinics, while Songas has provided support to communities on Songo Songo island and promoted projects around health and education in Tanzania (Busson 2011d, e). In Mozambique, Sasol has financed the construction of community clinics in the Pande Temane region, as well as invested ZAR22.9 million in community development projects along the Mozambique-Secunda pipeline route, while Petromac has supported a regional strategy for HIV prevention (Busson 2011f). Likewise, Chevron, BP, Engen, Petro SA, Shell and Total have all implemented community development projects in South Africa, largely focusing on HIV, education, health and job creation (Busson 2011a). In Madagascar, Total has rehabilitated roads and community buildings in the Bemolanga region, while Galana has provided support to cyclone-affected populations (Busson 2011b). Thus, while upstream activities do not normally generate substantial amounts of local employment, corporate social responsibility from sectoral actors has clearly provided benefits to local communities. This should continue as activities develop in the sector, and exploration companies should be further encouraged to investigate other forms of support to offset potential environmental impacts resulting from the oil, gas and biofuels industries (Andrew *et al.* 2011).

Overall, there are clearly a number of opportunities for growth in the sector, which have the potential to be maximized if the proper capacity and political environment is instilled. While food security and environmental protection issues need to be addressed in a responsible manner, the spillover benefits and government revenue that can potentially accrue from energy development in the region could be massive, particularly if oil deposits are tapped. This is even more promising when considering the projected demand for energy, both regionally and globally. Thus, while there are concerns in the sector that demand the attention of policymakers, if managed properly, the sector could bring great benefits to the region well into the future.

4.6 Ports and Coastal Transport

Ports and coastal transport in the Western Indian Ocean has the potential to expand in the coming years to support increases in mining and energy activity by maximizing throughput and capacity. There are, however,

many challenges in the sector, including a weak manufacturing sector, over-regulation and corruption, and capital constraints, all of which could potentially confine development in the future.

Over-regulation, corruption and burdensome state intervention in the sector have been highlighted throughout the region. For example, state management of ports and transport is believed to have constrained capacity and service delivery in Tanzania (Maasdorp 2011a), while corruption has also been highlighted as a weakness (Maasdorp 2011a). In Mozambique, government interference in private-sector operations, as well as corruption, have both been highlighted as constraints (Maasdorp 2011b). In South Africa, over-regulation and state management in the sector has produced high levels of inefficiency, while corruption has also been cited as a weakness (Maasdorp 2011c). Corruption has been highlighted as a constraint in the sector in Kenya (Massdorp 2011d).

Capital constraints have also become problematic in the sector. For example, in Madagascar, capital limitations around ports and sea-based economic activity have been identified as weaknesses in the sector (Maasdorp 2011e), while a lack of development capital is problematic for ports and transport in Kenya (Maasdorp 2011d). In South Africa, fiscal constraints have clearly negatively affected Transnet operations, while the need to engage the private-sector and increase investment in the sector has been documented in Seychelles, Comoros and Tanzania. In many cases, state management and overregulation are partly responsible for the capital constraints prevalent in the sector throughout the region as such activity is often a deterrent to private-sector investment. The utility and importance of engaging the private-sector is also evident in Mozambique. Following the civil war, funding to rehabilitate the country's dilapidated ports and transport system was very limited, however, the policy to privatize and formulate joint-ventures in the sector has led to rapid reconstruction. The Maputo port, in particular, has reaped great benefits from private-sector engagement, as private-sector investments in the Matola terminal have accelerated development and expanded the amount of cargo handled by the port (Maasdorp 2011b). The ports in Beira and Nacala have also been extensively rehabilitated with private-sector investment. Thus, Mozambique does appear to provide a model through which capital constraints and underdevelopment in the sector can be alleviated.

A weak and, in some cases, uncompetitive manufacturing sector has also been highlighted as a weakness. For example, reductions in manufacturing output and an adverse trade balance with major trading partners, particularly India and China, is likely to weaken port throughput for the next two to four years in South Africa (Maasdorp 2011c). Similarly, the failure of manufacturing economies in Tanzania, Mozambique, Kenya and Mauritius to compete with imports from the East has also been identified as a threat to the sector (Andrew et al 2011, Maasdorp 2011a, b, d, f). Madagascar has, however, witnessed a gradual increase in manufacturing activity, while the attractiveness of manufacturing investment in Mauritius still holds much promise. Nevertheless, competing with manufacturers from Asia will likely be a pressing challenge to regional port activity moving forward.

Countries in the Western Indian Ocean do, however, hold a great comparative advantage in terms of strategic geographical position. For example, not only is Madagascar a strategic point for sea lanes linking the Far East with Africa and South America, but it has very easy access to a vast expanse of ocean. Likewise, the sheer magnitude of the coastlines of Mozambique and Somalia provide a solid base through which to grow port activity, while the strategic location of ports in Kenya and Tanzania will be highly significant as economic activity in the region expands. Somalia, in particular, could facilitate massive expansion in the sector through its strategic position near the Gulf of Aden, where an estimated 25,000 ships pass through annually. South Africa is also situated on one of the world's busiest ship transport routes, where the transport of crude oil from the Middle East to Europe and the Americas is prevalent. Thus, throughout the region, tapping into and maximizing this strategic comparative advantage should be a priority and could potentially be utilized as a catalyst to stimulate development and employment in the coastal zone.

Increased mining and energy activity also has the potential to facilitate growth in the sector. For example, in Kenya, the potential for the development of a terminal for mining exports near the Lamu corridor could be very beneficial to ports and transport in the area, while the possible development of mineral sands mining at Moma, as well as coal fields in Tete province, could potentially facilitate the expansion of both the Sena railway to Beira and the Nacala port in Mozambique. Similarly, the development of the Mtwara corridor in Tanzania,

which is based around iron ore and coal mining development, will require significant rail construction and port expansion, while upgrades in the D'Ehoala port, as well as the potential spillovers from oil and gas activity and mining activity in Sakoa and Tamatave, are likely to facilitate sectoral growth in Madagascar. Likewise, if the potential for increased oil production is realized in the region, it is likely that storage and transport capacity will be widely increased.

4.7 Coastal Mining

Coastal mining has great potential in selected countries in the Western Indian Ocean, which could have positive spillovers across the region. Many mining companies in the region are also engaged in corporate social responsibility projects, which should enable local communities to benefit from activities in the sector irrespective of their economic inclusion in the sector itself.

Environmental issues in the sector, however, have been identified throughout the region, which could be highly problematic considering the dependence of the tourism sector on natural assets, particularly in the coastal zone. For example, in Kenya, erosion from sand and coral mining has been identified as a potential threat, while water pollution and waste have become prevalent in South Africa (Cushman 2011a). Similarly, the potential destruction of flora and fauna near Fort Dauphin in Madagascar has been cited as an issue associated with mining activity there (Cushman 2011b), while the use of beach sand for construction materials has led to the erosion and degradation of beaches in Comoros (Cushman 2011c). The destruction of mangroves and micro-biodiversity from informal coral mining in Tanzania has also been identified as a weakness (Cushman 2011d). Environmental regulations are, however, strong in many countries, which could mitigate some of the aforementioned issues. Seychelles, in particular, has been highly successful in mitigating coastal erosion with the Removal of Sand and Gravel Act, as well as the Environment Protection Act. While this did essentially suspend sand mining along the country's coast, it does highlight the necessity of designing proactive policies around specific environmental issues.

The potential spillovers from the mining sector, particularly in ports and coastal transport, could bring great benefit to the region. For example, in Mozambique, mining opportunities in the Tete province have facilitated the reconstruction of the Sena rail line linked to Beira (Cushman 2011e), while potential port expansion in Nacala is largely contingent on the development of mineral sands mining in Moma (Cushman 2011e). Likewise, the development of the Mtwara corridor in Tanzania, which will require port and rail upgrades, is based on iron ore and coal developments near Lake Nyasa, while the development of the Lamu corridor in Kenya is largely based around an expansion of mineral exports to neighboring landlocked countries. Port upgrades in Madagascar have also been directly linked to the mining sector (Cushman 2011b). Increased mining activity will also induce spillovers into the public sector and subsequently local communities, as increased activity will lead to growth in government revenue and an increased provision of social services. However government revenue could also become over-dependent on revenue from the mining sector, which could induce troublesome fluctuations in the provision of social services and infrastructure.

Local communities are generally benefitting from mining activity through both employment and community development programs initiated by the companies operating in their regions. For example, not only has mining activity created over 1,000 jobs in Kenya's coastal zone, but active companies have contributed to the development of education in the Mombasa region (Cushman 2011a). In Mozambique, development of the Moma Mine has led to the creation of the Moma Development Association, which is not only promoting the provision of secondary employment opportunities, but is also contributing to the development of schools, health care and financial services for rural communities (Cushman 2011e). Likewise, in Madagascar, not only has construction at the mines in Moramanga and Tamatave created over 11,000 direct and indirect jobs, but the companies Ambatovy and Qit Minerals have developed projects that support job skills improvement, enterprise development and microfinance (Cushman 2011b). Similarly, perhaps one of the most productive examples of corporate community engagement has been in South Africa, where Richards Bay Minerals has initiated a Black Economic Empowerment program, which has helped historically-disadvantaged populations develop small-businesses, as well as supply goods and services to the company, now worth an estimated $61 million USD (Cushman 2011f). These programs implemented by Richards Bay Minerals, in particular, provide

a great model of corporate social responsibility that other companies operating in the region could emulate, as not only has the company created employment in economically-marginalised communities, but they have integrated these communities into their own supply chain. Overall, the mining sector clearly has the potential to produce great benefits in the western Indian Ocean region. While environmental issues and the effects of the resource curse should be carefully monitored and managed by policymakers, the spillovers and increases in government revenue facilitated by the sector should allow local communities in the coastal zone to benefit from mining activity. Thus, with proper management, responsible growth in the sector will likely contribute significantly to the development of the region in the future.

5. Cost Benefit Analysis of the Fisheries of the WIO region

The cost benefit analysis presented in this section covers Comoro, Kenya, Madagascar, Mauritius, Mozambique, Seychelles, Somalia, South Africa, and Tanzania (together with Reunion (France) they form the WIO region countries). For the period between 2008 and 2010, the GDP per year for Comoros, Kenya, Madagascar, Mauritius, Mozambique, Seychelles, Somalia, South Africa and Tanzania are estimated at US$0.55, US$35.80, US$8.50, US$10.30, US$11.70, US$0.97, US$5.70, US$383.10 and US$23.30 billion, respectively. Figures 23-26 present the main types of major coastal and marine resources contributing to the GDP of the countries of the ASCLME region. The total contribution to GDP from the coastal and marine resources of the WIO region is almost US$ 22.4 billion a year, which in turn is based on Dyck and Sumaila (2010) and Sumaila *et al.* (2012). This is a significant amount, especially when one takes into account that coastal communities which depend on these resources are generally poorer that the more urban population. Coastal tourism contributed the largest amount to GDP at over US$11 billion a year, followed by coastal agriculture and forestry (Sumaila *et al.* 2012).

The ASCLME is part of the western Indian Ocean (WIO) and therefore their fisheries should be discussed in the context of the WIO as a whole. Table 14 provides a summary of the landings and landed values of fish caught in the WIO, split according to the various large marine ecosystems (the Red Sea, Somali Coast, Agulhas Current, Arabia Sea and the High Seas) within the WIO.

Table 14: Economic data on the fisheries active in the WIO region (Sumaila *et al.* 2012).

Country/Entity	Catch (000 tonnes)	Ex vessel price (US$/t)	Average variable fishing cost (US$/t)	Catch value or revenue (million US$)	Total fishing cost (million US$)	Subsidies (US$/t)	Total subsidies (million US$)
ASCLME Countries							
Comoros	26.87	214	128.49	5.75	3.45	45	1.21
Kenya	1.30	1,207	724.02	1.57	0.94	680	0.89
Madagascar	136.86	1,082	649.23	148.09	88.85	123	16.83
Mauritius	11.54	1,082	649.23	12.49	7.49	226	2.61
Mozambique	121.80	1,201	720.50	146.26	87.76	730	88.91
Seychelles	86.15	294	176.41	25.33	15.20	268	23.09
Somalia	17.85	701	420.34	12.51	7.50	144	2.57
South Africa	17.12	1,260	756.05	21.57	12.94	85	1.45
Tanzania	18.66	612	366.98	11.41	6.85	181	3.38
France	7.54	2,630	1,577.77	19.83	11.90	762	5.75
Regional total ASCLME Region							
Sub-Total	445.69			404.82	242.89		146.69
Non-ASCLME region							
	46.20			69.66	41.80		31.17
TOTAL	**491.89**			**474.48**	**284.64**		**177.86**

The ASCLME produces a relatively small catch compared to the total catch from the WIO as a whole. However, this relatively small catch is still important to both the countries of the ASCLME and some countries outside of the region.

A detailed analysis on the fisheries concerning economic and social indicators to capture a broad view of the value of resources extracted from the ASCLME region by both regional and non-regional countries in terms of (i) normal profit or payment to investors in the sector; (ii) wages or payments to owners of labor; (iii) the resource rent generated or payments to the owners of the resource; and (iv) the economic impact throughout the provides the following results.

About half a million tonnes of fish are caught from the ASCLME, with the bulk of it caught by ASCLME countries. This catch brings in about half a billion US dollars, with over 80% of it captured by ASCLME countries. The total cost of fishing is estimated at US$284.64 million a year, with subsidies of US$177.86 million provided by governments annually.

Table 15: Estimates of economic indicators (Sumaila *et al.* 2012).

Country/ Entity	Jobs (000)	Wages to fishers (million US$)	Earnings to fishing enterprise (million US$)	Resource Rent (million US$)
ASCLME Countries				
Comoros	160	4.14	1.59	1.09
Kenya	51	1.13	0.16	-0.26
Madagascar	630	114.03	15.38	42.40
Mauritius	23	6.25	0.15	2.39
Mozambique	900	108.23	14.43	0
Seychelles	7	18.24	7.22	0
South Africa	66	9.00	3.69	2.43
Somalia	480	14.24	2.13	7.17
Tanzania	190	12.55	2.18	1.19
France	1.85	22.41	0.93	2.19
Total ASCLME	2,509	310.22	47.86	58.86
Non-ASCLME	233	55.47	12.31	8.84
Total	2,742	365.69	60.16	67.70

Table 15 presents the estimates of resource rent, wages and normal profits earned by the fisheries of the ASCLME both by country within and outside the region. The fisheries of the ASCLME are estimated to generate a resource rent of just about US$68 per year currently, of which about US$59 million are generated by ASCLME countries and the reminder by countries outside of the region. The largest resource rent is generated in Madagascar, at US$ 42 million per annum. The fisheries are estimated to support almost 2.7 million people, generating wages of about US$366 million per year. For owners of fishing capital, we estimate normal profits of US$60 million per year for2005 (Sumaila *et al.* 2012).

Table 16: Direct output, income and economic impacts

Country/Entity	Direct output (million US$)	Output multiplier	Economic impact (US$)
ASCLME Countries			
Comoros	6	2.95	17
Kenya	2	2.95	5
Madagascar	148	2.34	347
Mauritius	12	1.62	20
Mozambique	146	1.83	268
Seychelles	25	2.95	75
South Africa	13	2.95	37
Somalia	22	3.13	68
Tanzania	11	2.72	31
France	20	4.11	82
ASCLME Regional Total	405	-	948
Non-ASCLME region			
Non-ASCLME region	70		200
TOTAL	474		1,147[6]

Table 16 presents the direct output impact, the output multiplier, and the economy-wide impacts of the activities dependent on the coastal and marine resources of the ASCLME region. While the direct output impact or landed value of catch from the ASCLME is about US$475 million a year, the total economic impact is more that 2 times the DOI, estimated at about US$1,150 million a year (Sumaila *et al.* 2012).

Economic wealth generated under different scenarios

Economic wealth, as captured by resource rent, wages and economic impact generated by the fisheries of the WIO region is estimated under two scenarios. In Scenario 1, the wealth generated currently by the fisheries operating in the ASCLME is computed. Fisheries around the world are known to be plagued by overcapacity (e.g., Porter 1998), and the fisheries of the ASCLME are no exception. This overcapacity results in overfishing and higher than necessary fishing costs. In Scenario 2 the wealth (resource rent, wages and economic impact) that could be generated if overcapacity is eliminated and the fisheries of the ASCLME are rebuild and sustainably managed thereafter (Table 17).

Table 17: Estimated landed values, costs and subsidies under current and rebuilding scenarios (million USD) (Sumaila *et al.* 2012).

Country	Current Landed Value	Rebuilt Landed Value	Current Costs	Rebuilt Costs	Current Subsidies	Rebuilt Subsidies
Comoros	5.75	5.66	3.45	1.73	1.21	0.90
Kenya	1.57	1.56	0.94	0.47	0.89	0.21
Madagascar	148.09	145.98	88.85	44.43	16.83	14.58
Mauritius	12.49	12.51	7.49	3.75	2.61	1.18
Mozambique	146.26	146.20	87.76	43.88	88.91	17.21
Seychelles	25.33	25.44	15.20	7.60	23.09	5.21
Somalia	12.51	15.42	7.50	3.75	2.57	2.39
South Africa	21.57	29.25	12.94	6.47	1.45	0.95
Tanzania	11.41	11.98	6.85	3.42	3.38	1.83
France	19.88	21.82	11.90	5.95	5.75	1.70
Total	404.82	415.82	242.89	121.44	146.69	46.15

The data reported in Table 18 shows that most of the gains from rebuilding fisheries of the ASCLME will come mostly from reducing cost and fishing the resources more efficiently, including eliminating or redirecting harmful subsidies currently provided by governments.

Table 18 presents the gains in resource rent, income and economic impacts that could be expected if fisheries of the ASCLME are rebuilt and sustainable managed through time.

Table 18: Gains in economic indicators from a rebuilt ASCLME (million US$) (Sumaila *et al.* 201

Country	Gain in Rent	Gain in Income Impact	Gain in Economic Impact
Comoros	1.94	0	0
Kenya	1.13	0	0
Madagascar	44.57	0	0
Mauritius	5.20	0.01	0.03
Mozambique	115.52	0	0
Seychelles	25.59	0.08	0.34
Somalia	6.85	2.10	8.60
South Africa	14.66	5.07	24.06
Tanzania	5.54	0.63	1.55
France	0.77	2.24	8.15
Total	221.77	10.13	42.73

Rebuilding and effectively managing fisheries of the ASCLME would result in annual gains in economic rent of US 221 million while wages and economic impact are likely to increase by US$10 million and $43 million per year, respectively. The latter two do not increase significantly because to rebuild, fishing capacity and therefore wages and normal profits need to be reduced.

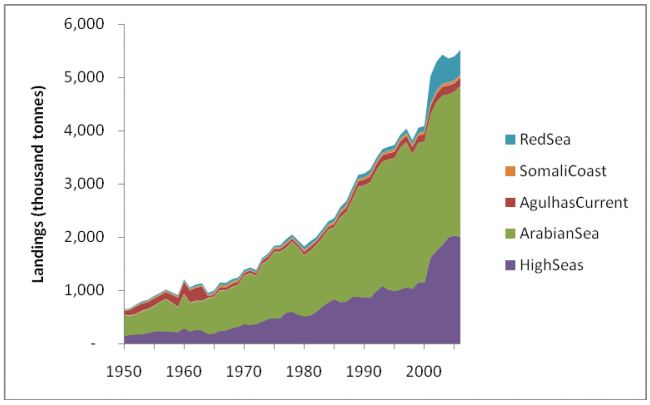


Figure 23: Marine fish landings from the Western Indian Ocean by Large Marine Ecosystems

Distribution of benefits among different countries of the ASCLME

Using the economic values computed above, it is possible to provide analysis of the distribution of benefits between (i) WIO countries and non- WIO countries; (ii) WIO countries themselves; and (iii) labour, capital and the state. This analysis would in turn serve as a basis for discussing the poverty implications of current patterns of resource use at the regional, national and sectoral levels. The results obtained in this study indicate that the bulk of the economic benefits from the coastal and marine resources of the ASCLME remain in the countries of the regions. We also see that wages are a multiple higher than earnings to owners of capital, which is both an indication of the labour intensive nature of resource sectors in the region, and the fact that workers such as fishers, capture a good part of the revenues generated in these sectors.

Indicators of improved economic and social performance

The study has provided initial numbers that serve as the beginning of a time series data collection that could be used for the analysis of economic and social performance over time.

Conclusions and Recommendations

- The estimated coastal and marine resources of the ASCLME contribute almost US$22.4 billion a year to the GDP of the countries of region. Coastal tourism contributed the largest to GDP at over US$11 billion a year, followed by coastal agriculture and forestry;
- The fisheries of the ASCLME are estimated to generate a resource rent of just about US$68 million per year currently, of which about US$59 million are generated by ASCLME countries and the reminder by countries outside of the region. The largest resource rent is generated in Madagascar, at US$ 42 million per annum;
- The fisheries of the ASCLME are estimated to support about 2.7 million full and part time workers, generating wages of about US$366 million per year. On the other hand, owners of fishing capital earn normal profits of US$60 million per year;
- Rebuilding and effectively managing fisheries of the ASCLME could result in annual gains in economic rent of US 221 million while wages and economic impact are likely to increase by US$10 million and $43 million per year, respectively;
- In terms of distribution and equity, most of the economic benefits from the coastal and marine resources of the ASCLME remain in the countries of the region. Also, workers in the sector capture a multiple of what owners of capital capture from the gross revenues generated from the resources of the WIO region.

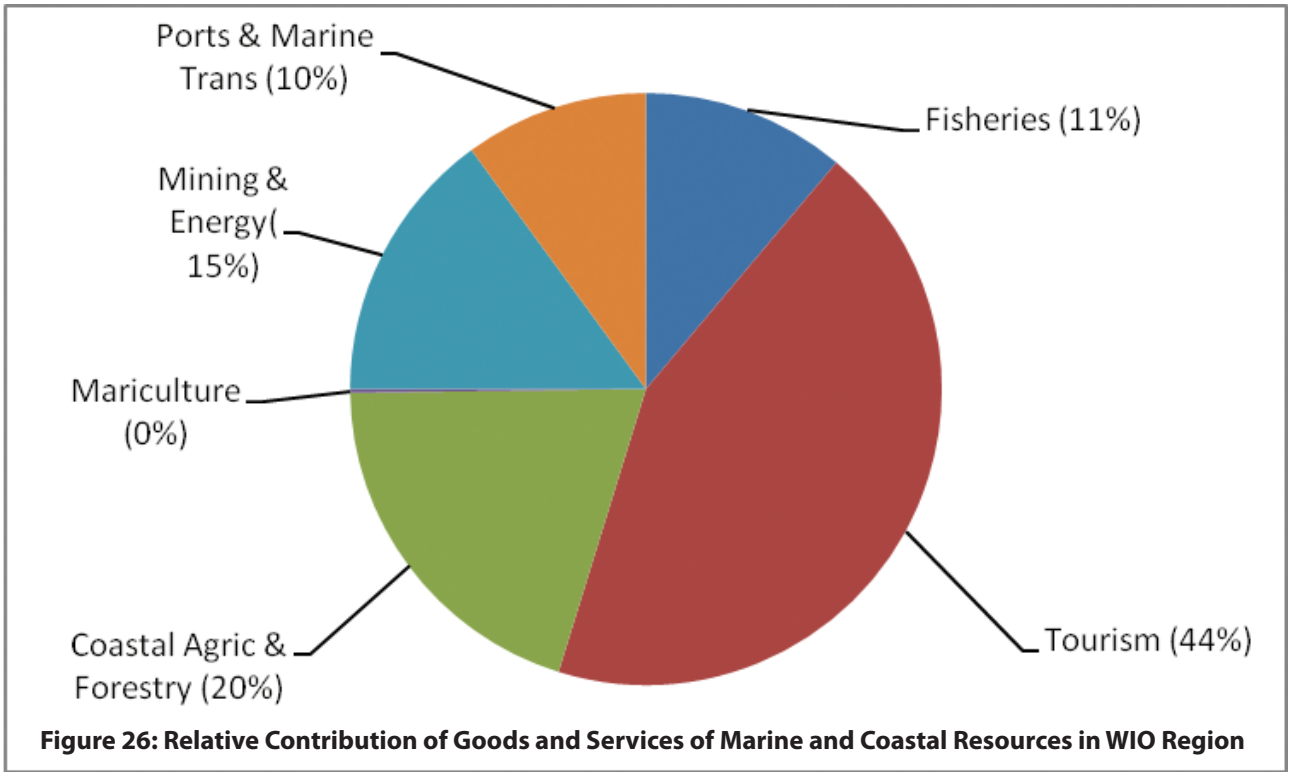
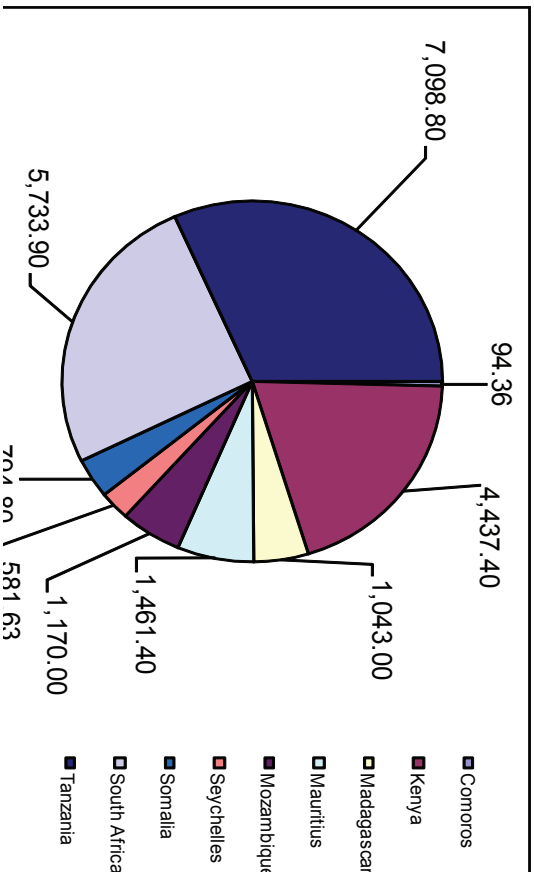
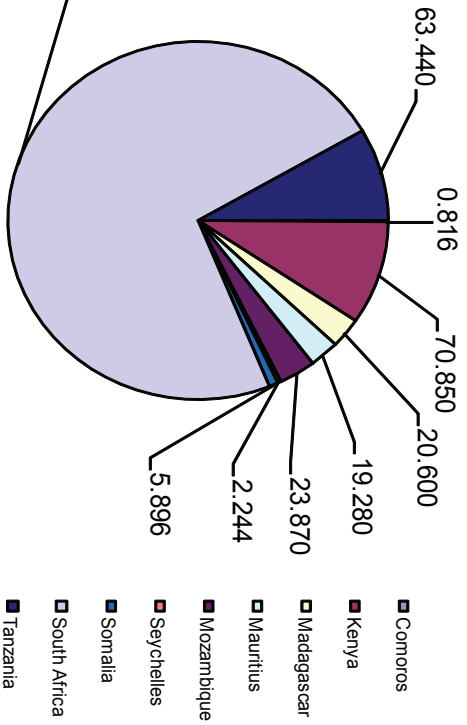
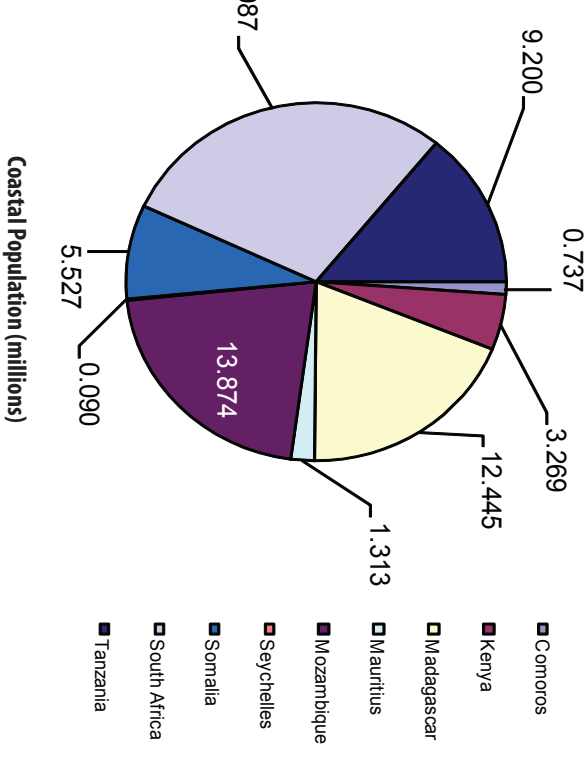


Figure 26: Relative Contribution of Goods and Services of Marine and Coastal Resources in WIO Region







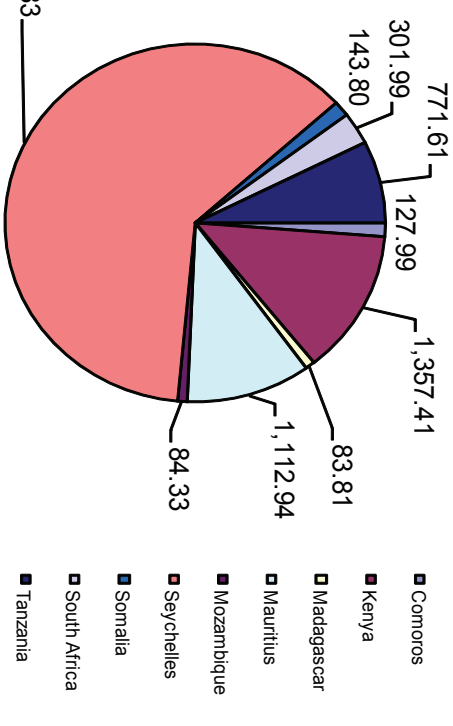


Figure 24: Measures of relative economic importance of countries of the Western Indian Ocean (Sumaila *et al.* 2012)

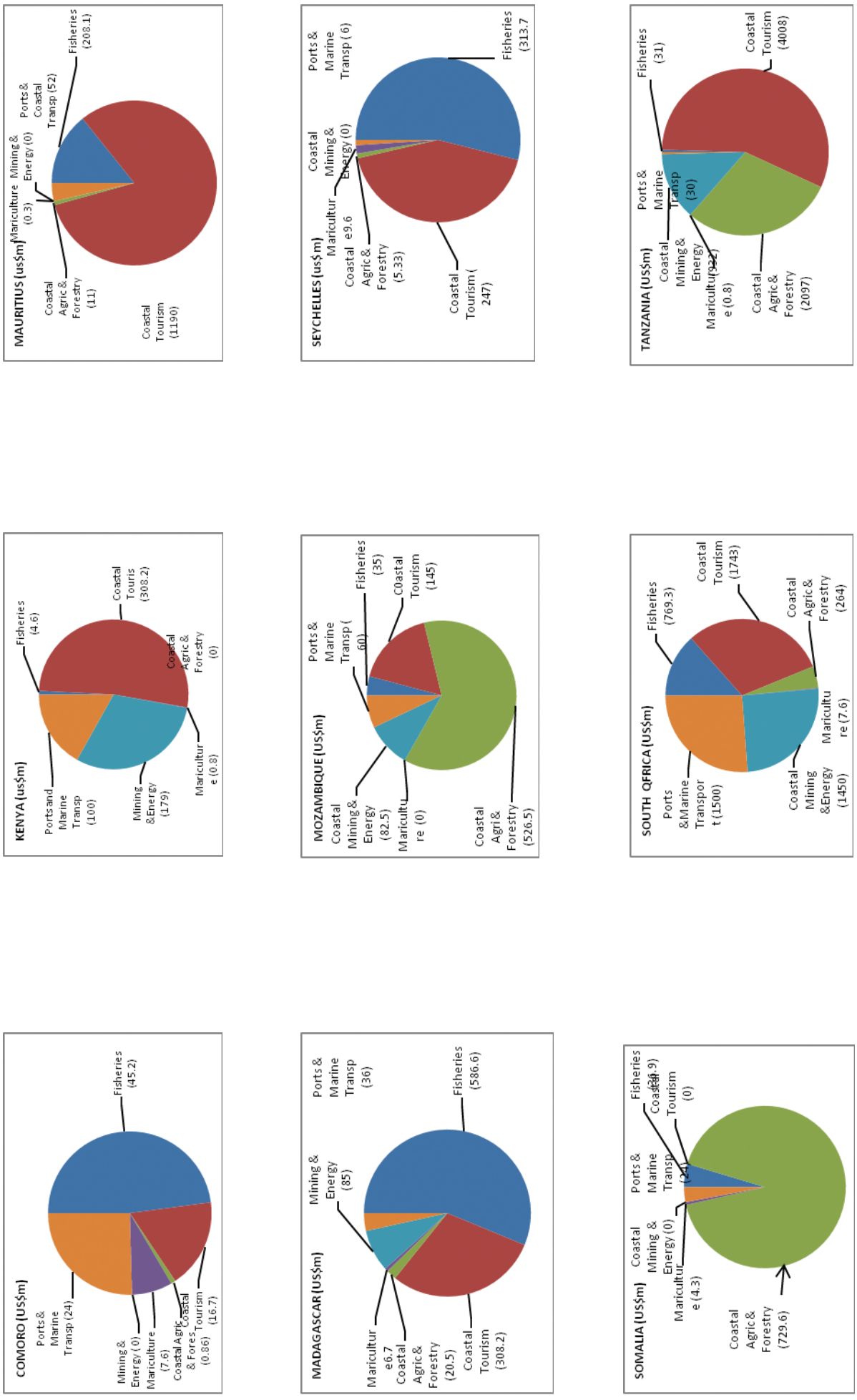


Figure 25: The contribution of goods and services (Million US $) to the economy of countries of the Western Indian Ocean

6. Marine pollution

Deteriorating quality of the coastal waters of the WIO region poses a significant threat to public health as well as to the health of its living marine resources and ecosystems – and thus also to the economy. The sources of pollution which contribute to this deterioration include both land-based and marine and maritime related activities. Since Land-Based Activities were the focus of the WIO-LaB project, the focus of this review was on marine sources which include dumping, shipping, ports, and oil and gas activities. While globally land-based activities are considered to contribute between 80 – 90% of the chronic pollution load to the marine environment, marine sources can make significant contributions to localised and trans-boundary pollution, especially in terms of single-point impacts such as blow-outs or massive-scale oil spills from tanker strandings.

The successful management of marine pollution requires an effective legal regime covering national, regional and international levels. Although the majority of ASCLME countries are party to most of the relevant international conventions – and are all members of the Nairobi Convention - there are a number of gaps and inconsistencies especially in their national legal and institutional frameworks which need to be addressed. For example:

- There are many cases of overlapping jurisdictions, and a lack of communication across sectors;
- Failure to domesticate the provisions of international conventions even when they have been ratified;
- Even where legislation is in place, the implementation is weak due to a lack of adequate financial, technical and human resources;
- Surveillance activities are split amongst various institutions – this is neither cost-effective nor efficient;
- Maritime borders between some of the countries have not yet been agreed and with the increasing interest in offshore resources, could lead to conflicts.

There is also a need to introduce and/or strengthen legislation on dredging – especially dredged material disposal – the environmental impacts of offshore oil and gas activities, liability and compensation related to offshore activities, and monitoring and standards.

At the regional level, additional technical protocols should be developed under the Nairobi Convention to "operationalise" the relevant articles and promote regional harmonisation in the management of marine pollution. These could include:

- A Protocol on dredging/dumping; and
- A Protocol on the management of pollution from offshore activities. This could be broadened to cover all environmental impacts rather than just pollution and including discharge standards.

These could be supported by the development of a Regional Policy on Marine Pollution and a Regional Code of Practice for Environmental Management in Ports be developed in collaboration with PENAf and PMAESA. Consideration should also be given to the establishment of Special Areas and or Particularly Sensitive Sea Areas under MARPOL in the region.

With respect to international conventions, efforts should be made to promote the ratification of Annexes IV (sewage) and V (garbage) of MARPOL, as well as the Anti-fouling Convention (2001) and the London Protocol (1996).

From a technical perspective, there is a lack of detailed information available on marine sources in most countries due, at least in part, to the fact that the sources are not being adequately managed either because there is limited or no legislation or there is a lack of technical capacity – or both.

While there is a limited amount of dumping (as defined in the London Convention/Protocol) taking place in the region it is highly likely that ports in all countries undertake dredging on a reasonably regular basis and that many of them are dumping the dredged material at sea. Moreover, although four of the countries are Party to the London Convention/Protocol, most of them do not appear to be implementing it. In addition, there have been reports of illegal dumping of toxic wastes off of the coast of Somalia. These represent a threat to the

region as a whole.

There is minimal information on shipping incidents and the associated pollution – although there is information on incidents involving piracy. Information on shipping traffic is outdated although it can be inferred from the port expansion plans that shipping activity in the region is increasing. Similarly, there is limited or no direct information on pollution in ports for most countries, although it is significant that the majority of the pollution hotspots identified by the WIO-LaB project are in or adjacent to ports. Efforts should be made to improve record-keeping and reporting for shipping and port activities.

Offshore oil and gas activities are expanding in most of the countries in the region and although there do not appear to have been any major pollution incidents to date, the risk of spills is increasing. Moreover, the growing number of platforms in the area increases the potential for conflicts with fisheries interests, not only due to pollution but as a consequence of habitat degradation and physical exclusion from drilling areas and abandoned rigs. At the same time, it is likely that the capacity to manage these activities is limited and since many of the companies involved are international, there may be problems of accountability.

Despite the general lack of data, the types of pollutant from marine sources likely to be of particular concern include:

- Litter from vessels, offshore rigs and port activities;
- Petroleum hydrocarbons from shipping, port operations and offshore oil and gas activities (including accidental and operational discharges);
- Tributyltins (TBTs) and other toxic constituents from anti-fouling coatings on vessels and submerged infrastructure;
- Heavy metals and other toxic contaminants (eg. pesticide residues) which accumulate in, for example, port sediments and which may then be discharged into other coastal areas after dredging operations;
- Noise pollution associated with seismic surveys used in oil and gas exploration;
- Suspended solids, accumulated deposits, antibiotics, heavy metals and other toxic constituents associated with the drilling muds used and/or produced water arising from offshore oil and gas exploitation;
- Microbiological pollutants and organic matter arising from sewage and garbage discharges from vessels and drilling rigs/platforms, particularly if they are located in shallow water and/or semi-enclosed areas where water circulation is limited.

There is therefore, in addition to the legal and institutional reforms, a need to introduce and/or enhance the management of all marine sources of pollution through:

- setting of standards as appropriate;
- implementing monitoring and assessment programmes;
- development of environmental management plans (for example, for ports, offshore rigs etc);
- development of Codes of Practice (for example, for ports);
- the provision of technical training, particularly for governmental officials.

Much of this can be achieved through collaboration with existing programmes and organisational partners already active in the region. The Office of the London Convention/Protocol and PENAf, for example, have already expressed a strong interest in a number of the proposed activities.

7. Management, Policy and Governance

The geographic coverage of the Western Indian Ocean GEF Projects includes the area under the influence of two currents – Agulhas Current and Somali Current as well as the South Equatorial Current which flow across the Mascarene Ridge and basin. This area encompasses ten countries including Comoro, France (Reunion and Mayotte), Kenya, Madagascar, Mauritius, Mozambique, Seychelles, Somalia, South Africa and United Republic of Tanzania (Tanzania Mainland and Zanzibar). As such the region also includes areas beyond the national jurisdiction (ABNJ) of the countries. The inclusion of the ABNJ has a significant implication on the governance marine and coastal resources of the region.

This section presents the governance systems practiced in managing marine and coastal resource both at national and regional levels. "An Ocean and coastal governance framework underpins a set of institutions, laws, regulations and mechanisms that guide the adoption and implementation of specific management and development actions. Good governance is achieved when such a framework progressively incorporates a set of agreed upon principles (such as participation, consensus, orientation; strategic vision; responsiveness, effectiveness and economic efficiency; accountability and transparency; and equity and rule of law). Governance sets the stage within which management occurs" (Olsen *et al.* 2006).

7.1 National Management and governance Instruments

The policy and governance assessments at national level explored the legislative framework and institutional structures that are responsible for managing major marine and coastal resources including fisheries, tourism, coastal agriculture and forestry, coastal mining and energy, marine transport, wildlife and conservations. The constitutions in the different countries were reviewed to assess how the ecosystem approach has been provided for in these key legal instruments (Table 19). Bilateral delineation of the boundaries of EEZs was also explored as this aspect is important in addressing transboundary issues.

The marine and coastal governance styles and patterns within the WIO region vary from one country to another based on their history and cultural backgrounds; and are influenced by regional and international agreements. These differences are expressed in terms of:

- Governmental organization, processes and priorities
- Levels of economic development
- The degree of scientific capability and the ability to incorporate science into policy process
- Patterns of social organization, culture and values as well as
- Political relations

Table 19: The basis of legal systems in the countries of the Western Indian Ocean

Country	Origins of the Legal System
Comoros	Arabic, Islamic and French Law
Kenya	English Law
Mauritius	English Law
Madagascar	French Law
Mozambique	Portuguese Law
Seychelles	English Law
Somalia	-
South Africa	English Law/South African Roman-Dutch Common Law
Tanzania	English Law

The countries have derived their legal systems from a variety of legal systems including the English, Arabic/Isalmic, French, Indian, Roman, Dutch etc.

Constitutional Standing

All the countries of the region have agreed constitutions. These constitutions make reference to the sustainable use of natural resource and conservation of the environment as a human right adopted by the UN. The constitutions are being amended from time to time to accommodate changes in the political system. The most recent is the change in the Kenyan constitution.

Sectoral Legislations

The governance of the major sectors related to the sustainable use of marine and coastal resources various from country to country. In some sectors there are more than six pieces of relevant legislation. Although the existing legislate adequately covers the management of coastal and marine resources, there are inadequacies and gaps in the application of the existing legislation to effectively guide the implementation of ecosystem based management – the LME Approach. The gaps and recommendations are presented for each of the WIO countries.

Comoros

The maritime zones of Comoros have not been delineated with Seychelles, Tanzania, Mozambique, Madagascar and France. This has serious negative implications in addressing trans-boundary issues amongst these countries.

The legal regime of the Comoros consists of a large number of texts, laws and decrees whose existence is sometimes not known to the institutions which are responsible for implementing them. It is believed that law enforcement depends in part on the establishment of a parliamentary system because of the advantage of empowering the executor. It also makes the legislative body be accountable to the nation. The turn-over of governments in Comoros have made it difficult for the Parliament to seat. The success of implementation also depends on political will, capacity and material resources.

With regard to fisheries sector, the key issue is the conflict of competences between the Union and the Autonomous Islands governments on the management of financial aid among multistate holders and potential donors. Forestry resources are key to the livelihoods of the communities in Comoros. The challenge in the forestry sector is how to mobilise and sensitise all stakeholders for their involvement in the sustainable management of natural resources, preservation and conservation for future generations as well as validation of the forest policy and strategy developed in 2010 and seek appropriate funding for its implementation. Further challenges facing the forestry and fisheries sectors as well as the environment include how to find alternative livelihoods for the communities and promote income generating activities. Parks and Wildlife have to ensure that the renewal of stocks of species dependent on coral reefs and deasgrass beds because they are the lifeline of the communities. There is need to update and implement the agricultural strategy adopted in 1994. In addition, it is important to address the problem of land tenure, regulating the landowners so as to provide for the landless to allow a real intensification of agricultural production.

Kenya

The maritime zones of Kenya have not been designated with Somalia. Addressing transboundary issues has further been complicated by civil conflicts in Somalia.

The Fisheries Management Bill (GOK 2009) requires to be fully reviewed to empower it with coordination role since it has been weakened by various overlaps in mandates of institutions that directly or indirectly interlink with fisheries resources and its environment. There is further need to review the Fisheries Act to domesticate the regional and international conventions, and agreements into Kenyan law.

The Tourism Policy (GOK/MOTW 2006) and the Tourism Bill (GOK/MOT 2010) have still created more corporate bodies in the Ministry of Tourism which still promotes administrative overlaps in their mandates and can cause conflicts. The conflicts may be aggravated further by other institutions with linkages to these increased number of tourism institutions. It is recommended that the Tourism policy, existing Acts and the Tourism Bill provide for domestication of relevant regional and international treaties and convention to which Kenya is part. Further it is recommended that the Tourism Policy and Law should embrace ecosystem based management since Kenya's tourism is essentially anchored on nature and its resources and mostly its biodiversity.

Although in the Seventh National Development Plan of 1994- 1996, the government policy recognised the economic contribution of mineral wealth to the economy and at the same time the need of preservations of a clean environment for sustainable mineral utilisation and management this was not embraced in the mining and minerals Act and the Petroleum (Exploration and Production) Act to embrace environmental sustainability

issues and ecological sustainable development. There is need to review the Acts which empower their mandates to embrace ecological sustainable development.

Growth of commerce in the East African region has necessitated expansion of port and maritime transport facilities not only to serve the country but also neighbouring landlocked states in the region. Policies and Acts created to have in place appropriate mandates for institutions to manage maritime transport and ports should be broad enough to facilitate creation of synergy with other supportive policies and Acts for sustainable management that will promote healthy environment and economic growth both at national and regional levels.

To support agricultural production in line with addressing the MDG7 and the National Food Policy which advocates for good land use for self sufficiency in food production, an integrated ecosystem based management supported by especially the Integrated Coastal Zone Management, Wetlands Policy, Land Policy and Forest Policy and their corresponding Acts have to be enforced. This is essential noting also the fragile nature of the coastal areas being variably arid to semi arid in nature and that poor management can lead to collapsed agricultural production. Policies and Acts to support appropriate technological advances in sustainable agricultural production and environment management in the prevailing environmental conditions and climate variability are required and appropriate monitoring, control and surveillance are enforced.

Madagascar

The gaps and recommendations for improving the application of an LME approach in Madagascar include but not limited to:

- Harmonization of existing laws and policies to improve and reduce fragmentation;
- Amendments to fisheries legislation to allow greater community involvement in designation and management of marine resource;
- Adoption of comprehensive legislation on ICZM
- Strengthening local capacity for good governance;
- Update the legislation on all relevant sectors so as to address the emerging issues;
- Application of science based Governance so as to improve decision-taking
- Human resources capacity building especially on judiciary and surveillance.

Mauritius

Mauritius and Seychelles have jointly extended their seabed in the Mascerene Bank and Plateau. In 2010, the governments of Mauritius and Seychelles signed a Memorandum of Understanding for the setting up of a Joint Management Council. Further, Mauritius has made a submission for the extension of the sea bed east of Rodrigues Island. However, there are pending negotiations on Chagos Archipelago, including Diego Garcia, between Mauritius and United Kingdom and also on Tromelin Island between Mauritius, Seychelles and France.

There is presently no ocean management policy developed. MOI envisages the formulation of an ocean management policy in the coming 5 years. The recent ICZM framework study commissioned by the Ministry of Environment and Sustainable Development has made a recommendation to amend the MZA 2005 to incorporate:

- provision for the authorization and regulation of the construction, operation and use of any installation or structure within the territorial sea, internal waters, archipelagic waters and historic waters of Mauritius;
- equirements that specified activities may not be carried out within the maritime zones of Mauritius except within an area that has been leased for that purpose and in accordance with that lease;
- prescription of offences and penalties in relation to the matters dealt with in the regulations, provided that the penalties do not exceed the maximum penalties specified in section 28.

The Fisheries and Marine Resources Act 2007 (amended in 2008) is the legal tool administered by the Ministry of Fisheries. It provides a holistic framework ensuring sustainable methods of exploitation of marine resources. The Act consolidates the management, conservation and protection of fisheries and marine resources, and the protection of marine ecosystems within the Republic of Mauritius and its territorial waters. The key gaps and needs identified include, the need for a fisheries Master Plan and development of fisheries management plans

for lagoon and off-lagoon fisheries and improvement in MPAs, development of sea cucumber and coral farming in the lagoons. Other needs include implementation of the National Plan of action against IUU including the improvement in fishing licensing, and capacity building in all aspects of fisheries management.

Tourism in Mauritius is guided by Tourism Act 2004, Tourism Authority Act (2006), Environment Protection Act 2002, The Finance and Audit (Tourism Fund) Regulations 2003 (GN no. 195 of 2003,) The Tourism Employees Welfare Fund Act 2002. These legal instruments indicate the multifaceted nature of the tourism industry, requiring many actors to work together synergistically. The gaps that exist in the tourism sector include the assessment of the carrying capacities, monitoring of impacts of tourism development, the need for focusing on regional tourism by marketing Mauritius as a stop-over destination, additional legislation that will guide other activities such as surfing and the non-formal tourism sector. Need to establish Environment Management Systems, audits and verification in hotels and IRS. Further the need to develop an ecotourism strategy to promote inland tourism and ease pressure on the coastal zone.

There is no formal report that indicates that Mauritius has oil and gas within its territory including its EEZ. However, India and Mauritius had signed a Memorandum of Understanding to cooperate in the exploration for oil and gas in Mauritian EEZ.

Like tourism, there are several pieces of legislation that guide the establishment and management of parks and wildlife conservation. The gaps that have been identified include, limited technical, financial and human resources at the level of institutions dealing with conservation, preservation, protection and management of biodiversity resources and overlapping institutional mandate in the case of Forestry Services and National Parks and Conservation Service. In 2010, an Integrated Coastal Zone Management (ICZM) strategies, policies and guidelines have been finalised and approved by the Cabinet of Ministers. Implementation is underway. The ICZM approach has contributed towards rallying the stakeholders towards common understanding and goals. The gaps in ICM include:

- Absence of systematic monitoring programme for the coastal zone
- Knowledge gaps in certain aspects pertaining to Coastal Zone Management, e.g., nutrient enrichment and chemical (pesticides) runoff

Agriculture is a complex sector. There are 23 pieces of legislations of direct relevance and aiming at promoting sustainable agriculture. The key ones are Sugar Efficiency Act 2005, Chemical Fertilisers Act 1980, Dangerous Chemical Control Act 2004, Cane Planters and Millers Arbitration and Control Board Act 1973, Board of Agriculture, Natural Resource Act 1977, Agricultural Chemists Act 1979, Genetically Modified Act 2004, Forests and Reserves Act, Plant Protection Act 2006 and so on. Identified gaps as they relate to ecosystem management of martine and coastal resources include capacity to formulate climate-resilient policies for agriculture, including food crops and livestock; to buffer overexploitation of marine resources and unsustainable agricultural practices in certain cases. Needs to promote Sustainable Land Management practices.

Mozambique

Although Mozambique has concluded the delineation of it EEZ boundaries with Tanzania the same has not been concluded with the other neighbours. Therefore, there is a strong and urgent need for establishing maritime boarders, with Comoros, France (Mayotte and Europe), Madagascar and South Africa in order to minimize existing and (mainly) potential conflicts related to economic use of coastal and marine resources, like fisheries and, very recently, hydrocarbon exploration and exploitation.

The Fisheries Law, which is presently under revision, sets out the legal framework for fisheries management in Mozambique. It defines the type of fisheries according to fishing zone, complexity of used vessels and their autonomy and used fishing gears as subsistence, artisanal, semi-industrial, industrial, scientific research and experimental, and recreational and sport. The challenges include, the turnover of the fisheries sector within the government structure (in the last 35 years, it changed 4 times) mainly when it was aggregated with the agriculture sector, affected heavily the progress achieved for more than 16 years. Further, MPA and aquatic conservation is not mandated to the Ministry of Fisheries and this affects the use of MPAs as a management and conservation tool for fisheries. Mozambique has ratified UNCLOS Straddling Stocks and Highly Migratory Fish, and adhered to International Agreement on Conservation and Management Measures of High Seas

Resources, meaning that all other neighboring countries would also be advised to do so. For effectiveness of these instruments it is recommended that regional bodies, like SADC, SWIOFC, EAC and IOTC to adopt these international instruments into agreed regional legally binding Protocols.

Although the Tourism Law, in its Article 3 c) addresses the need for harmonious and balanced development by guarantying mechanisms of inter-sectoral participation and articulation, this has not always been the case, resulting in conflicts. Therefore, it is extremely important to institutionally address adequately inter-sectoral coordination and articulation, where the Ministry for Coordination of Environmental Affairs (MICOA) should play a coordinating and impartial role for adequate and balanced development of the country.

The high turnover of the mineral resources sector within the government structure (in the last 35 years, it changed 6 times) affects the continuity of progress achieved at a particular time. The creation of the National Oil Institute is a way to increase the resilience of this sector from changes in government structure and for keeping a continuous progress on oil and gas issues.

Although many existing legal instruments, within this oil and gas sector address environmental aspects, the huge investments that are taking place in Tete Province and along the coast call for the increase and improvement of technical capacity (which is presently very low) to monitor their environmental impacts, within the Ministry for Coordination of Environmental Affairs (MICOA) and other related institutions.

From the analysis of the existing legal documentation, it is obvious that the creation of conservation areas is mainly driven by tourism purposes, rather than the conservation of natural resources in its broad sense. Although it is a huge contribution for conservation, it raises some concerns, since other areas which could not be attractive for tourism could be left out, and other areas attractive for tourism may be forced to be conservation areas unnecessarily. Transboundary conservation areas are reality on land, following the history of conservation in Mozambique, but still not existing on the coast and at sea, although biological studies carried out support their establishment in the North (on the border with Tanzania) and in South (on the border with South Africa).

With regard to ICZM, the Environmental legislative framework can be considered adequate mainly in relation to pollution and conservation aspects, however, national strategies and/or policies related to integrated coastal zone management (the most important developing and conflicting area within the country) are lacking. This aspect should be urgently addressed.

The coordination role of MICOA is still weak, although coordination mechanisms exist at higher levels, namely CONDES (National Council for Sustainable Development), which is headed by the Prime Minister and includes the Ministers of the Ministries related directly or indirectly to the use of Natural Resources, in part (i) because sometimes MICOA itself confuses its coordination role from that of implementation (which is for the other Ministries); (ii) on other side, because coordination is not an easy task at all (traditionally, sectoral ministries embark on the implementation of their sectoral plans); and (iii) also because at the technical level, there are not strong, permanent and continuous coordinating mechanisms and finally the lack of human, technical, material and financial resources affects greatly the full enforcement of the existing legislative framework.

Seychelles

Seychelles and Mauritius have submitted a joint extension of the sea bed. However, Seychelles has yet to delineate its EEZ boundaries with Comoros, Tanzania, Madagascar and France. Concerning Tanzania the main negotiations have now been completed except for a minor agreement concerning the tri-points where the three neighboring States (Seychelles-Comoros-Tanzania) meet, which needs to be settled. As for the Comoros negotiations are still on-going concerning the median line. Negotiations to delineate the EEZ boundaries with Madagascar have not progressed as the latter cannot confirm it's availably. Negotiation with France and/or Mauritius concerning the island of Tromelin is still pending whilst sovereignty over this island is being sorted out between France and Mauritius.

There is a lack of monitoring and enforcement of the domestic fisheries regulations. In this respect there is a need for the local laws to be harmonised and for the local enforcement agencies – SFA, NPA, Coast Guard, the

Police and the AG's Office to work in closer cooperation. For this to happen there is need to build capacity. The Fisheries Act of 1986 is being revised and this provides an opportunity for inclusion of other pressing emerging issues.. The issue of fishing License application and issuance is one that demonstrates lack of harmonization and coordination between the Licensing Authority (LA) and Seychelles Fishing Authority (SFA). Capacity building is needed in all areas of the fisheries governance.

Negative impacts of tourism developments include inappropriate land use and zoning, destruction of natural habitats, malfunctioning of sewerage plants, continued sale of marine souvenirs and use of large amounts of natural resources such as water and fossil fuels. These weaknesses have mainly occurred due to the lack of an overall detailed master plan for tourism and land use in Seychelles. As a result, appropriate policies, practices and monitoring systems have not been developed, coupled with a poor understanding by operators and tourism officers of environmental issues.

Integrated coastal management needs to take into account rapid urbanisation and growth and competing demands on coastal zone land use by different sectors, in particular housing, agriculture and tourism. The new Land Use Plan is currently being developed and it must be ensured that these issues are adequately addressed therein.

The involvement of the public in coastal management matters in the Seychelles remains relatively low. The public display of Class I EIA reports for a period of 2 weeks is compulsory, as required by the Environment Protection Act and EIA Regulations. This low turnout is often related to the perception of the public that the decision regarding the developments have already been made and that the meetings are only a formality. A second cause for the low participation is a lack of information dissemination and the fact that coastal communities are not organised into groups at the district level. This is slowly changing with the creation of CBOs and the involvement of NGOs at community level. Their increased involvement in decision making should be promoted.

Other gaps identified in the sectors of oil and gas, Parks and wildlife conservation and portscoastal agriculture and forestry include:

- Oil exploitation can potentially create a disturbance to local ecosystems, both for the physical (biocoenosis) and the biotic aspects (biotype). Mastering these effects requires not only monitoring, but also human and financial resources to do so;
- Currently there exists no coherent network or "system" of MPAs but rather a collection of Marine Protected Areas which address diverse objectives and have no unifying strategy. However, a diversity of management bodies is in principle good, as it allows for focused management initiatives taking into account the local communities and stakeholders;
- The mandate of the two main Agencies responsible for management of the MPAs, i.e. the SNPA and the SFA is quite distinct and offers a limited leeway for harmonisation;
- Revision and updating of the legislation concerning protected areas should be done in a holistic and comprehensive manner taking into account all aspects of the legislation on Biodiversity and taking into account the IUCN categories and guidelines (Domingue *et al.* 1999);
- The current infrastructure at the commercial port in Victoria is inadequate, not only is the quay too small and gives rise to congestion but modern loading and unloading facilities are lacking compared to regional port like Port Louis in Mauritius;
- There is the need to improve the planning, coordination and monitoring capacities of SNPA and DOE to enable them to fully benefit from the available external support and the national opportunities for increased mobilization of NGO and private sectors for conservation and sustainable utilization of forest resources.

Somalia

Stretching over 3,330 kilometres, Somalia has the longest coastline of continental Africa and is part of one of the most important large marine ecosystems in the Indian Ocean. The presence of a narrow continental shelf in this region along the Western Indian Ocean coupled with an upwelling makes this area one of the most productive in the Indian Ocean and an important breeding ground for many migratory fish species (Oduori *et al.* 2009).

The Republic of Somaliland unilaterally declared its independence in 1991, and has its own central bank and currency and conducts its own foreign and domestic policies. Although as yet unrecognised internationally, it has remained relatively stable and has achieved notable progress in democratization and development (Yassin 1981).

Unlike Somaliland, the autonomous Puntland State of Somalia positions itself as a regional entity in a future federal state. Puntland conducts its own foreign and domestic policies but has no central bank or currency of its own. Arid and sparsely populated, Puntland is the least economically developed region, but like Somaliland is relatively stable, and has developed its own (albeit embryonic) system of governance.

South-Central Somalia has most of the economic potential, notably in the Juba and Shabelle river basins and the major trading ports of Kismayo and Mogadishu. Clan rivalries and intense competition for economic resources have prevented the emergence of a regional administration in South-Central Somalia, which cannot be assigned a meaningful geopolitical identity in the same way as Somaliland and Puntland.

In Somalia natural resources are the basis of livelihood security and thus the foundation for economic growth and development. The objectives of the Somali Government policy on fisheries development are to maximise fish production and income therefrom, consistent with a sound fishery plan (Christy 1980). These objectives consider both the input or cost and the output or revenue. As the country is not endowed with other natural resources, policy-makers view fisheries as a source of food, employment and earner of foreign exchange in the future.

The establishment of public finance management, and the development and implementation of revenue generation and collection policies and frameworks lie at the heart of macroeconomic policy for Somalia and are strongly supported by the international community.

South Africa

South Africa has yet to agree on the EEZ boundaries with Mozambique. The gaps and recommendations identified for the effective implementation of an ecosystem based approach to managing marine and coastal resources are:

South Africa has not adopted several of the conventions related to marine and freshwater resources and marine pollution related conventions such as the Convention on the Conservation and Management of Fishery Resources in the South East Atlantic, 2001 (signed in 2001, not ratified); Convention on the Protection of the Underwater Cultural Heritage, 2001 (neither signed nor ratified); Revised Protocol on Shared Watercourses in the Southern African Development Community Region, 2003; Convention on Civil Liability for Bunker Oil Pollution Damage, 2001 (neither signed not ratified); and International Convention on the Control of Harmful Anti-Fouling Systems, 2001 (neither signed not ratified).

The South African Marine Living Resources Act 18 of 1998 includes a set of principles whose underlying tenet is sustainable utilisation and/or ecosystem based management. The question arises as to why this principle is not implemented in practise. Part of the answer may be to do with lack of capacity. The Marine Living Resources Act provides for a fisheries management mechanism, empowering the Minister to declare fisheries management areas, for the management of identified species (sect 43). The Minister may in addition approve a plan for the conservation, management and development of the fisheries in question. The Department of Fisheries should be encouraged to include an Ecosystem Based Approach in these fisheries management area plans. The application for the allocation of fisheries quotas could be made the subject of an environmental assessment and this could include the requirement that the effect on the ecosystem in question be taken into account prior the allocation of the quota.

South Africa has enacted a progressive National Environmental Management Act: Integrated Coastal Zone Act (24 of 2008) which rests on the foundation that the coastal ecosystem is a dynamic area and management decisions should be undertaken on a holistic basis. It provides a model for other legislation and it is recommended that an ecosystem approach be adopted in other legislation, for example planning laws.

South Africa is party to a number of Regional Fisheries Management Organisations (RFMOs). Of particular relevance are: the Western Indian Ocean Tuna Organiation (WIOTO), and the South West Indian Ocean Fisheries Commission (SWIOFC). It is recommended that South Africa promote an Ecosystem Based Approach ('EBA') in these regional fora.

It is recommended that an Ecosystem Based Approach be put on the respective inter-governmental committees known as MINTECs (Ministerial Technical Committees) and MINMECs (Provincial Ministerial Advisory Committees). There is much room to strengthen both institutional and law enforcement capacity in South African government agencies. This is the final recommendation.

Tanzania

Tanzania is negotiating with Mozambique, Comoros and Seychelles on the delineation of their common EEZ boundaries.

Tanzania has quite a number of laws which provide for legal and institutional frameworks that adequately address coastal and marine resources and environment management. Although financial and human resources have constrained them from operating in their full capacity, they complement each other well. In the long run they will be allocated sufficient funds to enable them to improve their enforcement operations. Tanzania is still in the process of implementing reforms in its legal sector. Old and outdated laws are repealed and replaced by new ones. The current trend in the enactment of new laws indicates a great likelihood that there will be very strong enforcement machinery.

The major recommendations for the effective application of the ecosystem based approach are:

- There is need for the Tanzanian Government to establish a coordination and monitoring institution in order to enhance its effective governance of its coastal and, marine areas;
- There is need for building the capacity of coastal districts to align well with the central government especially on coastal and marine issues. This could be done through training (Strategic Planning) and awareness-raising to district policy makers on the importance of such alignment;
- Marine fisheries and Environmental issues are not union issues - each side of the Union is dealing with these issues separately, in spite of them occurring in the same geographical setting. Both Mainland and Zanzibar Governments have different policies, laws, regulations and plans that are not harmonised. This situation creates some difficulties and confusion to resource users and management. There is a need to harmonise those policies and laws for effective governance and at the same time reduce unnecessary conflicts that are common every day;
- Marine resource theft at sea, IUU, Dynamite fishing, Piracy, drowning of mariners and oil spills are some of the threats and challenges to Tanzanian coastal and marine areas. Most of the responsible institutions lack capacity to deal with these challenges. They are generally constrains by one or more of the lack the right and appropriate equipment, trained personnel or plans to deal with those existing challenges. It is recommended that institutional and individual capacity is built in the responsible institutions and personnel in order to halt the existing alarming situation;
- Incomes obtained from licensing legal businesses related to Mangroves, prawn fishery, deep sea fishery, natural gas, marine transport, etc., to a large extent are all and always directed to the central government with less or none to the local government or community directly. This licensing system makes the local Government become weak in doing its business at local level because it lacks the financial capacity to deal with management issues of those coastal and marine resources. It is important that the distribution of these incomes can be adjusted to enable the local governments to cope with rising management challenges at local level;
- There is a need to constantly raise the knowledge and awareness of the importance of coastal and marine ecosystems to all stakeholders using different means. Use of several and different media like radio, TV, theatre arts, posters, electronic media etc., are among the recommended means to enhance knowledge and awareness to many stakeholders. As such, there is need to revive the semi-annual retreats and coastal and marine forums to enable the practitioners share their knowledge and experience on coastal and marine issues.

7.2 National Institutional Arrangements

Institutional Structure

The countries of the Western Indian Ocean have the three pillars of government practiced by most of the democratic systems in the world – The legislative, executive and Judiciary. The institutional setting varies according to the historical background. Figure 27 provides a generalised structure.

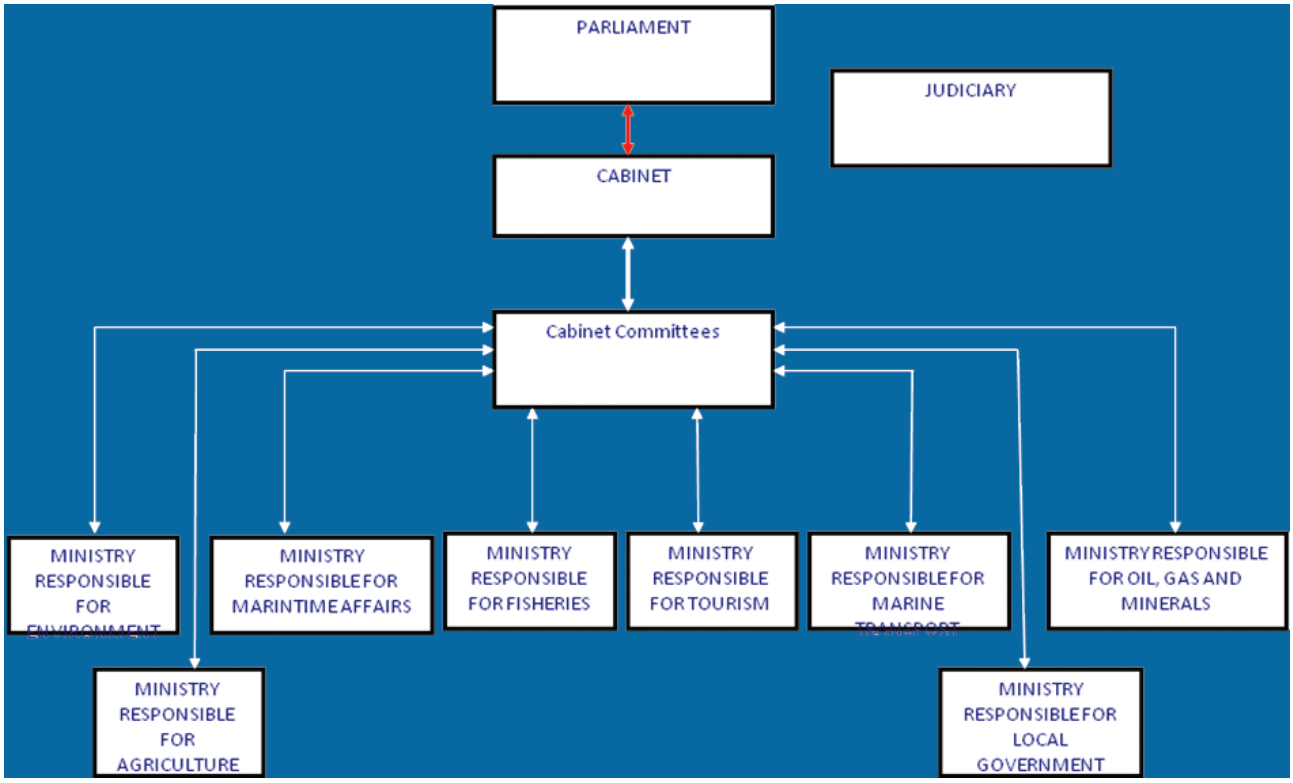


Figure 27: Framework Structure of Governments in the WIO countries (with some variations)

Ministries that are responsible for management of marine and coastal resources are those responsible for local government, fisheries, environment, tourism, agriculture, forestry, mining, gas, oil, marine transport, and their associated technical institutions such as training and research institutions, environmental councils meteorological centers, universities etc. The Western Indian Ocean Marine Science Association (WIOMSA) has a comprehensive database on the regional research and academic institutions. In all the countries there is no single ministry or institution that is solely responsible for marine and coastal issues. The national structures are replicated at sub-national level, normally under the ministry responsible for local government.

There are also non-ministerial government entities that work independently of Ministers, to whom they are nevertheless accountable. These include parastatal organisations, state companies, councils, boards, authorities and corporations. These organisations carry out set functions within a government framework with a varying degree of operational independence and are managed by the Chief Executive. These bodies exercise executive, administrative, commercial or regulatory functions. They are public institutions that deliver services for the Government, but they do not set the policy required to carry out their functions, as these are determined by the Ministry or Department that oversees the agency. Their assets are the general property of the state and their employees are public service employees.

Inter-Ministerial Committees

Implementation of Integrated Coastal Management (ICM) started from 1993 when Ministers of Environment from WIO region met in Arusha, Tanzania to deliberate on the strategy for implementation of Chapter 17 of Agenda 21 of the UNCED. Since then countries of WIO region are progressing towards developing national policies, legislations and strategies for the implementation of ICM. The implementation of ICM calls for the establishment of Inter-Ministerial Committees to oversee the integration of actions to achieve sustainable use

of marine and coastal resources. The status of these ICM Committees varies from country to country.

ICM in Comoros is built around the Environmental management legislation and the institutional framework is adapted to respond to the guidelines on Sustainable Development as well as compliance with the new country's institutions from the process of national reconciliation. Most of the ICM activities have evolved around regional initiatives including Ros, Regional Projects, pilot projects, taskforces and networks all being coordinatated by the National Sustainable Development Committee. This has improved the engagement of the government and the involvement of the civil society.

Kenya has developed a policy on Integrated Coastal Zone Management (GOK-MENR 2010). Section 55 of EMCA (1999) mandates the National Environment Management Authority (NEMA) to coordinate and implement the ICZM policy. However this should be done in cooperation with other institutions whose policies and mandates directly or indirectly offer synergy in promoting ICZM policy for appropriate integrated management approach to promote sustainability. The policy call for the establishment of an ICZM Committee to facilitate the coordination, as such NEMA has constituted an ICZM Steering Committee. The committee draws its membership from lead government agencies, NGOs, private sector and community groups. The main function of the Committee is to provide technical guidance and advise on the development and implementation of the ICZM Framework to address issues concerning the coastal and marine environment.

The National ICZM Committee for Mauritius was established since 2002. The National ICZM Committee has been established under the Environment Protection Act 2002, thus it has a legal standing. The National ICZM Committee is chaired by the Director of Environment and the Secretariat is ensured by the ICZM Division, Ministry of Environment & Sustainable Development. Meetings are convened as the Chairperson sees fit under the Annual Budget of the Ministry of Environment & Sustainable Development.

Madagascar has established an ICZM Inter-Ministerial Committee, The Committee has been established under the decree "arrêté n° 2169/2009 of February 12th, 2009" signed by the Prime Minister, stating its creation, organisation and functioning. The Mandate of the Committee is to ensure coordination and promotion of integrated coastal zone management including the implementation of the objectives of the Action Plan. The Committee is subdivided into three thematic Groups – ICZM Development and Integration; Pollution and Degradation; and Ecosystem Management and Socio-economic and Social Development. Each Thematic Group holds its meeting depending on needs – the Ecosystems Management Thematic Group meets once a month. The ICM Inter-ministerial Committee is provided budget by the Government of Madagascar.

Mozambique has established an ICM Committee and is operating at National Level. The CTIGC (Inter-Institutional technical committee for coastal management) advises the Technical Committee of CONDES (which is chaired by the Deputy Minister of Environment). This is the organ that advises directly CONDES, which is chaired by the Prime Minister and composed by the relevant Sectoral Ministers.

The CTIGC (ICM) advices the CONDES on matters related to conservation & development of the Coastal Zone and ICZM framework development. The Secretariat is under the Ministry for the Coordination of Environmental Affairs (MICOA), at the National Directorate of Environmental Affairs (DNGA). The CTIGC's Technical Council meets every Tuesday at the beginning of each month in the sector institutions. The CTIGC's extraordinarily meets whenever convened by the CTIGC's President. There is no government budget to support the holding of the meetings.

Traditionally, coastal zone management in Seychelles has been the responsibility of the Department of Environment and in particular the Division responsible for Pollution Control and Environmental Impact Assessments. Seychelles is in the process of drafting the third ICZM plan which is the EMPS. The EMPS Committee is well established since the year 2000 and still running and the Secretariat of the committee comprises of 1 Executive Secretary, 1 technical expert and 1 accountant. There is no specific budget for the committee, but certain activities like workshop are being financially supported projects.

Although Somalia has not established an ICM Committee, the possible composition will include:

- Minister of Fisheries, Marine Resources and Environment

- Minister of Agreculture, Livestock, Range and Forestry
- Minister of Information, Post and Tourism
- Minister of Air, Land and Marine Transport
- Minister of Interior and National Security
- Minister of Defence (Navy Battalion)

In South Africa, the Integrated Coastal Management Act 24 of 2008 (the 'ICM' Act) replaced the out-dated and outmoded Sea Shore Act of 1935. The ICM Act provides for a plethora of government agencies ranging from national, to provincial, to local spheres of government to be in one way or another involved in, developing or managing the coastal area.

The Department of Water Affairs and Environment (DWE) administers the Integrated Coastal Management Act, 24 of 2008 (ICM Act) as well as the National Environmental Management Act 108 of 1998 (NEMA) Chapter 6 of the Coastal Management Act requires that each of the three spheres of government have to develop coastal plans for their respective spheres:

- The Act requires the Minister of Water and Environment to adopt a national coastal management programme which is a policy directive on integrated coastal management providing for an integrated, coordinated and uniform approach to coastal management, including the use of coastal resources.
- Similarly at the provincial level the MEC of each of the four coastal provinces should adopt a provincial coastal management programme. Its contents must include a vision for the management of the coastal zone in the province, including the use of coastal resources.
- Finally at local level of government coastal municipalities must prepare and adopt municipal coastal management programmes. These municipal coastal management programmes must include "a vision for the management of the coastal zone within the jurisdiction of the municipality including sustainable use of coastal resources", coastal management objectives, priorities and strategies, performance indicators as well as other stipulated matters.

The Tanzania National Integrated Coastal Environmental Management Strategy (NICEMS) was launched in 2003. NSC-ICM provides policy oversight and guidance on the overall vision of the ICM activities in the country. The Permanent Secretary responsible for Environment is the Chair to NSC – ICM. Integrated Coastal Management Team serves as the backbone of a national ICM network to practitioners (local and national). We have the Inter-sectoral working groups (Core working group, Science and technical working group and Issue specific working. Last meeting of NSC-ICM was 2008 though supposed to meet twice annually. NSC-ICM was formally funded by Tanzania Coastal Management Partnership (TCMP). Currently, the strategy is under minor review, and there is a need to support and speedup strategy review process at national level.

7.3 Regional and International Management and governance

Legal Instruments:

The ASCLME region has a number of regional multi-lateral agreements and bodies (Table 20) such as the Convention on the Protection, Management and Development of the Marine and Coastal Environment of the Eastern African Region (Nairobi Convention) with its Regional Coordinating Unit (RCU) in Nairobi, Kenya; the South Western Indian Ocean Fisheries Commission (SWIOFC) with its Commission based in Harare, Zimbabwe; and the Intergovernmental Oceanographic Commission Regional Committee for the Investigations in the North and Central Western Indian Ocean (IOCINCWIO), coordinated by IOC-UNESCO in Paris. The expanded regional agreements include the Indian Ocean Tuna Commission (IOTC) based in Seychelles and the recently negotiated Southern Indian Ocean Fisheries Agreement (SIOFA) facilitated by FAO. Regional Economic Commissions include the Southern African Development Community (SADC) based in Gaborone, Botswana; Common Market for Eastern and Southern Africa (COMESA) based in Lusaka, Zambia and the Commission of Indian Ocean Islands (COI) based in Mauritius; and the Coastal and Marine Sub-programme of the African Union's New Economic Partnership for African Development (NEPAD) based in Midrand, South Africa.

Table 20: Western Indian Ocean Intergovernmental agreements

Type	Agreement
Intergovernmental Agreements	The Convention for the Protection, Management and Development of the Marine and Coastal Environment of the Eastern African Region (The Nairobi Convention)
	Indian Ocean Tuna Commission (IOTC)
	South west Indian Ocean Fisheries Commission (SWIOFC)
	South Indian Ocean Fisheries Agreement (SIOFA)
	Indian Ocean MOU on Port State Control
Regional Economic Organisations	African Union (AU)
	The Southern African Development Community (SADC)
	The Common Market for Eastern and Southern Africa (COMESA)
	The East African Community (EAC)
	Indian Ocean Commission (COI/IOC)

Further, the countries of the region are parties to a range of relevant international agreements (Table 21) notably the 1982 United Nations Convention on the Law of the Sea (UNCLOS); the 1992 Convention on Biological Diversity, the Jakarta Mandate of which addresses marine and coastal issues; maritime pollution and safety conventions under the International Maritime Organization (IMO); and fisheries related agreements and instruments such as the 1993 FAO Compliance Agreement, the 1995 UN Fish Stocks Agreement and the FAO Fisheries Code of Conduct. All these policy and management instruments bring in a diversity of policies and governance mechanisms, many of which are regional or sectoral and if not harmonized may lead to reduplication of efforts and to conflicts, resulting in unsustainable management of the marine and coastal resources.

Further, the countries of the region are parties to a range of relevant international agreements (Table 22) notably the 1982 United Nations Convention on the Law of the Sea (UNCLOS); the 1992 Convention on Biological Diversity, the Jakarta Mandate of which addresses marine and coastal issues; maritime pollution and safety conventions under the International Maritime Organization (IMO); and fisheries related agreements and instruments such as the 1993 FAO Compliance Agreement, the 1995 UN Fish Stocks Agreement and the FAO Fisheries Code of Conduct. All these policy and management instruments bring in a diversity of policies and governance mechanisms, many of which are regional or sectoral and if not harmonized may lead to reduplication of efforts and to conflicts, resulting in unsustainable management of the marine and coastal resources.

The status of ratification of these conventions and agreements by the WIO Countries is presented in Appendix V. These are a significant number of instruments to bring challenges to the countries if strategies are not put in place to ease their implementation.

Table 21: International Agreements to which WIO Region Countries are party

Category	Multi-lateral Agreements
Marine Related	Convention on Wetlands of International importance especially as Waterfowl Habitat (RAMSAR 1971) Convention on the prevention of pollution from Ships (1973), as modified by the Protocol of 1978 (MARPOL) United Nations Convention on the Law of the Sea (UNCLOS), 1982 Convention on the Protection, Management and Development of the Marine and Coastal Environment of the Eastern African Region and related protocols (Nairobi Convention), 1985 Jakarta Mandate on Marine and Coastal Biological Diversity, 1995 (programme of action) Convention for the Regulation of Whaling, 1946 International Convention on Civil Liability for Oil Pollution Damage (CLC), 1969 Protocol of 1976 to amend the CLC (PROT-CLC), 1976 International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage (FUND), 1971 Protocol amending the (FUND- PROT), 1976 Convention for the Safety of Life at Sea (SOLAS), 1974 Convention on the International Regulations for Preventing Collisions at Sea, 1972 Convention on Load Lines, 1966 Convention on Standards of Training and Certification of Watch Keepers (STCW), 1978 Agreement on the Organization for Indian Ocean Marine Affairs, 1990 Agreement for the Establishment of the Indian Ocean Tuna Commission, (Established under Article XIV of the FAO Constitution), 1996 Treaty on the Prohibition of the Emplacement of Nuclear Weapons and other Weapons of Mass Destruction on the Sea Bed and the Ocean Floor and in the Subsoil thereof, 1971
Biodiversity Related	African Convention for the Conservation of Nature and Natural Resources (Algiers Convention), 1968; Revised African Convention (Algiers Convention), 2003 Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES), 1973 Convention on Biological Diversity (CBD), 1992 Bonn Convention on Migratory Species (CMS), 1994: African-Eurasian Waterbird Agreement (AEWA), the largest agreement developed so far under CMS The Conservation and Management of Marine Turtles and their Habitats of the Indian Ocean and South East Asia (MT-IOSEA) Cartagena Protocol on Biosafety, 2003 International Plant Protection Convention, 1971 Revised text on International Plant Protection Convention, 1990
Atmosphere Related	United Nations Framework Convention on Climate Change (UNFCCC), 1992 UNFCCC Protocol, Kyoto, 1997 Vienna Convention for the Protection of the Ozone Layer, 1985 Montreal Protocol on substances that deplete the Ozone, 1987 Amendment to the Montreal Protocol (London), 1990 Amendment to the Montreal Protocol (Copenhagen), 1992 Amendment to the Montreal Protocol (Montreal), 1997 Amendment to the Montreal Protocol (Beijing), 1999 African Nuclear Weapons Free Zone Treaty, 1996
Chemicals Related	Stockholm Convention on Persistent Organic Pollutants, 2001 Basel Convention on the Control of Transboundary Movement of Hazardous Wastes, 1989 Rotterdam Convention 1988 Bamako Convention on the Ban of the import into Africa and the control of transboundary movement and management of hazardous wastes within Africa, 1991 Ban Amendment to the Basel Convention, 2005
Other Agreements	New Economic Partnership for Africa's Development (NEPAD), 2001 Agenda 21 and Johannesburg Plan of Implementation, 2002 Southern Africa Development Community (SADC), 1992 Cotonou Agreement, 2000 ACP-EU Economic partnership agreements World Trade Organisation (WTO) General Agreement on Tariffs and Trade (GATT), 1947
Others	Treaty Banning Nuclear Weapon Tests in the Atmosphere, in Outer Space and Under Water, 1963 Convention for the Protection of the World Cultural and Natural Heritage, 1972 Convention on the Prohibition of Military or any other Hostile Use of Environmental Modification Techniques, 1977

Table 22: International Agreements to which WIO Region Countries are party

Category	Multi-lateral Agreements
Marine Related	Convention on the High Seas, 1958 Convention on Wetlands of International importance especially as Waterfowl Habitat (RAMSAR 1971), 2001 Convention on the prevention of pollution from Ships (1973), as modified by the Protocol of 1978 (MARPOL) United Nations Convention on the Law of the Sea (UNCLOS), 1982 Convention on the Protection, Management and Development of the Marine and Coastal Environment of the Eastern African Region and related protocols (Nairobi Convention), 1985 Jakarta Mandate on Marine and Coastal Biological Diversity, no date (programme of action) (sic) Convention for the Regulation of Whaling, 1946 (sic) Convention on Fishing and Conservation of the Living Resources of the High Seas, 1958 Convention on the Territorial Sea and Contiguous Zone, 1958 International Convention on Civil Liability for Oil Pollution Damage (CLC), 1969 Protocol of 1976 to amend the CLC (PROT-CLC), 1976 International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage (FUND), 1971 Protocol amending the (FUND- PROT), 1976 Convention for the Safety of Life at Sea (SOLAS), 1974 Convention on the International Regulations for Preventing Collisions at Sea, 1972 Convention on Load Lines, 1966 Convention on Standards of Training and Certification of Watch Keepers (STCW), 1978 Agreement on the Organisation for Indian Ocean Marine Affairs, 1990 Agreement for the Establishment of the Indian Ocean Tuna Commission, (Established under Article XIV of the FAO Constitution),. The agreement was concluded in 1993 and came into force in in 1996 Treaty on the Prohibition of the Emplacement of Nuclear Weapons and other Weapons of Mass Destruction on the Sea Bed and the Ocean Floor and in the Subsoil thereof, 1971
Biodiversity Related	African Convention for the Conservation of Nature and Natural Resources (Algiers Convention), 1968; Revised African Convention (Algiers Convention), 2003 Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES), 1973 Convention on Biological Diversity (CBD), 1992 Bonn Convention on Migratory Species (CMS), 1994: African-Eurasian Waterbird Agreement (AEWA), the largest agreement developed so far under CMS The Conservation and Management of Marine Turtles and their Habitats of the Indian Ocean and South East Asia (MT-IOSEA) Cartagena Protocol on Biosafety, 2003 International Plant Protection Convention, 1971 Revised text on International Plant Protection Convention, 1990
Atmosphere Related	United Nations Framework Convention on Climate Change (UNFCCC), 1992 UNFCCC Protocol, Kyoto, 1997 Vienna Convention for the Protection of the Ozone Layer, 1985 Montreal Protocol on substances that deplete the Ozone, 1987 Amendment to the Montreal Protocol (London), 1990 Amendment to the Montreal Protocol (Copenhagen), 1992 Amendment to the Montreal Protocol (Montreal), 1997 Amendment to the Montreal Protocol (Beijing), 1999 African Nuclear Weapons Free Zone Treaty, 1996
Chemicals Related	Stockholm Convention on Persistent Organic Pollutants, 2001 Basel Convention on the Control of Transboundary Movement of Hazardous Wastes, 1989 Rotterdam Convention 1988 Bamako Convention on the Ban of the import into Africa and the control of transboundary movement and management of hazardous wastes within Africa, 1991 Ban Amendment to the Basel Convention, 2005
Other Agreements	New Economic Partnership for Africa's Development (NEPAD), 2001 Agenda 21 and Johannesburg Plan of Implementation, 2002 Southern Africa Development Community (SADC), 1992 Cotonou Agreement, 2000 ACP-EU Economic partnership agreements World Trade Organisation (WTO) General Agreement on Tariffs and Trade (GATT), 1947

Category	Multi-lateral Agreements
Others	Treaty Banning Nuclear Weapon Tests in the Atmosphere, in Outer Space and Under Water, 1963 Convention for the Protection of the World Cultural and Natural Heritage, 1972 Convention on the Prohibition of Military or any other Hostile Use of Environmental Modification Techniques, 1977

Regional Institutional Arrangements

Regional Intergovernmental Secretariats

Nairobi Convention Secretariat

The Nairobi Convention is coordinated by a Secretariat hosted by UNEP under the Division of Environmental Policy Implementation (DEPI). The Secretariat is supported by a Regional Coordinating Unit in Seychelles, (EAF/RCU), a forum of national focal points, and thematic and technical task forces. The Secretariat is guided by the governments of the region through a network of national focal points and thematic experts groups such as Coral Reef Taskforce; Marine Turtle Task Force; Marine Protected Areas; and Legal and Technical Working Group. The Secretariat also works closely with collaborating partners such as regional NGOs and various national and research institutions. It has recently successfully catalyzed the establishment of the "Consortium for Conservation of Coastal and Marine Ecosystems in the Western Indian Ocean" (WIO-C). This is a consortium between major NGOs in the Western Indian Ocean which have developed marine programmes. The aim is to enhance collaboration, exchange of information and synergy towards a joint programmatic approach in addressing marine and coastal environmental issue in the region.

The Contracting Parties of the NC meet every two years and are assisted by a Bureau of the Chair Person, three Deputy Chair Person, and a and Rapporteur and their function is to assist the Secretariat in decision making during the intercessional period.

The implementation of the Nairobi Convention has faced a number of problems and challenges that have affected its performance. These include inadequate financial resources and lack of capacity for implementing the Nairobi Convention, and its Protocols and Action Plan. However, regular Contracting Party meetings and other associated activities have provided an opportunity for the countries to exchange ideas, a factor which has influenced the direction of national actions in relation to the management of coastal and marine environment. The establishment of the EAF/RCU in Seychelles has strengthened the Nairobi Convention and related protocols in a number of ways. It has, for instance, encouraged the ratification of the Convention and the regular holding of meetings of the Contracting Parties that has led to the increased contribution by the contracting parties to the Trust Fund. It has also helped develop and update the programme of action and provide a regional framework for the implementation of regional and global action plans of conventions such as the Convention on Biological Diversity and the Global Programme of Action for the Protection of the Marine Environment from Land-based Activities The later has led to the development and signing of the LBA protocol

SWIOFC Secretariat

The governing body of SWIOFC is the Commission. It is composed of all Members. Meetings of the Commission are held at least once every two years. The Commission has established a Scientific Committee to consider the state of fisheries in the area of competence and to advise on the scientific basis for possible regulatory measures to be considered for adoption by the members of the Commission. The Commission may establish on an ad hoc basis such other committees or working parties as it may consider necessary on problems of major importance or of a specialised nature. The Commission has established one working party on fisheries data and statistics.

The Secretariat is provided by FAO Subregional Office for Southern Africa (SFS). It is based in Harare, Zimbabwe. SWIOFC is a member of the Regional Fishery Body Secretariats Network that meets biennially.

Part of the motive for establishing SWIOFC was that FAO research studies showed that in the entire West Indian Ocean -- the larger region encompassing the zone where SWIOFC would operate - 75 per cent of

fishery resources were being fished at their maximum biological productivity. The other 25 per cent were overexploited and required better management. But breaking that down to get an accurate picture of the state of stocks in the South-Western Indian Ocean is difficult, since data collection there is weak or non-existent. It is known that catches have grown by over 10 per cent over the last decade, with landings in 2001 (319,000 tonnes) representing an all-time high. However, the FAO statistical reviews show that as much as 33 per cent of catches are not identified by species, making analysis of the status of stocks -- and, by extension, responsible management - difficult. "These data gaps are why it's important to have a body like SWIOFC to help improve data monitoring and collection", says Jean François Pulvenis de Séligny, Director of FAO's Fishery Policy and Planning Division, adding that a strong and sustained commitment by the commission's members is necessary to ensure it will meet its goals.

As such the Scientific Committee was established to focus on fisheries data collection and on providing resource managers with much-needed information on the status of stocks and to advise on the scientific basis for possible regulatory measures to be considered for adoption by the individual member states of the Commission – for the Commission itself has no power to adopt collective binding regulatory measures.

IOTC Secretariat

Membership of IOTC is open to Indian Ocean coastal countries and to countries or regional economic integration organisations which are members of the UN or one of its specialized agencies and are fishing for tunas in this ocean. Sessions of the Commission are normally held annually. The officers of the Commission are elected from the delegates or alternates present at Commission meetings and hold office for a biennium.

Sub-commissions will be open to those Contracting Parties which are coastal States lying on the migratory path of the stocks concerned in the sub-commission or are States whose vessels participate in the fisheries of these stocks. They will provide a forum for consultation and cooperation on matters related to the management of the stocks concerned. In particular, they will examine management options and recommend to the Commission appropriate management measures. To date, no sub-commissions have been constituted. These bodies will become necessary when the Commission has determined that management of certain stocks is needed.

The Scientific Committee was formally created at the First Session of the Commission. This body will advise the Commission and sub-commissions on research and data collection, on the status of stocks and on management issues. The meetings of the Scientific Committee are held conjointly with those of the Commission. Working Parties are established by the Scientific Committee and endorsed by the Commission. The primary function of the Working Parties is to analyse in more detail, technical problems related to the management goals of the Commission. For example, Working Parties related to the different species analyse the status of the stock and offer options to the Scientific Committee for management recommendations to the Commission

In 2007, the IOTC in response to calls from the international community concerned at the ineffectiveness of many Regional Fisheries Management Organisations (RFMOs) commissioned a Performance Review. The 2009 Report of the Review Process highlights why the IOTC as currently constituted is not an appropriate body to implement an ecosystem approach.

SIOFA

The Secretariat for SIOFA is in the process of establishment. The Agreement was negotiated under the auspices of FAO in 2006 and signed by six states: the Comoros, France, Kenya, Mozambique, New Zealand and Seychelles, plus the European Union. The South Indian Ocean Fisheries Agreement (SIOFA) is aimed at ensuring the long-term conservation and sustainable use of fishery resources other than tuna in areas that fall outside national jurisdictions, taking into account the needs of developing States bordering the Area that are Contracting Parties to this Agreement, and in particular the least-developed among them and small island developing States. SIOFA has not come into force. With the expected signing of Australia, the Agreement will come into force and is expected to have the same institutional structure as SWIOFC or IOTC, being a Regional Fisheries Management body.

There is overlap between areas of application of SIOFA and the IOTC, however the two agreements are responsible for different species of fish. Whereas the IOTC has a mandate for tuna and tuna-like highly

migratory fish, the SIOFA is concerned with other fish species, with particular focus on demersal species (such as orange roughy) which have attracted significant fishing effort. Further there issues with regard to coming into force of SIOFA which include:

1. The widespread consensus that the new Agreement was too little, too late.
2. That there are only a few boats on the high seas now, so the work (and costs) involved in setting up an international arrangement makes it hard to justify support for SIOFA;
3. In the case of Australia, the UNGA Resolution 61/105 on Sustainable Fisheries will be strictly applied by Australia (given that Australia introduced the UN Resolution).
4. Similarly, states such as South Africa, New Zealand, Canada and the United States, (which strongly supported the Resolution), will also act to prevent their vessels engaging in an unregulated fishery operating in the Southern Indian Ocean area. The problem remains those states which will not exercise strong flag state jurisdiction to control their fleets.

Secretariats of Other Intergovernmental Agreements

African Union

The African Union consists of 53 African states, including all the ASCLME states. Established on 9 July 2002, the AU is a successor to the Organization of African Unity (OAU). The most important decisions of the AU are made by its assembly, a semi-annual meeting of the heads of state and government of its member states. The AU's Secretariat, the African Union Commission, is based in Addis Ababa, Ethiopia.

An important aspect of the organizational structure is the Specialized Technical Committees that are bodies in the African Union responsible to the Executive Council. They include:

- The Specialized Technical Committee on Rural Economy and Agricultural Matters.
- The Specialized Technical Committee on Monetary and Financial Affairs.
- The Specialized Technical Committee on Trade, Customs and Immigration Matters.
- The Specialized Technical Committee on Industry, Science and Technology, Energy, Natural Resources and Environment.
- The Specialized Technical Committee on Transport, Communications and Tourism.
- The Specialized Technical Committee on Health, Labor and Social Affairs.
- The Specialized Technical Committee on Education, Culture and Human Resources.

Although all these Specialized Technical Committees have a bearing to the work of ASCLME Project and SWIOFP, the most relevant is the Specialized Technical Committee on Rural Economy and Agricultural which oversees AU-IBAR. The AU has only started addressing issues on fisheries and related LMEs.

The Southern African Development Community (SADC)

On August 17, 1992, at their Summit held in Windhoek, Namibia, the Heads of State and Government signed the SADC Treaty and Declaration that effectively transformed the Southern African Development Coordination Conference (SADCC) into the Southern African Development Community (SADC). The objective also shifted to include economic integration following the independence of the rest of the Southern African countries. Currently SADC has a membership of 15 Member States Madagascar, Mauritius, Mozambique, Seychelles, South Africa, and United Republic of Tanzania which are WIO countries.
In response to the threat of IUU fishing, the SADC ministerial conference in Windhoek culminated in Ministers of the respective fisheries departments of eight of the coastal SADC states signing a 'statement of commitment' (SoC) to halt IUU fishing in the region. . However, this action has not contributed to increasing the capacity of SADC Secretariat for implementation of the commitments to stop IUU fishing. Hence the capacity of SADC Secretariat for coordinating coastal and marine resources is still very weak.

The East African Community (EAC)

The East African Community (EAC) is the regional intergovernmental organization of the Republics of Kenya, Uganda, Rwanda, Burundi and the United Republic of Tanzania. Its headquarters is located in Arusha, Tanzania.

The EAC Protocol on Environment and Natural Resources Management was signed on 30 November 1999. This is a very ambitious and comprehensive instrument which covers virtually all aspects of environmental and natural resource management and envisages a degree of legal and functional integration similar to the common environmental law of the European Union. Of specific interest to the ASCLME region are Articles 15 and 16 of the Protocol which provide respectively for the cooperative management of coastal and marine resources and of fisheries. The main weakness of the EAC is the capacity to address marine and coastal issues

Indian Ocean Commission (IOC)

The Indian Ocean Commission (IOC) was created in 1984 by the General Agreement of Victoria, Seychelles. It is an intergovernmental organization between Comoros, Madagascar, Mauritius, France (on behalf of Réunion) and the Seychelles to encourage diplomatic, economic and commercial cooperation between member States. The Commission is currently administering projects worth some 62 million Euros; its work is directed towards the protection of the interests of the island member states of the Indian Ocean in international and regional forums, protection of the environment and natural resources and regional human development. In February 2010 the Indian Ocean Commission completed a Feasibility Assessment of an ICZM Protocol to the Nairobi Convention which recommended further exploration of a protocol for East Africa – suggesting that the negotiation process itself would be a major capacity building exercise for the region. A Regional Working Group has been established the Nairobi Convention for the drafting of a new Protocol on Integrated Coastal Zone Management (ICZM. The Secretariat of COI is based in Mauritius.

Common Market for Eastern and Southern Africa (COMESA)

COMESA Agreement was signed on December 8th 1994, thus replacing the old PTA Agreement. Currently COMESA does not address issues of marine and coastal. It is expected that in the future COMESA like other RECS will address marine and coastal economic based activities

Regional Non-Governmental Organizations/Bodies (NGOs)

Western Indian Ocean Marine Science Association (WIOMSA)

The Western Indian Ocean Marine Science Association (WIOMSA) is a regional professional, non-governmental, non-profit, membership organization, registered in Zanzibar, Tanzania, and established in 1993. The organization is dedicated to promoting the educational, scientific and technological development of all aspects of marine sciences throughout the region of Western Indian Ocean (Somalia, Kenya, Tanzania, Mozambique, South Africa, Comoros, Madagascar, Seychelles, Mauritius, Reunion (France)), with a view toward sustaining the use and conservation of its marine resources. The Association has about 1000 individual members as well as about 50 institutional members from within and outside the region.

Recently, WIOMSA also signed Memorandum of Understanding with UNEP as the secretariat to the Nairobi Convention, whereby WIOMSA will be responsible for providing research, technical, managerial and advisory support to UNEP as requested. WIOMSA in collaboration with UNEP is hosting a regional Group of Experts on Marine Protected Areas for the Eastern African region (GEMPA). GEMPA has been established with the aim of building a constituency for marine protected areas in the region and to provide a forum for linkages and dialogue between MPA practitioners and experts, and between government and non-government organizations.

WIOMSA is also a key player in a number of important partnerships including: Forum of Heads of Academic/ Research Institutions in the WIO regions (FARI)
Socioeconomic Monitoring Network, Western Indian Ocean (SocMon WIO)

WWF East African Marine Eco-Region (WWF-EAME)

Building on the WWF East African Marine Ecoregion Programme , the WWF's Coastal East Africa initiative aims to catalyze opportunities to create lasting transformational change – change that will ensure that the region's natural capital positively contributes to people's livelihoods and economic development. The initiative focuses on three key areas:

- Strengthening institutions and policies
- Promoting responsible trade and investment

- Addressing emerging threats and adopting best practices

The initiative is coordinated from WWF Offices based in Dar es Salaam

Coastal Ocean Research and Development in the Indian Ocean (CORDIO)

The Coral Reef Degradation in the Indian Ocean Initiative initiated in 1999 (and now Coastal Ocean Research and Development in the Indian Ocean (CORDIO) as a direct response to the El-Niño related mass bleaching and mortality of corals in the Indian Ocean in 1998, focusing initially on Eastern Africa, Western Indian Ocean Islands and South Asia. Since the Indian Ocean tsunami in 2004 the programme also covers the Andaman Sea, and from 2007 has started work in the Red Sea.

Consortium for the Conservation of Coastal and Marine Ecosystems in the Western Indian Ocean (WIO-C)

The Consortium for the Conservation of Coastal and Marine Ecosystems in the Western Indian Ocean (WIO-C) was officially launched at the Fifth Meeting of the Contracting Parties to the Nairobi Convention held in Johannesburg, South Africa in November 2007. The founding members included a group of like-minded international and regional organizations and agencies who wished to work together to support partnerships that advance marine research, conservation and management in WIO region. Founding members of the WIO-C included IUCN, WCS, WIOMSA, WWF, EAWLS, CORDIO, IOC, IOC-UNESCO, Nairobi Convention and NEPAD-Cosmar. Other organisations such as Birdlife International, Wetlands International, Blue Ventures, Rare and TNC have since then become full members of the Consortium. The objective of the WIO-C is to align, harmonize, and move forward marine and coastal management activities within the context of a regional and country level framework. WIO-C's vision is that the Western Indian Ocean's unique and globally significant natural resource base provides the essential goods and services that support biodiversity as well as economic development and the livelihoods of present and future generations.

WIO-C's Mission is to achieve a healthy marine and coastal environment that sustainably supports people's livelihoods in WIO-region.

In order to achieve the above, the WIO-C undertakes to:

- Support synergy in programmes of work on marine and coastal ecosystem management and promote knowledge and information sharing amongst stakeholders in the Western Indian Ocean region.
- Provide a mechanism for non-governmental entities to anchor activities in the Nairobi Convention and other intergovernmental and regional processes and thus strengthen harmonization and alignment

The main activities of the WIO-C are intended to focus on networking, coordination, lobbying, decision support, resource mobilisation, and programme development and implementation.

The Western Indian Ocean Coastal Challenge (WIO-CC)

The WIO-CC was first proposed by President James A. Michel, Government of the Seychelles, in 2007 as a "platform to galvanize political, financial and technical commitments and actions at national and regional levels on climate change adaptation, promoting resilient ecosystems (marine and coastal resources), sustainable livelihoods, and human security".

To realise this broad objective extensive consultations have been held over the past three years among regional government representatives, members of intergovernmental organizations, multilaterals and non-governmental organizations facilitated through the Global Island Partnership (GLISPA) and often hosted by the Government of the Seychelles at significant international meetings including the United Nations Framework on the Convention for Climate Change (UNFCCC) and the Convention of Biological Diversity (CBD) Conferences of the Parties (COP).

The concept of the WIO-CC is to mobilize countries that share the ocean's vast and resource rich waters and coasts to come together and commit to action towards island (and more recently WIO coastal states) conservation and sustainable livelihoods including responses to the threat posed by climate change, including ecosystem based adaptation over the next twenty years. With a focus on coastal and marine zones, the WIO-CC will build on the long-standing efforts of regional organizations including the Indian Ocean Commission and Nairobi Convention by focusing on the following:

- Countries and territories at both the development and implementation level with a focus on local and

national needs and priorities
- Strengthening and aligning with existing conventions, strategies, action plans, networks, and partnerships as the basis for action
- Broader coastal zone management approach to ensure sustainable coastal economies and communities and safeguard the resilience of the region's marine and coastal ecosystems"
- Evidence and science-based approaches to integrated coastal zone management

The concept of the WIO-CC is based on other similar regional high-level political tangible commitments in Micronesia, the Coral Triangle and the Caribbean, which have been able to leverage extensive global attention and resources, and are recognized as a credible mechanism for advancing conservation of island biodiversity. Following on from the extensive consultations carried out over the last three years, the next step was to operationalize the Challenge through the creation of a Regional WIO – CC Platform under the leadership of the Seychelles. This Platform was launched during the 1st Regional Technical Meeting held in Seychelles in March 2012. The Platform and the actions needed to move forward in operationalizing the WIO - CC will initially (in the short-term) be supported as part of implementation of the SIDS Mauritius Strategy with funding from the European Union (ISLANDS Project). In addition, support has been provided from the ongoing WCS ABCG-funded project on 'undertaking a stocktaking exercise to identify gaps, opportunities, and lessons learned for marine and coastal resources conservation and management, with a focus on climate vulnerability and adaptation, in the Western Indian Ocean', which has as one of it's key outputs for 2012, the establishment of a partnership between the WIO – C and the ISLANDS project (based at the IOC) for the implementation of two of the ISLANDS project flagship activities: operationalization of the WIO-CC, and the Coral Reef Task Facility. An important element of this process is to ensure the full participation of both SIDS and Eastern African nations (who are currently not supported through the ISLANDS project).

South Indian Ocean Deep Sea Fishing Association (SIODFA)

South Indian Ocean Deep Sea Fishing Association (SIODFA) vessels have been engaged in a voluntary programme of collection of biological data of species targeted by the fishery, primarily orange roughy and alfonsino and also data on by catch of coldwater corals and deepwater sharks. Several of the Association's vessels have also been undertaking aggregation-based acoustic stock-assessment surveys as an integral part of their commercial fishing operations. All of the Association's vessels are equipped with the advanced acoustic systems needed to undertake such quantitative assessment surveys.

Management and Governance of ABNJ in the Context of Developing an LME-Based Regional Governance Strategy for the WIO

Seabed Exploration and Exploitation

The International Seabed Authority has jurisdiction over the non-living resources of the seabed in the area beyond national jurisdiction – termed 'the Area' by the LOS Convention. For technical purposes this means that all states may claim jurisdiction over seabed resources out to the 200 nautical mile limit from their coastal baselines, but in the case of states whose geological continental shelf extends beyond 200 nm (broad margin states) then they may claim such jurisdiction out to the physical limit of their continental shelf – in some case to 350 nm and beyond. A number of Western Indian Ocean States are broad margin states and have made applications to the Continental Shelf Commission (CSC). The CSC has such a heavy workload that it seems unlikely that these claims will be reviewed in the near future, so many of these claims are simply 'place holders' until the states can submit detailed geological data to support their claims. The Claim submitted jointly by Seychelles and Mauritius has already been considered by the Commission.

Beyond the areas of national continental shelf claims, the seabed is termed 'the common heritage of mankind' and known as the 'Area'. In the Area the LOSC gives exclusive jurisdiction to the ISA to regulate exploitation and exploitation of what the 1982 Convention terms 'solid, liquid or gaseous mineral resources.' The regime is now well developed; the ISA has developed the 1982 regime by the approval of Regulations– relating to the exploration and exploitation of manganese nodules – the Nodules Regulations and of sulphides- the Sulphides Regulations.

In terms of impacts from Seabed Activities in the Indian Ocean, at present the only sites which have been

approved by the ISA for mining in the Indian Ocean are in the Mid Indian Basin.

Regulation of Shipping Activities

At a global level, shipping activities are governed by a complex network of specialized conventions – sponsored generally by the International Maritime Organization (IMO).

Under the 1974/78 MARPOL Convention regulating the carriage of a range of hazardous and polluting materials, the parties can agree to the designation of Special Areas – even in ABNJ areas – where high requirement t are put in place for 'at sea discharges provided that the coastal states nearby have adequate reception facilities for the collection and safe disposal of these materials from vessels putting into their posts [insert section on Indian Ocean Special Areas]

Regional Seas Convention

As discussed above the relevant UNEP regional seas Convention is the Nairobi Convention. Its jurisdiction does not extend into areas beyond national jurisdiction.

Fishing Agreements in ABNJ

There are two fisheries agreements whose jurisdiction extends over vessels fishing in ABNJ. The Indian Ocean Tuna Convention (IOTC) and a second agreement intended to complement the South West Indian Ocean Fisheries Commission (SWIOFC) by regulating fishing for non-tuna species outside national waters – the Southern Indian Ocean Fisheries Agreement (SIOFA) which is designed to regulate fishing for deep sea species such as orange roughy on seamounts. This has just entered into force.

Two Important New Concepts

Over the last decade international concern has been growing at the lack of an adequate comprehensive framework for high seas governance, and within the context of the UN General Assembly and the Convention on Biological Diversity, two new concepts designed to protect important areas in ABNJ have emerged which will also be of major significance for the Western Indian Ocean region. These concepts are Vulnerable Marine Ecosystems (VMEs) and Ecologically and Biologically Significant Areas (EBSAs).

With the entry into force of the SIOF Agreement, that will be the international body with responsibility for developing regional provisions relating to the protection of vulnerable marine ecosystems in the Indian Ocean area, under the FAO International Guidelines for the Management of Deep-Sea Fisheries in the High Seas designed to assist States and regional fisheries management organizations and arrangements in sustainably managing deep-sea fisheries. These guidelines were adopted in August 2008 (FAO 2009).

The development and approval by the CBD COP10 of criteria for the description of "Ecologically and Biologically Significant Areas" (EBSAs) provides a major incentive for the protection of such areas once they have been described and a series of international workshops have been convened by the CBD Secretariat to identify marine areas – including high seas areas which can be described as EBSAs. The CBD Scientific Workshop to describe EBSAs in the Western Indian Ocean was held in Seychelles in 2012.

Towards an LME-Based Regional Governance Strategy

The countries of the Western Indian Ocean Region have agreed that the application of an LME governance approach, based on the advice of science, is required to address the diverse cultures, multi-agencies and multi-stakeholders, different national and regional management regimes as well as the challenges posed by ecosystem variability influenced by climate change and the sustainable management of sea areas beyond national jurisdictions (i.e outside the EEZs). Currently there is no single mechanism that lends itself to support an integrated region-wide approach to the governance of marine and coastal resources in the WIO region. As a consequence the countries are not optimizing the benefits from the goods and services provided by marine and coastal resources. This is critical considering that most of the countries have high levels of poverty and lack food security.

It is clear from the data collected above that the Western Indian Ocean has an unusually large number of sectoral regional treaty regimes, and that a considerable amount of financial resources is being channeled to marine environmental concerns through the UN Agencies, the GEF, the World Bank, the European Union, NGOs and the private sector. These resources will be optimized immensely if there was a mechanism for collaboration/cooperation and partnering through the application of an ecosystem based governance system. In designing such a system, it is worth recalling the essential elements of such an approach. A paper prepared for the 2010 Global Ocean Forum examined the various definitions endorsed by countries legislation and commentators and extracted the key common principles.

Implementing these objectives at a regional, multinational level poses specific challenges. The fact remains however that a regional governance strategy which encompasses all the separate elements necessary for an LME based ecosystem approach will need co-ordination and collaboration and that the range of issues involved suggest that no single existing body has the range of expertise, financial resources and the legal competence to take on such a role. This role needs to be exercised by the countries of the region at the highest-level and through a dedicated collaboration mechanism that can draw on the full range of national and regional skills and competences.

Analysis of the data and information provided by the Regional Policy and Governance Assessment report and the supporting information from the National Policy and Governance Assessments reports as well as expressions during various national, regional and international fora presents the following regional ecosystem based governance options:

- Business as usual
- Enhancement of an existing institution with new powers
- Establishment of a new institution
- Informal collaboration mechanism

The strengths and weaknesses of each one of them is presented below.

Business as usual –maintain the status quo.

Virtually all the national reports developed in this Assessment process as well as a series of reports prepared by the wider project and other financed projects have highlighted the defects of the current situation. Apart from specifically funded, project based activities and the activities of sectoral organizations discussed later, there are very few systemic transboundary collaborative management activities in the region.

Enhancement of existing institution – to give it wider powers

The Western Indian Ocean Region has a plethora of regional institutions that have legal competence in relation to various and diverse aspects of marine resource management in the region. These range from the Nairobi Convention primarily concerned with biodiversity issues, land based pollution, and possibly coastal zone management, through SWIOFC which is an advisory body on fisheries issues and restricted to EEZ resources to the tuna RFMO IOTC and SIOFA – the non-tuna RFB. All these treaty regimes have clear but separate mandates.

Therefore, despite, or perhaps because of, the large number of regional bodies that exist in the WIO regions there does not seem to be an obvious candidate for a leadership role in promoting the co-ordination of ecosystem based management for the LME as a whole.

Establishment of a new institution

Other GEF financed LME projects have sought to develop new institutions to take on an LME management role after the GEF project funding has been exhausted.

However it is clear that there is little appetite in the WIO region for a similar approach with the ASCLME/ SWIOF Projects. Participating countries have expressed concern on a number of occasions – including at Steering Committee meetings of the ASCLME Project - that they are not interested in supporting the creation of an Agulhas and Somali Currents Commission. The ASCLME Project Manager has had to make explicit assurances that this is not the intent of the project on a number of occasions.

A Structured Non-Binding Collaboration and Cooperation Mechanism

A new Commission is not the only model for the establishment of a region wide collaborative arrangement. In East Asia a new model has been remarkably successful. Partnerships in Environmental Management for the Seas of East Asia (PEMSEA), has eleven states in it partnership -which has been formalized by the Haikou Partnership Agreement and operating agreements among all the partners. These include states at very different stages of development including Cambodia, PR China, DPR Korea, Indonesia, Japan, Laos PDR, Philippines, RO Korea, Singapore, Timor Leste and Vietnam. The partnership also includes nearly 20 non-country partners such as IUCN, the International Ocean Institute and the IOC Sub-Commission for the Western Pacific. It is an arrangement based on this less formal model which seems to have arisen organically from the work of the ASCLME/SWIOFP projects. In seeking to find ways of establishing collaboration without creating new, or changing existing, institutions the model of the Western Indian Ocean Alliance is evolving.

Conclusion

These options were presented to the Joint Steering Committee Meetings of the ASCLME/SWIOFP which have endorsed the fourth option "A Structured Non-Binding Collaboration and Cooperation Mechanism. Such an approach was discussed at the First Western Indian Ocean Stocktaking Meeting for an Ecosystem-Based Management Programme, in March 2010, which was convened alongside the Conference of the Parties to the Nairobi Convention. This meeting was a high-level policy meeting of the Western Indian Ocean countries participating in ASCLME, SWIOFP and WIO-LaB along with a number of active regional and global agencies and funders. The countries and their partner agencies endorsed "the need for developing and implementing a Western Indian Ocean Sustainable Ecosystem Alliance based on the principles of ecosystem-based management, which will ensure the efforts and inputs of all stakeholders are captured and evolved into an effective regional management and governance system for the WIO LMEs".

Notes