Marine Sciences' Challenges for Sustainable Development in Mozambique

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Introduction

Mozambique possesses about:

- 571,955 km² of EEZ,
- 50,000 km² of territorial waters
- 73,307 km² of inshore fishing area
- 2,470 km of coast line (the third longest coast in Western Indian Ocean)
- 70% of the population of Mozambique live in coastal zone and gain their living out of the coastal and marine natural resources

Introduction

Biodiversity richness

Mozambique possess a diversity of habitats: sandy beaches, sand dunes, coral reefs, estuarines, bays, mangroves and seagrass beds

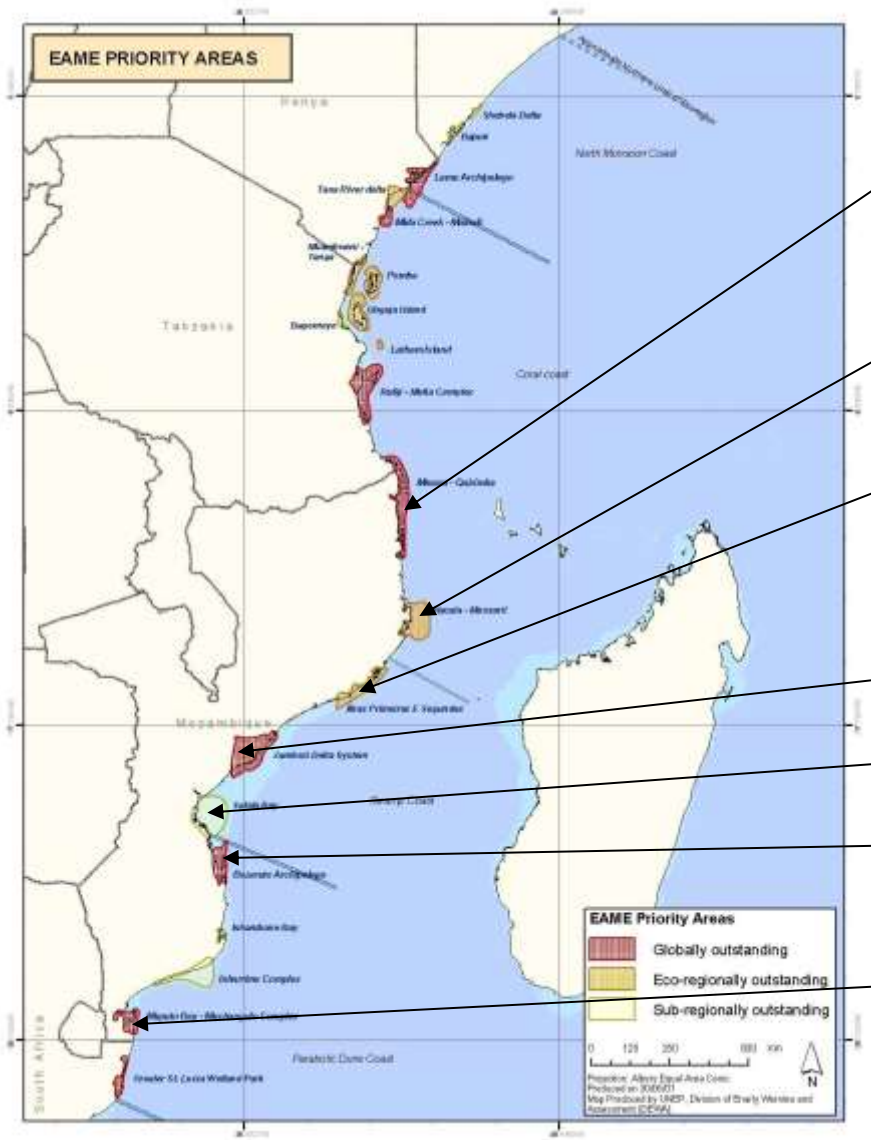
Mozambique has 9 sites of biodiversity importance out of 21 in East Africa (WWF East African eco-region)

4 of global interest

2 of regional interest

3 of local interest

Introduction



Quirimbas National Park

Nacala-Mossuril

Primeiras e Segundas Archipelago

Marromeu Complexo

Sofala Bank – Shrimp f

Bazaruto Arquipélago National Park

Maputo –Matutuine Special Reserve

Introduction

Fisheries

Overall fish production is about 115,000 to 140,000 tones per year,
87% of which is from artisanal fisheries,
with an annual income of over USD 50 Million

Basis for subsistence of the majority of coastal communities, they support the economy of the country

Introduction

Maritime transports and harbours

Mozambique harbours provide services to national and neighbouring countries (Swaziland, South Africa, Zimbabwe, Zambia, Malawi and Congo)

The total cargo handled ~8 Billions tonnes (1995/96)

Introduction

Coastal tourism

The coastal and marine areas constitute a major attraction to tourists due to their beautiful sandy beaches and extensive corals; abundant, diverse and exotic habitats and marine life.

The numbers of visitors were ~2 Million (2010/14)

Introduction

Emerging issue - offshore oil and gas

Mozambique posses abundant natural mineral resources: coal, titanium, natural gas, hydropower, tantalum and graphite, yet underexploited.

- Coal reserves:~6.7 billion tons
- Inland gas reserves: ~2.6Tcf
- Offshore oil and gas reserves: ~100Tcf

Introduction

The overall issue

In spite the thriving potential of natural marine resources and maritime services Mozambique is one of the poorest countries in the world.
The Growth Domestic Product per capita was USD646 in 2013

Further, the sustainability of these resources is at risk, challenged by a series of factors of natural as well as of anthropogenic origin.

Introduction

Natural factors are manly those brought by global climate changes such as global warming, with implication on rainfall and river runoff, draught and floods, cyclones, and sea level rise

Introduction

Anthropogenic factors:

- overharvesting of resources, heavy reliance on capture fisheries
- destruction of key habitats and ecosystems (e.g. Mangroves used for firewood, charcoal, building material)

Introduction

Major issues affecting the sustainability of coastal and marine resources in Mozambique:

- Modification of stream flow (abnormal river runoff, foods, draughts),
- Loss and modification of ecosystems and ecotones (erosion, depletion of mangroves, destruction of corals and seagrass beds),
- Over-exploitation of fisheries resources (shrimp resources, demersal fisheries), and
- Destructive fishing practices (use of mosquito nets, bottom trawling, dynamites, fish poisoning).

Introduction

The sustainability of the resources requires adoption of **scientifically sound management measures**, which requires:

- an **adequate understanding of the ecosystem structure and functioning**, knowledge about the role of the key driving factors and their reciprocal effects,
- innovative approaches on resources use,
- innovative technology for harvesting, processing and conservation of products.

These constitute the **main challenges of Marine science and Maritime technology** to development.

Introduction

Marine Science is multidisciplinary and multi-sectoral, with basic and applied science, technology and engineering.

Marine Sciences can be applied in natural resources use and exploitation, aquaculture, food security, biodiversity conservation, maritime transports, energy and security/defence, climate and climate change.

Introduction

The present dissertation discusses how Marine Sciences can address the challenges for sustainable development through marine and marine related resources.

Given the challenges coupled with limited capacity, there is a need to integrated efforts and use wisely the available resources

Hence, the need for **National Marine Science Strategic Plan**

Introduction

Based on identified overriding issues the **National Marine Science Strategic Plan** May be clustered in five main themes as follows:

- Climate and climate change
- Biodiversity conservation and ecosystem health
- Food security
- Energy security
- Service provision

Climate and climate change

The temperature rise caused by global warming has caused changes in other climate factors such as wind and rainfall patterns. Erratic rain causes changes in river flow which impact on ecosystems and living resources.
Consequences:

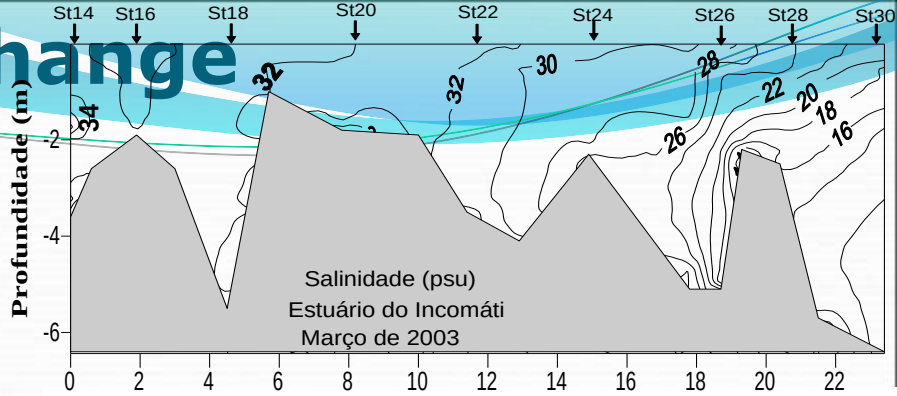
- Reduction in nutrient and sediment import to coastal waters
- Low coastal production
- Salt intrusion
- Erosion
- Reduction in fish availability

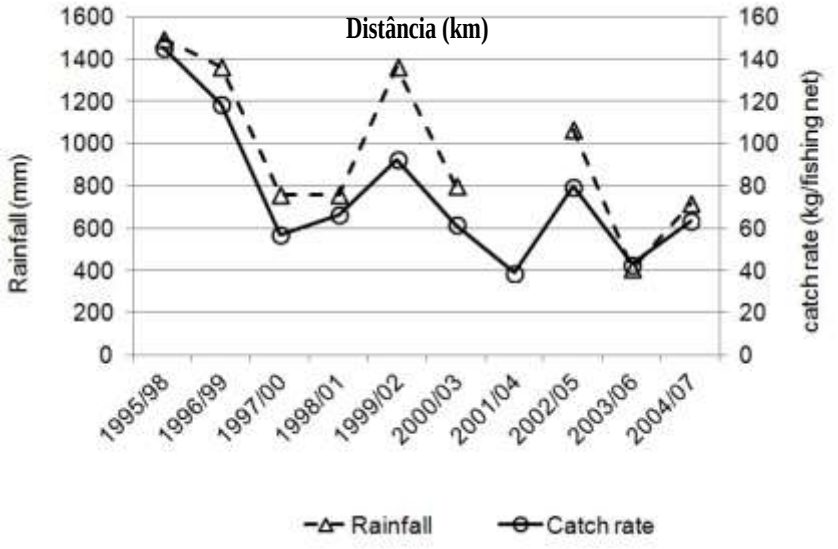
Climate and climate change

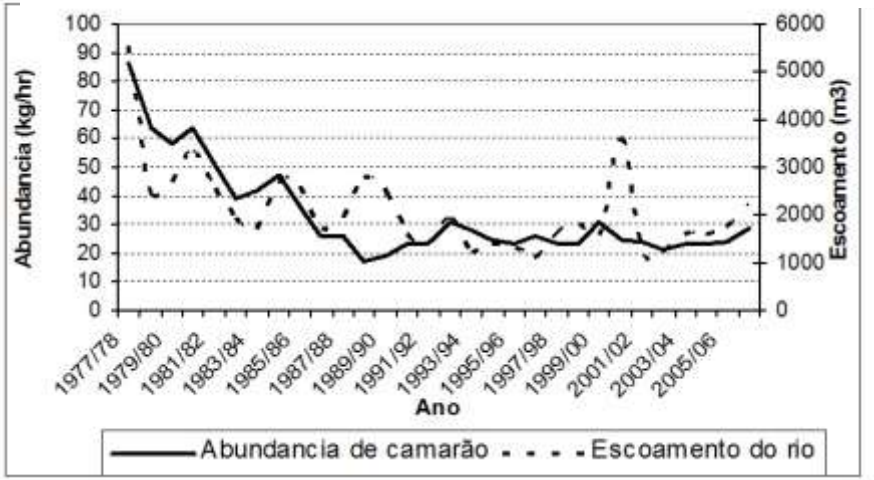
Saltwater intrusion in Incomati extends 40 to 80 km upstream

Few studies showed the influence of rainfall and of river runoff on fisheries production

Others showed the influence of river runoff on shrimp production Mozambique







Climate and climate change

Knowledge gap

Improving climate prediction and forecast – Knowledge towards understanding the influence of recurring large scale climate patterns (ENSO, IOD and PDO)

Improving understanding of the impact of climate change on ecosystems and natural resources dynamics – knowledge to contribute to the adoption of adaptation and mitigation measures for climate change impacts.

Climate and climate change

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Climate and climate change

Specific knowledge gap - Improving climate prediction and forecast:

- Understanding the variability and trends in wind patterns along the coast of Mozambique.
- Understanding the decadal variability and trends of temperatures along the coast of Mozambique
- Understanding the rainfall variations and trends in hydrology along the Mozambican coast

Climate and climate change

Specific knowledge gap - Improving climate prediction and forecast:

- Understanding the mean sea level changes in relation to changes in met-ocean and large scale climatic processes in the Mozambican coast
- Understanding and estimating of past rates of sea-level change
- Understanding the regional patterns of historical and projected sea-level change
- Understanding and estimating the effect of mean sea level and extreme events on different shoreline types

Climate and climate change

Specific knowledge gap - Improving understanding of the impact of climate change on ecosystems and natural resources dynamics:

−Understanding how the strengths and seasonality of rain and river runoff influences the hydrodynamics, biogeochemistry cycle in the estuaries and coastal waters and the productivity and fisheries production in coastal waters. There is a need to understand the coupled river basin and coastal system.

Climate and climate change

Specific knowledge gap - Improving understanding of the impact of climate change on ecosystems and natural resources dynamics:

- Understanding the adaptability of marine organisms and marine ecosystems to climate variations
- Understand the role of mangroves as carbon dioxide sequesters/sink
- Assessing food security and marine ecosystem resilience to climate change
- Understanding the effect of global warming on acidification and coral bleaching

Biodiversity conservation and ecosystem health

Major marine and coastal ecosystems: wetlands, mangroves, coral reef, coastal lagoons, river, coastal dunes and sand beaches

These ecosystems provide goods and services

Sustainable management measures should be based on science. There is a need to understand the ecosystem structure and functioning, the driving factors and their complex relationship.

Biodiversity conservation and ecosystem health

Studies conducted to understand the ecosystem:

– hydrodynamics and biogeochemistry of estuaries

– salt intrusion models

– water masses and hydrodynamics of the coastal waters

– mangroves and mangrove rehabilitation activities

– Fisheries ecology and catch

Biodiversity conservation and ecosystem health

Knowledge gap

- Lack of understanding of the ecosystem structure and functioning
- Do not know how to value the ecosystem services

Specific knowledge gap:

- Biodiversity discovery and classification – Knowledge of the distribution and abundance of organisms
- Understanding the organism-habitat relationships
- Understanding the ecosystem dynamics and functioning – Observations and experimental studies
- Assessing the cumulative impacts – given the fact that the ecosystems are under threat from multiple pressures

Biodiversity conservation and ecosystem health

Specific knowledge gap:

- Developing ecosystem models – This will allow exploration of the resilience of ecosystem components to stressors
- Harnessing the value of ecosystem and marine biodiversity richness through innovations in biodiscovery and marine biotechnology
- Understanding oceanographic processes determining the health of ecosystems
- Developing hydrodynamic models coupled with biogeochemical and sediment flux components of the estuaries and coastal waters
- Understanding the causes of erosion and of decline of ecosystem values in the river, especially in estuaries and coastal zones
- Understanding the coupled river basin and coastal system

Biodiversity conservation and ecosystem health

Knowledge gap

Specific knowledge gap:

- Understand the main drivers of ecological, hydrodynamics and morphodynamic changes downstream
- Understanding the ROFI system and its influence on the health of the ecosystems
- Understanding and modelling the effect of the waves and storm surges on the coastal ecosystems and habitats
- Conduct studies on the feasibility of existing Marine Protected Areas on conservation and protection of habitats
- Conduct studies towards identification of new potential marine protected areas
- Understanding and valuing the indigenous knowledge on ecosystem conservation

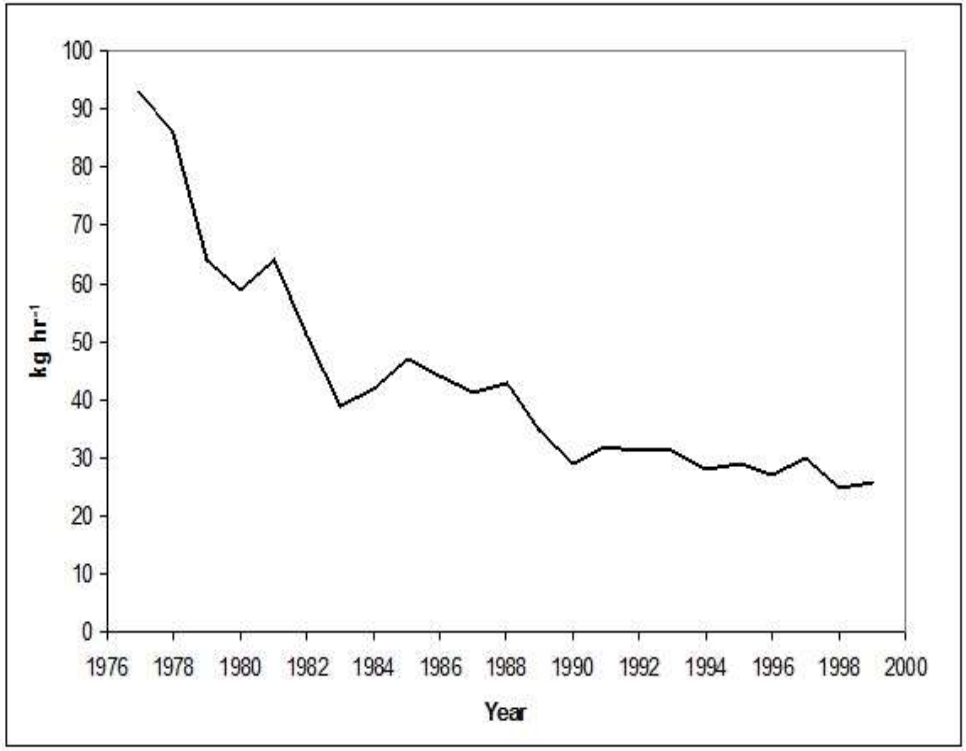
Food security

In the view of increased population food security becomes a challenge. Need to develop means of **producing more food**, in **small space** and **short time** – food production efficiency

Fisheries and aquaculture may become important.

Fisheries threatened by overexploitation, destruction of sustaining ecosystems and climate events

Major fisheries and diminishing – hence aquaculture is the hope



Food security

Specific knowledge gaps

- **Understanding aquatic ecosystems** –the physical drivers, linkages between catchment, coasts and oceans, impacts on habitats and fish production, predators and prey relationships, effect of climate change and variability in fisheries stocks.

- **Developing an effective fisheries observations and data acquisition**

- **Improving assessment** - stock assessment methods is a challenge, particularly with respect to artisanal fisheries, migratory and trans-ecosystem species

Food security

Specific knowledge gaps

- **Understanding the social and economic impact of fisheries** – overall benefits of fishing/seafood; the discards and under-utilised species; energy saving fishing; health and nutrition benefits from fish; market dynamics, trade and market access and linkages with the ecosystem and fisheries dynamics.
- **Adopting ecosystem based management approaches of**
- **Developing innovative fishing gears and fishing technology** – to reduce impact on habitats and on fisheries species.
- **Identifying and determining the feasibility of alternative livelihood to reduce pressure on wild fisheries**

Food security

Specific knowledge gaps

–**Developing a sustainable aquaculture** – aquaculture engineering; intensive aquaculture; polyculture; fish feed; breeding technologies; off-shore farming; harvesting and product quality; hatchery systems; biotechnological and genetic breeding.

Energy security

Artisanal fishermen based in villages with conventional electricity have access to fridges and ice for conservation of their catches - their products have high commercial value

Artisanal fishermen living in remote areas with no fridges neither ice – they dry or smoke their fish and it often rot and lose quality

Distribution of conventional energy to artisanal centres is too costly – Hence renewable energy (solar, wind, tide, waves).

Energy security

Applied research and technology development initiative aiming at promoting the use of renewable energy

- –Tide turbine
- –Wind turbine-A
- –Wind turbine – B
- –Solar concentrator

Energy security

Knowledge gaps

Given the low wind force (~5m s^{-1}), need to develop generators that **can operate at low rotation**, e.g. the permanent magnet DC generators.

Further, given the higher dependence of renewable energies on the weather, there is a and technology development initiative aiming at promoting the use of renewable enneed to consider combined or **hybrid** systems, e.g. Wind-Solar-Tides-Waves

Which will **require innovative technology**

Energy security

The specific knowledge gaps:

–Assessment to estimate the potential sources of renewable energy;
–Developing technology for use and conversion of renewable sources;
–Developing and operating floating facilities and, potentially, subsea structures for harvesting tide and wave energy;
–Conducting assessment studies and developing technology to extract hydrogen from the sea;

Energy security

The specific knowledge gaps:

- Improving technology to improve efficiency of solar cookers, solar fridges, and solar fish driers;
- Improving technology to improve efficiency of wind and tide turbines;
- Consolidating the existing and expanding the applications for renewable energy (solar, wind, tides);
- Developing and conducting assessment studies to determine the viability of hybrid systems;

Service provision

Ocean whether forecast to support ocean related activities: shipping, recreation, harbour operation, aquaculture, fishing, offshore oil and gas production.

Accurate description and a reliable prediction of the ocean behave , and improved scientific understanding of factors controlling these changes

Needed oceanographic data and information in adequate time and space scales to:

- improve safety and efficiency of maritime transport and marine operations
- enable sustainable exploitation and management of ocean resources
- support safe and efficient offshore energy related activities
- contribute to ocean climate variability studies and seasonal-to-internannual climate prediction.

Service provision

The specific knowledge gaps:

- Understanding the ocean climate and climate variability in the coastal areas – wave, surges and coastal currents
- Assessment of the coastal vulnerability to ocean derived hazards (Storms, cyclones and tsunamis).
- Understanding the oceanographic and meteorological processes influencing beaches processes, e.g. near coastal waves and currents – to assure safety to beach users and sustainability of tourism
- Understanding and predicting oceanographic processes for navigation safety, both for open sea and coastal navigation (waves, tides, currents);

Service provision

The specific knowledge gaps:

- Understanding the influence of environmental issues in the distribution and availability of resources (e.g. Fisheries oceanography, spawning, recruitment and fish growth);
- Understand the trends of climate and seasonal-to-interannual climate variations such as El-Ñino and La Nina
- Understand the trends and patters of the ocean and meteorological processes conditions affecting the distribution, abundance and vulnerability of fish populations, and fishing operations.

Concluding remarks

The rich and diverse Mozambican marine and coastal ecosystems and habitats sustain the population and economy of Mozambique

Their sustainability requires a thorough understanding of controlling processes and factors

Marine sciences and technology development required to aid sustainable use and management

Knowledge of the ecosystems' structure and functioning
The controlling factors interact with the resources and each other in a complex way

Concluding remarks

Need a multidisciplinary and multi-sectoral approach – National Marine Science plan

Clustered in five themes:

- Climate and climate change
- Biodiversity conservation and ecosystem health
- Food security
- Energy security
- Service provision

Acknowledgement

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Thanks