Moçambique Área 1, Lda

ENVIRONMENTAL IMPACT ASSESSMENT FOR SHALLOW WATER SEISMIC SURVEY & EXPLORATION DRILLING IN ROVUMA AREA 1

ENVIRONMENTAL IMPACT STUDY REPORT

Volume 2 – Part A

MAIN REPORT

Prepared by:

Impacto
Projectos e Estudos Ambientais

December, 2008

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[1] The Decree No. 12/2002 is published in the Boletim da República No. 22, 1st Series, 2nd Supplement of 6 June 2002 altered by Decree No. 11/2003 published in the Boletim da República No. 13, 1st Series, of 26 March 2003

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LIST OF ABBREVIATIONS AND ACRONYMS

2-D	Two-dimensional
3-D	Three-dimensional
AMA1	Anadarko Moçambique Área 1, Lda
AOO	Accommodation Only Operators
APC	Anadarko Petroleum Corporation
BID	Background Information Document
BOD	Biochemical Oxygen Demand
BOP	Blowout Prevention
CDBTP	Cabo Delgado Biodiversity and Tourism Project
CE	Critically Endangered
CMA	Community Mobilization Agent
CMO	Community Mobilization Officer
CMS	Community Mobilization Supervisor
CSA	CSA International, Inc.
dB	Decibels
DD	Data Deficient
DGPS	Differentiated Global Position System
DMAC	Diving Medical Advisory Committee
DNAC	*Direcção Nacional para Áreas de Conservação (*National Directorate for Conservation Areas)
DNAIA	*Direcção Nacional de Avaliação de Impacto Ambiental (*National Directorate for Environment Impact Assessment)
DST	Drill Stem Test
EA	Environment Australia
EC	Environmental Components
ECPRO	Environmental Control and Public Relations Officer
EPAC	Environmental and Public Affair Coordinator [AMA1]
EEM	Environmental Effects Monitoring
EIA	Environmental Impact Assessment
EHS	Environmental, Health, and Safety
EIR	Environmental Impact Report
ESIO	Environmental and Social Impacts Officer
ELG	Effluent Limitation Guides
EMC	East Madagascar Current
EMP	Environmental Management Plan
EN	Endangered
ENH	Empresa Nacional de Hidrocarbonetos, EP
EPC	Exploration and Production Concession
EPDA	*Estudo de Pré-Viabilidade Ambiental e Definição de Âmbito* (Environmental Pre-feasibility and Scoping Study)
ERP	Emergency Response Plan
FCCC	Framework Convention on Climate Change
GOM	Government of Mozambique
GPD	Gallons per Day
GPS	Global Positioning System
HESS	High Energy Seismic Survey
IFC	International Finance Corporation
IIP	Instituto Nacional de Investigação de Pesqueria
IMDG	International Maritime Dangerous Goods

IMO	International Maritime Organisation
INAM	National Institute of Meteorology
INGC	National Institute for the Management of Calamites
ITCZ	Intertropical Convergence Zone
IUCN	International Union for the Conservation of Nature
JNCC	U.K. Joint Nature Conservation Committee
L&AO	Leisure and Accommodation Operators
LC	Least Concern
LOO	Leisure Only Operators
LWD	Logging While Drilling
MBREMP	Mnazi Bay-Ruvuma Estuary Marine Park
MICOA	Ministry for Coordination of Environmental Affairs Mozambique
MITUR	Ministry of Tourism
MMO	Marine Mammal Observer
MMS	U.S. Minerals Management Service
MODU	Mobile Offshore Drilling Unit
MSDS	Material Safety Data Sheets
MSL	Mean Sea Level
MWD	Measure While Drilling
NADF	Non-Aqueous Drilling Fluid
NDVI	Normalized Difference Vegetation Index
NDWI	Normalized Difference Water Index
NCSD	National Commission for Sustainable Development
NEMP	National Environmental Management Program
NOSCP	National Oil Spill Contingency Plan
NGO	Non-Government Organization
NMFS	U.S. National Marine Fisheries Service
NRC	National Research Council
NT	Near Threatened
NTPIS	National Tourism Policy and Implementation Strategy
OBMs	Oil-Based Mud's
OCS	Outer Continental Shelf
OOC	Offshore Operators Committee
OSCP	Oil Spill Contingency Plan
PARPA	Action Plan for the Reduction of Absolute Poverty
PATI	Priority Areas for Tourism Investment
PAH	Polycyclic Aromatic Hydrocarbons
PPAH	Pollution Prevention and Abatement Handbook
PTS	Permanent Threshold Shift
QNP	Quirimbas National Park
SEA	Simplified Environmental Assessment
SEC	South Equatorial Current
SEL	Sound Exposure Level
SEMP	Safety and Environmental Management Program
SCP	Stakeholder Communications Plan
SOPEP	Shipboard Oil Pollution Emergency Plan
SPES	Strategic Plan for the Environmental Sector
SPL	Sound Pressure Level
SSAFC	Socio-economic Study of Artisanal Fishing Communities
STDs	Sexually-Transmitted Diseases
TFCA	Transfrontier Conservation Area

TOC	Total Organic Carbon
ToR	Terms of Reference
TPH	Total Petroleum Hydrocarbons
TPIS	Tourism Policy and Implementation Strategy
TSW	Tropical Surface Water
TSS	Total Suspended Soils
TTS	Temporary Threshold Shift
UNCED	United Nations Conference on Environment and Development
U.S. EPA	U.S. Environmental Protection Agency
VU	Vulnerable
VOC	Volatile Organic Compounds
WBC	Western Boundary Current
WHP	World Hydrographic Program
WIOMSA	Western Indian Ocean Marine Science Association
WOCE	World Ocean Circulation Experiment
WWF	World Wildlife Fund

Chapter 1

INTRODUCTION

Chapter 1

INTRODUCTION

Anadarko Moçambique Área 1, Lda (AMA1) signed an Exploration and Production Concession (EPC) contract with the Government of the Republic of Mozambique for the exploration of Offshore Area 1 in the Rovuma Basin. The EPC contract gives AMA1 exclusive rights to explore for and produce commercial quantities of hydrocarbons in the block. As part of the agreement, AMA1 will undertake 1000 Km of 2D and 3000 Km of 3D seismic surveys, and exploration drilling in Area 1. AMA1 has committed to drill a minimum of seven wells. Four of the exploration wells will be drilled in water depths greater than 200m and the remainder in shallower waters, less than 200m depth.

This project refers only to seismic surveys and exploration drilling of wells in shallow waters mainly less than 200m in depth in Offshore Area 1, as well as the coastal waters present within the concession area of the adjacent Onshore Block. The main objective of the project is to determine if the prospects, identified after the seismic surveys and exploration drilling, have hydrocarbons in commercial quantities. The seismic survey will allow the identification of prospects for exploration drilling, using acoustic energy to map the structure of the earth's crust below the seafloor. Exploration drilling is a temporary activity aimed to determine the presence of hydrocarbons. In the case of unsuccessful drilling, all structure will be removed from the ocean floor after completion of drilling operations. For a successful well, the wellhead will remain in the ocean floor, properly secured to avoid potential releases of hydrocarbons to the environment and covered with a safeguard to avoid creating a hazard for navigation and fishing.

The Ministry for the Coordination of Environmental Affairs (MICOA) has classified the project as a Category A project (**Annex 1**) in accordance with the Environmental Impact Assessment Regulations (Decree 45/2004). Therefore, an Environmental Impact Assessment (EIA) was required to be prepared for the Project. AMA1 has appointed the Mozambican company, Impacto Lda to carry out the EIA. In addition to Impacto, CSA International, a US-based company, provided specialized technical input to the document.

This document represents the EIA Report (or EIR only – Environmental Impact Report) for the seismic surveys and exploration drilling of wells in shallow waters operations proposed by Anadarko Moçambique Área 1, Lda (AMA1) in the Rovuma Offshore Area 1. The EIR is part of a larger Environmental Impact Assessment Report (EIAR), which consists of four volumes:

- Volume I – Non -Technical Summary;
- Volume II (this document) – Part A: EIS Report and Part B: Environmental Management Plan (EMP);
- Volume III – Specialist Studies
- Volume IV – Public Participation Report.

1.1 ANADARKO MOÇAMBIQUE AREA 1, LDA

AMA1 is a Mozambique-registered company and a wholly-owned subsidiary of Anadarko Petroleum Corporation (APC). AMA1 has its headquarters in Maputo at the following address: Rua António José de Almeida, 227, Maputo, Mozambique.

AMA1 signed an Exploration and Production Concession (EPC) contract with the Government of the Republic of Mozambique for Offshore Area 1 in the Rovuma Basin. AMA1 is responsible for operating Area 1 on behalf of the parent company (**Figure 1-1**). The EPC contract gives AMA1 and partners the exclusive rights to explore for and produce commercial quantities of hydrocarbons in the block. The initial term of the contract is for a period of 5 years.

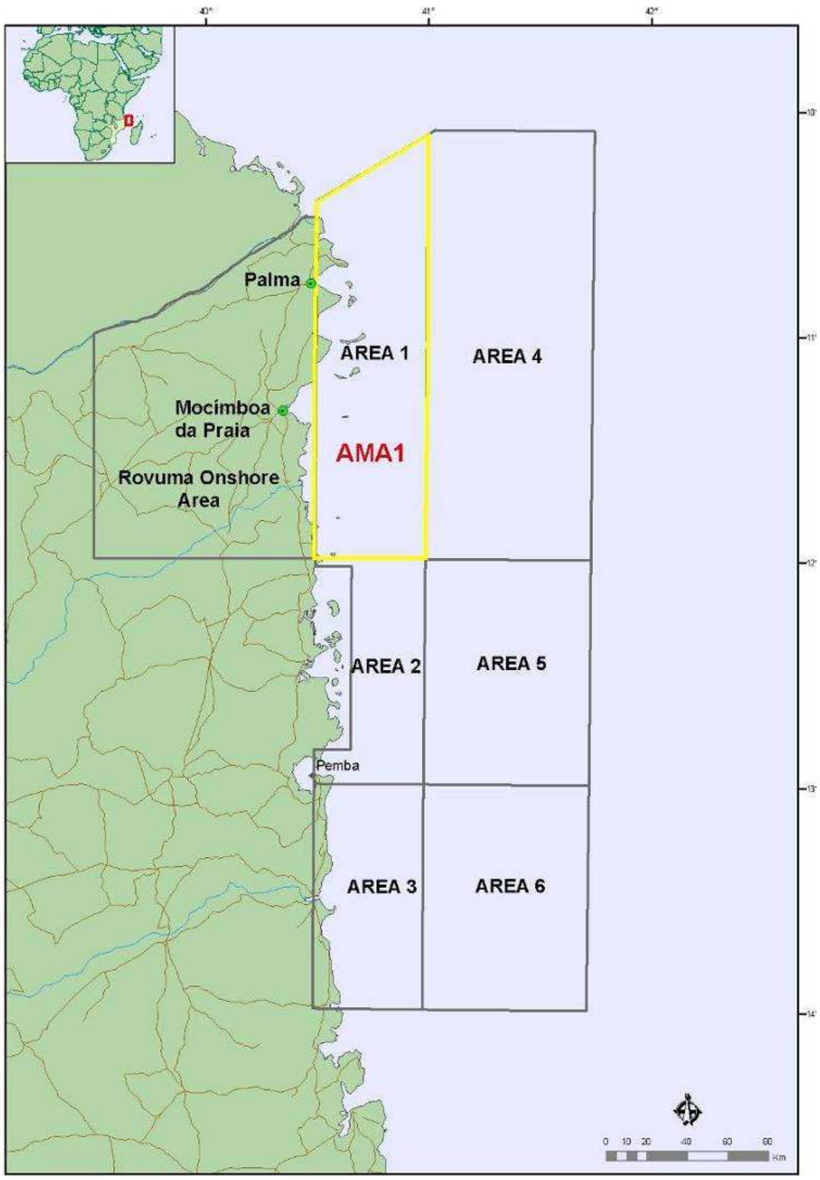

Figure 1-1 AMA1 Concession Area

APC is based in The Woodlands, Texas, USA. With nearly 2.4 billion barrels of oil equivalent (BOE) of proven reserves at year-end 2007, APC is among the largest independent oil and natural gas exploration and production companies in the world. The company's major areas of operation are located onshore in the Rocky Mountain and Texas/Mid-Continent Regions of the United States, the deep water of the Gulf of Mexico and in Algeria. APC also has production and/or exploration in Alaska, Brazil, China, Indonesia, Mozambique and West Africa.

APC is a premier deepwater explorer and producer that has discovered 26 fields and operates eight platforms in the deepwater Gulf of Mexico. The company has also successfully transferred this deepwater skill set to international basins, where it has made three recent deepwater discoveries offshore Ghana and is executing strategic exploration programs offshore Mozambique, Brazil and Southeast Asia.

APC is a member of the International Association of Oil & Gas Producers and is committed to promoting a safe, responsible, and profitable performance as a member of the global upstream oil and gas industry. By forming the subsidiary company AMA1, APC has made a long-term commitment to the Government and people of Mozambique to further the exploration and development of the country's potential petroleum resources in an environmentally sound and fiscally responsible manner.

APC is known for its involvement in community projects, both in the U.S.A. and abroad, and believes commercial success is tied to proper management of its relationship with the environment, the well being of its neighbors, and the safety of its people. For that reason, environmental, health, and safety (EHS) considerations, as well as an active concern for local laws and customs, are integrated into every aspect of APC's business.

APC maintains these goals through a strict system of internal management and accountability that begins with senior management personnel and extends down to individual employees and contractors. The EHS management system ensures that APC maintains consistently high environmental, health, and safety standards wherever it operates. The EHS management system defines how the company protects the health and safety of employees, contractors, neighboring communities, customers, partners, and the environment. It is a set of organized business processes that, when combined with various resources, helps the company achieve its goals and objectives.

The EHS management system is designed to be easily incorporated into APC's four business phases: planning, implementation, auditing and corrective action, and senior management review. Each phase is tied to key project decision points (**Figure 1-2**).

This system and the philosophy it represents ensure all APC operations are safe and that the company will be a good neighbor – environmentally and socially – no matter where it does business. More information on APC can be found by visiting its corporate website (www.anadarko.com).

Continuous Improvement for next phase or project

Planning

Exploration and drilling activities begin with extensive site surveys and the preparation of an Environmental and Social Impact Assessment (ESIA), a document that serves as a core resource for operations planning. By providing a clear understanding of local issues and safety and environmental considerations – and potential sensitivities – the ESIA allows Anadarko to adjust plans to meet local expectations, comply with laws and regulations, and mitigate potential impacts.

Part of environmental understanding includes building relationships with neighboring communities. Anadarko tries to always work in partnership with local people, making sure they understand what to expect from the Company and its contractors, and at the same time, that Anadarko respects their basic human rights and way of life.

Senior Management Review

Finally, as part of the business cycle, Anadarko's senior management annually reviews all environmental, health, and safety activities. This assures that operations are consistent with Company policy and philosophy and that Anadarko is prepared to deal successfully with future challenges.

Because every operating environment is unique and local environmental laws and regulations vary, there can be no absolute rules for handling local issues. That is why Anadarko subscribes to a uniform environmental, health, and safety management system that promotes a sensitivity and watchfulness regarding the physical and social environments where it operates.

Implementation

Out of the ESIA and dialogue with local stakeholders and government agencies comes a detailed Environmental Management Plan (EMP). Used by employees and contractors, this EMP specifies details of operations ranging from the hiring of local suppliers and employees to safety training, oil spill response, waste handling, protection of groundwater, and mitigation measures.

If the sensitivity of the environment or the situation warrants, a project may be monitored. By employing a third-party monitor, the Company invites a closer look at its operations and reconfirms its commitment to the environment, its employees, and the public. This kind of oversight also provides documentation to host governments that permit requirements and Company procedures are being followed.

Auditing and Corrective Action

Once operations are established, permit requirements and the Environmental Management Plan are reviewed to ensure they have been followed and mitigation requirements met.

The process concludes with an assessment: How good was the plan? Was it cost effective? What should be done differently? Partly a critique, this step is also the first stage of continuous improvement and planning for future operations.

Figure 1-2 Anadarko Petroleum Corporation's Environmental, Health, and Safety management system incorporated into its four project development phases.

1.2 PROPOSED PROJECT

This project refers to seismic surveys and exploration drilling of minimum of three wells in shallow waters - mainly less than 200m in depth in Offshore Area 1, as well as the coastal waters present within the concession area of the adjacent Onshore Block (**Figure 1-3**).

Figure 1-3. Area of proposed seismic surveys and exploration drilling in the AMA1 Concession Area in the Rovuma Basin

Seismic Surveys

During the initial phase of the project, a 2-D seismic survey will be conducted using a vessel trailing a shallow water streamer. The equipment will consist of:

a) a compressed air source to generate sound waves

b) a single short cable (e.g., 1-2 km long) containing many hydrophones to receive of the seismic sound,

c) a recording system and related equipment to place the seismic source and hydrophones in their appropriate positions and monitor them once in position.

d) a tail buoy equipped with a radar reflector and flashing light, which is attached to the end of the streamer for navigational purposes and to warn passing vessels.

In near shore locations with very shallow water, the use of ocean bottom receivers in a single cable (OBC) may be necessary. These are up to 1 km long and are laid passively on the bottom to record data closer to the shore. The source boat does not operate in these areas and thus the purpose is to extend only the recording length of the lines. Later phases of the project will include 2-D and 3-D seismic acquisitions using a combination of streamers and OBC.

A reconnaissance effort will precede the shallow water seismic program. A shallow draft boat will use GPS and photographic equipment to traverse the planned seismic program lines to gain a detailed understanding of the features along these lines. The purpose is to minimize damage to the seismic source and receiver arrays and avoid damage to any habitat that may be impacted by the operation of the equipment during the survey.

Exploration Drilling

Based on the information gathered during the seismic surveys, potential drilling locations will be identified. Standard rotary drilling technology will be used from a drilling rig. The rigs will be mobilized to site from international waters. Supplies to the rig will be routed through the AMA1 supply base at Pemba. Typical supplies will include fuel, water, food, drilling fluid chemicals, well cement and chemicals, well tangibles (tubular, wellheads, etc), and various other items.

The operations shall be coordinated from the AMA1 office in Pemba and all vessel supplies/support services shall commence from and terminate at Pemba Port. Wastes from the drilling rig shall also be transferred (where necessary) to shore via Pemba Port for appropriate disposal.

A more detailed description of the proposed project is given in Chapter 3.

1.3 PURPOSE OF THE ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

The purpose of the EIA is to evaluate potential impacts to the physical, biological and social environments arising from the shallow water seismic surveys and exploration drilling and to identify appropriate mitigating measures to reduce/eliminate potential negative impacts as well as measures to enhance any potential positive impacts.

In Mozambique, the EIA process is a legal requirement under the Environmental Law 20/97 and defined and governed by the Regulation on the Environmental Impact Assessment Process (Decree No. 45/2004) and the General Directive for Environmental Impact Studies (Ministerial Diploma nº 129/2006). In accordance with Decree No. 45/2004, the project was registered with MICOA on the 28th of April 2008 and on the 29th of April 2008 MICOA notified the Client that the proposed seismic survey and exploration drilling operations in shallow water was classified as a Category A Project which is subject to a detailed EIA.

1.4 TERMS OF REFERENCE

In accordance with Decree No. 45/2004 a Pre-Viability Report Scope Definition Study (EPDA) and Terms of Reference (TOR) for the Environmental Impact Study (EIS) must be submitted to and approved by MICOA: The EPDA and TOR were submitted to MICOA on the 20th of June 2008 and approved on August 1st of August 2008. **Annex 2** contains the TOR for the EIS submitted to MICOA and **Annex 3**, the letter of approval of the EPDA and TOR by MICOA.

The main potential bio-physical and socio-economic impacts associated with the seismic survey and identified in the EPDA and TOR are the following:

- Impacts of underwater noise arising from the seismic sound sources on marine resources, especially marine mammals, sea turtles and fish;
- Operation of streamers in shallow water with sensitive habitats could pose potential impacts due to direct contact;
- Interruption of artisanal fishing due to the safety zone around the seismic vessels, support vessels, and the recording cables;
- Impacts on artisanal divers due to the underwater noise coming from seismic sound sources;
- Interference with local shipping due to the safety zone around the seismic vessels, support vessels, and the recording cables;
- Impacts on tourist activities (scuba diving), due to the underwater noise arising from seismic sound sources, or to the safety exclusion zones around the seismic vessels (affecting sports fishing);
- The project will have a positive impact insofar that it will stimulate the local economy through the provision of services and goods. This will be limited during the exploration phase, but will be very significant for the national and local economy if economically viable reserves of hydrocarbons are discovered.

The main potential bio-physical and socio-economic impacts associated with exploration drilling are the following:

- Localized increase in water turbidity;
- Water contamination by potential hydrocarbon spills and subsequent impacts on marine fauna and socio-economic activities;
- Localized, physical impacts on habitats associated with locating the drilling rig on the substrate (sea grasses, corals, benthic fauna etc.);

- Localized, behavioral and physical impacts to marine mammals and sea turtles from drilling operations and vessel traffic associated with drilling operations;
- Interruption of artisanal fisheries due to the safety zone around the drilling rig;
- Interference with the tourism activities in the area (safety zone and aesthetic impacts).

These issues emerged from the initial stakeholder engagement and the EIA team's preliminary assessments.

The affected environment for this impact assessment encompasses the following three elements:

- Physical-chemical environment: climate, tides, currents oceanography and bathymetry;
- Biological environment – Corals, sea grasses, mangroves, fish, marine mammals (whales, dolphins and dugongs) and sea turtles; and
- Socio-economic environment – fishing and tourism.

The EIS comprised a combination of desktop studies (based on existing data) and field studies (for collection of primary data).

The following specialist studies were undertaken during the Environmental Impact Study:

1. Legal and institutional review
2. A description of the biophysical environment
3. A review of marine mammals and sea turtles that occur in the Project area that are sensitive to noise, and the potential impacts that affect these species
4. A review fish biology and impacts coral reef fish (either behavioral or physiological)
5. Underwater Noise Modeling for Shallow Water Seismic Surveys and Exploration Drilling
6. Assessments of potential impacts arising from oil spills on the marine and socio-economic environments
7. A socio-economic survey of artisanal fisheries activity to assess potential impacts
8. A study of tourism the Project area
9. Sensitivity analysis and sensitivity mapping of coastal and marine habitats and socio-economic features

Mapping of coastal and marine habitats using detailed satellite imagery was carried out a separate exercise. The results of this study were used to prepare a detailed description of the coastal, island and shallow water habitats including sandy beaches, seagrass beds, mangroves and coral reefs. Sensitivity mapping of coastal and marine habitats and socio-economic features was performed based on the habitat map

Additional biological data was obtained from two field studies that were commissioned by the AMA1 specifically for the project area *viz*.:

- An Aerial Census Survey of Marine Mammals and Sea Turtles in the Shallow Waters within the Offshore Area 1 Concession Block;

- A Representative Marine Habitat Survey of the northern Quirimbas Archipelago.

The information gathering methodology is presented in Chapter 5 and the environmental assessment methodology is presented in Chapter 6 of this report.

The impact assessment process started with a procedure to identify the activities from the project description detailed in Chapter 3 that could interact with the environment. In parallel to that procedure, an identification focused on the key environmental and social features from the baseline information detailed in Chapter 5 was undertaken, aimed at identifying the key biological, physical and human components of the project area.

The potential positive and negative changes resulting from the defined project activities were then predicted for the study area and for the entire project lifecycle. These predicted changes (impacts) were then evaluated using a significance ranking process.

For the impact identification of this project, professional judgment and the use of a matrix were the techniques used, whereas the impact evaluation was conducted using internationally accepted criteria as well as the Decree 45/2004.

A set of relevant Mozambican laws, regulations, policies, conventions and other environmental and petroleum industry related legal documents was prepared based on the Legal Framework prepared for the Seismic EIA[1]. In addition, international protocols, laws and conventions adhered to by Mozambique have been identified and described. Finally, relevant international petroleum operations guidelines and Anadarko's EHS policy were also reviewed.

Two rounds of public consultation meetings took place in Cabo Delgado Province; the first one to present the EPDA and TOR (week of 22nd of May 2008) and the second one to present the Draft EIA (week of 1st December 2008). The Public Participation Process, Minutes of Meetings and Issues and Response Reports for each of the meetings is presented in Volume III of EIA Report and was conducted based on Guidelines for Public Participation (Ministerial Diploma 130/2006).

In accordance with Decree 45/2004, the EIS Report contains following information:

- Abbreviations and acronyms
- Non-Technical Summary
- Introduction
- Legal and regulatory framework
- Description of the proposed project
- Approaches and techniques utilized for collection of information
- Environmental and Socio-economic baseline
- Description of all noise and spill trajectory models employed
- Methodology for Consultation with the stakeholders
- An analysis of alternatives

[1] Deepwater Seismic survey in Rovuma Offshore Area 1 (Impacto and CSA, 2007)

- Description of the environmental impacts over the proposed Project area
- Proposal for mitigation methods
- List of people / institution contacted
- Bibliography/ References

An Environmental Management Plan that will be implemented by AMA1 during the course of its operations in the area of study has been prepared and this forms Part B of this Volume II.

As part of the EIA the following documents have been prepared and these form part of the EMP:

- Communication Plan

AMA1 also commissioned the preparation of the following documents:

- Oil Spill Trajectory Modeling for shallow waters
- Emergency Response Plan/ Oil Spill Contingency Plan

These documents were reviewed by the Consultant and incorporated, as required, into the Environmental Management Plan (EMP).

1.5 ENVIRONMENTAL CONSULTANT

AMA1 have commissioned Projectos e Estudos de Impacto Ambiental, Limitada (Impacto, Lda) of Mozambique to prepare an Environmental Impact Assessment (EIA) for seismic surveys and exploration drilling operations in the shallow waters of Rovuma Offshore Area 1.

Impacto, is a fully registered Mozambican company financed entirely by Mozambican capital. Impacto was officially constituted in writing and the registration was published in the Boletim da República, n°33, series III, on the 14th August 1996.

Impacto is registered with the Ministry for the Coordination of Environmental Affairs (MICOA) to conduct Environmental Impact Assessments (EIAs) in Mozambique and has extensive experience in EIAs.

The contact address for Impacto is:

Dr Mia Couto, Managing Director
Impacto, Lda.
Av. Mártires da Machava, 968
Maputo, Mozambique
Tel: +258 21 499636
Fax: +258 21 493019
Cell (Office): + 258 82 3011956

The consultants that formed part of the study team are the following:

Project Management

- Mia Couto – Project Director
- Carlota Quilambo – Project Manager
- John Hatton – Technical Coordinator

Project Scientists

- John Hatton – Technical Director of IMPACTO, Environmental Scientist
- Paula Santos – Coordinator, Social Impact Evaluation
- Horácio Gervásio – Field Coordinator, Social Survey
- Johan van der Walt - Social Impact Assessment Specialist
- Lucinda Cruz – Legal Expert
- Naíca Costa – GIS Specialist
- Mia Couto – Public Consultation Expert
- Sandra Fernandes – Public Consultation Assistant
- Almeida Guissamulo – Marine Biologist

1.6 STRUCTURE AND CONTENT OF THE EIA REPORT

As indicated above, the overall EIA Report comprises four Volumes; namely:

- Volume I – Non -Technical Summary;
- Volume II – Part A: EIS Report and Part B: Environmental Management Plan (EMP);
- Volume III – Specialist Studies
- Volume IV – Public Participation Report.

This specific volume is comprised of two parts: A – Environmental Impact Study and B – Environmental Management Plan.

Part A – Environmental Impact Study

This volume comprises the following chapters:

Chapter 1 **Introduction** – Explains the purpose of the EIA process, identifies the project, describes AMA1 and its parent company APC, identifies the environmental consulting team, presents the Terms of Reference and summarizes how the EIA is structured and finally, it indicates the availability of the Report to the public.

Chapter 2 **Project Description –** A detailed description of (a) the proposed seismic survey (including the survey area, seismic survey vessels and seismic survey methods, emissions and production and treatment of wastes) and (b) drilling operations (including drilling rig and equipment to be used, the drilling and testing operations, support and supply operations, emissions and production and treatment of wastes).

Chapter 3 **Alternatives Considered –** Discusses the alternatives considered, including the "no action" alternative, project location and project technologies.

Chapter 4 **Legal and Regulatory Framework** – Describes the overall legal and regulatory framework for environmental management in Mozambique; identifies environmental protection and management measures as laid out in laws and regulations specifically for petroleum operations in Mozambique; identifies relevant international conventions; summarizes international health, safety and environmental guidelines for the petroleum industry and provides the APC Environmental, Health and Safety Policy.

Chapter 5 **Environmental Baseline –** Presents the information gathering methodology and describes the existing biophysical and socioeconomic components and conditions in the shallow water area of the Rovuma Offshore Area 1 concession block.

Chapter 6 **Environmental Impact Assessment –** Describes impact criteria and the methodology employed to assess the significance of identified potential impacts and discusses the potential impacts.

Chapter 7 **Environmental Mitigating Measures and Residual Impacts -** Presents mitigation measures to avoid or minimize potential impacts and/or enhance the positive impacts. Describes and discusses residual impacts, after mitigation, showing their significance rates (before and after mitigation).

Chapter 8 **Conclusions and Recommendations –** Draws conclusions based on the assessment of impacts and recommended mitigation measures.

Chapter 9 **Literature Cited –** Lists the literature that was used to produce the EIS Report.

Part B – Environmental Management Plan

Chapter 1 **Introduction –** Describes the purpose and format of the EMP and environmental obligations and policies.

Chapter 2 **Scope of the EMP –** Provides the scope of the EMP.

Chapter 3 **Government entities with responsibilities for environmental management and maritime safety -** Indicates the main entities for inter-institutional liaison and coordination during this project.

Chapter 4 **Basic Principles for the Environmental Management Plan –** indicates the basic principles to be adopted by AMA1 for environmental management.

Chapter 5 **Obligations and Responsibilities in Environmental Management –** presents the main obligations and responsibilities for AMA1, the contractor and additional recommended staff.

Chapter 6 **Independent Auditors –** refers to MICOA's responsibility in auditing the activity and the possibility for AMA1to hire an independent auditor.

Chapter 7 **Implementation of the EMP –** Presents a matrix summarizing he environmental impacts, mitigation and monitoring requirements and responsibilities for compliance with the EMP.

Appendices to the EMP include the following:

- Communication Plan
- Oil Spill Contingency Plan / Emergency Response Plan
- Waste Management Plan

1.7 REPORT AVAILABILITY

For more information about the project, please contact the Public Participation Office as follows:

Impacto Lda - Public Participation Office
Av. Mártires da Machava, 968
Maputo, Mozambique
Tel: +258 21 499 636
Cell (Impacto): +258 82 304 6650
Fax: +258 21 493019
E-mail: impacto@impacto.co.mz

Contact person: Carlota Quilambo
E-mail: cquilambo@impacto.co.mz

Chapter 2

PROJECT DESCRIPTION

Chapter 2

PROJECT DESCRIPTION

AMA1 proposes to conduct seismic surveys and exploratory drilling in the offshore shallow water portion of Area 1, beginning in 2009. AMA1 is required to collect these seismic data and to drill at a minimum of three wells as part of the work commitment of the EPC contract granted by the Republic of Mozambique.

Seismic surveying is the main technique used by geophysicists to collect data needed to map subsurface geology; therefore, it is a requirement for oil and gas exploration. While seismic surveying does not image the oil and gas directly, it does provide a structural image of the subsurface geology, which a geophysicist can use to identify and locate buried faults and structural features that provide a favorable situation for oil and gas accumulations or reservoirs. Advanced seismic data analysis techniques can sometimes provide indications of whether such features are likely to contain oil and gas or only water. Seismic data are required to define a prospect, and then to select the optimum well location to test for, and hopefully find, oil and gas. Ultimately, an exploratory well must be drilled to determine whether the prospect reservoir contains oil and/or gas.

2.1. PROJECT AREA

The project area is primarily located in Area1 offshore Mozambique, but includes also the coastal waters of the Rovuma Onshore Exploration Concession, which is contiguous to the AMA1 Concession Area along the northern section of the coastline of Mozambique. The Project area is limited by the northern and southern borders of the block, while the western border is defined by the coastline and the eastern border is defined by the line that joins the most eastern points of the 200 m bathymetry line. The western border of the Project area also encompasses those offshore areas contained within the Rovuma Onshore Area (**Figure 2-1**).

Figure 2-1 Project Area

2.2. SEISMIC ACTIVITIES

2.2.1. 2-D Survey

Marine seismic surveys are conducted using a vessel fitted for the survey, equipped with full navigation, communications, and safety equipment and manned by a marine crew and seismic survey crew. There are many types of acquisition technologies used in shallow water environments. Each type is based on specific needs and objectives of the survey. ***Shallow water streamer*** acquisition is the most common method and likely to be the first technique employed in Area 1.

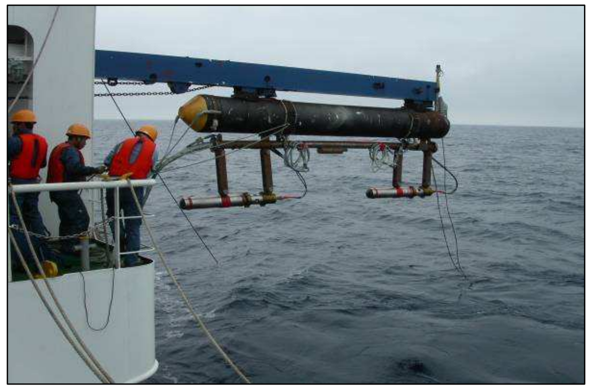

Figure 2-2 A compressed air sound source being deployed.

The equipment consists of a compressed air seismic sound source (**Figure 2-2**) that is sometimes deployed on a separate marine vessel, a single short cable (e.g., 1-2 km long) containing many hydrophones (underwater microphones) that serve as receivers of the seismic sound, a recording system, and related equipment to place the seismic source and hydrophones in their appropriate positions and monitor them once in position. Sound waves from the seismic source are directed downward into the seafloor and subsurface geology below and reflected back to the surface, where they are detected by hydrophones in the streamer towed behind the vessel (**Figure 2-3**).

A tail buoy (**Figure 2-4**) equipped with a radar reflector and flashing light is attached to the end of the streamer for navigational purposes and to warn passing vessels. Data recorded by the hydrophones and positioning information are transmitted through the streamer to computers aboard the survey vessel.

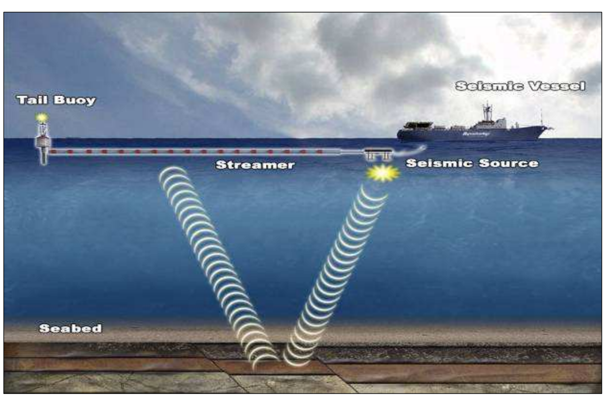

Figure 2-3. Schematic diagram of a marine seismic survey

Figure 2-4. Tail buoy (in red) at the end of a 1-2 km streamer being deployed

In those cases where two separate vessels are deployed (depending on water depth and conditions of the sea), the recording vessel (**Figure 2-5**) is a small shallow draft boat with excellent maneuverability, while the source vessel (**Figure 2-6**) has multiple compressed air sources and operates independently from the recording vessel.

Figure 2-5. Example of a small shallow draft 2-D cable vessel

Figure 2-6 Example of a source vessel for shallow water

These vessels are deployed during acquisition in the configuration below (**Figure 2-7**).

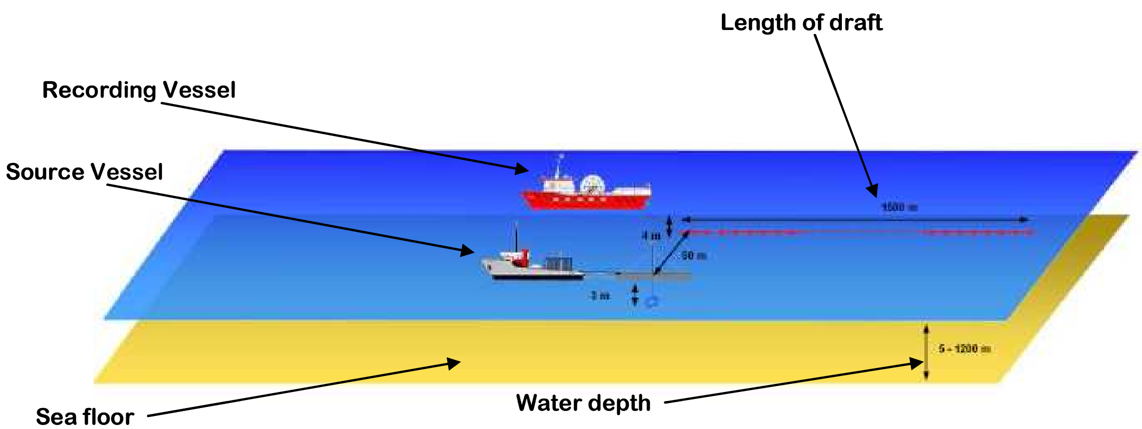

Figure 2-7. Diagram of a seismic survey vessel towing a single streamer

Table 2-1 contains the characteristics of the seismic survey equipment and data acquisition parameters for the shallow water streamer methodology

Table 2-1a. Proposed Specifications for Seismic Survey Vessel (Shallow Water Streamer)*

	Source Vessel	**Streamer Vessel**	**Accommodation Barge**
Name	*Faraday*	*Hippo*	*Commander*
Type	Purpose Built	Purpose Built	Converted Barge
Length	17.0m	13.0 m	23.33 m
Beam (extreme)	4.26m	4.8m	8.57 m
Draft	1.2m	0.6m	0.9 m
Gross Tonnage	45 T	15 T	Not Available

*Courtesy of USPL

Table 2-1b. Seismic Survey Equipment and Data Acquisition Parameters (Shallow Water Streamer)

Sound Source Specification	
Number of Sources	1
Depth of Sources	3-6 m
Total Volume per Source	Between 500-1,500 cu.in.
Pressure	2,000 psi
Vessel Speed	4-5 knots
Streamers and Recording System	
Number of Streamers	1
Length of Streamers	1000 m - 2,000 m
Type of Streamers	Fluid-filled or solid
Sensor Group Interval	12.5 m
Total Sensor Groups	120 - 160
Sensor Depth	3-6 m
Recording Length	6 seconds
Bin Size	6.25 m
Seismic Offset	2,000 m – 4,000 m

Other methods of acquiring 2-D data include the use of bottom cable recording systems or the use of individual autonomous bottom receivers. In near shore locations with very shallow water, the use of receivers or nodes in a single Ocean Bottom Cable (OBC) is common. These are up to 6 km long and are laid passively on the bottom to record data closer to the shore. As the source boat does not operate in waters less than 2 meters depth, the purpose is to extend only the recording length of the lines using passive receivers (no sound sources).

In both of these methods the source equipment consists of a compressed air source deployed on a separate marine vessel operating independently from the receivers. Sound waves from the seismic source are directed downward into the seafloor and subsurface geology below and reflected back to the surface, where they are detected by hydrophones (receivers) in the bottom cable or individual receivers.

The use of short cable streamers and ocean bottom receivers with a separate source vessel has greatly enhanced the ability to operate safely in shallow water environments. The cables will be deployed and recovered by either (a) pulling cables up by hand, and coiling them on the deck of the cable boat, or (b) using a cable reel to feed out and retrieve these OBC cables.

In advance of the seismic vessel arriving in the project area, an ultra-shallow draft vessel will sail the exact line transects in areas with potential environmental concerns. The vessels will have on board a marine scientist and be equipped with, at a minimum, a high-resolution fathometer and a high resolution underwater camera, ensuring the accuracy of all bathymetric charts, reef locations and general marine and sea floor conditions. The pre-survey evaluation will be used to refine the current program by identifying areas with potential hazards or environmental risks. Based on this information, specific lines will be confirmed, shortened or eliminated as required by the guidelines contained in the EMP. A report will be prepared following the survey. This survey will help ensure that the seismic operations will proceed safely and successfully without causing harm to the environment.

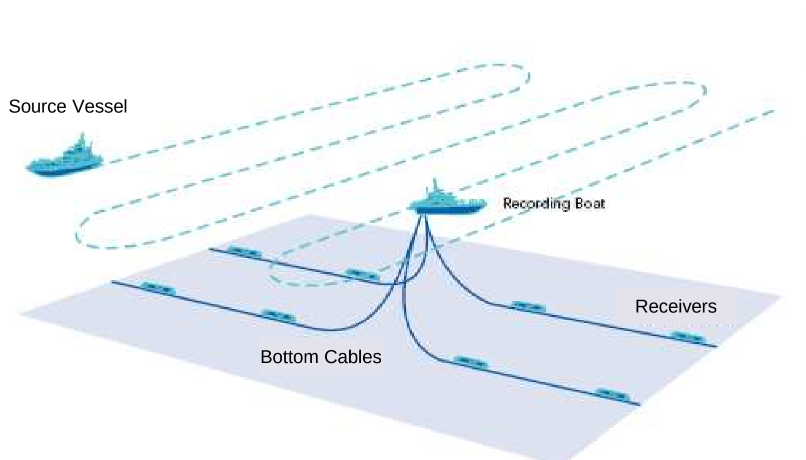

Figure 2-8a. Schematic of seismic vessel recording from bottom cables, 500 m apart

Figure 2-8.b) Schematic of a cables laying on seafloor. Typical diameter 3.8 cm-7.6 cm (1.5in-3in) - Courtesy of Sonardyne.co.uk).

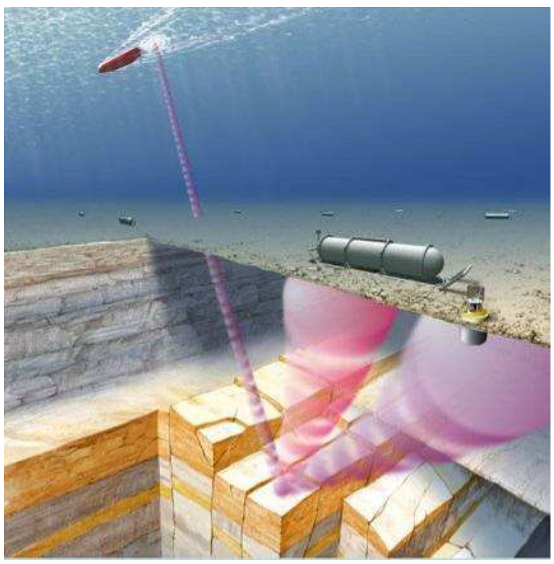

Figure 2-9. Seismic acquisition using individual receivers

Table 2-2 contains the characteristics of seismic survey equipment and data acquisition parameters that would be employed during an OBC survey.

Table 2-2 Potential Seismic Survey Equipment and Data Acquisition Parameters for OBC Technology)

Sound Source Specification	
Number of Sources	2
Intensity	7 -25 Bar-meters (peak to peak amplitude).
Minimum Bandwidth	10 - 300 Hz at -6 dB.
Primary to Bubble Ratio	20 : 1
Depth of Sources	3-6 m
Total Volume per Source	Between 500 – 1,500 cu.in.
Pressure	2,000 psi.
Vessel Speed	5 knots
Streamers and Recording System	
Number of OBC cables	Maximum 12
Length of OBC cables	6 km
Type of OBC cables	Fluid-filled or solid
Sensor Group Interval	12.5 m
Sensor Depth	On sea bottom
Recording Length	6 seconds
Bin Size	6.25 m
Seismic Offset	2,000 m – 4,000 m

2.2.2. 3-D Survey

The proposed surveys include both 2-D and 3-D seismic acquisition. 2-D seismic surveys are acquired along a set of lines where distances between lines and directions vary based on subsurface imaging objectives and surface conditions. This methodology is primarily a reconnaissance tool to help determine whether an area is prospective for accumulation of hydrocarbons.

Unfortunately, 2-D data provide no information about the subsurface geology between the survey lines. Sometimes, an exploration well is drilled based on 2-D seismic interpretation, but, in most cases, a successful 2-D program is followed by a 3-D program. The 3D survey is usually more focused and covers a smaller area then a 2D survey. In shallow waters, a 3-D seismic survey is conducted by placing a rectangular grid pattern of bottom cables or individual receivers on the sea floor. These recording devices are placed between 100m and 500m apart. The source vessel again sends sound waves into the seafloor and the subsurface geology below. These sound waves are reflected back to the surface where they are detected by hydrophones in the bottom cable or individual receivers.

The main difference between bottom cable and individual receiver systems is the presence of a cable that connects the receivers (**Figure 2-8**). The individual receivers store the data in memory and thus do not need the cable to operate. However, the cable makes deploying and retrieving the receivers more efficient.

Interpretation of 3-D data provides a volume image of the subsurface rather than a large grid of discrete lines, resulting in better definition of the subsurface structure. Simply put, 3-D seismic data fill the gaps between the widely-spaced 2-D data, providing a much more accurate representation of the subsurface geology. The additional data acquired during a 3-D survey allow interpreters to optimize drilling locations for wells. Wise use of 3-D data generally results in fewer wells having to be drilled in an area, while improving the chance of success through improved imaging.

The difference between 2-D and 3-D data is illustrated in **Figure 2-10** and as in a painting, the 3-D acquisitions allows to fill the spaces between the “dots” collected with 2-D seismic data.

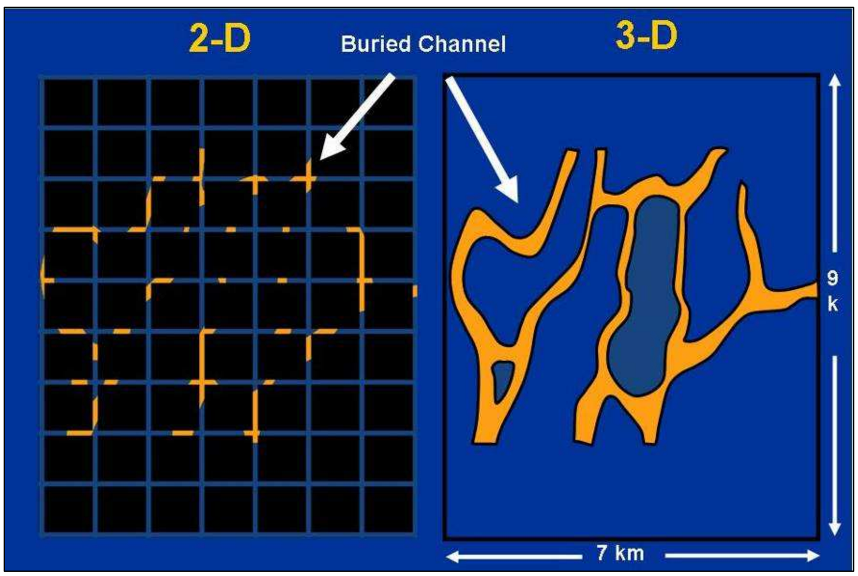

Figure 2-10. Comparison of interpretation of a channel complex using 2-D versus 3-D seismic data

2.2.3. Proposed Seismic Lines

Although both 2-D and 3-D surveys will be conducted as part of the program, the initial seismic data will be acquired using a 2-D shallow water streamer survey. **Figure 2-11** depicts the proposed lines that will be acquired as part of the 2D in the project area. Note that in this map, the seismic lines have been depicted as blue or green, or a combination of both. The blue portion of the lines is subject to the results of the pre-scouting of the lines, which could result in modification of lines due to the identification of sensitive environmental conditions or potential hazardous features on the sea floor.

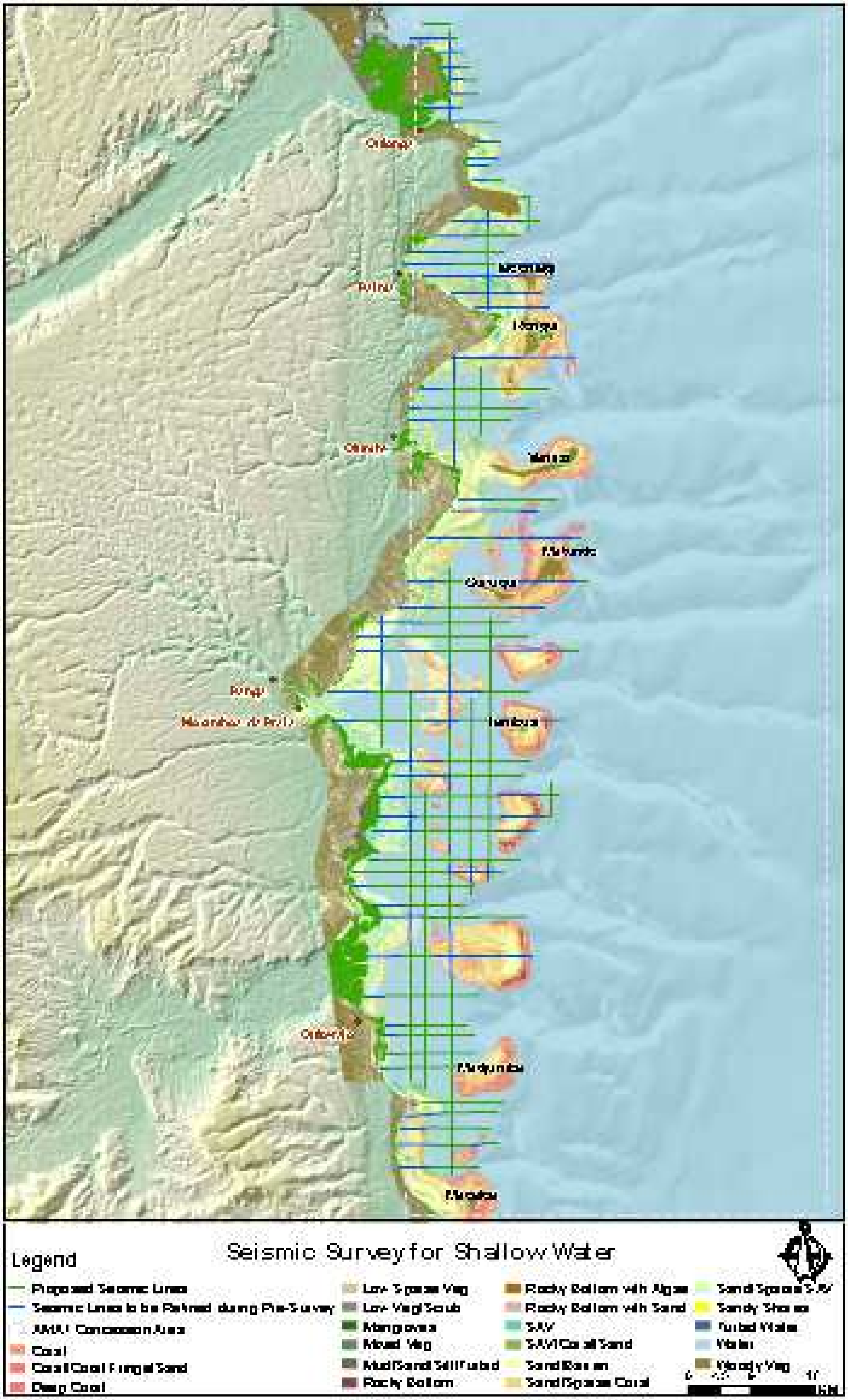

Figure 2-11. Expected location of proposed 2D program

2.3. EXPLORATORY DRILLING ACTIVITIES

2.3.1. Drilling Rig

The proposed shallow water wells will most likely be drilled using a jack up drilling rig. To describe such equipment, AMA1 has provided as an example, the specifications of a typical mobile offshore jack-up drilling rig known as Rowan Gorilla III (see **Figure 2-12** and **Table 2-3**).

The drilling rig proposed for this project will occupy a surface area of approximately 9,600 m^2 above the waterline. Navigation and some other activities such as commercial fishing may be restricted from operating in an area closer than 0.5 km to the drilling rig for safety reasons.

Figure 2-12. Typical Jack up Drilling Rig (Rowan Gorilla III) -(Courtesy of Rowan Companies Inc)

Three wells in water depths less than 200m are required to be drilled under the project PSC. It is anticipated this is the minimum number of wells which will be placed in shallow water during the First Exploration Phase. Each well will be evaluated after it is drilled to total depth, and then be either temporarily plugged, or permanently plugged and abandoned depending upon the results of the evaluation.

Table 2-3. Rowan Gorilla III Specifications

Rig Specifications	
Owner	Rowan Companies Inc.
Port of Registry	Houston, Texas
Flag	U.S.A.
Builder	Marathon Letourneau
Max. Drilling Depth	30,000 ft. (10,000 m)
Max. Water Depth	328 ft. with 55 ft. air gap (109 m)
Min. Water Depth	30 ft. (10 m)
Height	300 ft (100 m) above MSL
Length	297 ft (99 m)
Width	292 ft (97 m)
Gross Tons	13,190 tons
Storage Capacity	
Drilling Water	17,188 bbl (2,040 m^3)
Potable Water	1,450 bbl (172 m^3)
Base Oil	1,492 bbl
Lube Oil	160 bbl
Used Oil	242 bbl
Accommodations	
2-man rooms	10
4-man rooms	18
Other	
Medical Unit	6 bed spaces
Potable Water Maker	12,417 GPD capacity
Sewage Unit	Capacity of 3,600 GPD

2.3.2. Drilling Procedures

Standard rotary drilling technology will be used for the proposed wells. This technology utilizes a drill bit to cut the subsurface rock formations. The drill bit, composed of industrial grade diamonds or tungsten on the cutting surface, is attached to a steel pipe called a drill pipe. The drill bit and drill pipe rotate when engaged by the rotary table or top drive unit at the surface. Drilling involves rotating the bit and pipe down the borehole, periodically a new segment of drill pipe is added to the top of the drill string. Drilling continues in this fashion until a new drill bit is needed, the bottom hole assembly needs to be changed, or a predetermined depth is reached and casing is required.

The following step by step procedure will likely be used during the drilling of the shallow water exploratory wells

1. The mobile offshore drilling unit (MODU) is mobilized to location. Once the position is confirmed via differentiated global position system (DGPS), the spud cans and legs are lowered to the seafloor.
2. All jack-up legs are pre-loaded per contractor specifications to ensure MODU stability. The MODU unit (jack-up rig) is raised to the desired height above sea level.
3. All necessary drilling materials are offloaded from supply boats. Sufficient drill pipe is picked up to reach planned total depth.
4. Plans are to jet the initial hole section prior to setting the first planned structural casing. In this case there will be no well cuttings extruded to the seafloor. If jetting is not possible due to hard substrate then using a 26" bit and 42" hole opener the well will be drilled to the first structural casing depth (40 m below the sea floor). Once that depth is achieved, the 36" structural casing is run and cemented. At the same time, a measure while drilling (MWD) tool is used to measure the well trajectory and to confirm that the well is being drilled as planned. A total of 40 m^3 of material will be extruded to the sea floor if this top section is drilled.
5. The 26" hole section will then be drilled with full returns (as will be the case for subsequent hole sections). Once the next planned casing depth is achieved, the 20" conductor casing is run and cemented.
6. For the 17½" hole, a logging while drilling tool (LWD) is used to evaluate formation, while the MWD is used (at the same time) to define the well trajectory to planned surface casing depth.
7. After the surface casing depth is achieved, an open-hole wireline logging tool may be run to evaluate the formation.
8. Once the 13-3/8" surface casing is run and cemented at the desired depth, the BOP (diverter, 20¾" x 13-5/8" casing spool and 13-5/8" BOP) will be installed and tested.
9. For the 12¼" hole, a 12¼" bit is used along with MWD/LWD tools. As previously described, drilling and survey will be conducted at the same time in the 12¼" hole to planned total depth.
10. After the total depth is achieved, an open-hole wireline logging tool may be run to evaluate the formation.
11. Based on formation evaluation, the well will be either permanently abandoned or a drill stem test performed prior to temporary abandonment.

If a DST (drill stem test) is to be conducted, a 9-5/8" production casing will be run and cemented. A 13-5/8" x 13-5/8" casing spool and 13-5/8" BOP (Blowout Prevention equipment) will then be installed and tested.

2.3.3. Casing Program

Casing consists of a series of steel or alloyed metal pipe segments with specific thickness and diameter. The exact size of casing to be used is determined according to the characteristics of the well, the proposed completion, and geological formations to be drilled. Casing joints are coupled one after the other with specific connections. When the casing is in place, cement is pumped down the casing to the bottom of the hole. By continuously pumping, a planned volume of cement displaces the drilling fluid that occupies the space between the borehole wall and the casing (annulus). Once the desired volume of cement has been pumped, displacing all the drilling fluid above it, the cement is allowed to set. This process is repeated several times in a typical wellbore.

Casing functions include:

- Support for the Blowout Prevention (BOP) equipment, which is used to control the well,
- Provide support for weak or fractured rock formations,
- Prevent potential pollution of shallow freshwater formations,
- Isolate hydrocarbon producing formations.

Table 2-4 summarizes one potential program to be used in Area 1 Block Offshore Mozambique.

Figure 2-13 shows the potential planned drilling program. Please note that such configuration is considered the largest that will likely be drilled in Area 1. The use of this configuration is based on AMA1's desire to be prepared to respond to all potential possibilities.

Table 2-4. Preliminary Drilling Program

Casing Type	**Interval**	**Mud Type**	**Hole Size (in)**	**Casing Size (in)**	**Proposed Depth (m)**
Structural pipe	I	Seawater+ Bentonite	Jetted or Drilled	36	90
Conductor Casing	II	Seawater+ Bentonite	26	20	460
Surface Casing	III	WBM or SBM	17 ½	13 3/8	2,290
Production hole	IV	WBM or SBM	12 1/4	none	5,500

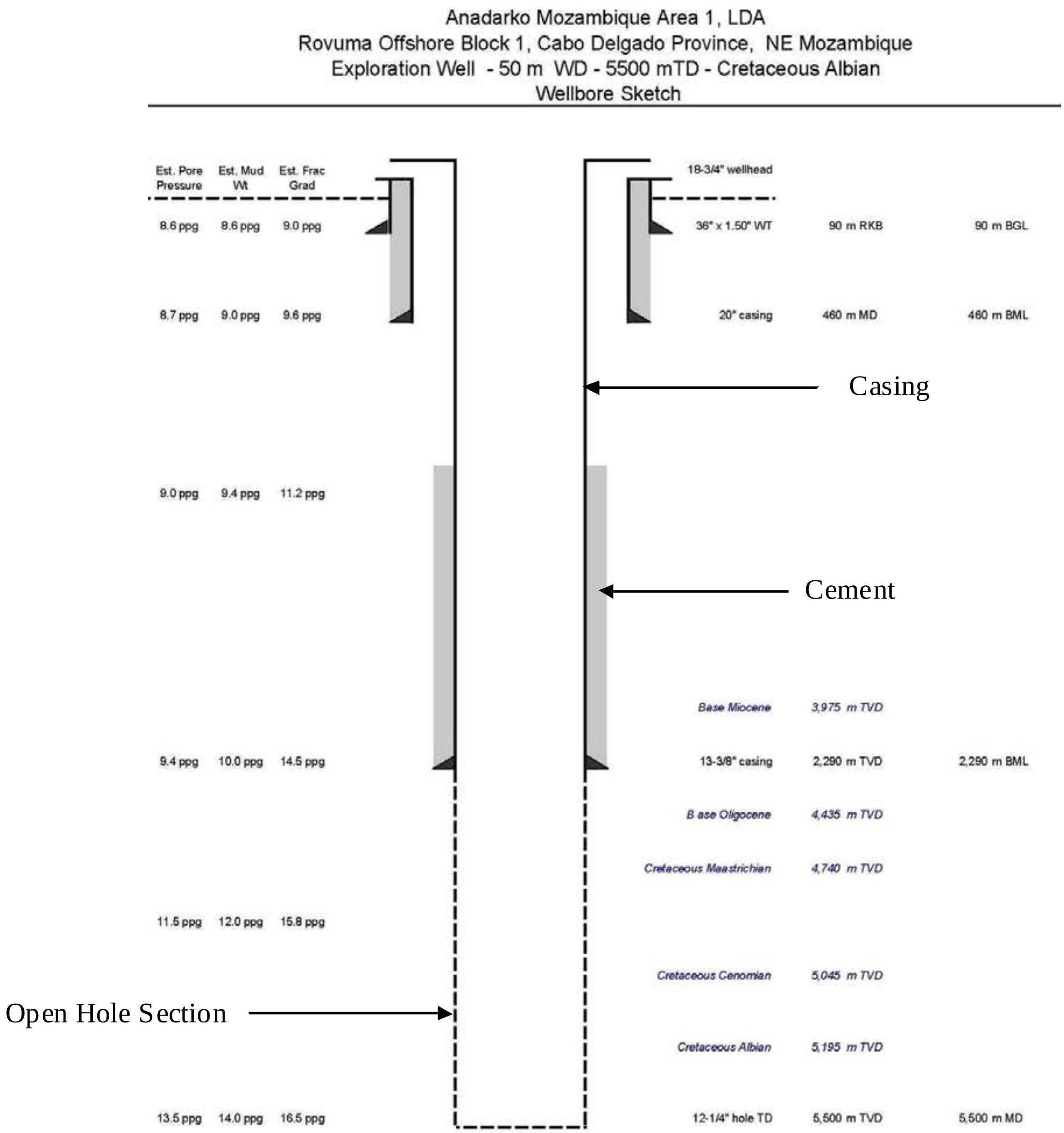

Figure 2-13. Wellbore Sketch

2.3.4. Drilling Fluid Program

Drilling fluids are continuously circulated inside the borehole during active drilling. A carefully planned fluid program will be designed to optimize penetration rates and reduce time spent drilling the well.

The fluids are pumped down the hole through the drill stem and come back to the surface along the space between the drill pipe and the borehole wall, known as “annulus”.

The functions of the drilling fluid are to:

- Clean the hole and provide a vehicle for the rock cuttings from the bit to the surface
- Contain formation pressures by providing a hydrostatic “head” from the density of mud column in the wellbore
- Stabilize the walls of the well bore
- Clean and cool the drill bit and in-hole tools
- Lubricate the hole and the drill string
- Prevent corrosion
- Minimize rock formation damage

Drilling fluids have four basic components: a based fluid, a viscosifier, a weighting material, and one or several special purpose additives. The viscosifier thickens the fluid to obtain a consistency capable of suspending the cuttings and other materials. Bentonite, a naturally occurring, expansive clay known also as sodium montmorillonite, is the most common viscosifier for water based mud systems. Polymers and organophilic clays may also be used according to the type of base fluid and the required properties.

The weighting material is added to the formulation to provide the proper density to the fluid column so pore pressure can be contained along the borehole walls. The most common weighting material is barite (barium sulfate), another naturally occurring mineral. Calcium carbonate and hematite are also frequently used.

The special additives, normally incorporated in drilling fluid formulations, respond to particular needs during the drilling process and include thinners, fluid loss reducers, corrosion inhibitors, and lubricants.

Generally drilling fluids are classified as water-based or oil-based according to the type of base (oil or water) used to prepare the formulation. The water-base fluids are prepared with fresh or salt water, oil-based normally use diesel or mineral and a third generation formulation using synthetic polymers similar to oil as base.

As indicated in Table 5.6, AMA1 intends to drill the required shallow water wells with a mix of seawater and viscosifier to depths between 0 and 460 m (36’’ hole). The 17 ½ ‘’ hole and the production hole (12 ¼ ‘’) may be drilled using a water based mud (WBM) or low toxicity synthetic oil based fluid (SBM). Details related to both formulations known as Ultradrill (WBM option) and Paradrill (SBM option) are provided in Section 5.4.3.2 of this chapter.

2.3.5. Well Control Equipment

The blowout preventer (BOP) is a critical component of the well and provides a mechanical means of shutting the well in the event of drilling into over-pressured zones. This equipment is installed on top of the well head and ensures the well integrity and pressure control during the drilling operations. The following table (**Table 2-5**) summarizes an example configuration used for shallow water wells on board of the Rowan Gorilla III drilling rig. **Figure 2-14** presents a sketch of the BOP proposed for this drilling program.

Table 2-5. Description of Well Control Equipment

General Description	
Diverter	
Manufacturer	Hydril, FSP 2000, size 28”,
Outlet Pressure	2,000 WP
Control System	NL-Koomey, model UD4R-7H-3A
13-5/8" BOP Stack	
Annular	Hydril, Type GK, 13-5/8" x 10,000 psi-WP (BX 159)
Ram Type Preventers	Two (2)- Cameron, 13-5/8", Type "U" doubles, 15,000 psi
Choke manifold	
Valves	21- Cameron 3-1/16", Type "F" gate valves, 15,000 psi
Chokes	Two (2)- Hydraulic Cameron Ultra Chokes Two (2) – Cameron Manual Adjustable Chokes 15000 psi WP. 1 ¾” full open

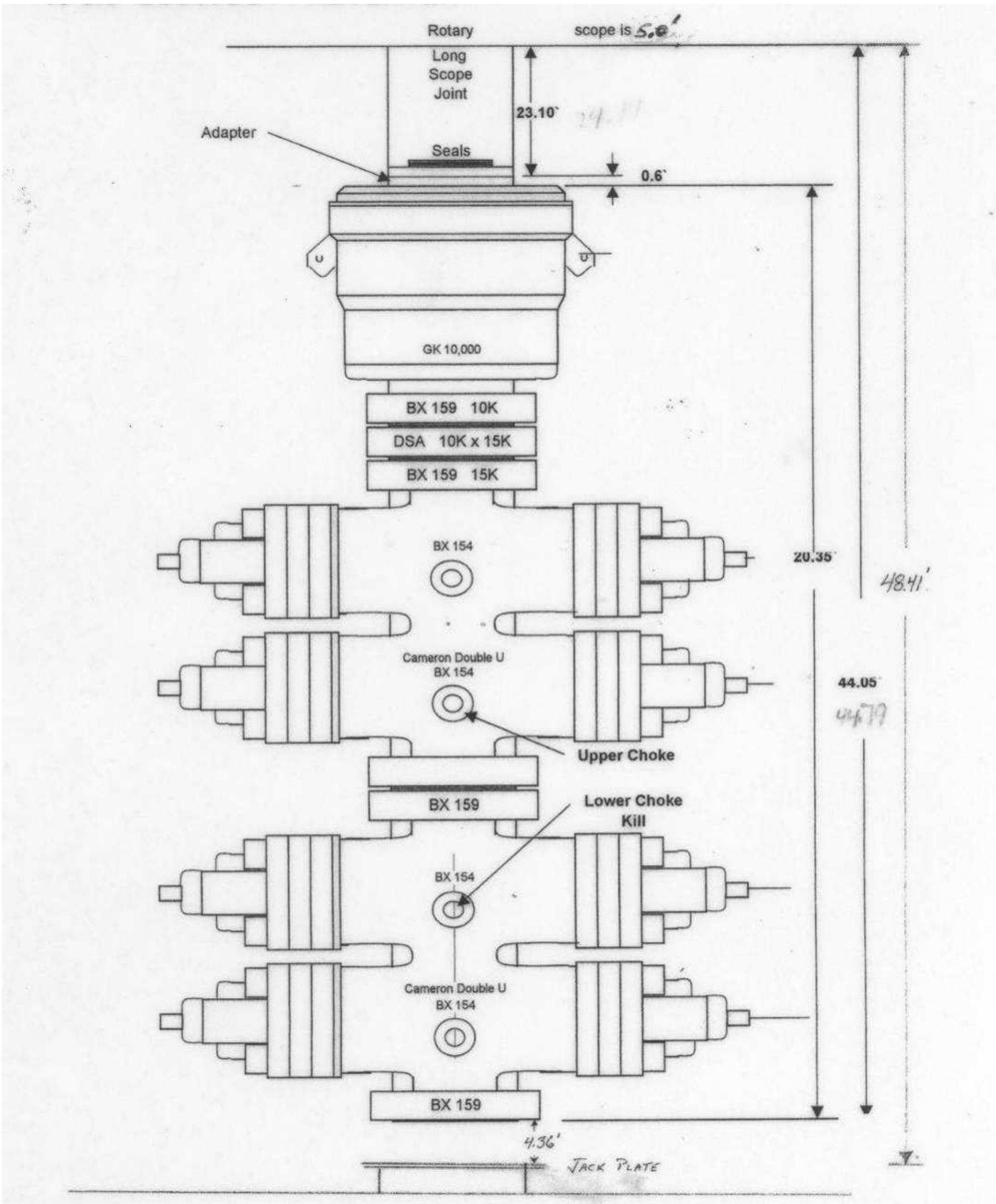

Figure 2-14. 13 5/8 BOP Sketch

2.3.6. Well Testing

There are no plans to perform Drill Stem Tests (DST) during the initial exploration phase of this project. However, cased- hole DSTs may be performed by re-entering the wells at a later date to better define the quality of hydrocarbon reservoirs discovered during the drilling phase.

During a cased hole DST, penetrations are made through the casing at specific intervals corresponding to prospectively productive horizons using shaped charge devises known as perforating tools. A length of appropriately sized tubulars know as the test string is lowered into the wellbore to a depth near the top of the perforated interval, and the annulus between the test string and the casing isolated from the test interval by means of a packer.

After installing surface control equipment, the well is induced to flow by reducing the hydrostatic pressure inside the test string. Over flow periods of various durations and rates information is gathered regarding the flow characteristics of the reservoir and properties of the produced fluids. By subsequent analyses of these data, the commerciality of the tested interval can be inferred and decisions taken regarding further development activities.

The fluids produced during the test will be run through a three-phase separator where gas, oil and water will be segregated and metered. Produced hydrocarbons (oil and gas) will be flared through a burner boom, and produced water, if any, will be discharged overboard per MARPOL standards. In the event that produced water cannot be processed to meet MARPOL, the fluids will be captured in tanks pending re-injection into the tested interval at the conclusion of the flow test.

A simplified schematic of a generic cased-hole DST is shown below.

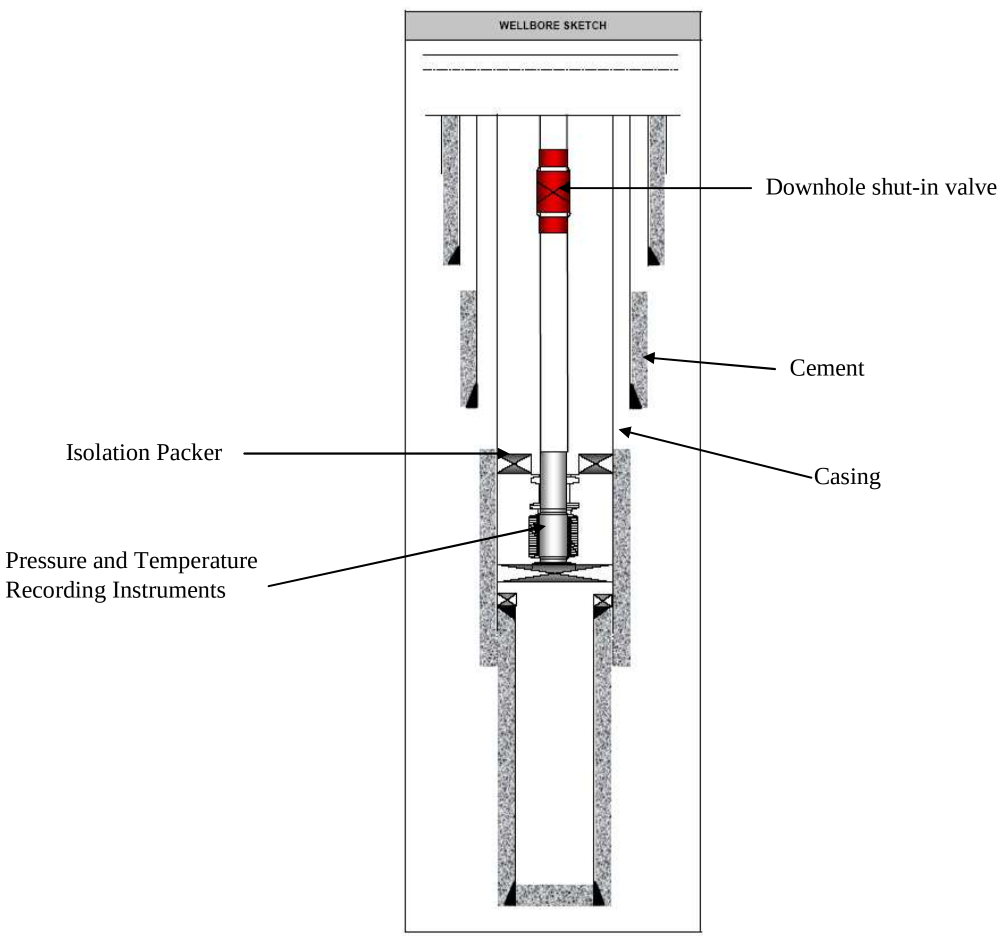

Figure 2-15. Simplified schematic of a generic cased-hole DST

2.4. SITE PREPARATION

As mentioned, prior to the recording of each seismic profile, an ultra-shallow draft scout vessel will sail along the exact location of the proposed line, equipped with a high-resolution fathometer, gathering necessary data related to bathymetry, tidal schedules, reef locations, and general marine and sea floor conditions. If environmentally sensitive areas or potential physical hazards are identified by the scout vessel, line locations will be adjusted in accordance with the Environmental Management Plan (EMP) prepared in conjunction with this EIA. The use of a scout vessel will help ensure that the operation will proceed safely and successfully without causing harm to the environment.

Once all the conditions are known and the lines are adjusted as necessary, the seismic vessel will be mobilized to the seismic project area, and positioned at the selected starting location.

For the drilling phase of the project, site preparation includes geotechnical studies on potential drilling locations to determine soils stability, the mobilization of the drilling rig to the well site, the positioning of the rig over the proposed well bore location, and the stabilization of the rig for drilling operations.

No ROV is planned for the shallow water drilling program. However, prior to the mobilization and depending of the water depth, AMA1 will evaluate the appropriate methodology (use of side scan sonar, video cameras, or divers) to conduct a site reconnaissance. Also, a pre-drilling environmental survey including the collection of water and sediment samples for analysis of biological, physical, and chemical parameters will be conducted at each well location.

2.4.1. Access Route to the Project Area

The seismic survey vessel will be temporarily anchored at Pemba while administrative duties are being conducted. When those efforts are completed the vessel will depart Pemba for the survey area. The vessel is self-sufficient, so it is unlikely that the vessel will stop at any other port, until the survey is completed.

Well sites will be accessed by mobilizing a drilling rig (also known as a mobile offshore drilling unit, or MODU) to the exact coordinates determined by the seismic data. The rig mobilization is assisted by support vessels with dynamical positioning capabilities.

2.4.2. Required Personnel

A total of 25 to 35 crew personnel, Anadarko representatives and monitors will be directly involved in the seismic activities, either as part of the seismic crew or the support vessel personnel. The number of people involved in the drilling activities, either housed on the drilling rig or on support vessels, will be approximately 92.

2.4.3. Equipment and Materials

2.4.3.1. Energy

Fuel will be required to operate engines and run generators which provide electricity for all electrical equipment onboard seismic vessels and the drilling rig. For the seismic, bunkering will be done using the support vessel with the likely fuel coming from Pemba. For the drilling, a fuel barge with approximately 3,000 m3 of fuel will be stationed offshore near Mocimboa da Praia for bunkering purposes. The estimated volume of fuel required to conduct the site preparation and operation phase of the project is presented in **Table 2-6**.

Table 2-6 Estimated Fuel Requirements

Equipment	**Horsepower/ Engine**	**Number of Engines**	**Operation Day**	**Fuel Use (m^3)**
Seismic Survey[1]				
Source Vessel	250	2	90	1 m^3
Receiving Vessel	212	2	90	1 m^3
Floating Accommodation vessel	1 x 139 HP 1 x 120 HP	2 (electrical generation only)	24 Hour	1.5 m^3
Supply Vessel 1	2 x 300 HP	2	24 Hour	2.5 m^3
Supply Vessel 2	212	2	Day Only	0.5 m^3
Exploratory Drilling				
Drilling Rig	1,325	6	180	2,285[2]
Work Boat	2,260	2	180	1,127
Cement Skid[3]	1,600	2	30	75
Total				3,493.5

[1] Related only to 2-D survey. Courtesy of UPSL
2 Based on a drilling rig daily consumption of 80 bbl (12.7 m3)
3 Might be electric-powered so it may be omitted.

2.4.3.2. Materials

During the seismic operations, all operations will take place on the vessels. These survey vessels are self-sufficient and will have all necessary equipment and supplies for the survey as well as living accommodations for the crew. Water and fuel as well as some food and miscellaneous supplies may be obtained in Pemba, however most will arrive onboard the vessel.

Several chemicals will be required as part of the formulation of the drilling fluids necessary for well operations as described in section 5.5.2 and subsections contained therein. Material Safety Data Sheets (MSDS) for all of these chemicals are attached in **Annex 4**. In addition to substances related to the drilling fluid formulation, certain materials such as radioactive components and explosives might be used during the drilling phase of the program. Both of these materials are typically limited to quantities less than 50 kilograms (?) and are employed deep in the wellbore. The radioactive materials, if needed, are used for specialized well logging operations while the explosives would be part of the well completion process. More details will be provided in the addendum to this EIA to be submitted once the locations have been determined.

Table 2-7 summarizes the drilling fluid formulation and quantities.

Table 2-7 Drilling fluid Formulation Plan

Hole	Component	Description	Primary Effect	Amount (kg)
36”	Bentonite	Sodium montmorillonite	Viscosifier	59 MT
26”	Caustic Soda	Sodium hydroxide	Alkalinity control	500
	Soda Ash	Sodium bicarbonate	Precipitation of calcium ions	500
Water Based Fluid Option				
17 1/2” and 12 ¼”	ULTRACAP PLUS	Acrylic polymer	Shale inhibitor	12,250
	ULTRAFREE	Acrylic polymer	Shale inhibitor	22,660
	ULTRAHIB	Acrylic polymer	Shale inhibitor	22,660
	M-I PAC UL	Polyanicoinic cellulose	Fluid loss reducer	9,950
	FLO-TROL	Polysaccharide	Fluid loss control	13,275
	ASPHASOL SUPREME	Sulphonated Organic Residuum	Shale Stabilizer Fluid Loss Additive	76,350
	SALT PVD	Sodium chloride	Shale inhibitor	530
	BARITE	Barium sulphate	Density control	1,540,500
	SUPRAVIS	Biopolymer	Viscosifier	2,660
Low Toxicity Synthetic Oil Based Fluid Option				
17 1/2” and 12 ¼”	VG PLUS	Organophilic clay	Viscosifier	3,000
	SUREMUL	Polyamide	Emulsifier	11,880
	SUREWET	Fatty acids	Emulsifier	2,860
	LIME	Calcium hydroxide	pH modifier	23,000
	ECOTROL RD	Methylstyrene / Acrylate Copolymer.	Fluid loss reducer in invert emulsion drilling fluids.	7,000
	(MOSSPAR H)	Isoparaffinic solvent	Base synthetic oil	6,160
	CACL2 95-97% Purity	Calcium chloride		139
	BARITE (1.0 MT)	Barium sulphate	Density control	1,256,000

2.4.3.3. Water

The estimated amount of water that will be used during the proposed activities is presented in the following table:

Table 2-8 Estimated Water Requirements

Type of Water	Use	Source	Consumption Rate	Estimated Total (lt)
Seismic Survey[1]				
Fresh water	Drinking Water	Onshore	4 lt/day/person	10,800
Fresh water	Domestic water	Onshore	110 l/day/person	297,000
Seawater	Sanitary	Ambient waters	83 l/day/person	224,100
Exploratory Drilling[2]				
Fresh Water	Drinking Water	Onboard treatment	4 lt/day/person	66,240
	Domestic water	Onboard treatment	110 l/day/person	1,821,600
Seawater	Drilling	Ambient waters	Per well geometry	9,164 m3

[1] Refers to 2-D only. Based on 90 days and 30 people
[2] Based on 180 days and 92 people on board.

2.4.3.4 Emergency Response Equipment

AMA1 will implement an Emergency Response Plan which directs actions to be taken in the event of several types of emergencies, including oil spills. The Oil Spill Contingency Plan (OSCP) describes the equipment that will be available at the onshore base in Pemba, as well as the global resources that could be mobilized to Mozambique within 24 hours of a spill. The OCSP includes a list of the equipment that will be available in Pemba and onboard of the supply vessel. This plan will be continually updated as exact drilling locations are decided.

2.5. OPERATIONS

2.5.1. Logistics

The seismic survey vessels and crews are highly specialized and will be mobilized from outside Mozambique. The vessels will have onboard provisions; however, an escort vessel will be designated to bunker the fuel and supplies from Pemba when needed, while one or more other escort vessels continue to ensure there are no obstacles in the survey vessel's path. Half the crew will be rotated approximately every three weeks through Pemba via helicopter and international flights to Johannesburg, South Africa.

The seismic vessel will be mobilized from Pemba. Anchoring and mooring of the vessels will be done only in designated areas.

During drilling, fuel will be bunkered from a fuel barge located offshore near Mocimboa da Praia. The support vessels will bunker the fuel from the barge to the drill platform. The supply vessels will also travel to Pemba frequently to obtain various supplies for crew support and drilling operations. The crew will most likely work a 28 day rotation schedule with crew changes through Pemba via helicopter and international flights to Johannesburg, South Africa.

A pre-drill assessment of shallow geohazards will be carried out for each possible well location. The geohazard assessment will be based on interpretation of 2-D exploration seismic data. The geohazard assessment is limited to the seafloor and shallow geologic section. Features such as shallow deposits of natural gas, if present near the selected drill site, will be detected so as to properly design and manage the well bore when drilling commences.

2.5.2. Project Generated Wastes

2.5.2.1. Solid and Liquid Wastes

The specific details of how this project will handle seismic, exploration drilling and well testing wastes will be given in the project Waste Management Plan associated with this EIA. The following information is included in this Project Description to provide an overview.

Wastes generated during the seismic process include domestic wastes, sanitary water, trash, used oil and lubricants, and a small amount of solvents. The total amount of wastes generated will be relatively small due to the brief duration of this phase of the project. Based on the duration and characteristics of the project it is estimated that 0.560 tons of non-hazardous waste (paper, cardboard, scrap metal, etc.) and 0.245 tons of hazardous wastes (oily rags, paint cans, etc) be generated. Also, it is estimated that 400 liters of used oil be stored onboard for later disposal in a licensed facility.

Used drilling fluids and cuttings generated during the drilling process constitute the largest volume of any of the various types of wastes generated during the proposed drilling operation. Other wastes generated during the process include deck drainage, domestic wastes, and sanitary water, trash, used oil and lubricants, solvents and excess cement. Estimated volumes of liquid waste generation are presented in the following table (**Tables 2-9a and 2-9b**).

Table 2-9a Estimated Solid Wastes

Waste stream	Seismic Operations[1]	Drilling Operations[2]	Estimated Total (Kg)
Paper	80 kg	2.50 ton	2580
Plastic	80 kg	1.62 ton	1700
Glass	180 kg	0.60 ton	780
Metal scrap	180 kg	76.5 ton	76680
Batteries	-	0.21 ton	210
Plastic drums	-	0.48 ton	480
Oily rags	180 kg	92.15 ton	92330
Metal drums	9 units (40.5kg total)	3 ton	3040
Cement	-	3.15 ton	3150
Drilling cuttings	-	1,430m3	1,430m3
Aerosol cans	22.5 kg	0.09 ton	112

[1] Refers to 2-D only. Based on 90 days
[2] Based on 180 days and 92 people on board. .

The rig has drip pans and piping to collect drill floor and cantilever deck waste into a collecting tank for pollution control as required by the U.S. Coast Guard; as well as a 6" skirt around the aft main work deck to prevent discharge over the side of potentially hazardous waste. The six aft deck drains lead into a common skimmer tank and collection pans around all diesel day tanks are capable of containing the contents of the respective tanks.

Table 2-9b Estimated Liquid Wastes

Waste stream	Seismic Operations[1]	Drilling Operations[2]	Estimated Total (m^3)
Used oil	0.4 m^3	12 m^3	12.4 m^3
Oily water (from oil/water separator	-	1,591 m^3	1,591 m^3
Sanitary Wastes	90 m^3	2,160 m^3	2,250 m^3
Non Aqueous fluids	-	43m^3	43 m^3

[1] Refers to 2-D only. Based on 90 days
[2] Based on 180 days and 92 people on board. .

2.5.2.2. Air Emissions

Air pollutants that will be emitted during the project include nitrogen oxides (NOx), sulfur oxides (SOx), carbon monoxide (CO), volatile organic compounds (VOC's), and particulate matter (PM10). The primary sources of these pollutants are the diesel engines that power the seismic vessel, the drilling rig and support vessels, generators and other equipment required for the project.

Table 2-10. Estimated Maximum Air Emissions (kg/hr)

Engine	Number of Engine	NOx (as NO2)	CO	Total HC	SOx	Particulates
Seismic survey						
Source Vessel	2 (250 HP)	5.45	1.25	0.16	1.84	0.01
Receiving Vessel	2(212 HP)	4.62	1.06	0.14	1.56	0.01
Floating Accommodation vessel	1 x 139 HP	1.51	0.35	0.04	0.51	0.01
	1 x 120 HP	1.31	0.30	0.04	0.44	0.01
Supply Vessel 1	2 x 300 HP	6.54	1.50	0.19	2.20	0.02
Supply Vessel 2	2 x 212 HP	4.62	1.06	0.14	1.56	0.01
Exploratory Drilling						
Drilling Rig 1325 Hp	6 (1325 HP)	86.62	19.9	2.54	29.20	0.22
Work Boat	2(2260 HP)	49.24	11.3	1.44	16.6	0.12
Cement Skid	2(1600 HP)	35	8	1.1	11.76	0.08
Total		194.91	44.7	5.79	65.67	0.48

2.5.2.3. Noise Emissions

During the seismic operations, noise will also be produced by equipment that functions as the sound source for the survey. Noise will also be produced by the diesel-powered generator and operation of the ship engine and propellers on the main survey vessel as well as the smaller support vessel, and by operation of the helicopter that is onboard the survey vessel.

The seismic sources produce an impulse of strong sound with low frequency at frequent and regular intervals. The noise levels emitted are typically around 220 dB re 1uPa for a single source.

The volume of a single compressed air cylinder (the source of acoustic energy for the seismic work) to be used is 1,500 cu. in. Sources of this magnitude would be expected to generate a maximum sound pressure level in the source of approximately 220 dB. These noises or sound impulses would be emitted every 7 seconds as the sources are released.

During the drilling operations, noise will be produced by the diesel-powered engines used to operate vessels, helicopters, and drilling equipment. Noise will also be produced by the drilling itself, as well as associated activities such as welding. The most significant types of equipment in this regard are:

- Prime movers (main power source for drilling rig),
- Generators,
- Cranes,
- Cement pumps,
- Support vessels (survey, tug, supply, work, and crew), and
- Helicopters.

Typical average noise levels reported in the literature for jack-up rigs running 24 hr/day are 119-127 at the source (dB/1uPa/1m) with the strongest tones near 5 Hz.

2.6. SITE ABANDOMENT

The abandonment phase of the proposed project consists of all temporary and permanent plugging and abandonment of exploratory wells drilled for this project. Abandonment refers only to the abandonment of the proposed wells, not to the field itself, as temporarily abandoned wells may be revisited in the future.

The typical procedure in well abandonment is to set several cement plugs into the well bore at various depths. These plugs permanently seal the well bore so that no liquids can move up or down the well bore between formations.

For permanent abandonment, the casing is cut below the surface of the seafloor (also know as the mudline) and capped, this is followed by removal of all equipment and material that could pose a hazard to navigation or fishing activities. During temporary abandonment the surface casing is left extending 1-2 m above the mudline, but protected by a cage or net guard, or above the sea level, covered by a net guard and equipped with light feature, so as to avoid creating a hazard to navigation and fishing. It should be noted that the procedures are subject to change or modification depending on the operational situation and mechanical conditions encountered on site at the time of abandonment.

2.7. WORK SCHEDULE

AMA1 intends to conduct the proposed 2-D seismic survey in the second quarter of 2009. It is planned that the seismic program will be conducted in 90 days. The 2-D lines will serve as a reconnaissance tool to determine the location of any 3-D surveys required in the area. The schedule for the 3 D surveys has not been determined and will be controlled by the interpretation of the 2D data and equipment availability. Drilling may proceed with out acquisition of a 3D seismic survey.

The exploratory drilling phase is expected to commence in the first quarter of 2010. The duration of individual wells is expected to be less than 90 days. Three obligation wells will be drilled before February 2012.

Chapter 3

ALTERNATIVES CONSIDERED

CHAPTER 3

ALTERNATIVES CONSIDERED

The project consists of 2D and 3D seismic surveys and the exploratory drilling of three wells in shallow waters less than 200m in depth.

According to the Mozambican EIA legislation, an analysis of alternatives is required. This report assesses two types of alternatives: a) The No Action Alternative and b) Project Alternatives, including the project location (adjustments to the location of the seismic survey configuration and location of the rigs), adjustments to project scheduling (timing of seismic surveys) and project technologies (seismic methods and rig and drilling fluids alternatives).

3.1 NO ACTION

Seismic surveying and exploratory drilling are required elements in searching for petroleum resources (natural gas or oil).

Should the “No Action” alternative be accepted, opportunities to find hydrocarbons in the project area would be eliminated. This would result in Mozambique’s continued dependence on hydrocarbons from other countries and prevent Mozambique from accruing significant economic benefits from this research.

This option is not recommended for the following reasons:

3.1.1 Contractual reasons

- AMA1 signed an Exploration and Production Concession (EPC) contract with the Government of the Republic of Mozambique for Offshore Area 1 (Area 1) in the Rovuma Basin;
- The EPC contract between AMA1 and the Republic of Mozambique requires AMA1 to prospect for petroleum resources in the Rovuma Offshore Area 1 within 5 years;
- AMA1 is required to drill three wells in shallow water less than 200m deep (this project);
- The “No Action” alternative represents a failure to meet the requirements of the EPC between AMA1 and the Government of Mozambique.

3.1.2 Socio-economic reasons

- This alternative is likely to have a negative impact on the Mozambican economy as the potential to discover commercial quantities of hydrocarbons will be eliminated.
- Major drivers for the development of hydrocarbon natural resources in Mozambique are: (1) the potential for substantial increases in revenues from success scenarios, and (2) the global demand for fuel. The ability to produce and supply crude oil to the local and world market could lead to the basis of great strategic importance to the national economy of Mozambique for decades into the future adding to the Gross National Product, generate foreign exchange and create job opportunities;
- The Country needs investments that can stimulate its economic development and thus improve the quality of life for its inhabitants;
- Possibility for long term technology and knowledge transfer, further bringing economic development;
- Cabo Delgado Province needs projects that can improve the socio-economic conditions and allow for their multiplying effects to take place in order to develop the province;

The positive impacts of choosing the “No Action” alternative are there will be no negative impacts on the marine environment and on artisanal fishing activities or tourist activities.

3.1.3 Environmental Reasons

As detailed in this EIA, if the project follows internationally accepted protocols, local and national laws, as well as applying suggested project-specific mitigation and monitoring measures, the hydrocarbon exploration will be developed with acceptable socio-economic and environmental impacts.

Based on the discussion above, whereby several potential socio-economic benefits have been indicated and taking into account the absence of fatal flaws provided that the mitigating measures are fully implemented, it is recommended that the “No Action” alternative should be rejected, i.e. the project should be allowed proceed.

3.2 PROJECT ALTERNATIVES

3.2.1 Seismic Program

Various alternatives in the scheduling and configuration of the seismic program and potential mitigation measures for possible impacts have been evaluated as part of this EIA.

The two main types of alternatives evaluated in detail were temporal alternatives (i.e., adjustments to project scheduling) and spatial alternatives (i.e., adjustments to the survey configuration within the shallow water area of Concession Area 1). The surveys will be scheduled to avoid the humpback whale season (July through December). The survey schedule is discussed further in **Chapter 2 (Project Description)**, and the rationale for project scheduling as mitigation is discussed in **Chapter 6 (Impacts and Mitigating Measures)**.

Spatial Alternatives within Project Area

Spatial alternatives were considered and included in the Seismic Program. **Figure 3-1** shows the survey area as originally prepared by AMA 1.

The analysis of project spatial alternatives within the Project area took into account several criteria for development of an alternative seismic configuration. These criteria include:

1. Seismic lines occurring within, or near to, sensitive habitats identified in the sensitivity mapping exercise.
2. Seismic lines occurring near to islands with tourism complexes
3. Seismic lines occurring with, or near to, the buffer zone of the Quirimbas Nation Park.

Based on these criteria alternatives to the initial seismic configuration were made *viz*.:

1. Seismic lines passing through certain sensitive habitats and associated buffer zones as defined in the Environmental Sensitivity Analysis Report (CSA, October 2008) were excluded.
2. Seismic lines passing adjacent to islands with tourist complexes (Vamizi and Medjumbe islands) were moved or excluded
3. Seismic lines within the Concession Area 1 but also falling within the Quirimbas National Park buffer zone were excluded.

The initial seismic program comprised 2503 km of seismic lines (**Figure 3.1**) whereas the revised seismic program comprises 1180 km of seismic lines (**Figure 3.2**).

Alternative Scheduling
Reasonable temporal alternatives were considered and these have been included into the seismic program. Surveys will be scheduled to avoid the humpback whale migration season in the coastal waters off the Cabo Delgado coast which takes place from July through to December.

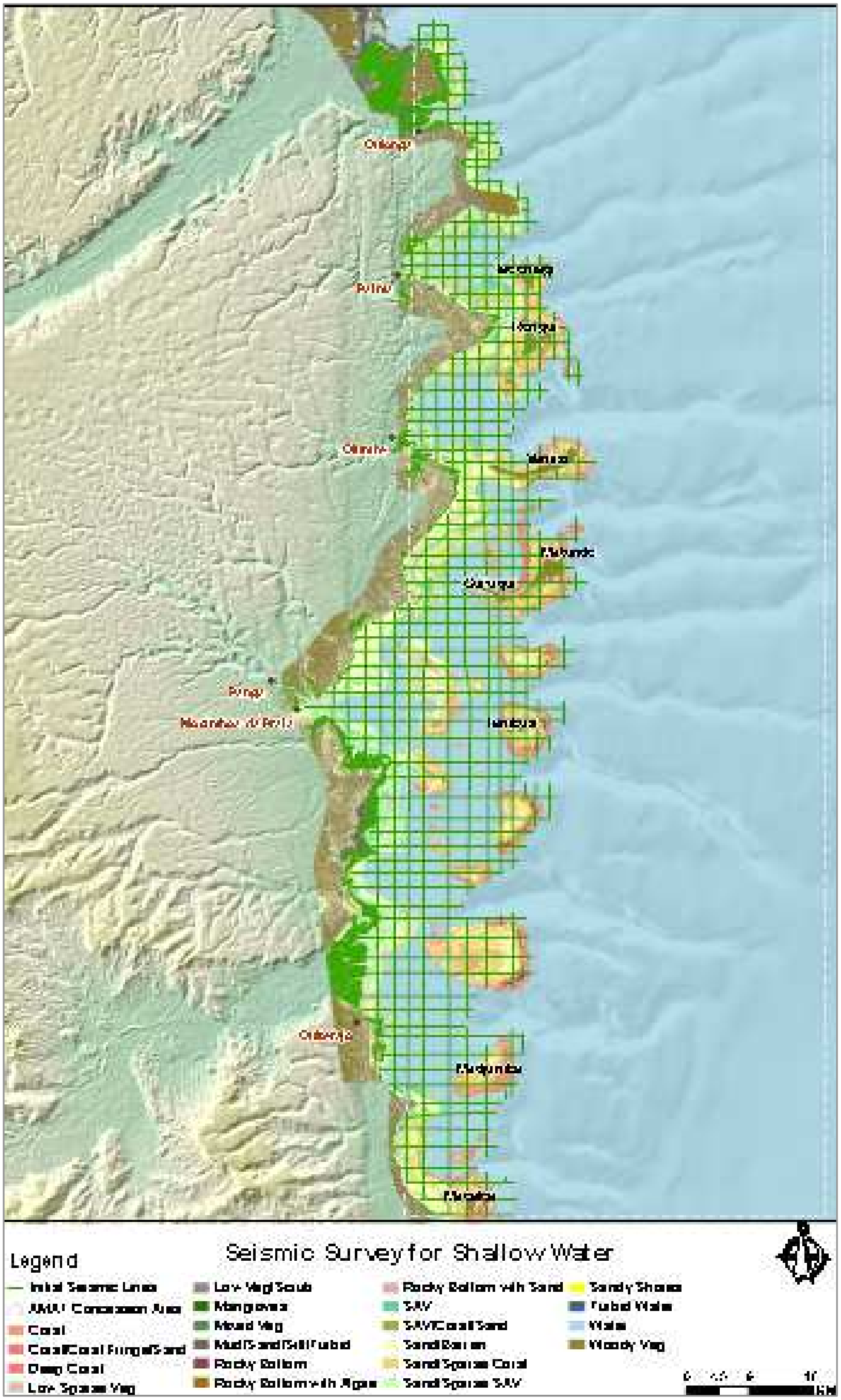

Figure 3-1. Initial AMA1 2-D seismic survey program in shallow water

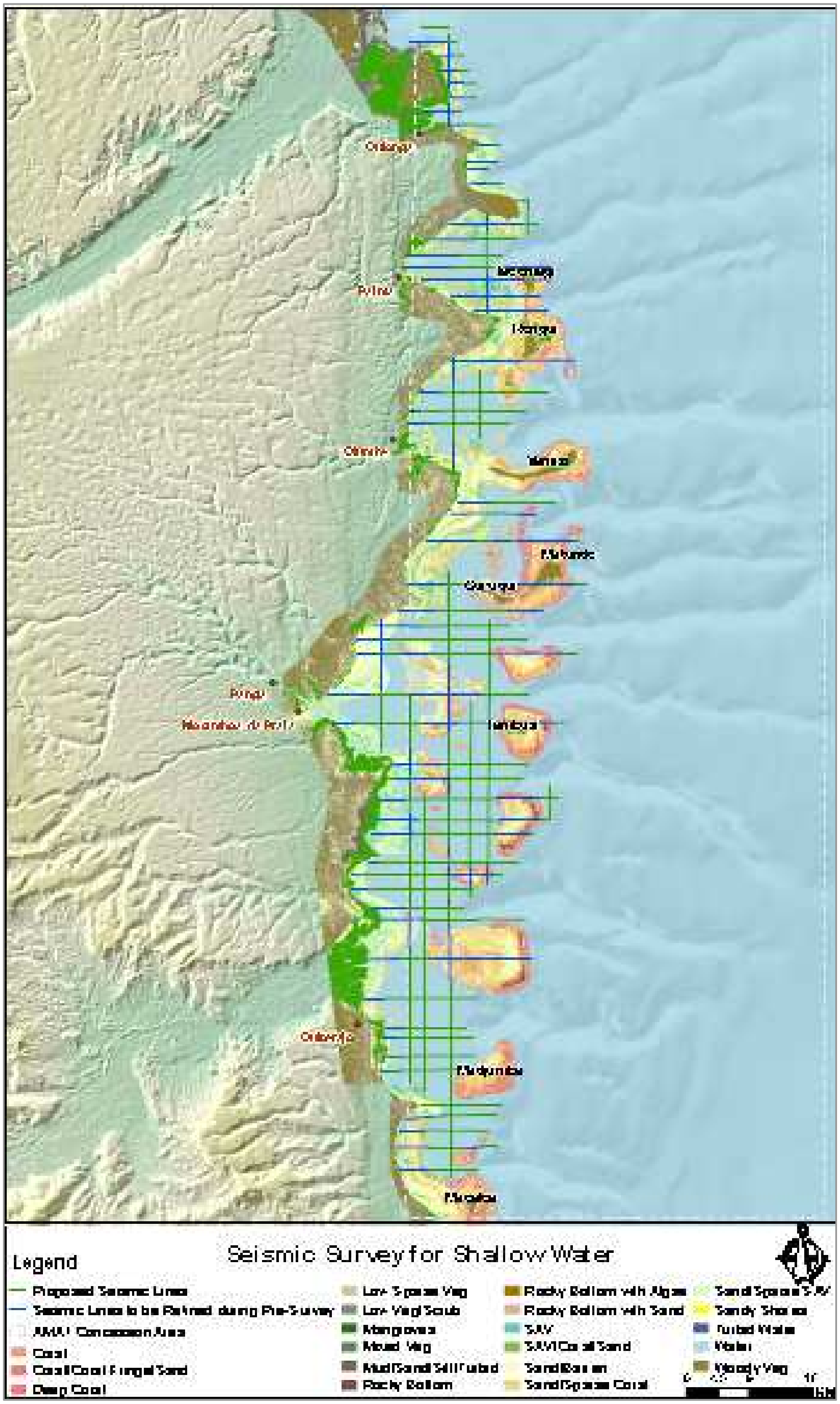

Figure 3-2. Revised 2-D seismic survey program in shallow water.

3.2.2 Drilling

Project location

The area where the drilling will take place is located within the 200m bathometry line of the Concession Area granted to AMA1 by the Mozambican Government as part of the Exploration and Production (EPC) Contract, which is limited to Area 1.

In projects of this nature, the site location is determined after seismic acquisition and detailed geophysical and geological studies with the well location determined by the probability of existence of reserves at a specific site within the Concession Area. Therefore, for contractual reasons it is not possible to consider geographical alternatives outside the Project or Concession Area. However, once the location of the proposed drilling sites within the shallow water portion of the Concession Area is known an analysis of location alternatives will be carried out.

Project technologies

With regard to project technologies, the types of rig and drilling fluid system alternatives to be used are considered.

a) Rig Selection

There are various rig types that can be considered but this analysis will compare two types of rigs that are suitable for shallow water *viz*.:

- Jack ups
- Moored rigs

With a jack-up rig a pre-site survey can be conducted to determine sea floor environmental features prior to placing the rig on the seafloor in order to minimize environmental impacts.

Moored drilling rigs are either ship-shaped or column-shaped semi-submersibles. The rig is maintained on location through a system of moored lines (8 to 10 anchors) anchored to the sea floor. The surface area directly impacted by the positioning of the vessel comprises the area where the anchor lines make contact with the seafloor, covering a radius of about 3 – 4 times the water depth at the rig location. Thus the contact with the sea floor is more extensive and there is less control over the placement of the anchors as compared to the legs of the jack-up. Jack-up rigs are, therefore, environmentally preferable to a moored rig due to the large area of anchoring disturbance of the latter that would result from the mooring process.

The Jack up rig will be used in this drilling program.

b) Drilling Fluids Selection

Drilling fluids are continuously circulated inside the borehole during active drilling. There are two primary types of drilling fluids: water based fluids (WBFs) and non-aqueous drilling fluids (NADFs).

WBFs consist of water mixed with bentonite clay and bariumsulphate (barite) to control mud density and thus, hydrostatic head. Others substances are added to gain the desired drilling properties. Conventional water-based muds (WBM) offer the benefits of environmental compliance, attractive logistics, and a relatively low unit cost but fail to approach the drilling performance of NADFs at greater depths. In other words, WBMs are the most environmentally friendly fluids, however at greater depths they lose efficiency and NADFs are required.

There are several NADFs on the market some of which are less toxic and thus have less potential environmental impacts. The NADFs comprise all non-water and non-water dispersible base fluids. Similar to WBFs, additives are used to control the properties of NADFs. The base fluid provides sufficient lubricity to the fluid, eliminating the need for lubricating agents. NADFs are grouped according to aromatic hydrocarbon concentrations (which contribute to fluid toxicity) as follows:

Group I non-aqueous fluids (high aromatic content)

These were the first NADFs used and include diesel and conventional mineral oil based fluids. They are refined from crude oil and are a non-specific collection of hydrocarbon compounds including paraffins, olefins and aromatics, and polycyclic aromatic hydrocarbons (PAHs). Group I NADFs are defined by having PAH levels greater than 0.35%.

Diesel oil based fluids: The PAH content of diesel-oil fluids is typically in the range of 2-4% and the aromatic content is up to 25%.

Conventional mineral oil (CMO) based fluids: These were developed as a first step in addressing the concerns over the potential toxicity of diesel oil-based fluids and to minimize fire and safety issues. CMOs are manufactured by refining crude oil, with the distillation process controlled to the extent that total aromatic hydrocarbons are about half that of diesel. The PAH contents are 1-2 %.

Group II non-aqueous fluids (medium aromatic content)

These fluids, usually referred to as Low Toxicity Mineral Oil Based Fluids (LTMBF) were developed as a second step in addressing the concerns over the potential toxicity of diesel-based fluids. Group II NADFs are also developed from refining crude oil, but the distillation process is controlled to the extent that total aromatic hydrocarbon concentrations (between 0.5% and 5%) are less than those of Group I NADFs and PAH content is less than 0.35% but greater than 0.001%.

Group III non-aqueous fluids (low to negligible aromatic content)

These fluids are characterized by PAH contents less than 0.001% and total aromatic contents less than 0.5%. Group III includes synthetic based fluids which are produced by chemical reactions of relatively pure compounds and can include synthetic hydrocarbons (olefins, paraffins, and esters).

Synthetic hydrocarbons: Synthetic hydrocarbons are produced solely from the reaction of specific, purified chemical feedstock as opposed to being distilled or refined from petroleum. By virtue of the source materials and the manufacturing process, they have very low total aromatic hydrocarbon and PAH content (<0.001%). The most common synthetic hydrocarbons are esters, polymerized olefins (linear alpha olefin (LAO), internal olefin (IO)) and synthetic paraffins.

Highly processed mineral oils: These fluids are produced by refining and/or separation processes and can have composition and properties similar to those of synthesized paraffins. The composition of these fluids depends on the feedstock and the refining or separation processes used.

Historically, diesel and mineral oils were the base fluids (together referred to as Group I NADFs) used in NADFs. These however have higher aromatic content and consequently higher toxicity and greater potential impact on the environment. The drilling advantages of Group I NADFs can be obtained with the use of the Group II and Group III NADFs that have technical performance properties and uses similar to Group I fluids. Group II and III NADFs have lower aromatic content and PAH than diesel oil or mineral oil and have thus lower acute toxicity – this is especially the case if the Group III NADFs.

The use of water-based mud (WBM) and Group III synthetic-based mud (SBM) as Non Aqueous Drilling Fluid is expected for this program. The Group III Non Aqueous Drilling Fluids which correspond to the most recent internationally used and are the most acceptable from an environmental point of view as it has very low to negligible aromatic content.

Mozambican legislation, in Article 77 of Decree 24/2004 (Regulation of Petroleum Operations), regulates the use of synthetic-based drilling fluids, restricting its use to “only when necessary and according to operational and safety criteria”.

3.3 CONCLUSIONS REGARDING ALTERNATIVES

Should the “No Action” alternative be accepted, opportunities to find hydrocarbons in the project area would be eliminated. This would result in Mozambique’s continued dependence on hydrocarbons from other countries and prevent Mozambique from accruing significant economic benefits from this research. This option is, therefore, not recommended.

For the seismic survey program project alternatives related to spatial alternatives and scheduling (timing) alternatives are available. For the drilling program technological alternatives for the type of drilling rig and type of drilling fluids are available.

The selection of the alternatives described will reduce environmental and socio-economic impacts. Any potential impacts arising from the revised seismic and drilling program can further be minimized through the implementation of the mitigating measures as outlined in Chapter 6.

Chapter 4

LEGAL AND REGULATORY FRAMEWORK FOR ENVIRONMENTAL MANAGEMENT IN MOZAMBIQUE

Chapter 4

LEGAL AND REGULATORY FRAMEWORK FOR ENVIRONMENTAL MANAGEMENT IN MOZAMBIQUE

4.1 Overall Environmental Management

The key elements for environmental management in Mozambique are the following:

- Strategic Plan for the Environmental Sector
- The Environmental Law;
- EIA Regulations, including the General Directives for Environmental Impact Assessment and for the Public Participation Process in the Environmental Impact Assessment;
- Regulations on Environmental Quality and Effluents Emission Standards;
- Regulations for the Environmental Audit Process.
- The Forestry and Wildlife Law and the Forestry and Wildlife Regulations

Environmental management in the context of the petroleum industry is defined through the Petroleum Law and the Regulation on Petroleum Operations.

The Sea Law and the Regulations for the Prevention and Protection of the Marine and Coastal Environment add a certain level of protection to marine ecosystems in relation to marine pollution.

The protection of certain marine species is regulated by the Forestry and Wildlife Law and the Regulations on Recreational and Sport Fishery.

4.1.1 Strategic Plan of the Environmental Sector

In 2004, the Ministry for the Coordination of Environmental Affairs prepared a Strategic Plan for the Environmental Sector (SPES) for the period of 2005 – 2015. The SPES replaces the 1994 National Environmental Management Program

The SPES covers four broad areas.

1. Protection and Management of Natural Resources covering:

   - Land and associated resources
   - Water resource and associated
   - Ocean, coast and island (with the objective of promoting the productive and sustainable use of maritime and coastal resources)
   - Biodiversity (species and protected areas)

2. Urban Environment:

- Urbanization and planning
- Health & Environment

3. Atmospheric Pollution:

- Promote systematic monitoring.
- Adhere to relevant international conventions.
- Provide incentives to industry for improved technology ,

4. Population:

- Population dynamics and structure
- Endemic diseases and health care
- Water and sanitation

The SPES takes its lead from Government of Mozambique's Action Plan for the Reduction of Absolute Poverty (PARPA) as well as the United Nations Millennium Goals as developed by the UN Summit held in Johannesburg in 2002.

The SPES comprises Strategic Plans for seven specific areas:

1. Environmental heath and waters
2. Land Planning
3. Land degradation
4. Management of natural resources
5. Legal and institutional aspects
6. Water , soil and pollution
7. Nature and environmental calamities.

The Strategic Plan in the area for the Management of Natural Resources identifies the formulation and implementation of a program for the protection of marine and fisheries biodiversity as a key action for the preservation of Mozambique's biodiversity.

4.1.2 The Framework Environment Law

The Framework Environmental Law was passed by the Mozambican Parliament in July 1997[1].

The aim of this law is to provide a legal framework for the use and correct management of the environment and its components such that it assures sustainable development.

The Environmental Law is applicable to all public or private activities, which may influence the environment either directly or indirectly.[2]

[1] Law No. 20/97, Boletim da República No. 40, 1st Series, 3rd Supplement, of 7th October 1997
[2] Article 3, of the Environmental Law.

The salient features of the Law include the following:

- With regard to liability, those who pollute, or in any way degrade the environment, are always under obligation to rehabilitate it or to compensate for the resulting damage.[3]
- The Law forbids pollution from the discharge of any polluting substances into the soil, subsoil, water or atmosphere or any other form of degradation of the environment, which fall outside the limits stipulated by the law.[4]
- The law also forbids, explicitly, the importation of dangerous residues or dangerous waste, except for that laid down in specific legislation.[5]
- Projects and operations that are likely to have a negative impact on the environment are required to be subject to an Environmental Impact Assessment by independent assessors.

The Law also forbids all activities that may threaten the conservation, reproduction, quality and quantity of biological resources, especially those in danger of extinction.[6]

Licensing of activities that are liable to cause significant environmental impacts shall be required. The issuance of an environmental license shall be based upon an environmental impact assessment.

In order to protect the environmental components that have a recognized ecological and socio-economic value, environmental protection zones can be created. These protected zones may be national, regional or local and may cover land areas, lakes, rivers, marine waters and other distinctive nature zones.

To ensure the effective co-ordination and integration of sectoral policies and plans related to environmental management at the highest level, a National Commission for Sustainable Development (NCSD), linked to the Council of Ministers, has been created by a provision in the Framework Environmental Law.

4.1.3 Regulations for the Environmental Impact Assessment Process

According to Article 2 of the Regulations on the Environmental Impact Assessment Process the dispositions of this diploma apply to all public or private activities that can, directly or indirectly, influence the environment, in accordance to the terms of the Article 3 of the Environmental Law[7].

Article 2 further states that: "*Environmental impact studies for the exploration, research and production of petroleum, gas and mining industry will be guided by specific regulations*".[8]

Article 5 describes the institutional competences for environmental impact assessment:

[3] Idem, paragraph (g).
[4] Article 9 of the Environmental Law.
[5] Idem.
[6] Article 12 of the Environmental Law
[7] The Decree N.º 45/2004 of 29th September is published in the Boletim da República No. 39, 1st Series, Supplement, of 29th September 2004
[8] Note: Currently, there is no specific regulation for Environmental Impact Assessment for the oil sector, although the Petroleum Law (Law no. 3/2001) and the Regulations on Petroleum Operations (Decree no. 24/2004) acknowledge the need for environmental protection and management (see Section 1.1.5).

1. The Environmental Impact Assessment Authority is responsible for[9]:

   a) Managing and coordinating the EIA process;

   d) Naming and chairing the Technical Evaluation Committee for each category A activity, whenever deemed necessary;

   e) Conducting and guiding the analysis of EPDA, ToR, EIA Reports as well as their approval for Category A activities;

   f) Requesting the participation of specialist technicians from the public sector or hire private sector consultants whenever necessary for the EIA process;

   g) Holding public meetings and ensuring that public participation is complied with in accordance to the terms of this Regulation;

   h) Notifying the proponent on the payment of environmental licensing fees in accordance to the terms of the current Regulation;

   k) Issuing environmental licenses;

   l) Carrying out, in coordination with the sectoral authorities bodies responsible for the activity, the post-evaluation process including analysis of monitoring reports, environmental auditing and promoting inspection and supervision of licensed activities.

According to the EIA Regulations the granting of an Environmental License is a prerequisite to a range of development activities (defined in the Regulations, Annexes I, II and III). The Proponent can begin the project implementation only once the Environmental License has been granted.
The EIA Regulations define three project categories (A, B and C) on basis of which the extent of the environmental assessment is determined by MICOA. Three categories of project are defined by the new Regulations (Article 3):

- Category A: Activities presented in Annex 1 are considered to have significant adverse impacts on the environment and are subject to an EIA;
- Category B: Activities listed in Annex II are those for which potential environmental impacts are less adverse than those of Category A projects and are subject to a Simplified Environmental Assessment (SEA); and
- Category C: Activities listed in Annex III are exempt from an EIA and SEA but still require observance of good management practices.

In accordance with EIA Regulations, there are three distinct steps to carrying out an EIA for a Category A Project:

[9] i.e. The National Directorate for Environmental Impact Assessment, MICOA.

1. Registering the EIA with the Ministry for the Coordination of Environmental Affairs (MICOA) ("Instrução do processo");
2. Preparation of an Environmental Pre-feasibility and Scope Definition Study (EPDA) ("Estudo de Pré-viabilidade Ambiental e Definição de Âmbito") and Terms of Reference for the Environmental Impact Study (EIS);
3. The EIS Study, *per se*.

Registration of the EIA

In the first instance the proponent must register the project with MICOA in order for the project to be classified (Category A, B or C).

The documentation for registering the EIA with MICOA are as follows:

- Descriptive Memoir;
- Description of the activity;
- Justification for the Activity;
- Legal framework;
- Summary bio-physical and socio-economic description of the area;
- Resource use in the area;
- Information about the environment in the area of the proposed activity;
- Information about the EIA steps, i.e. production and submission of the Terms of Reference (TOR), Environmental Pre-feasibility and Scoping Study (EPDA); and Environmental Impact Study (EIS);
- Preliminary Environmental Information Form (available at the National Directorate for Environmental Impact Assessment).

Environmental Pre-feasibility and Scoping Study and Terms of Reference

Upon confirmation from MICOA that a project is classified as a Category A the proponent must prepare an Environmental Pre-feasibility and Scoping Study Report (EPDA Report) and prepare Terms of Reference (ToR) for the EIS.
EPDA Report contains as a minimal the following information[10]:

- Non-technical Summary, including the main issues addressed, as well as conclusions and recommendations;
- Identification and address of the Proponent and the multi-disciplinary team responsible for conducting the EIS;
- The limits of the indirect influence area of the activity and land use patterns in the direct and indirect influence areas;
- Description of the activity and the anticipated actions, as well as the respective alternatives in planning, implementation and operation (or deactivation, in case of temporary activities);
- Biophysical and socio-economic description of the area;
- Identification and evaluation of any potential fatal flaws of the activity;
- Identification and description of the issues to be addressed in detail in the EIS; and
- Terms of Reference of the EIA

[10] Article 10

The Terms of Reference for the preparation of EIS must include, at least[11]:

a) Description of specialist studies, identified as necessary during the EPDA and to be carried out during the EIS, in the case of category A activities;

b) Description of identified feasible alternatives that must be investigated in the EIS;

c) Methodology to identify and evaluate environmental impacts in the construction, operation and deactivation phases;

d) Description of the public participation process;

e) Identification of the proponent;

f) Identification of the team responsible for the preparation of the EIS;

g) Requirements for additional information needed.

The EPDA Report and corresponding ToR for the EIS must be submitted to the DNAIA in the form of hard copy reports written in Portuguese. The proponent must submit the number of hard copy reports as specified following registration of the project with DNAIA. In addition, one sealed digital copy must be submitted.

Environmental Impact Study

Upon approval of the EPDA and ToR for the EIS by MICOA, the proponent may proceed with the EIS, *per se*.

The minimum contents of an EIS Report include the following:

- Abbreviations and acronyms;
- Executive Summary;
- Introduction;
- Description of the proposed project and its social and economic integration;
- Description of the implementation area;
- Outline of the legislation, regulations and administrative organization;
- Approaches and techniques utilized for collection of information and analysis of the impacts;
- Consultation with the stakeholders;
- Description of the environmental impacts over the proposed project area;
- Proposal for mitigation methods;
- List of people/institution contacted; and
- Bibliography/References.

Guidelines and procedures for EIA are further defined in General Directives for Environmental Impact Assessment.[12]

[11] Article 11

[12] The Ministerial Diploma 129/2006 published in the Boletim da República No. 29, 1st Series, of the 19 July 2006

Public Consultation

Public Consultation is an integral part of the EIA process for projects classified as Category A as laid out in Article 14 of the EIA Regulations:

> "Public participation from the phase of the conception of the activity until submission of the EIA Report is the responsibility of the proponent."

An invite for any public meeting shall be made public 15 days before it takes place using the means deemed adequate for it's advertisement. All interested or affected parties, directly or indirectly, are entitled to take part in the EIA process. All technical reports produced within the scope of the EIA shall be made available for public consultation.

The final EIA Report submitted to MICOA shall include a Public Consultation Report.

The Guidelines for Public Participation are further defined in the General Directive for the Public Participation Process in the Environmental Impact Assessment Process.[13]

Review of EPDA[14]

The Environmental Impact Assessment Authority will designate a Technical Evaluation Committee to review the EPDA comprising the following elements:

a) A representative of DNAIA who will chair the Committee.

b) A representative of the Ministry responsible for the activity.

c) Other representative(s) of government agencies, teaching institutes or research centers.

d) Technicians specialized in a particular area as required (by request or under contract)

Upon final review of the EPDA the Technical Committee will prepare a technical review report and minutes signed by all members of for submission to DNAIA.

Reviews of EIS Report [15]

The same Technical Evaluation Committee that evaluated the EPDA will evaluate the EIS Report.

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[13] The Ministerial Diploma 130/2006 published in the Boletim da República No. 29, 1st Series, of the 19 July 2006

[14] Article 15

[15] Article 16

The Technical Committee will review the EIS Report and submit a technical report to DNAIA. DNAIA must communicate the results of the technical evaluation to the proponent and may request complementary information. The proponent has 10 working days to comply with the request for additional information.

After a final review of the EIS Report the Technical Evaluation Committee will prepare a technical review report with minutes signed by all the members. The signed minutes forms the basis for decision to issue an environmental license.

Deadlines to inform about decisions

The Environmental Impact Assessment Authority must comply with the following deadlines:

a) Pre-assessment – up to five working days;

b) EPDA and ToR – up to thirty working days;

c) Environmental impact study – up to forty-five working days.

Fees for environmental licensing

For environmental licensing for a Category A Project a fee of 0.1% of the investment is applied and is payable to the Ministry of Finances.

4.1.4 Regulations on Environmental Quality and Effluents Emission Standards

The Decree 18/2004 of 2 June[16] establishes environmental quality and emission effluents standards in order to ensure an effective control and monitoring of the quality of the environment in terms of the provisions of Article 10 of the 1997 Framework Environmental Law.

The purpose of the Regulation is to establish the standards of environmental quality and of effluents emission, aiming at the control and maintenance of the admissible levels of concentration of pollutants in the environmental components.

Article 3 states that the provisions of this Regulation are applicable to all public and private activities that directly or indirectly may influence on the environmental components.

Jurisdictional responsibility for enforcing the Regulation lies with MICOA (Article 4).

Article 12 of Regulations on Environmental Quality and Effluents Emission Standards (water quality parameters) defines water quality for recreational purposes (swimming, water skiing, and diving):

[16] The Decree 18/2004 of 2nd June is published in the Boletim da República No. 22, 1st Series, Supplement of the 2 June 2004

- Null of chlorine, odor, taste and turbidity;
- Total bacteria <1,000/100 ml; and
- Coliforms <100/100 ml.

Article 16 refers to the discharge of industrial liquid pollutants or effluents into the marine environment stating that "the discharge of effluents into the ocean shall obey the standards established in Annex V of the Regulation."

According these Mozambican Regulations effluent discharge into the sea must obey the following standards:

a) Floating materials: virtually absent
b) Oils and greases: virtually absent
c) Substances that produce color, odor and turbidity: virtually absent
d) Artificial coloring: virtually absent
e) Substances that form objectionable deposits: virtually absent
f) Substances and conditions that facilitate undesired aquatic life: virtually absent
g) BOD 5 to 20ºC≤5mg/l
h) Dissolved oxygen (DO) ≤6mg/l
i) pH between 6.5 and 8.5; change in normal pH value must not exceed 0.2 units

4.1.5 Regulations for the Environmental Audit Process

This regulation was approved by the Council of Ministers by Decree 32/2003 on the 12th of August 2003[17], with the purpose of establishing parameters to carry out environmental audits.

These regulations apply to all public or private activities, which, during their implementation, may have a direct or indirect impact on the environment.

Article 4 refers to the scope Environmental Audits:

- The impacts caused by routine activities on the environment;
- Risk of accidents and contingency plans for the evacuation and protection of workers and the populations in the project's area of influence;
- Degree of compliance of activities as established in the process of environmental licensing and its compliance to regulations and standards in practice;
- The actual or potential levels of pollution or environmental degradation resulting from the implementation of activities;
- The conditions of operation and maintenance of equipment and systems to control pollution;
- The measures to be taken into consideration to restore the environment and protect public health;
- The capacity building of persons responsible for the operation and maintenance of systems, routines, installations, and equipments to protect the environment and public health;
- The management and conservation of energy sources, raw material, water;
- Re-use, recycling, reduction, transport, and elimination of residues;

[17] Decree 32/2003 is published in the Boletim da República No. 34, 1st Series of 20th August 2003

- Noise and vibration inside and out of the installations;
- Selection of new methods of production and alteration of existing methods of the industrial processes and systems of continuous monitoring for the reduction of the pollutants levels; and
- The measures to prevent and limit environmental accidents.

Article 10 refers to the contents of an Environmental Audit Report:

- Introduction and project/activity background;
- The methodology;
- Executive summary, assessment of compliance between the environmental management plan and the findings;
- Assessment of the results based on the recommendations from previous audits;
- Description of the identified non-compliances and summary of the audit findings and analysis; and
- Conclusions and recommendations.

It is the responsibility of MICOA to promote Environmental Audits and ensure that audits are carried out for activities requiring auditing. Environmental auditors must be registered with MICOA.

4.1.6 The Forestry and Wildlife Law (Law nº 10/99) and the Forestry and Wildlife Regulations (Decree No. 12/2002[18])

The Forestry and Wildlife Law passed in 1999 covers the creation of protected areas. Article 10 recognizes three types of protected zones for the conservation of biodiversity and fragile ecosystem:

a. National Parks
b. National Reserves
c. Historical – Cultural Use Zones

National Parks are total protection zones for the protection, conservation and management of vegetation and wildlife as well as the protection of sites of special scientific, cultural or aesthetic interest and for recreation that are representative of the national heritage (Article 11).

National Reserves are for the protection of rare species of fauna and flora, endemics, species threatened with extinction, or in decline, sensitive ecosystems such as wetlands, dunes, mangroves, and corals as well as the conservation of flora and fauna within these ecosystems (Article 12). Activities that are prohibited in national parks are also prohibited in national reserves although private sector co-management is contemplated (for e.g., for tourism).

The recognition of Historical–Cultural Use Zones (Article 13) is a new category for Mozambique reflecting the new policies to ensure that local communities are involved in natural resource

[18] The Decree No. 12/2002 is published in the Boletim da República No. 22, 1st Series, 2nd Supplement of 6 June 2002 altered by Decree No. 11/2003 published in the Boletim da República No. 13, 1st Series, of 26 March 2003

management. These Use Zones are for protection of areas of cultural use in accordance with the customary norms and practices of the respective communities.

The Quirimbas National Park was created under this Law in 2002. In accordance with the Wildlife and Forestry Law hydrocarbon prospecting activities are not be permitted within the QNP which is located at 7,8 Km from the southern limit of the concession area.

Article 5 of the Forestry and Wildlife Regulations state that “a buffer zone must be created around a protected area comprising an adjacent area of land, which forms a transition strip between the protected area and the areas of multiple uses, with the objective of reducing the impact resulting from human action in the respective protection area”. The Regulations further state that the delimitation of the buffer zone, and restrictions for activities within the buffer zone, will be determined, *inter alia*, by the management plan for the protected area taking into account the need to reduce impacts in the protected area resulting from the human actions outside the protected area.

Article 6 Forestry and Wildlife Regulations also state the formulation of management plans for protected areas is carried in participation with stakeholders including local communities.

The Management Plan (2004-2008) for the Quirimbas National Park was approved by dispatch dated the 20th of December 2003 of the Minister of Tourism. The QNP Management Plan refers to a buffer zone of 10 km around the park.

4.2 Environmental Management in relation to the Petroleum Industry

4.2.1 Petroleum Law No. 3/2001, of 21 February 2001

The Preamble to the Law[19] states that “petroleum resources are assets whose proper exploitation can contribute significantly to national development.”

The Petroleum law provides for environmental protection through Article 23 (Environmental Protection and Safety).

This article states that in addition to carrying out their Operations in accordance with Good Oilfield Practice, all holders of Exploration and Production rights shall conduct Petroleum Operations in accordance with environmental and other applicable legislation as well as the respective Contracts in order to accomplish the following:

- Ensure that there is no ecological damage or destruction caused by Petroleum Operations, but where unavoidable, ensure that measures for protection of the environment are in accordance with internationally acceptable standards. For this purpose, the holder of a right shall prepare and submit to the relevant authorities for approval an environmental impact assessment, including environmental impact mitigation measures;
- Control the flow and prevent the escape or loss of Petroleum discovered or produced within the Contract Area;

[19] The Petroleum Law is published in the Boletim da República No. 8, 1st Series, Supplement, of 21st of February 2001.

- Avoid damage to Petroleum reservoirs;
- Avoid destruction to land, the water table, trees, crops, buildings or other infrastructure and goods;
- Clean up the sites after the closure of Petroleum Operations and comply with the environmental restoration requirements;
- Ensure the safety of personnel in the planning and conduct of Petroleum Operations and take preventive measures if their physical safety would be at risk; and
- Report to the competent entity regarding the amounts of operational and accidental discharge, leakage and waste resulting from Petroleum Operations.

In addition, Article 23 states “A holder of a right under this Law shall act in a secure and effective manner when conducting Petroleum Operations in order to guarantee the disposal of polluted water and waste oil in accordance with approved methods, as well as the safe plugging of all boreholes and wells before these are abandoned.”

4.2.2 Petroleum Operations Regulation Decree No. 24/2004, of 20 August

The Petroleum Operations Regulations[20] were approved in August 2004 in order to define the types, terms and conditions of contracts, the petroleum operations’ practices, including the management of resources, safety, health and environmental protection, as well as the submittal by the holders of rights to conduct petroleum operations of plans, reports, data, samples and other information.
Petroleum Operations are carried on the basis of a concession contract, which may be of survey, exploration and production, or construction and operation of an oil or gas pipeline (Article 3, General Conditions).

In the case a discovery is commercially developed, Article 30 establishes that the Operator must prepare a Development Plan, programming the Development and Production of the corresponding Petroleum Deposits within two years from the Declaration of Commerciality. The Development Plan must include the Environmental Impact Assessment (Article 30 j).

Article 42 of the regulations pertain to Risk Analysis:

1. Based on duly pondered criteria, the Operator shall perform mandatory risk analyses of the facility’s operation and associated therewith, which shall be deemed part of the layout and designs.

2. Risk analyses shall be carried out in order to identify the consequences to people, environment and goods, including financial interests, of single or sequential failure that may occur.

3. For the purpose of risk analyses, it should be taken into account, among other elements, the design of the facilities, the operations to be carried out, equipment, work processes and training programs for personnel engaged in the activity.

[20] The Petroleum Operations Regulation Decree No. 24/2004 is published in the Boletim da República No. 33, 1st Series, 2nd Supplement, of the 20 of August 2004

4. Measures shall be taken in the design of the facilities and planning of operations to eliminate or reduce the risks identified through risk analyses.

5. Risk analyses must be performed so as to be in line with the progress of petroleum Operations.

6. Special emphasis shall be given to incorporation of risk analyses results into operation manuals, procedures and reporting requirements.

Article 56 refers to safety aspects of drilling and well facilities and includes, *inter alia* the following:

1. The Operator shall establish safety objectives and tolerance criteria for risk and carry out the risk analysis set out in Article 42. A general safety objective for drilling and well activities is that no single failure shall entail life-threatening situations for the personnel involved or significant damage to material and the environment. This applies both to operational errors and to failure related to equipment with auxiliary functions.

2. Work areas within drilling and well drilling activities shall be arranged so as to ensure adequate safety for personnel and operations. Special attention must be given to storage, assembly, disassembly and suspension of drill, pipe, and drill collars and with the rotary table, as well as to transport between the storage location and the drilling platform.

3. Pressure exposed equipment shall be designed, built, tested and maintained in accordance with requirements contained in the these regulations and with the internationally accepted technical standards. Safety shall to be tested in accordance with established procedures. When safety devices are activated to avoid excessive pressure limits, a pressure control system shall be implemented so as to avoid injuries to personnel, to environment and to assets and financial interest.

4. The facility shall be equipped with a tank with sufficient to capacity support the quantity of drilling fluid necessary to ensure full control of the well and to contain, at all times, sufficient quantities of drilling fluids and other substances. The drilling fluid system shall have adequate capacity to support a rapid increase of drilling fluid in an active system, as well as capacity for the increasing weight of the drilling fluid for well instability. A reconditioning system with the necessary equipment for the separation of gas from drilling fluid shall be implemented in order to ensure the required quality of the drilling fluid. The composition of the drilling of completion fluids shall, at all times, be adjusted in order to ensure that the required properties of the fluid are preserved. It shall be possible to monitor, on a continuous basis, the fluids wich comprise a barrier or that form part of the initial phase of operation.

5. The Blowout Preventer (BOP) shall be designed and installed in order to preserve its capability to function as a barrier and will be installed and start functioning during the initial phase of the operation.

Article 75 provides the general requirements for drilling and other well operations:

1. Drilling and well activities shall at all times be carried out in a safe and proper manner, i.e.:
    a) Measures shall be taken to ensure regularity and prevent the interruption of operations;
    b) Operating and maintenance procedures shall take due consideration of relevant equipment specifications such as their pre-determined operating and maintenance limits;
    c) Operational measures shall be taken to prevent fires, explosions, pollution, or any sort of damages;
    d) Well casing shall be conceived and developed so as to be under control at all times;
    e) Safety equipment for drilling shall be installed in accordance with the requirements of the planned activities and with these Regulations;
    f) The ground or seabed shall be examined prior to drilling or prior to the installation or setting up of well facilities so as to ensure that the external environment will not cause damage to existing facilities;

2. The Operator shall:
    a) Establish plans and procedures for drilling and simultaneous operations on wells;
    b) Identify, by means of risk analysis, situations where well control may be lost or other hazardous situations that may occur as a result of simultaneous activities;
    c) Establish the operational limits applicable to drilling and well activities undertaken within the same facility;
    d) In accordance with the established procedures, shut down wells in areas where falling objects are capable of causing damages thereto.

3. Prior to drilling and well activities, the Operator shall:
    a) Develop an Emergency Plan for the cases of a Blow out of oil, gas or water, and that identifies suitable locations for drilling of a relief well;
    b) Develop a plan for the mobilization and organization of personnel, as well as for equipment and services required both for drilling and relief well and control of an erupting relief well, inclusive of a possible direct intervention in the erupting well.

Article 77 provides Operation Requirements, including:

a) In accordance with safety and operational criteria, oil based and synthetic oil based drilling fluids shall only be used when such is required;
b) Fluid volumes shall be verified prior to, during and subsequent to the removal of equipment from the well. Procedures shall be established to remove the unintentional influx of fluids from the well, as well as to maintain pressure control in the event of their loss;
c) Formation testing including drilling, hydraulic fracturing, acid treatment or other physical or chemical treatment of the well shall be done according to requirements in these Regulations and with best practices of the Petroleum Industry;
d) Well control equipment shall be periodically tested and examined under pressure so as to verify that its barrier functions;
e) Prior to temporary or permanent plugging of a well is carried out, the zones with flow potential shall be located so as to prevent the eruption of hydrocarbons and other formation fluids.

Article 82 refers to hazardous material management:

a) Transport, storage and use of hazardous material shall take place in a controlled manner and in accordance with national legislation, as well as internationally accepted rules and principles, for which purpose documented rules and procedures of their handling shall be made available;
b) The danger of chemical exposure involving health hazards shall be minimized in the storage, use, handling and disposal of chemicals, as well as in work operations or processes which produce chemical substances. Chemicals hazardous to health shall be classified, labeled and identified in accordance with internationally accepted standards;
c) If chemicals are moved into other containers or appliances, it must be ensured that the contents are labeled and clearly identified so as to allow the identification of their contents by personnel, of which hazards are connected with the use of such chemicals, and of which safety precautions should be taken. Prior to the use of chemicals hazardous to health, a table of instructions, regarding the applicable safety rules of such substances, shall be available at the work site;
d) Personnel shall wear individual protective equipment against risks which may not be otherwise avoided or limited to an acceptable extent. Use of radioactive substances shall be restricted on a need of use basis.

Article 86 provides general Emergency and Contingency Requirements, which include:

a) The Operator shall be prepared to handle accidents and emergencies which may lead to loss of life, injuries, pollution or major damage to property;
b) The Operator shall take the necessary measures to prevent or minimize harmful effects of accidents and to restore the environment in accordance with a Contingency Plan which shall identify the potential accident events and consequences of such events.

Article 87 refers that the Operator shall submit to the National Petroleum Institute a Contingency Plan for handling accidents and hazardous situations which may occur during Petroleum Operations and provides the contents of such a plan. It also states that the National Petroleum Institute shall be notified prior to the carrying out of emergency exercises and shall receive a report on such emergency exercises.

Article 88 indicates that the National Petroleum Institute may require the installation of emergency equipment such as fire-fighting equipment, oil barriers, vehicles, standby boats or aircrafts near or at the facilities or at major equipments involved in Petroleum Operations and stipulate the operational requirements of each of such equipment under these circumstances.

Article 90 of the Regulations deals specifically with the environment and requires the operators to comply with the following requirements:

- Environmental impact assessments, including impact reduction measures, shall be carried out in all areas which may be affected by Petroleum Operations.

- Registration of all environmental aspects influenced by the Petroleum Operations shall be created and maintained for all phases.

- The Operator shall prevent:

    - Accidents and material damage resultant from its activities and from the facilities' operation;
    - Damage or risk of damage to third parties' personnel and assets;
    - Damage to animals, vegetation, marine life and monuments;
    - Sea pollution and of water fountains discovered in the course of Petroleum Operations;
    - Air pollution; and
    - Damage in petroleum reservoirs.

- The Operator shall monitor and reduce the effect of all operational and accidental discharge, handling of waste and pollution emissions into the air, sea, lakes, rivers, and soil. Operational discharges shall be within the limits defined by the entity with authority over environmental matters.

- The Operator shall inform the National Petroleum Institute of the amount of operational and accidental discharges, leakages and waste and such information shall be made public.

- The Operator shall take remedial measures and repair damage to the environment when the Petroleum Operations it carried out endanger the physical safety of persons or property, or cause pollution or other environmental damage harmful to persons, animals, marine life, monuments or vegetation.

- Preferential treatment shall be given to materials and chemicals least dangerous to health and of greater safety so as to minimize the risk to persons, to the environment and to the facilities. The recycling of materials and chemicals shall be duly taken into account.
- The operator shall take due consideration of the health of personnel, as well as of the qualification and requirements applicable to medical staff. Health related aspects shall include, *inter alia*, the following:
    - Health service;
    - State of readiness in respect of health care and health services;
    - Transport of sick and injured personnel;
    - Hygienic aspects; and
    - Supply of drinkable water, catering and distribution of food supplies.

- A system of safety delegates and a work environment committee for each facility shall be established.

4.3 Maritime Protection

4.3.1. The Law of the Sea

The Law of the Sea (Law No. 4/96 of 4th January 1996[21]) covers mainly aspects related to maritime traffic, but also refers to activities concerning the conditions of security and the control of the pollution of the marine environment.

The Law applies to:

[21] The Law No. 4/96 is published in the Boletim da República No. 1, 1st Series, of the 4 of January 1996

a) The sea and all waterways and the corresponding bed and subsoil under maritime jurisdiction, in accordance to the terms of the applicable law, as well as the public domain adjacent to those waters;
b) To all vessels and other maritime objects, including cables, pipelines, facilities and maritime structures under Mozambican jurisdiction;
c) To all national vessels, wherever their location;
d) To all entities, personal, individual or collective somehow connected to vessels or with navigation in Mozambique;
e) To all maritime activities taking place within the limits of specific jurisdiction applicable to fishing activities and others.

As regards the area adjacent to territorial sea:

1. The area adjacent to territorial sea is defined as the strip of sea adjacent to territorial sea that extends up to 24 nautical miles as of the baseline.

2. In the area adjacent to territorial sea, the State exercises the necessary control for:

   a) prevent breaching of customs, tax, migration and sanitary laws and regulations for the protection and conservation of the maritime environment, in force in the Mozambican territory;
   b) Prevent infractions against laws and regulations referred to in the previous line.

As regards the Exclusive Economic Zone:

The exclusive economic zone of the Republic of Mozambique encompasses the strip of sea adjacent to territorial sea up to 200 nautical miles as of the baseline where the territorial sea is measured.

Article 11 refers to the sovereign rights in the exclusive economic zone. The jurisdiction of the State over the exclusive economic zone will be exercised in accordance to the terms of the present law, as regards:

a) Scientific maritime research;
b) Protection and preservation of the maritime environment.

The regulatory measures (Article 33) include:

a) All issues regarding safety of commercial vessels, investigation of accidents or maritime events in Mozambican jurisdictional waters
b) Control of maritime traffic, as well as pilotage and towing in Mozambican waters;
c) Issues regarding maritime pollution;
d) Issues regarding maritime commerce and industry.

It is also the responsibility of the Government to regulate and administrate all sea use activities within the Mozambican jurisdiction waters, in accordance to international laws, namely:

a) Scientific maritime research;
b) Exploration and use of all natural marine resources, living and otherwise;
c) Protection and preservation of maritime environment;
d) Protection of archaeological objects in the sea;
e) Maritime sports and maritime recreational activities;
f) General management of territorial sea, adjacent area; exclusive economic zone and Mozambican continental platform.

The law defines the constitution of maritime courts whose jurisdiction covers port areas, construction and rehabilitation areas. The constitution of such courts is planned for Maputo, Beira, Quelimane, Nacala, Inhambane and Pemba.

4.3.2. Prevention of Pollution and Protection of the Marine and Coastal Environment

Decree 45/2006 of 30 November[22] approved the Regulation for the Prevention of Pollution and Protection of the Marine and Coastal Environment.

The first chapters of this Regulation transpose general provisions included in several Conventions on the subject-matter into the domestic legal order, adjusting them to the Mozambican situation. Among these are the International Convention for the Prevention of Pollution from Ships (MARPOL 1973/1978), the Convention for the Protection, Management and Development of the Marine and Coastal Environment of the Eastern African Region (Nairobi Convention) and the International Convention on Oil Pollution Preparedness, Response and Cooperation 1990 – OPRC 90.

As established in Article 1, the objective of this Regulation is to determine the appropriate measures to prevent and limit pollution resulting from illegal discharges carried out by ships, platforms or by land-based sources, off the Mozambican coast as well as the establishment of legal bases for the protection and conservation of the maritime, lacustrine and fluvial public domain areas, of beaches and of fragile ecosystems.

The Regulation applies to all national or foreign natural or legal persons, performing activities susceptible of causing negative impacts on the environment, in maritime, lacustrine and fluvial public domain areas, including all fragile ecosystems bordering the coast and inland waters.
In addition, the Regulation applies to discharges of harmful or dangerous substances by ships, in ports, harbor facilities, emission facilities along the coast, platforms or by other land-based sources, namely:

a) In inland waterways, including ports and wetlands;
b) In the territorial waters of the Mozambican State;
c) In the Mozambique Channel, when used for international navigation subject to the transit passage regime, established in Part III, Section 2, of the Convention of the Law of the Sea, ratified by Resolution 21/96, of 26 November, insofar as the Mozambican State exercises jurisdiction over the Channel;
d) In the exclusive economic zone, established in agreement with international law; and
e) In the international waters.

[22] Decree 45/2006 is published in the *Boletim da República* N.º 48, 1st Series, Supplement of 30 November 2006

The Regulation also applies to all domestic and foreign ships navigating the jurisdictional waters of the Republic of Mozambique as well as to facilities situated off the Mozambican coast, regarding any discharge or dumping occurred under its terms.

Regarding the classification of harmful or dangerous substances, the Regulation refers to the waste management legislation in force[23].

Heading II of this Regulation deals with ships and platforms.

In the scope of pollution prevention and control systems, the Regulation stipulates that all ports, port facilities, platforms, emission facilities along the coast as well as their support facilities, have the obligation to have adequate facilities or means for the collection and treatment of the various types of waste and for pollution control at their disposal. Their owners must prepare a procedures manual for the management of the various types of waste produced by or deriving from the movement and storage of oil and harmful or dangerous substances. This procedures manual shall be approved by the entity supervising the area of the environment. The owners must also have contingency plans available for fighting oil pollution and pollution by harmful or dangerous substances[24].

Ships have furthermore the obligation to store all waste produced onboard, before leaving the port, respecting, however, the conditions under which this may not be done[25].

The Regulation also stipulates the obligation to provide data about this waste[26]. In Chapter II (Articles 11 to 14), the Regulation deals with issues related to the transport of oil, hydrocarbons and harmful or dangerous substances, stipulating obligatory Record Books and the data that should be entered, and the obligation to inform about their onboard location as well as the data that the packing of harmful or dangerous substances should provide.

Chapter III (Articles 15 to 25) deals with aspects related to oil and harmful or dangerous substance discharges, prohibiting their occurrence in waters of national jurisdiction, and defines the exceptions to this prohibition. Chapter III also includes the obligation to communicate incidents occurring in ports, ships, platforms and support facilities liable to cause pollution of waters of national jurisdiction.

Chapter IV (Articles 26 to 32) defines the competences of the maritime authority to avoid pollution, among which the possibility to demand that the ship master and/or owner:

a) Carry out transshipment to another ship available or discharge to a specific part of the same ship or to a port depot, within a given time frame;
b) Move the ship under his command to a specific location;
c) Retain the ship at a given location, until a contrary order is given according to the ship's specific conditions and its actual position;
d) Abstain from any unloading or transshipment of hydrocarbon or part of it until a contrary order is given by the maritime authority;

[23] Article 3 of the Regulation for the Prevention of Pollution and Protection of the Marine and Coastal Environment
[24] Articles 5, 6 and 7 of the Regulation for the Prevention of Pollution and Protection of the Marine and Coastal Environment
[25] Article 8 of the Regulation for the Prevention of Pollution and Protection of the Marine and Coastal Environment
[26] Article 9 of the Regulation for the Prevention of Pollution and Protection of the Marine and Coastal Environment

e) Carry out operations for sinking or destroying the ship or its load or part of it, in agreement with Government decisions;
f) Follow a given route, in the event that the ship is navigating in territorial waters or in the contiguous zone;
g) Seek to obtain help from one or more vessels adequate to support the maritime authority in the measures that turn out to be necessary;
h) Take other measures in relation to the ship or its load to impede the hydrocarbon discharge or the continuation of this discharge.

The maritime authority may demand the suspension of the facilities' operation or that the above-mentioned measures be undertaken.

Chapter V (Articles 33 to 42) deals with the investigation of incidents, sanctions and compensation for damages. In addition to the pecuniary sanctions, the Regulation stipulates other punitive measures, particularly the seizure of the ship and the product's destruction or rendering it unusable.

Heading III (articles 43 to 86) of this Regulation deals with the prevention of marine and coastal pollution by land-based sources.

The Regulation has an Annex, consisting of a reference summary of the 73/78 Marpol Convention Rules with respect to oil and harmful liquid spills.

4.4 Protection of Marine Species

A certain level of protection is given to selected marine species by way of two laws: 1) the Forestry and Wildlife Law and Regulations, and 2) the Recreational and Sport Fishery Decree. The Forestry and Wildlife Law and Regulations also provide for the creation of national parks and reserves. Currently, there are no marine protected areas in the AMA1 concession area although the Quirimbas National Park is located 7.8 km south of southern limit of the concession area.

Article 43 of the Forestry and Wildlife Regulation (Decree No. 12/2002) states that "animals listed in Annex II of the Regulations are considered to be protected under the present Regulation."

The protected marine species listed in Annex II are:

- dugongs (*Dugong dugon*);
- marine turtles (all species);
- sea gulls (all species); and
- pelicans (all species).

4.4.1. The Recreational and Sport Fishery Decree

The Recreational and Sport Fishery Decree No. 51/99[27] (Annex II) provides a list of protected marine species, including marine mammals (dugongs, whales, and dolphins), marine turtles, and five species of fish, two species of bivalves, and two species of gastropods, as shown in **Table 4-1**.

Table 4-1. List of protected species included in Annex II of Recreational and Sport Fishery Decree

Common Name	Scientific Name
Fishes	
Brindle bass	*Ephinephelus lanceolatus*
Seventy-four	*Polyleganus undulosus*
Potato bass	*Ephinephelus tukula*
Red steenbras	*Petrus nupestris*
White shark	*Nebrius concolor*
Reptiles	
Marine turtles	All species
Mammals	
Dugong	*Dugong dugon*
Whales	All species
Dolphins	All species
Bivalves	
Giant clam	*Tridacna gigante*
Scaled clam	*Tridacna squamosa*
Gastropods	
Giant clam	*Cassis cormuta*
Horned helmet	*Charonia tritonis*

4.5 National Policies and Strategies

Relevant national policies and strategies include:

- National Strategy and Action Plan for the Conservation of Biodiversity; and
- Tourism Policy and Implementation Strategy.

4.5.1 National Strategy and Action Plan for the Conservation of Biodiversity

National Strategy and Action Plan for the Conservation of Biological Diversity for Mozambique formulated by MICOA was passed by the Council of Ministers in August 2003. The

[27] The Decree No. 51/99 is published in the Boletim da República No. 34, 1st Series, 4th Supplement, of 31 August 1999

implementation of the Strategy and Action Plan for the conservation of biological diversity in Mozambique covers a period of 10 years.

The overall goal of the National Strategy and Action Plan for Biodiversity Conservation is to provide guidelines and define priority actions to be implemented by various economic sectors in order to guarantee sustainable development.

The areas for action identified in the Strategy are as follows:

- Identification and analysis of biological diversity components and their relationship within ecosystems, as well as an analysis on the processes and activities that might have an adverse impact on them.
- To determine the conservation status of species in Mozambique and to identify and implement appropriate conservation measures for threatened and endemic species.
- Determine the extent of indigenous cattle breeding species in the country, their conservation status and implement appropriate preservation measures.
- To determine the conservation status of ecosystems and habitats in Mozambique and to identify and implement appropriate conservation measures and ecosystem management with an emphasis on fragile ecosystems.
- To establish and manage a representative system of areas for protection.
- Development and strengthening of *ex-situ* potential for national conservation of the components of biological diversity, with the purpose of supporting and complementing *in-situ* conservation.
- Recuperation and rehabilitation of degraded ecosystems and where applicable, develop management plans for the recovery of species.
- Restrict the introduction and propagation of alien species that cause damage to the indigenous biological diversity and establish mitigation and eradication measures of alien species that might affect the ecosystems, habitats and indigenous species.
- To promote sustainable and integrated use of forestry resources (timber and non timber products), whilst guaranteeing that all parties involved in the exploration have benefits, with an emphasis on the local community.
- To guarantee the sustainable use of agricultural resources with the purpose of improving the quality of life of the Mozambican rural population. To avoid aspects related to the loss of specific and genetic variability of main agricultural crops.
- To guarantee the rational use of wildlife, in order to contribute to the well being of the rural population and the country's development.

- To promote the sustainable use of fishing resources for the benefit of the population and economic prosperity, as well as for the conservation of resources and maintenance of the biological diversity.

- To promote the integrated management of hydrological basins, guaranteeing the minimum amount of flow necessary for the prosperity of the ecosystems adjacent to rivers

- To guarantee that industrial and tourism development occurs in accordance with the sustainable use of biological diversity.

4.5.2 National Tourism Policy and Implementation Strategy

The objectives of tourism are laid out in the National Tourism Policy and Implementation Strategy (NTPIS) approved by the Resolution No. 14th of April 2003[28]. Tourism objectives are established to balance economic interests with socio-cultural and environmental considerations. The overall objectives of the tourism policy are to:

- develop and position Mozambique as a world-class destination;
- contribute to employment creation economic growth and poverty alleviation;
- develop sustainable and responsible tourism;
- participate in the conservation and protection of biodiversity;
- preserve cultural values and national pride; and
- enhance the quality of life for all the people of Mozambique.

With regards to the environment the main environmental objectives related to the development of tourism, in Mozambique are to

- ensure that tourism and the environment are mutually supportive;
- promote a proactive approach by all tourism stakeholders to develop, market and manage the sector in a responsible and integrated manner;
- prioritize the preservation of the quality and sustainability of biodiversity;
- contribute to the rehabilitation, conservation and protection of eco-systems and natural heritage;
- promote the development of natural resources, especially those that possess an ecological and historical value in a recreational, aesthetic and/or socio-cultural way; and
- make Mozambique a prominent player in responsible environmental practices.

The realization of the objectives defined in the policy leads to the establishment of the priority areas for intervention and action.

The identification of areas with high biological value such as Transfrontier Conservation Areas (TFCAs) future natural world heritage sites, interior lake eco-systems, wetlands and montane and coastal areas are considered as a priority for both tourism development and conservation. The TFCAs identified in the NTPIS are shown in **Figure 4-2**.

[28] The Resolution No. 14/2003 is published in the Boletim da República No. 18, 1st Series, of the 4 April 2003

Note: The term Transfrontier Conservation Area has no legal basis in Mozambique. It is considered to be a large area that contains a core conservation area where biodiversity protection and land and natural resource use practices will be compatible with biodiversity conservation.

The Government recognizes the necessity to prioritize areas for development of tourism and Priority Areas for Tourism Investment (PATIs) in Mozambique have been identified.

The PATI's represent areas of focus for the Government in terms of investment promotion, prioritization in resources allocation for the development of tourism, human resources infrastructure provision and environmental protection. The approach to tourism development within PATI's will be in line with international practices with regard to responsible tourism development. The promotion the PATI's will form the core of the strategy aimed at maximizing the results for tourism development. The location of the PATI's is shown in **Figure 4-1**.

Note: The Priority Area for Tourism Investment (PATI) area is a geographical area that has a high potential for tourism development. It does not imply that other activities are prohibited in the area.

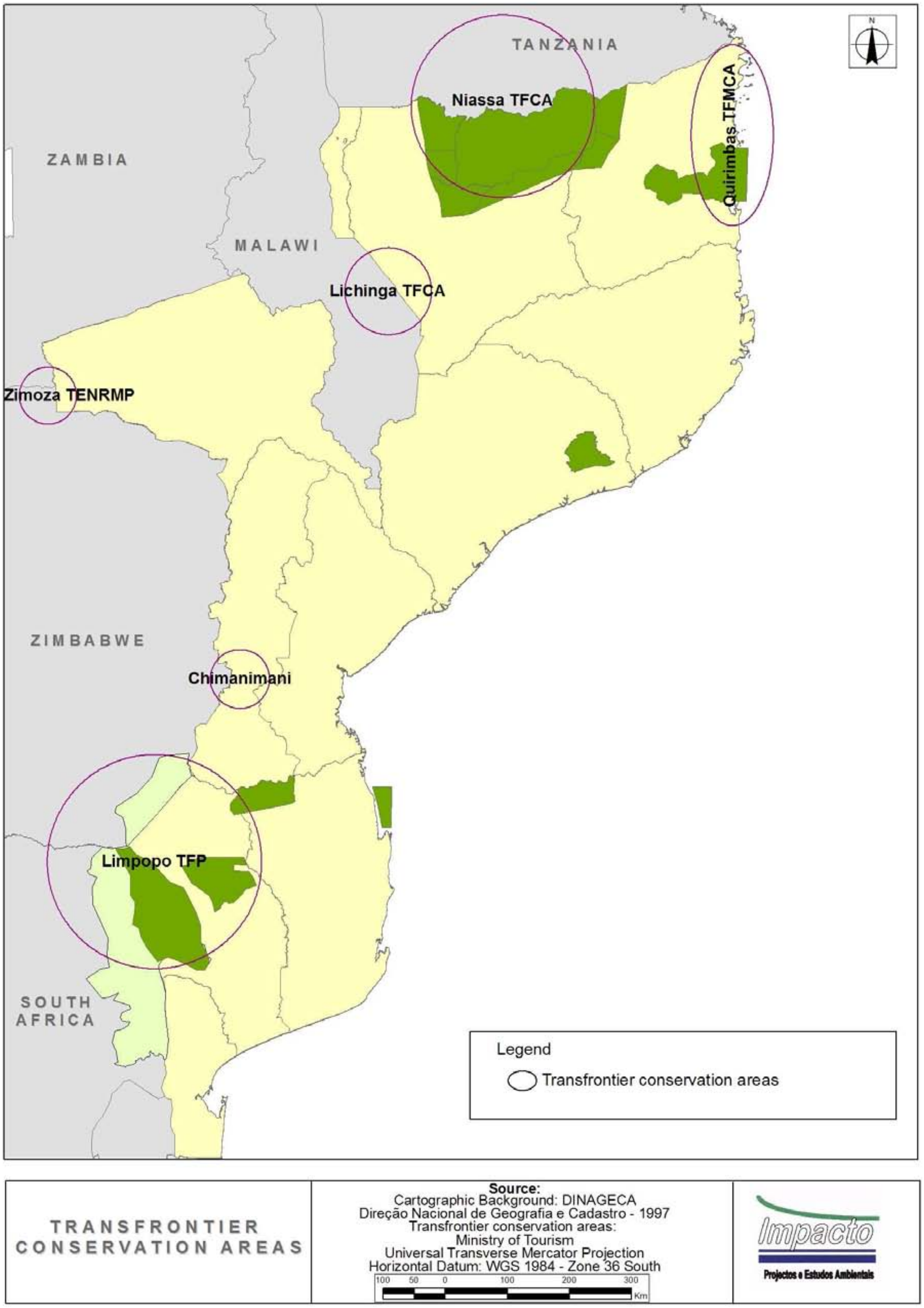

Figure 4-1. Location of TFCAs

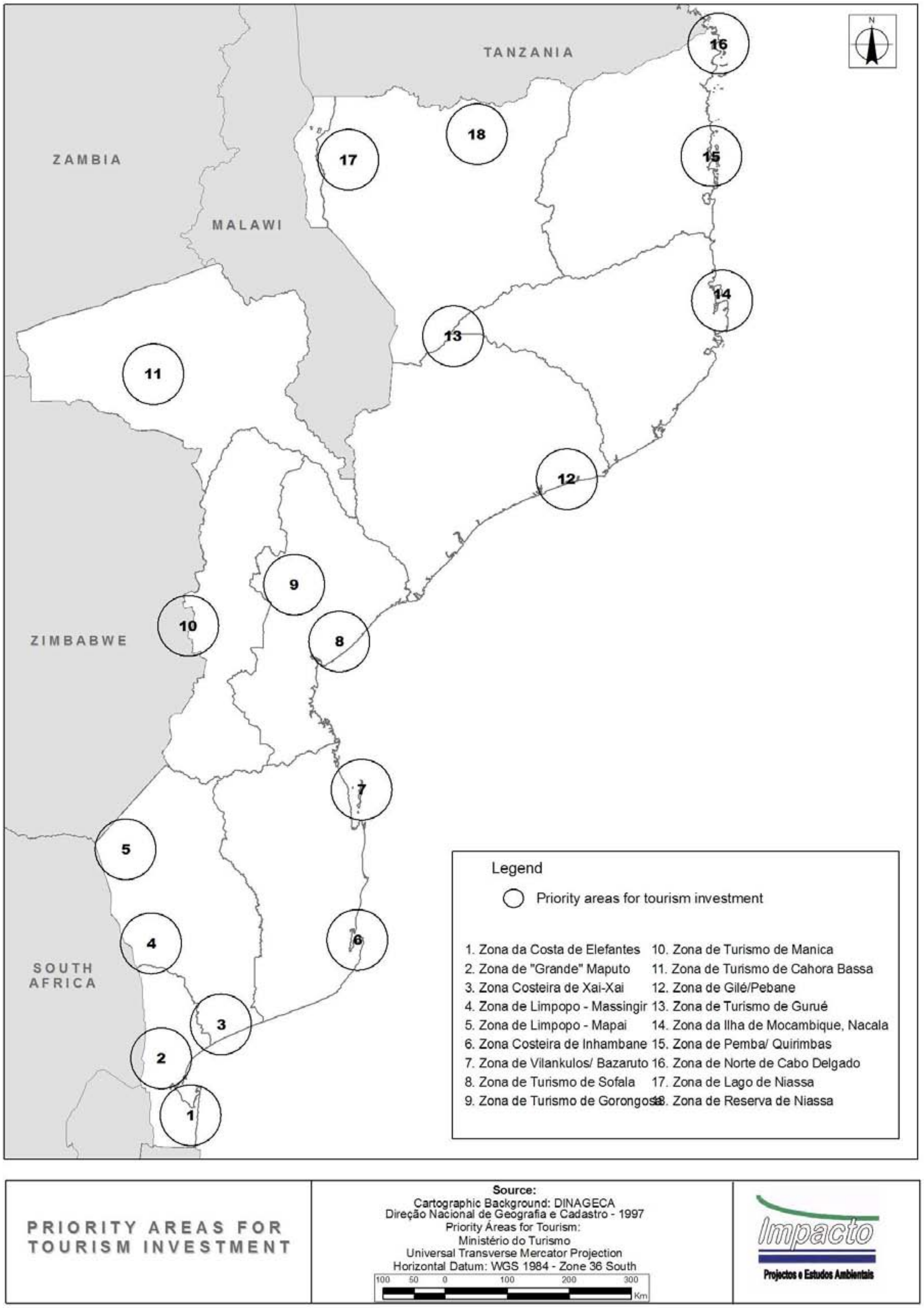

Figure 4-2. Location of PATI's

4.6 INTERNATIONAL FRAMEWORK

The Government of Mozambique (GOM) has signed and ratified several International conventions regarding environmental management and marine protection.

4.6.1 The Nairobi Convention

The Nairobi Convention, formally known as the Convention for the Protection, Management and Development of the Marine and Coastal Environment of the Eastern African Region, was concluded in 1985 in Nairobi and was ratified by Mozambique in 1996 by the Resolution No. 17/96 of 26th November[29].

The Nairobi Convention was adopted on June 21st, 1985, with two Protocols and an Action Plan under the UNEP Regional Seas Program. The Convention is directed towards marine and coastal environmental management from the perspective of the eastern African reality and requirements. Key components of the Nairobi Convention include the following:

For the purpose of the Convention the "Convention Area" comprises the marine and coastal environment of that part of the Indian Ocean situated within the Eastern African region and falling within the jurisdiction of the Contracting Parties to the Convention.

The Contracting Parties may enter into bilateral or multilateral agreements, including regional or sub-regional agreements, for the protection and management of the marine and coastal environment of the Convention Area.

The Contracting Parties shall co-operate, directly or with the assistance of competent regional and international organizations, in scientific research, monitoring, and the exchange of data and other scientific information.

To this end, the Parties shall develop and co-ordinate natural resources in the Convention Area and shall establish, in co-operation with competent regional and international organizations, a regional network of national research centers and institutes to ensure compatible results.

The Contracting Parties shall take all appropriate measures to ensure the strictest protection of to endangered wild fauna species which are listed in an Annex II.

The Contracting Parties shall, where necessary, establish protected areas in areas under their jurisdiction with a view to safeguarding the natural resources of the Eastern African region and shall take all appropriate measures to protect those areas.

Such areas shall be established in order to safeguard the following:

- The ecological and biological processes essential to the functioning of the Eastern African region;
- Representative samples of all types of ecosystems of the Eastern African region;

[29] The Resolution No. 17/96 of 26th November is published in the Boletim da República No. 47, 5th Supplement, of 28th November 1996

- Populations of the greatest possible number of species of fauna and flora depending on these ecosystems;
- Natural habitat, and in particular as critical habitats, for species of fauna and flora, especially those which are rare, threatened or endemic;
- Migration routes or as wintering, staging or feeding sites for migratory species;
- Areas necessary for the maintenance of stocks of economically important marine species; and
- Rare or fragile ecosystems.

If a Contracting Party intends to establish a protected area contiguous to the frontier or to the limits of the zone of natural jurisdiction of another Contracting Party, the two Contracting Parties shall, as necessary, consult each other with a view to reaching agreement on the measures to be taken and shall examine the possibility of the establishment by the other party of a corresponding protected area or buffer area.

The Contracting Parties shall establish a regional program to co-ordinate the selection, establishment, and management, of protected areas and the protection of wild fauna and flora with a view to creating a representative network of protected areas in the Eastern African region.

The Contracting Parties shall forward to the Organization:

- Comparable information for monitoring the biological development of the Eastern African region;
- Inventories, publications and information of a scientific, administrative and legal nature, in particular;
- On the measures for the protection of the protected areas and wild fauna and flora;
- On the wild fauna and flora present in the protected areas; and
- On any threats to protected areas or wild fauna and flora.

The Contracting Parties shall designate persons responsible for protected areas. Those persons shall meet at least once every two years to discuss matters of joint interest and especially to propose to the Contracting Parties recommendation concerning scientific, administrative and legal measures to be adopted to improve the application of the provisions of this Protocol.

Parties to the Convention shall take appropriate measures in order to prevent, reduce, and combat pollution, from ships, land based sources, and waste dumping.

Key components include the following:

Article 5: POLLUTION FROM SHIPS

The Contracting Parties must take all necessary measures to prevent, reduce and fight pollution in the Convention area caused by discharges from vessels and also ensure the effective implementation of internationally established applicable laws and standards.

Article 6: POLLUTION CAUSED BY DUMPING OF RESIDUE

The Contracting Parties must take all adequate measures to prevent, reduce and fight pollution in the Convention area caused by the dumping of residues and others into the sea from vessels, planes, or other man-made structures taking the internationally applicable laws and standards and recommended practices and procedures into consideration.

Article 8: POLLUTION FROM ACTIVITIES IN THE SEA BED

The Contracting Parties must take all adequate measures to prevent, reduce and fight pollution in the area of the Convention resulting from, directly or indirectly, the exploration and excavation of the sea bed and its subsoil.

Article 10: SPECIAL PROTECTION AREAS

The Contracting Parties must, individually or together, take the adequate measures to protect and preserve rare or fragile ecosystems as well as rare, extinct or endangered species of wild fauna and flora and corresponding habitats within the Convention area. In this context, the Contracting Parties must, in their jurisdiction areas, establish protected areas, such as parks and reserves and regulate, and when needed and in accordance to the rules of international law, forbid activities that can cause harmful effects in the species, ecosystems and biological processes in these protected areas. The establishment of these areas must not affect the rights of other Contracting Parties and third States and, in particular, of other legitimate maritime users.

Article 11: COOPERATION TO FIGHT AGAINST POLLUTION IN CASES OF EMERGENCY

1. The Contracting Parties must cooperate in taking all necessary measures to address pollution related emergencies in the Convention Area and to reduce or eliminate pollution or the threat of pollution. In this context, the Contracting Parties must, individually or together, develop and promote contingency plans to address incidents involving pollution or the threat of pollution in the Convention Area.

2. When one of the Contracting Parties is made aware of a case in which the Convention area is in eminent danger of being polluted or has been polluted, it must immediately notify the other States likely to be affected by that pollution, as well as relevant international organizations. Apart from that, it must inform, as soon as possible, those other States and the Organization of any measures taken to minimize or reduce pollution or the threat of pollution.

Article 13: ENVIRONMENTAL IMPACT STUDY

1. As part of their environmental management policies, the Contracting Parties must, in cooperation with relevant regional and international organizations, develop, if necessary, technical guidelines and others to support the planning of its major development projects in order to prevent or minimize harmful impacts in the Convention area.

2. Each one of the Contracting Parties must evaluate, within its capacities, the potential environmental effects of major projects that can cause substantial pollution or harmful and significant changes in the Convention Area.

3. As regards the assessments mentioned in paragraph 2, the Contracting Parties must, if adequate and in consultation with the Organization, develop procedures for the dissemination of information and, if necessary, for consultation among the involved Contracting Parties.

The Convention also collaborates with non-governmental organizations such as the Western Indian Ocean Marine Science Association (WIOMSA) that manages the organizational capacity building program of Management for Marine Science supported by the Swedish International Development Agency. Apart from this, the World Wildlife Fund (WWF) has started a process for the conservation of biodiversity in the Marine Eco-region of Southern Africa (EAME). Through regional partnerships, the secretariat of the Nairobi Convention developed memorandums of understanding that were signed between UNEP and WWF on 30^{th} May 2002, and the Regional Headquarters of Southern Africa of the World Conservation Union (IUCN) on 16^{th} October 2002. The memorandums of understanding serve as support for the working program of the Nairobi convention and a project for the improvement of the efficiency of the management of protected marine areas in the Western Indian Ocean.

The work program (2002-2003) was developed by the Contracting Parties in Maputo, Mozambique, from 5 to 7 December 2001 and includes:

Protection of endangered species

- The Contracting Parties must take actions for the conservation of marine turtles in the Convention area including joining the Convention for the Conservation of Migratory Wildlife Species and participate in conservation and management activities for marine turtles in the Indian Ocean.

- The Contracting Parties must reaffirm the need to maintain the status of the Indian Ocean as a sanctuary for the protection of endangered marine mammals in the region and make an appeal for the renewal of the Indian Ocean Sanctuary created in 1979.

- The Contracting Parties must ask regional and international organizations to facilitate the development of a regional initiative to protect the dugong, involving all the countries in the region.

Protection of coral reefs and associated ecosystems

- To appeal to all the parties to adhere to the International Coral Reefs Initiative.

- The Contracting Parties must establish national bodies to coordinate the activities in coral reefs in each country and to develop national action plans for coral reefs, when needed, in particular the creation of a working group union for coral reefs.

The fourth meeting of the Contracting Parties for the Nairobi Convention was held in Antananarivo, Madagascar, from 6 to 8 July 2004. Two new areas of interest were included in the work program between 2004 and 2007:

1) Pollution from maritime sources (different from land sources of pollution) and the development and improvement of national contingency plans in cases of marine pollution emergency.

2) The environmental, economic and public health impacts related to ballast waters, one of the four major threats to oceans after the invasion of aquatic species. All the participants agreed that the ballast waters issues would be relevant for the Nairobi Convention and should be integrated in the work program.

The Contracting Parties may enter into bilateral or multilateral agreements, including regional or sub-regional agreements, for the protection and management of the marine and coastal environment of the Convention Area.

The Contracting Parties shall co-operate, directly or with the assistance of competent regional and international organizations, in scientific research, monitoring, and the exchange of data and other scientific information.

To this end, the Parties shall develop and co-ordinate natural resources in the Convention Area and shall establish, in co-operation with competent regional and international organizations, a regional network of national research centers and institutes to ensure compatible results.

The Contracting Parties shall take all appropriate measures to ensure the strictest protection of to endangered wild fauna species which are listed in an Annex II.

The following countries are the original signatories: the Comoro Islands; Reunion/France/European Union; Kenya, Madagascar; Seychelles and Somalia. Mozambique and Tanzania participated in the Conference but did not sign the Convention. Mauritius was invited but did not attend. The latter three countries have subsequently signed the Convention.

The Nairobi Convention has been reviewed and several amendments have been made. The Signatories are now firmly committed to the implementation of the Action Plan. The administration has recently been restructured and comprises the Chair (main secretariat - held by Seychelles) and three vice chairs *viz*., Kenya (follow-up secretariat), Mauritius (fund-raising) and Tanzania (development of program).

4.6.2 International Convention for the prevention of pollution from ships (MARPOL, 1973/1978)

The International Convention for the Prevention of Marine Pollution from Ships 1973 as modified by the Protocol of 1978 relating thereto (MARPOL 73/78) was ratified by Mozambique in 2003 by the Resolution No. 5/2003 of 18th February[30].

This International Convention came into force on 2nd October 1983. The 1983 Convention initially comprised two annexes: Annex I (Regulations for the Prevention of Pollution by Oil Regulations) and Annex I (Regulations for the Control of Pollution by Noxious Liquid Substances in Bulk).

Since 1983 four additional annexes have been added to the Convention which currently includes six technical Annexes aimed at preventing and minimizing pollution from ships - both accidental pollution and that from routine operations (**Table 4-2**).

[30] The International Convention for the Prevention of Marine Pollution from Ships is published in the Boletim da República No. 7, 1st Series, 3rd Supplement, of 25th February 2003.

Table 4-2. Annexes to MARPOL 1973/1975.

Annex I	Regulation for the Prevention of Pollution by Oil
Annex II	Regulations for the Control of Pollution by Noxious Liquid Substances in Bulk
Annex III	Prevention of Pollution by Harmful Substances Carried by Sea in Packaged Form
Annex IV	Prevention of Pollution by Sewage from Ships
Annex V	Prevention of Pollution by Garbage from Ships
Annex VI	Prevention of Air Pollution from Ships (entry into force 19 May 2005)

Parties must accept Annexes I and II, but the other Annexes are voluntary. Mozambique has ratified Annexes III, IV, and V, but still has to ratify Annex VI (Prevention of Air Pollution from Ships).

Annex I: Prevention of pollution by oil.
Entry into force: 2 October 1983. Revised Annex I entered into force 1 January 2007.

Annex 1 of MARPOL mainly pertains to oil pollution from oil tankers. However, Chapter II, Regulation 9 states that discharges into the sea of oil or oily mixture from ships shall be prohibited except when the following conditions satisfy:

"…from a ship of 400 tons gross tonnage and above other than an oil tanker and from machinery space bilges excluding cargo pump-room bilges of an oil tanker unless mixed with oil cargo.

- the ship is not within a special area;
- the ship is more than 12 nautical miles from the nearest land;
- the ship is proceeding en route;
- the oil content of the effluent is less than 100 parts per million; and
- the ship has in operation an oil discharge monitoring and control system, oil-water separating equipment, oil filtering equipment or other installation."

Annex II: Control of pollution by noxious liquid substances.
Entry into force: 6 April 1987 (Revised Annex II entered into force 1 January 2007).

Annex II details the discharge criteria and measures for the control of pollution by noxious liquid substances carried in bulk.

According to Rule 3 of this Annex, noxious liquid substances are divided into four categories:

(a) Category "A" – Noxious liquid substances from tank cleaning or ballasting-up operations that, if discharged to the sea, represent a serious health risk for marine resources or for human health or significantly harm recreational locations or other legitimate uses of the sea and thus justify the enforcement of strict measures against pollution.

(b) Category "B" – Noxious liquid substances from tank cleaning or ballasting-up operations that, if discharged into the sea, will represent a risk for marine resources or for human health or seriously harm recreational locations or other legitimate uses of the sea and thus justify the application of special measures against pollution.

(c) Category "C" - Noxious liquid substances from tank cleaning or ballasting-up operations that, if discharged into the sea, will represent a low risk for marine resources or for human health or seriously harm recreational locations or other legitimate uses of the sea and thus justify the application of special operation conditions.

(d) Category "D" - Noxious liquid substances from tank cleaning or ballasting-up operations that, if discharged into the sea, will represent a low risk for marine resources or for human health or seriously harm recreational locations or other legitimate uses of the sea and thus justify some attention as regards operations conditions.

Some 250 substances were evaluated and included in the list appended to the Convention. The discharge of their residues is allowed only to reception facilities until certain concentrations and conditions (which vary with the category of substances) are complied with.
In any case, no discharge of residues containing noxious substances is permitted within 12 miles of the nearest land.

Annex III: Prevention of pollution by harmful substances in packaged form.
Entry into force: 1 July 1992.

Annex III is the first of MARPOL optional annexes and contains general requirements for the issuing of detailed standards on packing, marking, labeling, documentation, stowage, quantity limitations, exceptions and notifications for preventing pollution by harmful substances.

As regards application, paragraph 1 of Rule 1 of this Annex establishes that, *"except for otherwise stated, the rules of the present annex are applicable to all ships transporting harmful substances in packaged form, containers, portable tanks, tank-trucks or rail tank wagons"*.

For reference, it is worth noting that *"since 1991 that the International Maritime Dangerous Goods Code (CMICP) also known as 'IMDG Code' includes maritime pollutants"*.

Annex IV: Prevention of Pollution by Residual Waters from Ships

Entry into force: 27 September 2003

Annex IV defines, in detail, how to handle or preserve residues on the ship and the circumstances in which discharge into the ocean can be allowed. It requires the Convention Parties to provide for adequate containers to hold the residues and includes a model of an International Certificate for the Prevention of Pollution from Sewage that can be issued by the national navigation authority for ships under its jurisdiction.

The Annex is applied to ships that make international trips. It is applied to all new ships with 400 tons and higher and new vessels with less than 400 tons that are certified to take more than 15 people. It will be applied to existing vessels of 400 tons and higher and new vessels with less than 400 tons but that are certified to take more than 15 people, five years after its entry into force.

The discharge of residues into the ocean is forbidden, except when the ship has an operation approved device for treatment of residue or when it is discharging disinfected residues and in small amounts, using an approved system at more than three miles form the nearest coast; or discharging non-disinfected and un-fragmented residues, at more than 12 nautical miles from the nearest coast.

Annex V: Prevention of pollution by garbage from ships.
Entry into force: 31 December 1988.

This deals with different types of garbage and specifies the distances from land and the manner in which they may be disposed of. The requirements are much stricter in a number of "special areas" but perhaps the most important feature of the Annex is the complete ban imposed on the dumping into the sea of all forms of plastic.

Another specific aspect of this annex is Rule 2, single paragraph: *"the dispositions of this annex apply to all ships"*. According to Rule 6, the only exceptions contained in this annex only refer to the application of rules 3, 4 and 5, on the disposal of garbage, discharge of garbage or accidental loss of fishing nets.

Annex VI: Prevention of Air Pollution from Ships.
Adoption: September 1997.
Entry into force: 19 May 2005.

The regulations in this annex set limits on sulfur oxide and nitrogen oxide emissions from ship exhausts and prohibit deliberate emissions of ozone depleting substances.
Sulfur Oxides:

Annex VI IMO of Marpol 73/78, that entered into force on 19th May 2005, limits the sulfur content of heavy oils to a maximum of 4.5 % m/m globally and a maximum of 1.5 % m/m in SOx Emission Control Areas (SECAs)[31]. In alternative, if the ship is equipped with an approved cleaning system for subsequent treatment of exhaustion gases or any other technical method that is verifiable and that reduces Sox emissions to a maximum of 6.0 g/kWh measured as S02[32].

NOx Emissions:

The limits of NOx emissions are established for diesel engines that vary from 9.8 to 17 g/kWh depending on the engine's maximum operating speed, as **Table 4-3** shows**.**

[31] m/m = per mass (1% m/m means that the mass of the substance is 1% of the total mass of the solution or mix)
[32] g/kWh = grams per kilowatt-hour

Table 4-3. Annex VI MARPOL NOx Emission Limits

Engine Speed (n, rpm[33])	**NOx, g/kWh**
n < 130 rpm	17.0
130 rpm ≤ n < 2000 rpm	$45 \cdot n^{-0.2}$
n ≥ 2000 rpm	9.8

More technical details on NOx emissions, such as methods to control emissions, are included in the mandatory “Technical NOx Code”, that was adapted under the coverage of “Resolution 2”.

Other air pollutants:

Annex VI forbids the deliberate emission of substances that can harm the ozone layer, including halon and chlorofluorocarbons (CFCs). New facilities that contain substances that harm the ozone layer are forbidden in all ships. But the new facilities that contain hydro-chlorofluorocarbons (HCFCs) are allowed up to 1st January 2020.

The Annex also forbids the on-board incineration of certain products, such as contaminated packaging materials and polychlorinated Biphenyl (PCBs).

4.6.3 International Convention on Oil Pollution Preparedness, Response and Cooperation 1990 – OPRC 90.

Mozambique joined the International Convention on Oil Pollution Preparedness, Response and Cooperation 1990 – OPRC 90 through Resolution 6/2003 of 18 February[34].

The International Convention on Oil Pollution Preparedness, Response and Cooperation, signed in 1990 and effective since 13 May 1995, stipulates that States Parties to this Convention adopt a series of measures laid down in the Convention so as to be prepared for combat and cooperation against marine pollution. Especially relevant for the Project are the provisions of Articles 6 and 3 of the Convention.

Article 6 determines that each Party shall have ”a national system for responding promptly and effectively to oil pollution incidents”. The same article also lays down the main aspects of the contents of such a national system[35].

Article 3 of the Convention determines that each State Party shall require that ”operators of offshore units under its jurisdiction have oil pollution emergency plans, which are coordinated with the national system established in accordance with Article 6 and approved in accordance with procedures established by the competent national authority”.

[33] rpm = rotations per minute
[34] This Resolution is published in the *Boletim da República* No. 7, 1st Series, 3rd Supplement, of 25th February 2003
[35] Mozambique does not, currently, have a National Oil Spill Contingency Plan although the National Marine Institute (Ministry of Transport and Communications) has produced a draft Plan but this has not been approved by the Government of Mozambique.

Article 4 lays down the procedures to be adopted with respect to reporting oil pollution:

1. Each Party shall:

a) Require masters or other persons having charge of ships flying its flag and persons having charge of offshore units under its jurisdiction to report without delay any event on their ship or offshore unit involving a discharge or probable discharge of oil:

i) in the case of a ship, to the nearest coastal State;
ii) in the case of an offshore unit, to the coastal State to whose jurisdiction the unit is subject;

b) Require masters or other persons having charge of ships flying its flag and persons having charge of offshore units under its jurisdiction to report without delay any observed event at sea involving a discharge of oil or the presence of oil:

i) in the case of a ship, to the nearest coastal State;
ii) in the case of an offshore unit, to the coastal State to whose jurisdiction the unit is subject;

c) Require persons having charge of sea ports and oil handling facilities under its jurisdiction to report without delay any event involving a discharge or probable discharge of oil or the presence of oil to the competent national authority;

d) Instruct its maritime inspection vessels or aircraft and other appropriate services or officials to report without delay any observed event at sea or at a sea port or oil handling facility involving a discharge of oil or the presence of oil to the competent national authority or, as the case may be, to the nearest coastal State;

e) Request the pilots of civil aircraft to report without delay any observed event at sea involving a discharge of oil or the presence of oil to the nearest coastal State.

2. Reports under paragraph (1) (a) (1) of this Article shall be made in accordance with the requirements developed by the Organization and based on the guidelines and general principles adopted by the Organization. Reports under paragraph (1)(a)(ii), (b), (c) and (d) shall be made in accordance with the guidelines and general principles adopted by the Organization to the extent applicable.

Article 4 of this Convention is reflected in Article 21 Regulation for the Prevention of Pollution and Protection of the Marine and Coastal Environment – see Section 4.3.2.

The remaining sections of the Convention are related to the provisions about oil spill combating equipment, reporting, training, assistance and international cooperation.

4.6.4. United Nations Convention on the Law of the Sea and the Agreement relating to the Implementation of Part XI of the Convention

Mozambique joined the United Nations Convention on the Law of the Sea and the Agreement relating to the Implementation of Part XI of the Convention through Resolution 21/96 of 26 November[36].

The United Nations Convention on the Law of the Sea was adopted in 1982 and is in force since 1994. It is one of the most important international treaties regarding sea regulation, since the large majority of its provisions are accepted by almost all countries, even if they haven't ratified the Convention. In many cases, the Convention adopted several principles from other international or regional conventions and, on the other hand, subsequent international or regional conventions and agreements have adopted the principles and provisions established in the United Nations Convention on the Law of the Sea.

As its name already indicates, the United Nations Convention on the Law of the Sea covers a broad spectrum of issues with respect to the "Law" of the Sea.

The articles directly dealing with marine pollution deserve special attention.

Article 1, paragraph 4 gives the definition of pollution of the marine environment: "it means the introduction by man, directly or indirectly, of substances or energy into the marine environment, including estuaries, which results or is likely to result in such deleterious effects as harm to living resources and marine life, hazards to human health, hindrance to marine activities, including fishing and other legitimate uses of the sea, impairment of quality for use of sea water and reduction of amenities".

Paragraph 5 of the same article 1 refers to "dumping", defining it as:

i) any deliberate disposal of wastes or other matter from vessels, aircraft, platforms or other man-made structures at sea;
ii) any deliberate disposal of vessels, aircraft, platforms or other man-made structures at sea;.

Part XII of the Convention, covering Articles 192 to 237, deals with the Protection and Preservation of the Marine Environment.

Article 192 establishes the obligation of the States to protect and preserve the marine environment and Article 194 assigns the right to States, and particularly the coastal States, to take all measures necessary to prevent, reduce and control pollution of the marine environment, irrespective of its source, using to this end the most viable means at their disposal and in conformity with their possibilities.

Article 194 is especially important because it defines in general the measures that can and should be taken by the States to protect and preserve the marine environment, as well the possible sources of pollution.

[36] Resolution 21/96 is published in the *Boletim da República* No. 47, 1st Series, 6th Supplement of 28th November 1996

4.6.5 *Convention for the Suppression of Unlawful Acts against the Safety of Maritime Navigation, 1988*

This Convention was adopted on 10th March 1988 and came into force on 1st March 1992.

Mozambique acceded to this convention in 2003. This Convention requires governments to take measures to prevent unlawful acts which threaten the safety of ships and the security of their passengers and crews.

The Protocol for the Suppression of Unlawful Acts against the Safety of Fixed Platforms Located on the Continental Shelf extends the requirements of the Convention to fixed platforms such as those engaged in the exploitation of offshore oil and gas.

4.6.6 Additional International Conventions

Mozambique is also party to several additional international environmental conventions, including:

- Vienna Convention for the Protection of the Ozone Layer, 1985 ratified by Mozambique by the Resolution No. 8/93 of 8th December[37].
  This convention commits governments to take appropriate measures to protect human health and the environment against adverse effects resulting from depletion of the ozone layer. Cooperative research and information exchange are encouraged to better understand and assess the effects of ozone layer modification on human health and the environment.
- Agenda 21 of the United Nations Conference on Environment and Development (UNCED), 1992. Agenda 21 is a comprehensive plan of action to be taken globally, nationally, and locally by organizations of the United Nations System, governments, and major groups to reduce human impacts on the environment. Chapter 17 of Agenda 21 addresses protection of the oceans, and Section 17:30 calls for states to assess the need for additional measures to control degradation of the marine environment from sea-based activities, including activities associated with oil and gas platforms.
  Framework Convention on Climate Change (FCCC), 1992 ratified by Mozambique by the Resolution No. 1/94 of 24th August 1994[38]. The FCCC's goal is the stabilization of greenhouse gas concentrations in the atmosphere consistent with sustainable development and at levels and on a time scale that would prevent dangerous anthropogenic interference with the climate system. Governments should take precautionary measures to anticipate and prevent or minimize the causes of climate change and mitigate its adverse effects.

[37] The Resolution No. 8/93 is published in the Boletim da República No. 49, 1st Series, 2nd Supplement, of 8th December 1993

[38] The Resolution No. 1/94 is published in the Boletim da República No. 34, 1st Series, 2nd Supplement, of 24th August 1994

- Convention on Biological Diversity, 1992 ratified by Mozambique by the Resolution No. 2/94 of 24th August[39].
  In support of conserving biological diversity, governments commit to integrating conservation and sustainable use of biological resources into national decision-making, establishing a system of protected areas, and requiring environmental impact assessments of proposed projects that may adversely affect biological diversity.
- Convention on the Conservation of Migratory Species of Wild Animals (1979) and the Memorandum of Understanding Concerning Conservation Measures for Marine Turtles of the Atlantic Coast of Africa (1999).

Mozambique also is party to the international agreements on climate change-Kyoto Protocol[40], desertification[41], endangered species[42], hazardous wastes[43], and wetlands[44].

4.7 INSTITUTIONAL FRAMEWORK

4.7.1 Ministry for the Coordination of Environmental Affairs

The Ministry for the Coordination of Environmental Affairs (MICOA) is responsible for coordinating all environmental activities at national level in order to promote the management, preservation and rational use of the country's natural resources as well to propose environmental policies and strategies for integration in sectoral development plans. The Ministry is to promote the sustainable development of the country through the steering of the implementation of the country's environmental policy[45].

In order to execute its objectives and duties, this ministry is structured in the following areas of activity[46]:

a) Inter-sectoral Coordination;
b) Research, Environmental Planning and Management;
c) Land Planning and Organization;
d) Environmental Impact Assessment;
e) Environmental Promotion, Education and Dissemination;
f) Inspection and Supervision.

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[39] The Resolution No. 2/94 is published in the Boletim da República No. 34, 1st Series, 3rd Supplement, of 24th August 1994
[40] Ratified by the Resolution No. 10/2004 of 28th July published in the Boletim da República No. 30, 1st Series, Supplement, of 28th July of 2004
[41] Ratified by the Resolution No. 20/96 of 26th November, published in the Boletim da República No. 47, 1st Series, 5th Supplement, of 28th November 1996
[42] Ratified by the Resolution No. 20/81 of 30th December, published in the Boletim da República No. 52, 1st Series, Supplement, of 30th December 1981
[43] Basel and Bamako Conventions ratified respectively by the Resolutions 18/96 and 19/96 both of 26th November, both published in the Boletim da República No. 47, 1st Series, 5th Supplement of 28th November 1996
[44] Ratified by the Resolution No. 45/2003 of 5th November, published in the Boletim da República No. 45, 1st Series, 2nd Supplement of 5th November 2003
[45] See Presidential Decree No. 6/95 of 10th November published in the Boletim da República No. 48, 1st Series, Supplement, of 29th November 1995
[46] See Ministerial Diploma No. 259/2005 of 29th December published in the Boletim da República No. 52, 1st Series, 2nd Supplement of 29th December 2005 and Ministerial Diploma No. 28/2007 of 18th April, published in the Boletim da República No. 16, 1st Series, of 18 April 2007

In order to implement the above mentioned activities, the Ministry for the Coordination of Environmental Affairs presents the following structure:

a) General Inspection;
b) National Directorate of Environmental Management;
c) National Directorate of Land Planning and Organization;
d) National Directorate of Environmental Impact Assessment;
e) National Directorate for Environmental Promotion;
f) National Directorate for Planning and Studies;
g) Directorate of Human Resources;
h) Directorate of Administration and Finances;
i) Department of International Cooperation
j) Judicial Office;
k) Ministre's Office.

The Ministry for the Coordination of Environmental Affairs has as it subordinate institutions:

a) Centre for Sustainable Development for Coastal Areas (CDS-ZONAS COSTEIRAS);
b) Centre for Sustainable Development of Urban Areas (CDS-ZONAS URBANAS);
c) Centre for Sustainable Development of Natural Resources (CDS-RECURSOS NATURAIS

The relevant directorates for Environmental Impact Assessment studies are:

1. National Directorate of Environmental Management
2. National Directorate for Environmental Impact Assessment.

The duties of the National Directorate for Environmental Management are:

a) To propose policies, plans and standards for the correct use of the environmental components and environment control quality;
b) To promote global and integrated air, water, soils and other environmental components quality program;
c) To propose the establishment of environmental quality standards and to promote its implementation;
d) To participate in the definition of sustainable development indicators;
e) To promote environmental conservation actions, aiming in particular, to preserve biodiversity, sustainable management of sensitive or protection areas and the rehabilitation of degraded areas;
f) To promote the integrated and sustainable management of urban and coastal areas.

The duties of the National Directorate for Environmental Impact Assessment are:

However, the duties of the National Directorate for Environmental Impact Assessment are:

a) To propose legislation to guide the implementation of environmental management of potential degrading activities;
b) To conduct environmental licensing of potentially degrading activities for the environment;

c) To conceive and implement pilot-projects for the evaluation of cumulative environmental impacts in the main economic development areas;
d) To manage and coordinate the environmental impact assessment process;
e) To prepare and issue general and specific guidelines on the environmental impact assessment process;
f) To act, in collaboration with public and private entities interested and the civil society for the analysis of environmental studies in the scope of the environmental impact assessment;
g) To promote the monitoring of environmental impacts and environmental audits to ventures that can cause harm to the environment;
h) To approve the specific terms of reference presented by the proponents of the development activities that will serve to guide the environmental impact studies;
i) To register and keep a record of professionals and consulting companies qualified to conduct environmental impact studies and environmental audits;
j) To conduct strategic environmental evaluation, of policies, plans and programs.

It is important to note that the National Directorate for Environmental Impact Assessment, apart from managing and coordinating the Environmental Impact Assessment process, is also responsible for monitoring the environmental impacts as well as environmental audits.

4.7.2 National Petroleum Institute

The National Petroleum Institute INP is the regulatory body for hydrocarbon research, production and transportation activities[47].

The National Petroleum Institute is a legal entity governed by public law, with administrative, financial and patrimonial autonomy that performs its competences based on technical capacity and impartiality.

The NPI is based in Maputo, with delegations in the provinces, including one in Cabo Delgado (Pemba).

In the scope of the research activity, the NPI has the following competences:

a) To evaluate and update the knowledge of petroleum potential in the national territory;

b) To develop actions to promote investment in petroleum surveying;

c) To participate in the definition of the contract, minimum work obligations of the title holders of the contracts and concessions.

Without judgment of other powers awarded by law and other applicable standards, the NPI, in the scope of its competences and attributions, must inspect the locations, buildings and facilities where petroleum operations are conducted and must also observe the execution of petroleum operations and inspect all assets, registry and data in the possession of the operator.

[47] The National Petroleum Institute was created by Decree No. 25/2004 of 20th August, published in the Boletim da República No. 33, 1st Series, of 20th August 2004

The NPI has as main bodies:

a) The Board of Directors
b) The Supervisory Board
c) The Governing Board

The Board of Directors will create support and technical consultation bodies or any others, permanent or temporary, needed for the operation of the NPI. The mandates of the members of the Board of Directors, including the Chairman are 5 (five) years, renewable.

It is based on these statutes that the NPI is responsible for the supervision and monitoring of all aspects of seismic exploration and must ensure that the proponent complies with the proposed Environmental Management Plan (EMP).

4.7.3 National Maritime Institute (INAMAR)

INAMAR – National Maritime Institute is the institution commonly known and designated by Maritime Authority and replaces SAFMAR – National Administration and Maritime Supervision Service (terminated by Decree No. 32/2004 of the Cabinet dated 18th August 2004, in its Article 8) that was created by Decree No. 34/94 dated 1st September and that had been performing the role of Maritime Authority in the Republic of Mozambique.

INAMAR, is a legally constituted public institution with administrative and financial autonomy created by the Government of the Republic of Mozambique through Decree No. 32/2004[48] as the "Regulatory Maritime Authority" (Article 1 of Decree No. 32/2004), in accordance to Article 30 of Law No. 4/96 dated 4th January 1996: Law of the Sea, in its Chapter VII on Maritime Administration.

INAMAR's aim is to act in the fields of maritime safety, protection of ships and port facilities, maritime transportation, agency and stowing, maritime personnel, preservation of marine environment and maritime administration (Article 3 of Decree No. 32/2004 of the Cabinet).

INAMAR's duties (Article 4 of Decree No. 32/2004) are:

a) To exercise maritime authority in the maritime jurisdiction areas, lakes and rivers and on the public maritime domain;

b) To promote the establishment and maintenance of maritime safety conditions for the execution of navy activities;

c) To promote and encourage efficiency and competition through economic and specific regulation in the interest of the users and service providers.

The competences of INAMAR include, inter alia, the following:

- To apply and ensure the compliance of national legislation on maritime safety and international conventions on maritime issues the country has ratified;

[48] The Decree 32/2004 of 18th August is published in the Boletim da República No. 33, 1st Series, of 18th August 2004

- To license, supervise and control the Navy's activities;
- To supervise compliance with legislation, regulations and safety procedures in maritime infra-structures and to support maritime navigation;
- To certify, supervise and license maritime equipment and material;
- To inspect and license the exploration of port infra-structures and to support maritime navigation and related activities;
- To license, provide credentials and acknowledge the classified partnerships of ships and maritime material;
- To instruct and make decisions on licensing processes for transportation activities and maritime works;
- To promote actions to prevent and fight against maritime pollution;
- To act on and penalize the offenders of legislation and relevant procedures for the safety of maritime navigation, maritime industry and related activities;
- To participate, in coordination with other relevant authorities, in search and rescue activities;
- To collect taxes and fees due for services rendered;

In the context of hydrocarbon research activities, special attention must be given to paragraphs 2 (Maritime safety), 4 (Maritime transportation, agency and stowing), 6 (Preservation of the marine environment) and 7 (Maritime administration) of Article 3 of the Organic Statute, regarding the specific competences of INAMAR that detail the mandate of INAMAR as a Maritime Authority.

The specific competences of INAMAR are the following:

Article 3 - Paragraph 2: With regards to maritime safety:

- To control vessels and registered national maritime, wherever they are, and foreign vessels in national territorial waters;
- To apply and enforce safety standards on national and foreign vessels related to maritime trade, fishing, recreation and on any other floating constructions;
- To lead the supervision, inspection and certification processes for national and foreign vessels related to maritime trade, fishing, recreation and any other floating constructions;
- To lead the validity processes for vessel certificates granted by foreign maritime authorities;
- To ensure communications between vessels and national coastal stations, aiming to safeguard human life and goods at sea;
- To control the handling and transportation of dangerous goods, in coordination with other competent authorities;
- To conduct investigations on accidents, incidents and processes related to maritime offenses and submit them to the relevant authorities;

Article 3 - Paragraph 4. With regards to maritime transportation, agencies and stowing:

- To license, authorize and supervise commercial maritime transportation activities, ship managers, private maritime transportation, maritime tourism transportation and recreational navigation;

- To license and supervise agency activities and complementary services;
- To license and supervise diving activities;
- To license and supervise towing and maritime rescue activities;
- To license and supervise related maritime activities;

Article 3, Paragraph 6. With regards to the preservation of the marine environment:

- To propose legislation and regulations to prevent, reduce, control and combat pollution of the marine environment by vessels, floating or fixed at sea, taking international conventions into consideration;
- To lead and coordinate actions for prevention and fight against marine pollution, with the participation of other relevant national and international entities;
- To participate or join organizations and international forums aimed at the establishment of rules and standards, as well as international and regional practices and procedures to prevent, reduce, control and fight against the pollution of marine environment by ships;
- To take other measures necessary to prevent, reduce and control marine pollution.

Article 3. Paragraph 7. With regards to maritime administration:

- To register vessels, issue related documentation, establish and maintain records updated;
- To sanction employment contracts between crews and ship owner's or their representatives;
- To define the minimum safe manning for vessels under national flag and issue corresponding certificates;
- To issue opinions on activities to be carried out in public maritime domains, rivers and lakes;
- To authorize or determine the opening or closing of ports and port terminals;
- To hold or participate in inquiries on accidents and maritime incidents;
- To supervise maritime activities committed to it (the institute) by law.

4.7.4 National Hydrography and Navigation Institute (INAHINA)

INAHINA has the following competences:

- Responsible for safety of maritime navigation, through emission and dissemination of "Notice to Mariners" for maritime navigation in the waters under the jurisdiction of the Republic of Mozambique (Line (d) of Article 5 of the Organic Statute of INAHINA integrated in Decree No. 27/2004 dated 20th August)[49];

- Responsible for preparation and sale of nautical publications such as charts, navigation routes, lists of lighthouses, tide tables, among others;

[49]*Aviso aos Navegantes* is an Information Newsletter on any changes to safety in navigation in waters under national jurisdiction.

- Responsible for the operation and maintenance of Navigation Aids (Lighthouses, Beacons, Buoys, and other signals) in the waters under the jurisdiction of the Republic of Mozambique.

4.8 INTERNATIONAL DRILLING OPERATIONS GUIDELINES

4.8.1 International Association of Drilling Contractors (IADC)

This guide is designed to supplement company Health, Safety and Environmental programs and operating procedures. It is based on experience and careful study over many years. Practicability has been substantiated by the adoption of the safe operating procedures by many drilling contractors and government regulatory bodies. It gives the drilling contractor a basis on which to build a Health, Safety and Environmental program.

Of particular interest for the present project are chapters 12, related to Offshore Safety, covering aspects such as medical evacuation to rough weather procedures; and chapter 14, related to the Protection of the Environment covering air emissions, waste management, spill prevention and control amongst others.

The guidelines also cover aspects related to Fire Prevention and Control, Personal Protective Equipment and Emergency Action Plan(s). These aspects are also addressed in the Mozambican Regulations for Petroleum Operations.

4.8.2 International Association for Oil and Gas Producers (OGP)

The OGP have been producing many documents and guidelines over the past few years to help its members to develop best practices in Health, Safety and Environment. Of special importance for the project are:

- Environmental Aspects of the use and disposal of non aqueous drilling fluids associated with offshore oil and gas operations – it provides a comprehensive synopsis of what is known around the world about the environmental impacts of this discharge;

- Environmental management in oil and gas exploration and production – It provides an overview of the environmental issues and the technical and management approaches to achieving high environmental performance in the activities necessary for oil and gas exploration and production around the world;

- Guidelines for the development and application of Health, Safety and Environmental Management Systems – it describes the main elements necessary to develop, implement and maintain a Health, Safety and Environmental Management System by the operators;

- Exploration and Production (E&P) Waste Management Guidelines – it provides a general description of waste management principles; an identification and overview of

E&P activities and associated wastes; and options of waste reduction, recycling, treatment and responsible disposal; and

- Key questions in managing social issues in Oil & Gas Projects – it provides a tool to help with social planning issues and are targeted to: project management, by helping to identify questions that may be important in their leadership role; and business and project teams, by helping in the identification of questions that may be important in project development and management.

4.9 APC ENVIRONMENTAL, HEALTH, AND SAFETY POLICY

Anadarko Petroleum Corporation (APC)'s EHS policy emphasizes the company's commitment to managing and operating its worldwide assets in a manner consistent with its core values in order to protect the health and safety of people and the environment, as well as comply with applicable EHS laws, regulations, and internal EHS principles. The EHS policy applies to all employees of APC and its subsidiaries, including AMA1. Key elements of the policy include the following:

- Design and execution – APC shall incorporate the protection of human health and safety (along with methods to mitigate community impact) and be responsible for the minimization of waste and the reduction of emissions in all phases of operations, including planning and design. Ongoing compliance activities shall include appropriate monitoring, incident investigations, and the evaluation of concerns raised by management or employees to continuously improve EHS performance.

- Training and Communication – APC shall train officers and employees in EHS-compliance policies and procedures in a manner appropriate for the position of the individual or group. Appropriate information regarding means of compliance shall be prepared and distributed to directors, officers, and employees. Officers, managers, and supervisors shall demonstrate their support by regularly communicating this Policy to their direct reports and ensure appropriate training is provided. Communication of EHS requirements, expectations, hazards, and measurements shall be made during new-employee orientation and on-assignment to a new position or location. Ongoing communication will include regularly scheduled site safety meetings, shift/tour handover briefings, written alerts, orientation and induction briefings, or refresher training. Contractors and visitors shall be informed of appropriate EHS requirements.

- Auditing – Corporate EHS shall conduct periodic audits of APC's operations to assess risk areas and determine whether employees are abiding by the Policy, EHS principles, and programs and procedures adopted hereunder. Audit results will be reviewed, any incidents of non-compliance addressed, and necessary changes to the EHS compliance system implemented.

EHS considerations and an active concern for local laws and customs are integrated into every aspect of APC's business. EHS goals are maintained through a strict system of internal management and accountability that begins with senior management personnel and extends down to individual employees and contractors. The EHS management system ensures APC maintains consistently high EHS standards wherever it operates.

Chapter 5

BIOPHYSICAL AND SOCIO-ECONOMIC DESCRIPTION OF THE STUDY AREA

Chapter 5

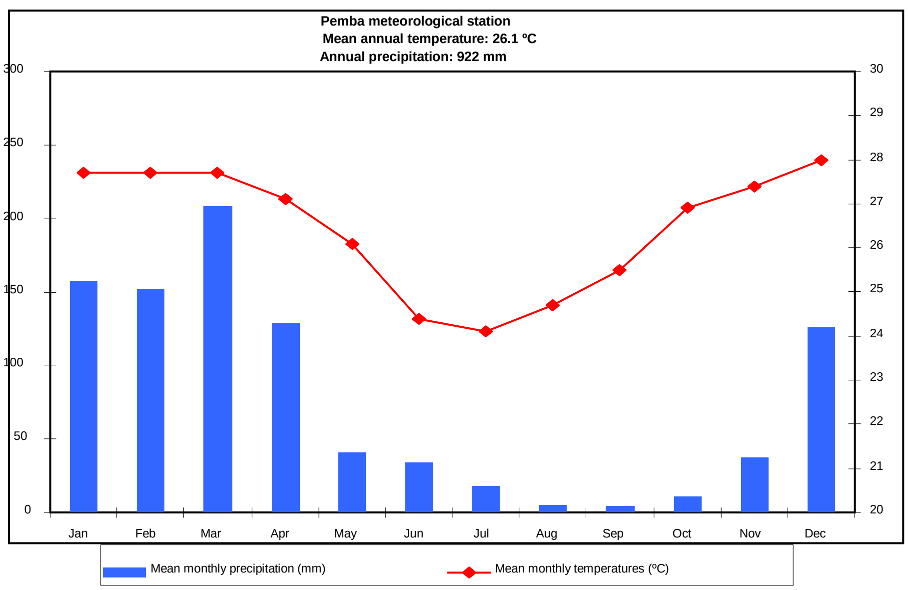
BIOPHYSICAL AND SOCIO-ECONOMIC DESCRIPTION OF THE STUDY AREA

5.1 PHYSICAL ENVIRONMENT

5.1.1. Climate

The climate of the study area is strongly influenced by the Intertropical Convergence Zone (ITCZ)[1]. In January the ITCZ is located at about 15°S of the Equator and the East African coast is under the influence of northeasterly winds.[2] In July the ITCZ is situated at about 15°N and most of East Africa is under the influence of southeasterly and southerly winds.[3] The climate is thus subject to alternating and distinctive wet (November to April) and dry (May to October) seasons.

Average monthly temperatures vary between 25°C and 27°C during the warm wet season (November to April) and during the cooler drier period (May to October) average monthly temperatures vary between 22°C to 25°C. Total annual rainfall for the northern Cabo Delgado coast varies between 900 and 1,000 mm. Average annual rainfall for Pemba and Mocimboa da Praia is 922 and 956 mm, respectively (**Figures 5-1 and 5-2**)



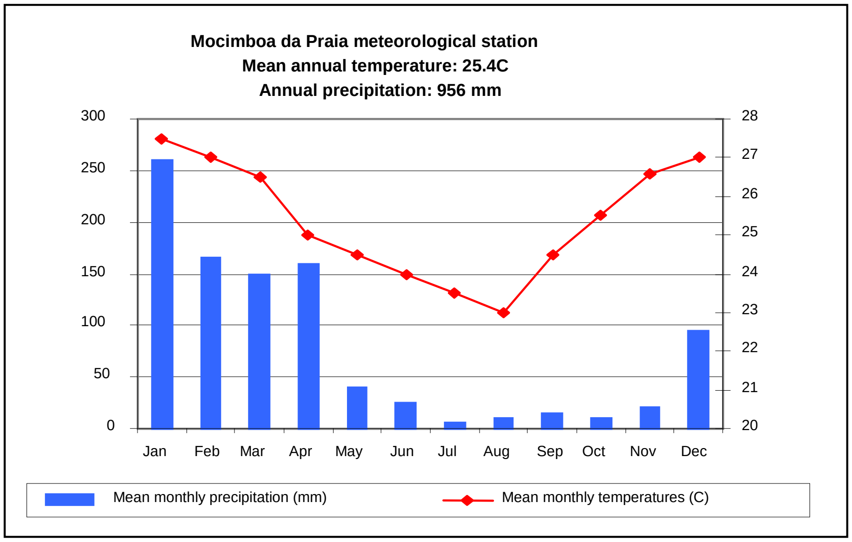
Source: National Institute of Metheorology

Figure 5-1. Climate data for Pemba

1 The ITCZ is an area of low pressure that forms where the Northeast Trade Winds meet the Southeast Trade Winds near the equator. As these winds converge, moist air is forced upward causing water vapor to condense and cool resulting in heavy precipitation.

2 South of the Equator, the winds may become more north-westerly due to the effect of the earth's rotation.

3 These seasonal wind regimes are known as monsoons



Source: National Institute of Metheorology

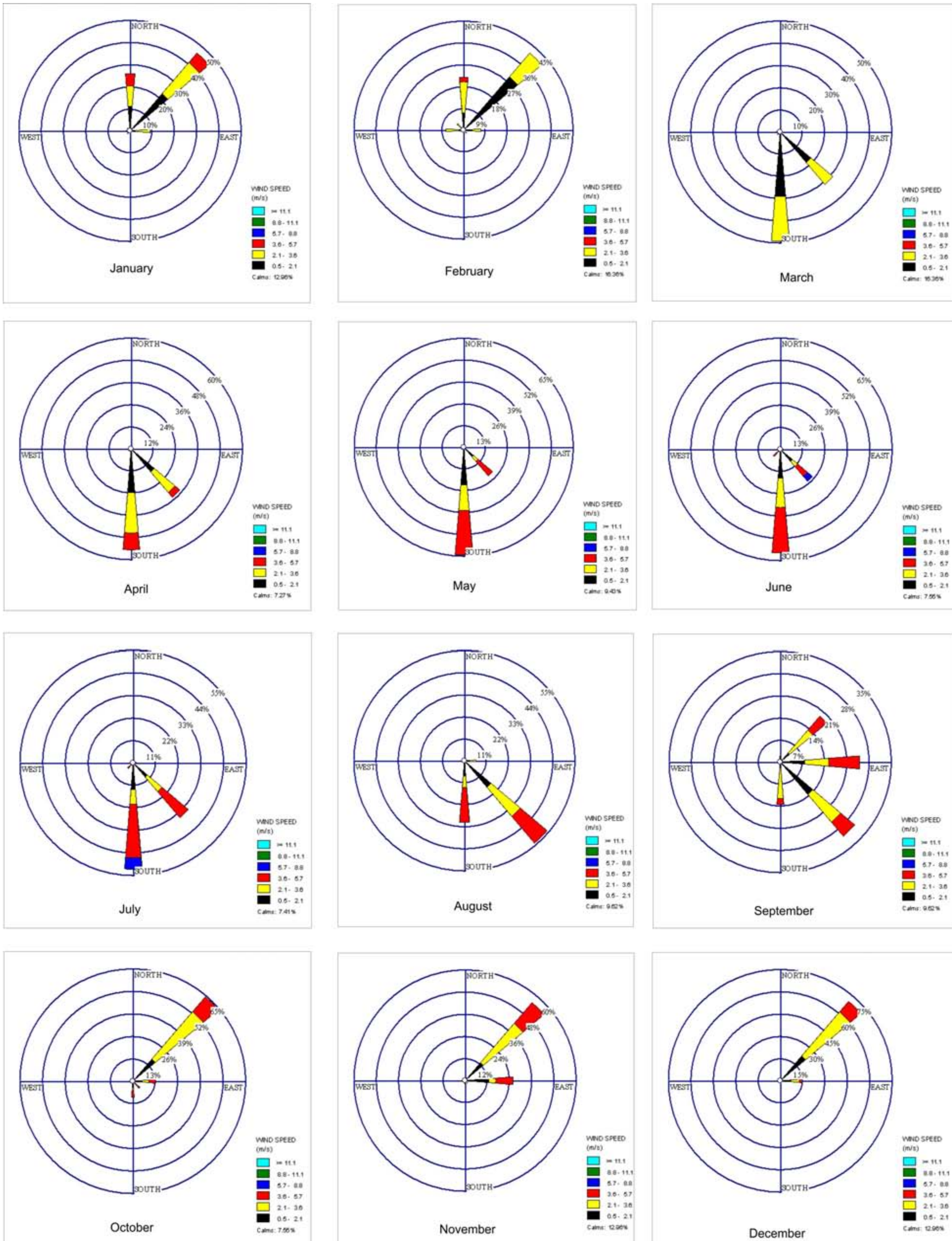
Figure 5-2. Climate data for Mocimboa da Praia

Monthly wind directions (% per direction) for Pemba are shown in **Table 5-1**. Monthly wind direction data and wind speeds are shown in the form of wind roses are shown in **Figure 5-3**. During the months of October, November, December, January and February the winds are predominantly north-easterly whilst from March to September the winds are predominantly southerly/south-easterly.

Table 5-1. Wind directions (%) for Pemba

	N	NE	E	SE	S	SW	W	NW
January	27	51	13	0	0	2	2	2
February	18	51	9	2	0	2	7	4
March	0	12	12	22	35	4	4	0
April	0	0	0	37	59	2	2	0
May	0	0	0	29	65	6	0	0
June	0	0	0	29	65	6	0	0
July	0	0	0	40	57	4	0	0
August	0	0	4	63	31	0	0	0
September	0	24	28	34	14	0	0	0
October	0	68	17	6	9	0	0	0
November	0	67	29	2	2	0	0	0
December	2	80	19	0	0	0	0	0

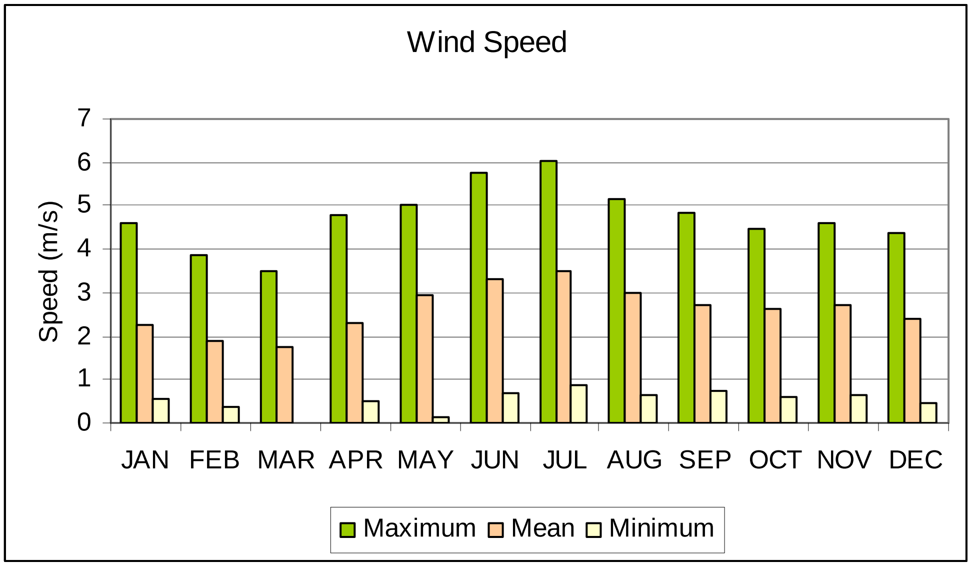
Source: National Institute of Metheorology



Source: National Institute of Metheorology

Figure 5-3. Wind roses for all months, Pemba

Average mean, maximum and minimum monthly wind speeds are shown in **Figure 5-4**. The lowest monthly wind speeds occur during the months of February and March when more than 70% of winds recorded are less than 3 m/second and mean monthly wind speeds are less than 2m/s. The windiest months are June and July and August when more than 40% of the winds recorded are > 4 m/s and when mean maximum monthly wind speeds are > 5.0 m/s.



Source: National Institute of Metheorology

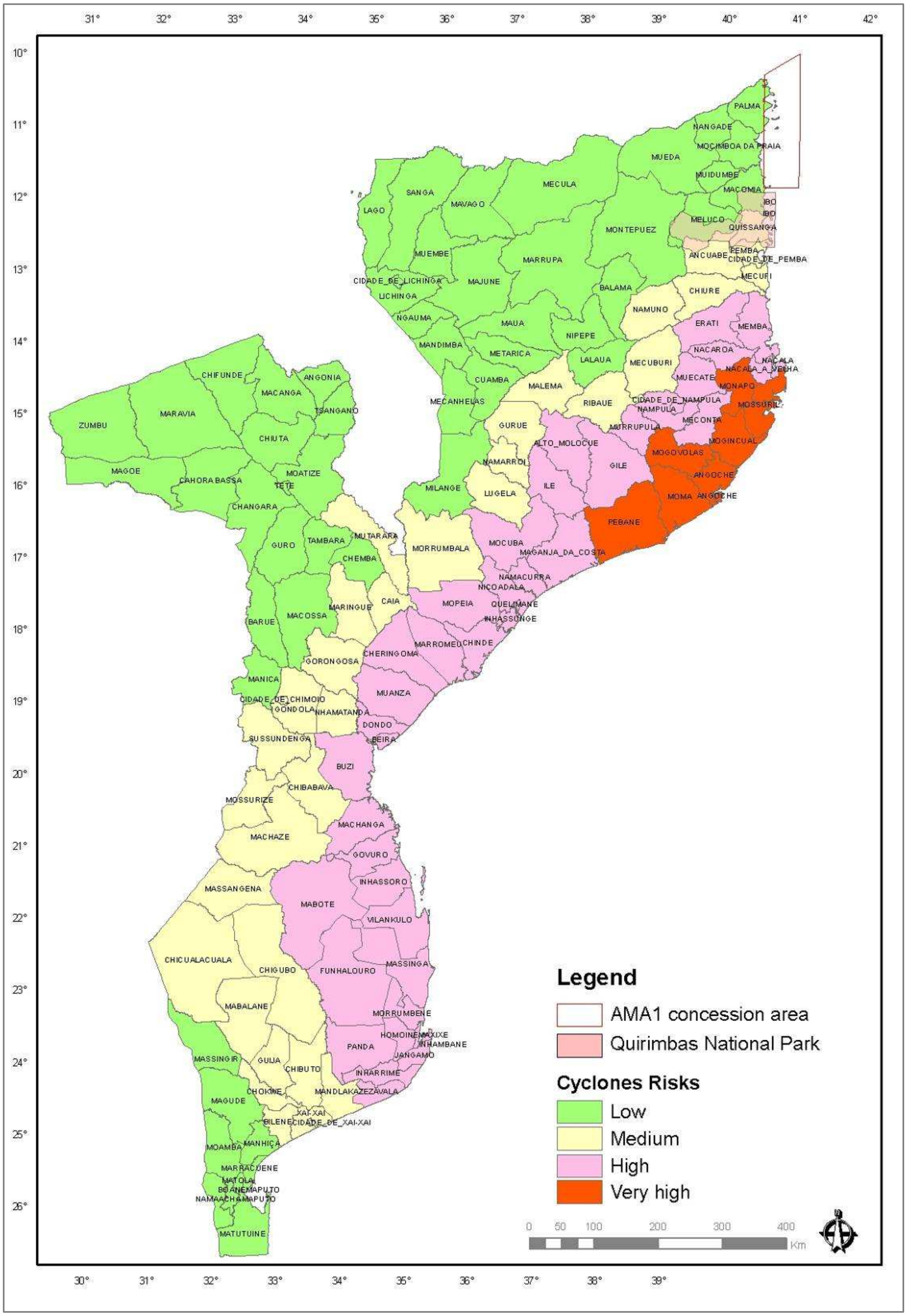
Figure 5-4. Average mean, maximum and minimum monthly wind speeds for Pemba

Historically and statistically, northern Cabo Delgado is not a cyclone prone region (**Figure 5-5**). Most cyclones make landfall along the central and southern coastal areas Over the last fifty years 30 cyclones have struck the Mozambican coast affecting mainly the central sector of the coastline bringing torrential rains, flooding and severe wind damage (**Figure 5-6**). The only one cyclone has struck the northern Mozambican coastline during the last 50 years viz*.,* in 1959 when a cyclone made landfall near Mocimboa da Praia.

In 1952, Cyclone Lindi affected southern Tanzania very close to the Mozambican border causing limited damage to Mtwara town in Tanzania and Palma district in northern Mozambique. More recently a tropical disturbance formed on 4 November 2002 in southwest Indian Ocean basin and developed into a tropical depression (cyclone Atang).[4] On 10 November 2002 it intensified when it moved into the warm waters of the Mozambique Channel, but weakened. It was in this weakened state on 11 November making landfall at the border between Mozambique and Tanzania on the evening of 12 November. Wind gusts observed in the affected areas were up to 70 Km/h. Moderate rain occurred in some places of Cabo Delgado Province.[5] The affected districts were Ibo, Palma, Mocímboa da Praia, Mueda and Macomia. With exception of moderate off-season rains in those districts no damage was reported due to this storm.

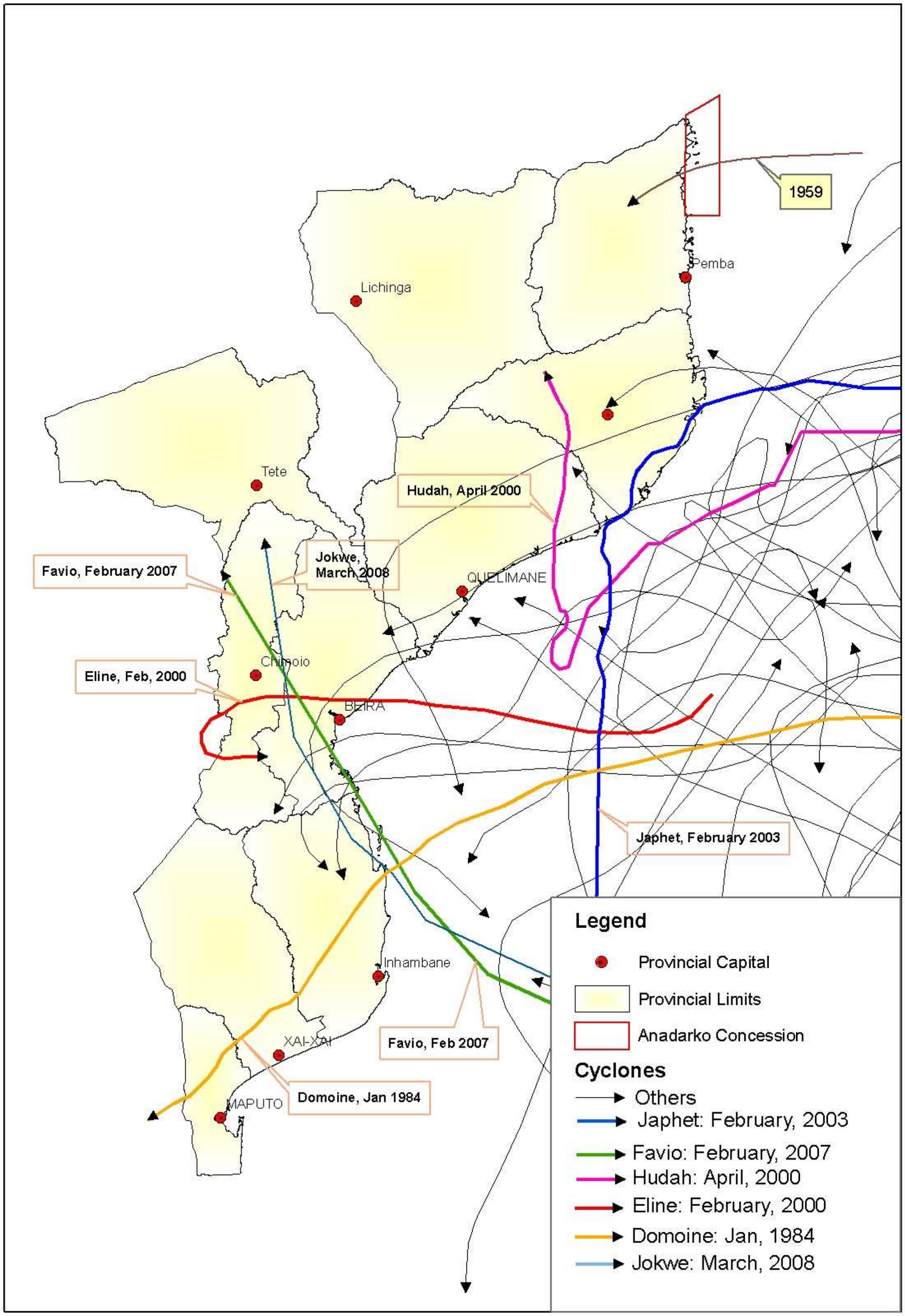
[4] http://www.fews.net/centers/innerSections.aspx?f=mz&m=1000751&pageID=monthliesDoc

[5] National Institute of Meteorology (INAM)



Source: National Institute of Metheorology

Figure 5-5. Frequency of cyclones per district along the Mozambican coast



Source: National Institute of Metheorology

Figure 5-6. Cyclones making landfall along the Mozambican coast (1958 to 2008)

Mozambique has developed a Cyclone Alert system that rapidly provides information and warnings via the national, local and naval radio stations in the event of a risk of a cyclone hitting the Mozambique coast: see **Box 1**.

BOX 1

A newly adopted Cyclone Warning System for Mozambique came into force on 1st November 2002. This system, which was developed by National Institute of Meteorology (INAM) and the National Institute for the Management of Calamities (INGC) in collaboration with United States Agency for International Development (USAID) Famine Early Warning System Network (FEWS NET) comprises a cyclone severity category system and a color alert system.

Categories of cyclone severity range from 1 for a moderate tropical storm to 5 for the most severe tropical cyclones. (Note: Atang was classified as a category 4 cyclone in the Mozambican Channel but was downgraded to a Category 1 storm when it hit the coast. A Category 5 cyclone is rare and has not been recorded for Mozambique).

The Color Alerts provide communities with an indication of the time available to prepare for the onset of high winds as follows:

Blue: A tropical cyclone may affect the area within 24 to 48 hours. High winds are not yet a threat but communities should start to take precautions. Some ships may leave harbor. Check fishing boat moorings.

Yellow: A tropical cyclone is moving closer and is highly likely to affect communities within 24 hours. Communities are advised to start taking actions quickly. Make ships and fishing boats safe. Listen for cyclone advice updates.

Red: High winds are imminent (within 6 hours) or may be happening. In this critical stage, communities are advised to take final safety measures before the onset of high winds. Ensure doors and windows are safely secured, stay indoors. Roads and bridges may close. Radio will broadcast warning messages around the clock.

5.1.2. Tidal Range

Waves along the Cabo Delgado coastline are relatively small, ranging from calm to about 2m wave height except during cyclones.

The tides along the entire Mozambican coast are semidiurnal between 2 m and 6.5 m in range (**Figure 5-7**). The tidal range at Pemba is 4.0 m (mean high spring tide) and 2.8 m (mean high neap tide). The tidal range varies markedly throughout the month and can be as low 0.6 m during low neap tides (**Figure 5-8**).

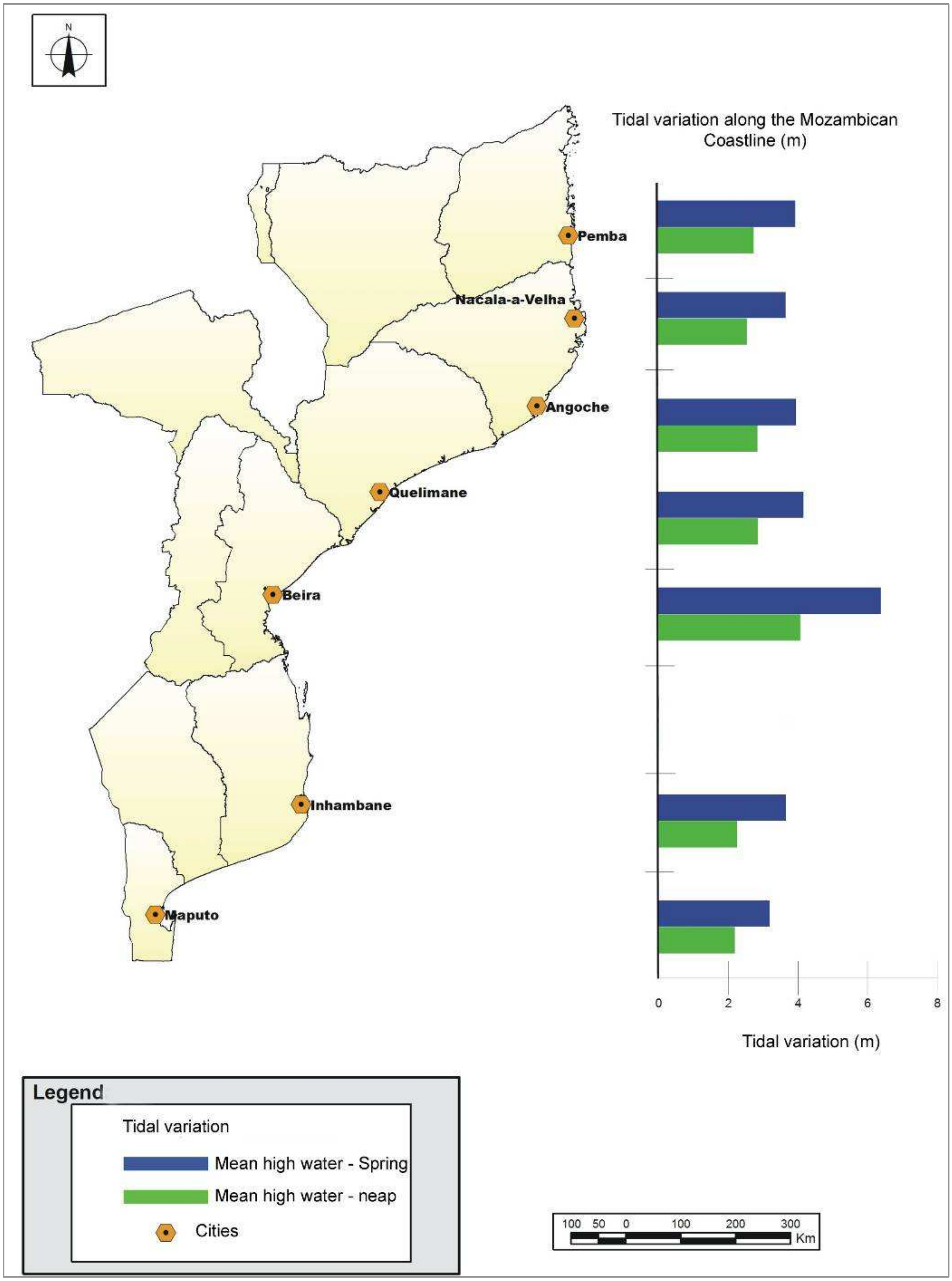


Figure 5-7. Tidal ranges along the Mozambican coast

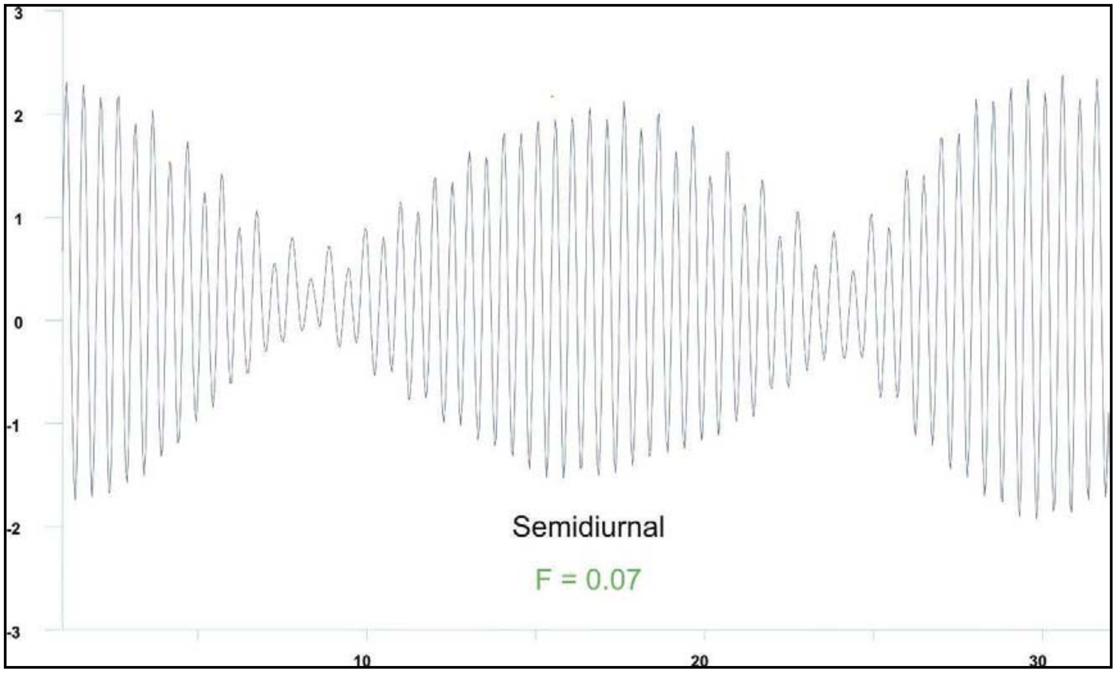


Figure 5-8. Monthly variation in tidal range at Pemba (Mahongo, 2006)

5.1.3. Ocean Currents

The equatorial water mass known as the South Equatorial Current (SEC) flows westward across the Indian Ocean and splits when it reaches east Madagascar, into a southward flowing branch, the East Madagascar Current (EMC), and a northern branch that flows north to Cape Amber, the northern point of Madagascar. The latter branch veers westwards at Cape Amber towards the coast of Africa, where it bifurcates into northward and southward branches. The northward flow becomes the East African Coastal Current, while the southward flow becomes the Mozambique Current

Saetre and da Silva (1982, 1989) postulated that the current in the channel occurs in the form of various large-dimension clockwise and counter-clockwise eddies rather than a continuously flowing southward current. From this developed the model of an overall flow southward flow of Mozambique Current but with several smaller semi-basin and regional circulation patterns. Closer inshore, cooler pockets of water flow parallel to the coast, but in a direction opposite to the Mozambique Current (**Figure 5-9**).

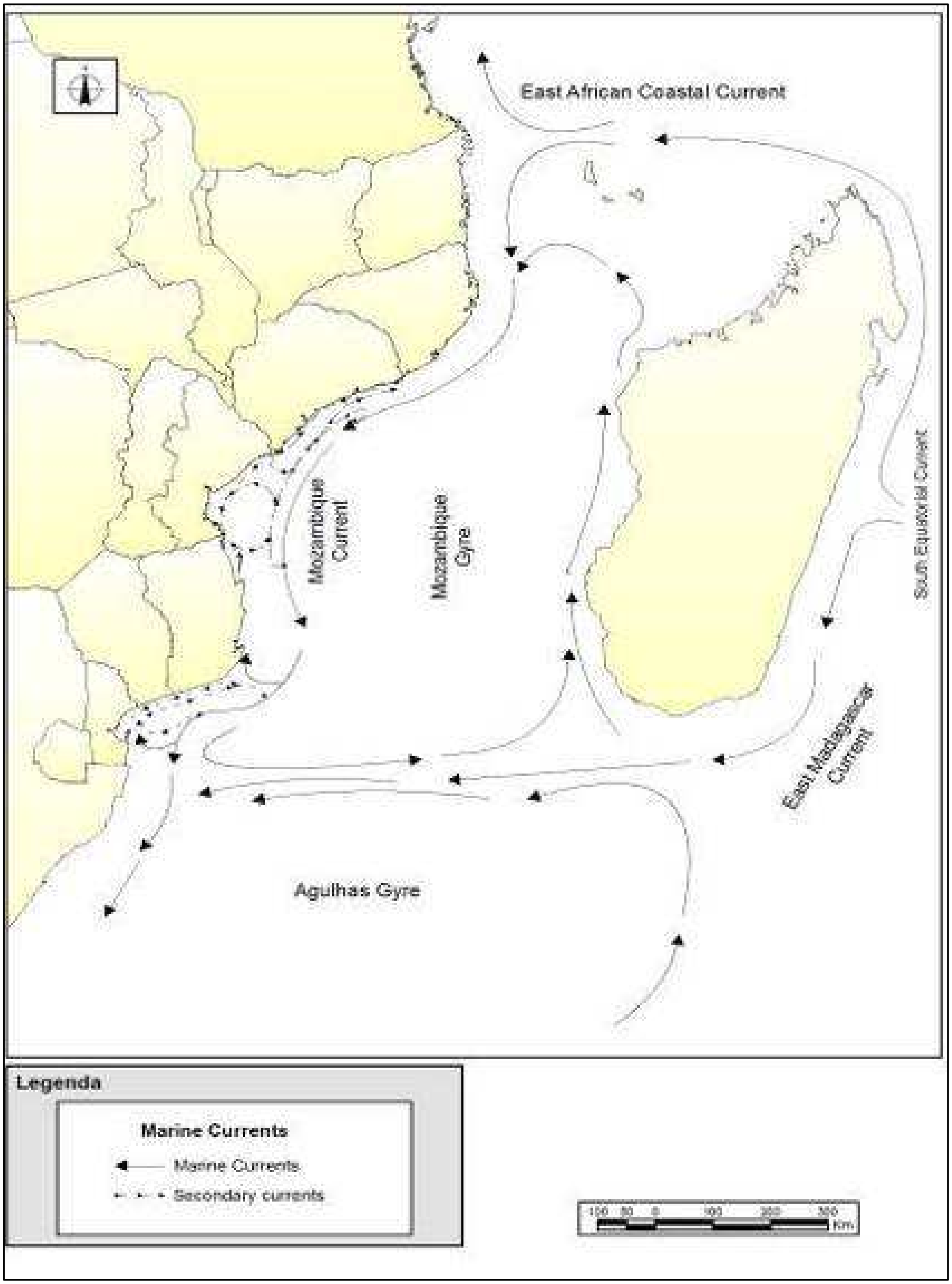


Figure 5-9. Circulation patterns, Mozambique Channel

Recent modeling of circulation patterns in the Mozambique Channel also indicates an anti-clockwise gyre in the overall the southward flowing Mozambican current induced by topography

(Asplin et al, 2006). The mean surface layer (20m depth) circulation (speed and current vectors) in the Mozambique Channel for the winter season (left) and the summer season (right) is shown in **Figure 5-10**.

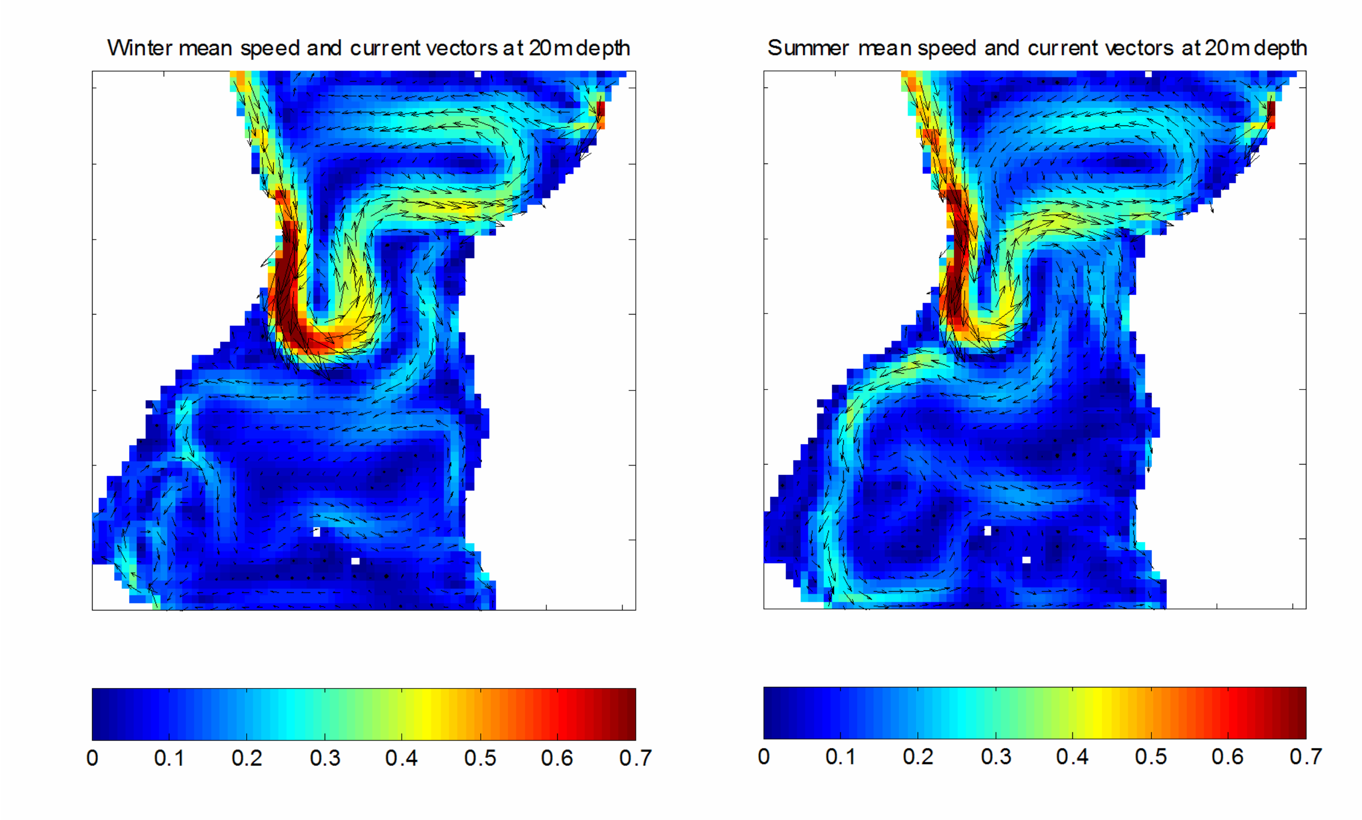


Figure 5-10. Numerical results of the mean surface layer (20m depth) circulation (speed and current vectors every second grid node) in the Mozambique Channel for the winter season (left) and the summer season (right) from NORWECOM model (Asplin et al, 2006)

Di Marco *et al* (2002) re-evaluated hydrographic data in the Mozambique Channel from World Ocean Circulation Experiment (WOCE)[6] in the channel's northern and southern extremes (the latter at c. 24º30'S). The researchers found a southward transport above 2500m depth of 29.1 and 5.9 Sv for two hydrographic lines in the Channel (1 Sv = $1x10^6 m^3 S^{-1}$).

De Ruijter et al (2002) using satellite tracking of floating buoys clearly show the movement of the buoys in a southerly direction, but via a series of counter-clockwise eddies of around 300 km in diameter, along the whole water column (**Figure 5-11**).

The WOCE was a component of the World Climate Research Program (1990 to 2002) the main aim of which was to establish the role of the oceans in the earth's climate using ships to make physical and chemical observations, and employing moored and drifting instrumentation

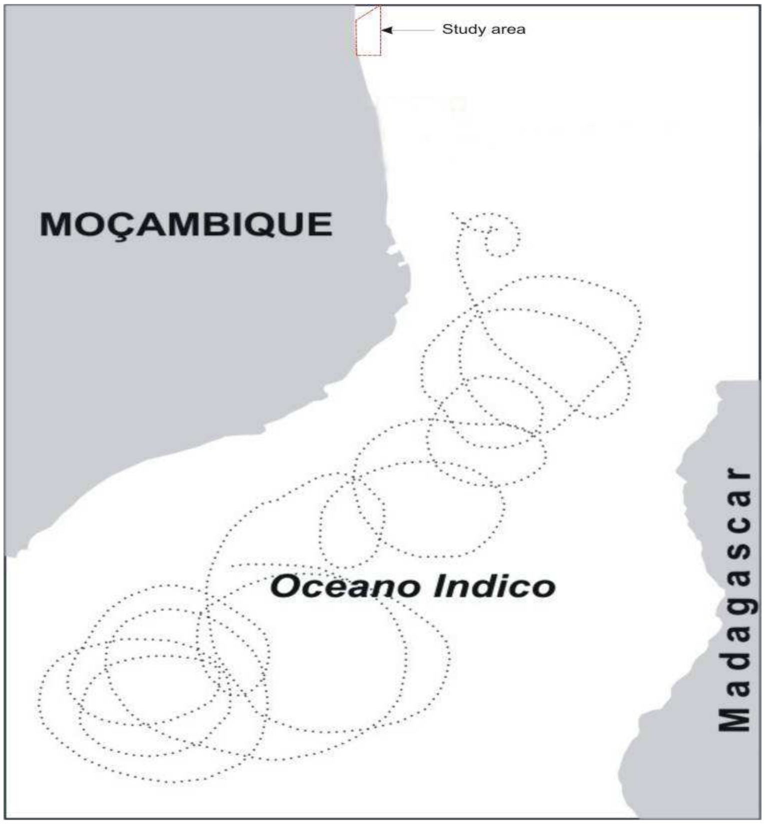


Figure 5-11. Patterns of buoys tracked by satellite in the Mozambique Channel from Ruijter et al, 2002

Rinderinkhof et al (2003) placed current measuring devices along a narrow part of the channel (around 17º S), clearly indicating a current of $1ms^{-1}$ in a southerly direction along the western side of the channel.

These data, therefore, indicate an overall southward flowing current of varying velocities via a series of anti-cyclonic eddies rather than a consistent southerly flow.

5.1.4. Bathymetry

The continental shelf of the study area is very narrow and incised with east-west orientated submarine canyons. These canyons run westwards from deepwater, between the islands towards the coast (**Figure 5-12**).

The coast is characterized by a fringe of islands surrounded by corals. Beyond the fringing coral reefs on the eastern side of the islands, the water depth increases sharply in many places; gradients of > 1:1 (45º) may be found in water depths exceeding 200m (**Figure 5-13**) below.

Figure 5-12. Bathymetry of the Project area

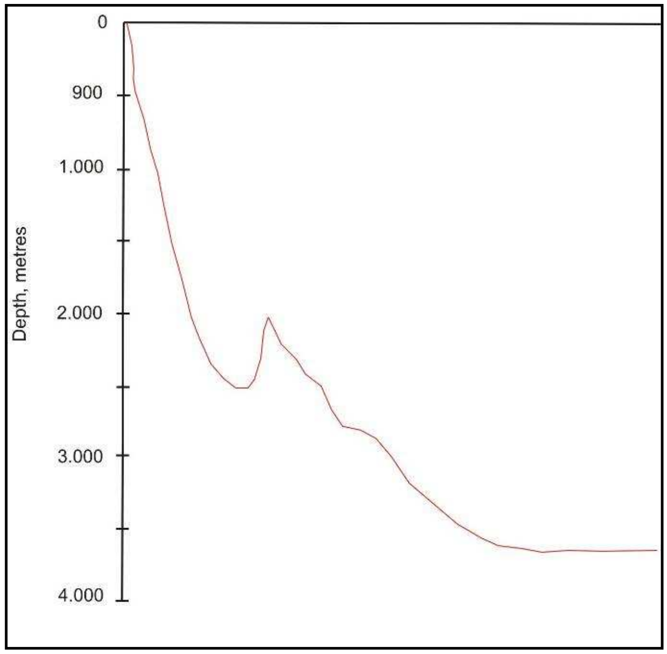


Figure 5-13. Profile of continental shelf and slope in Mocimboa da Praia (from Impacto & CSA, 2007)

5.1.5. Temperature, salinity and oxygen

There is no systematic and detailed information on the physical and chemical parameters of the waters in the north of the Mozambique Channel. Some scientific data were obtained during the cruise of the "Dr Fridtjof Nansen" between 1977 and 1978 and are described in 1982 by Saetre and da Silva. During this cruise, measurements were carried out at various hydrographic stations, including stations located within the concession area (see **Figure 5-14**).

More recently, in 2002, Di Marco et al (2002) presented additional data chemical and physical water parameters of the Mozambique Channel.

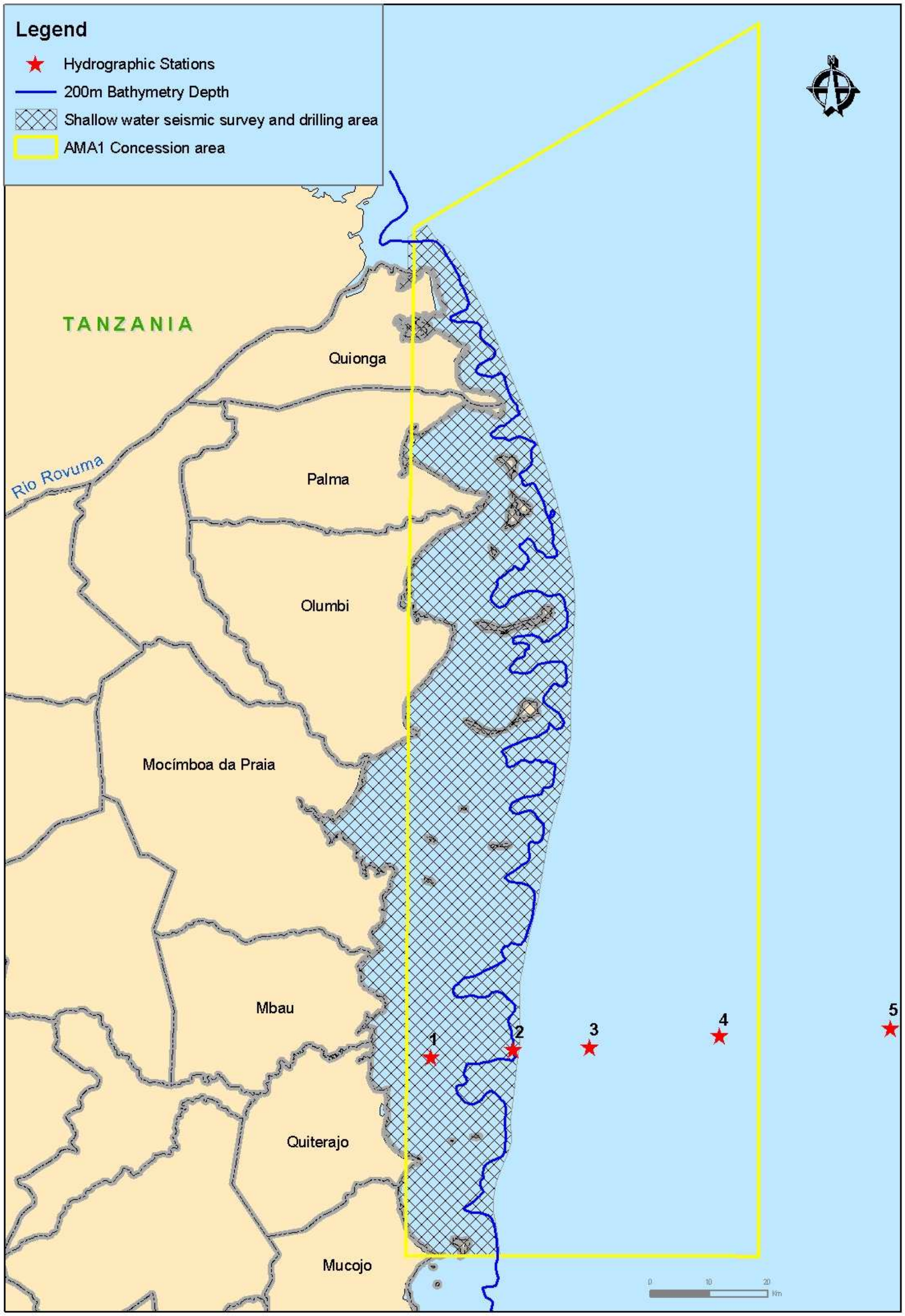


Figure 5-14. Hydrographic stations subject to research by the ship Dr. Fridtjof Nansen (1977-1979) near to, and within, the AMA1 concession area

Studies by Saetre and da Silva's (1982) indicate that in the summer the temperatures on the surface of the water range from 28 to 28.5°C and during the winter months, they range between 25 and 25.5°C. There is a notable decline in temperature with depth: at 100m depth the average temperature is 24°C, while at 300m the temperature is 14°C, reaching 10º C at 500m **(Figures 5-15, 5-16 and 5-17).** This is due to the fact that most of the heat energy of sunlight is absorbed in the first few centimeters at the ocean's surface, which heats up during the day, and cools at night (as heat energy is lost to space by radiation). Waves mix the water near the surface layer and distribute heat to deeper water, such that the temperature may be relatively uniform for up to 100 m. Below the 100m the temperature of the deep ocean drops gradually with depth.

In relation to salinity, the variations along the water column are not very noticeable (between 35.0 0/00 and 35.3 0/00). In January one notes a slight reduction in the salinity levels of the surface water (reaching 34.7 0/00), probably due to the dilution caused by a greater precipitation.

Dissolved oxygen presents high values in the surface water, as one would expect (average of 5.0 ml/L). A slight reduction occurs in the intermediate zone (between 300 and 400 meters), increasing once again in the deeper waters.

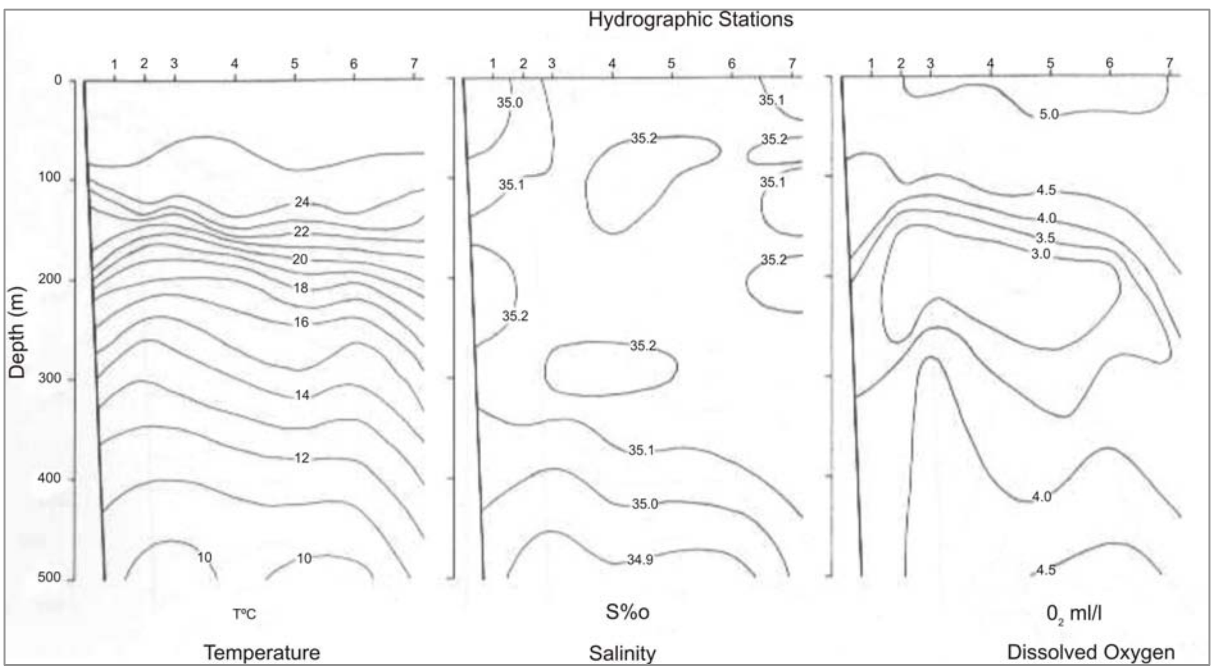


Figure 5-15. Variation in temperature, salinity and dissolved oxygen with depth, along the Mozambique Channel - September 1977

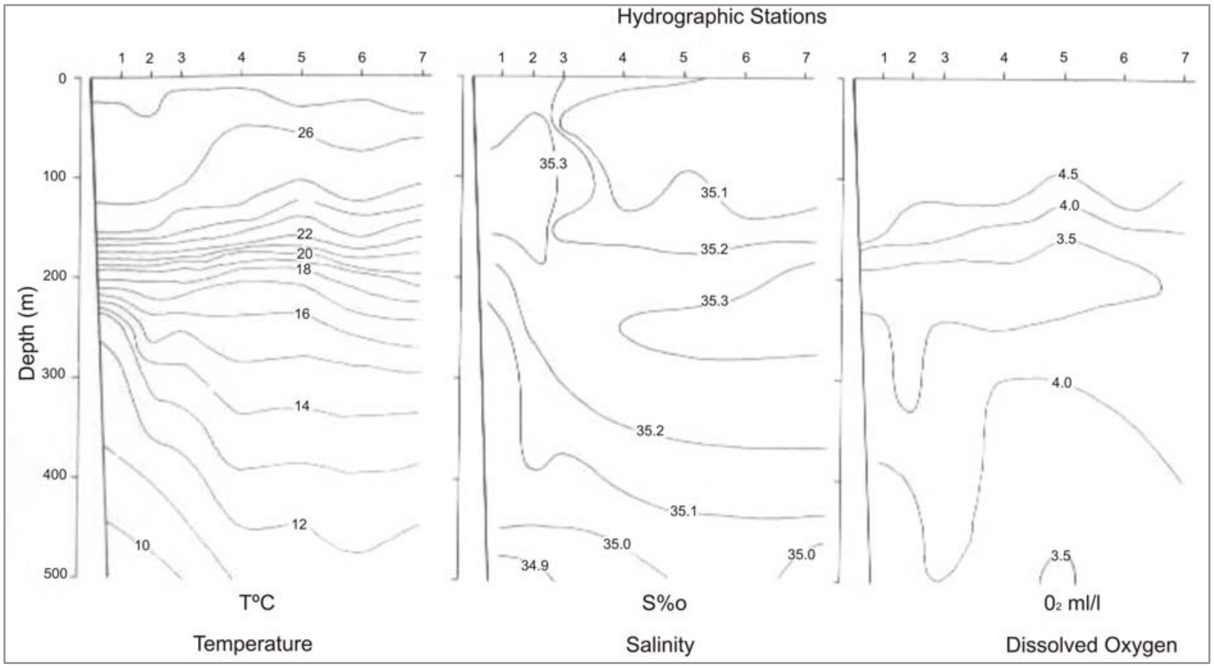


Figure 5-16. Variation in temperature, salinity and dissolved oxygen with depth, along the Mozambique Channel - November 1977

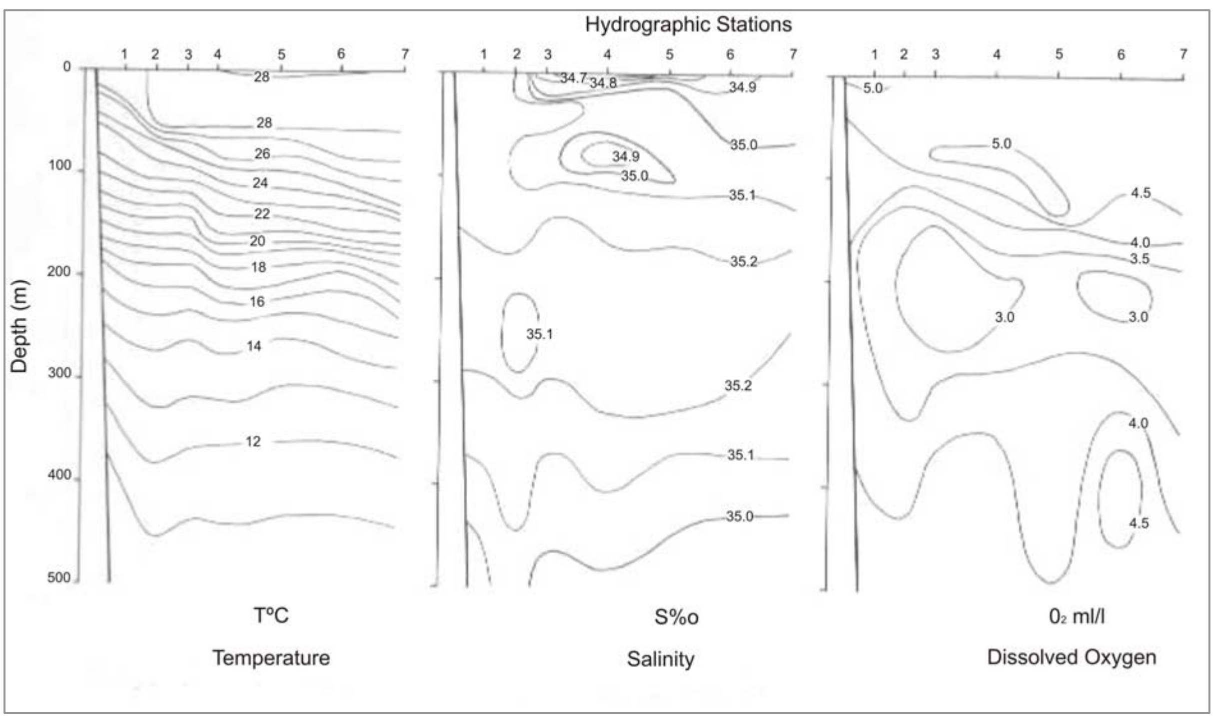


Figure 5-17. Variation in temperature, salinity and dissolved oxygen with depth, along the Mozambique Channel - January 1978

The studies by Di Marco et al (2002) show that the oxygen concentration reaches maximum values in the order of 200 µmol kg^{-1} **(Figure 5-18)**, at the latitude of 12º south in the Mozambique Channel. Minimum oxygen values of 120 µmol kg^{-1} in the water column were found at depths of between 900m and 1500m. At greater depths (between 1500 and 2000m), the oxygen levels increase once again to 140 µmol kg^{-1}.

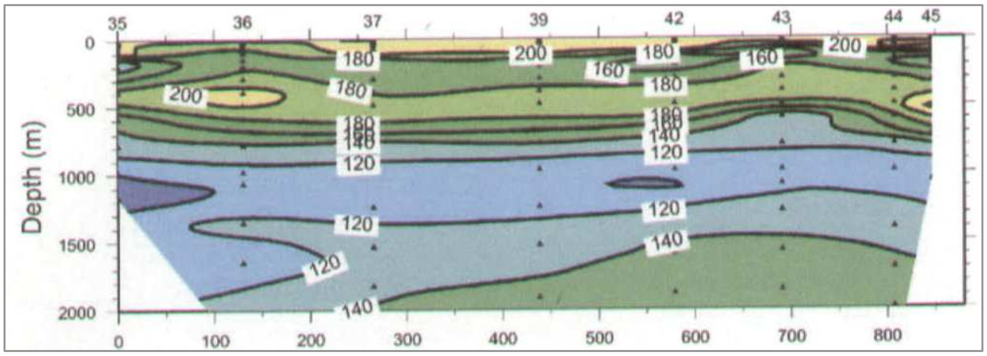


Figure 5-18. Oxygen levels in the water column in the Mozambique Channel at 12º south latitude

5.2 BIOLOGICAL ENVIRONMENT

5.2.1. Overview

The study area lies in the East African Marine Ecoregion, as defined by the World Wildlife Fund (WWF).

The Quirimbas Archipelago stretches a distance of approximately 400 km from the Tanzanian border at the mouth of the Rovuma River southward to Pemba, the capital of Cabo Delgado Province. The Archipelago comprises 32 islands with associated coral reefs, seagrass beds, mangroves, sandy beaches and mud flats. Rodrigues *et al.* (2000) indicates that over 50 genera of corals have been reported from the reefs along the Quirimbas Archipelago The CDBTP 2003 report (Garnier, 2003) identified 125 coral species in 42 genera from 14 families in the Vamizi Island area.

Extensive mangrove forests along the mainland shoreline and islands also contribute to the Archipelago's productivity. At total of 11 species of seagrass and 10 species of mangroves are known to occur in these near-shore and coastal habitats.

5.2.2. Habitats

The coastal waters, coastal mainland and islands are characterized by the wide variety of habitats, including corals (various types), sub-aquatic vegetation (seagrasses and macro-algae), sandy beaches, sandy bottoms, mangroves, rocky substrates, coastal thicket and open-sparse terrestrial vegetation. These habitats and have been mapped using high quality satellite images and the detailed habitat maps are presented in **Annex 5** of this report.

5.2.2.1. Coral Reefs

Overview of Coral Habitats in the Quirimbas Archipelago

Coral reefs represent one of the main attractions for tourism industry in the Quirimbas Archipelago. Fringing coral reefs are associated with the islands and coral formations can also occur in shallower waters.

There are few published studies on coral reefs specifically within the Quirimbas Archipelago (Bandeira et. al., 2007). Rodrigues et al. (2000) indicates that over 50 genera of corals have been reported from the reefs along the Quirimbas Archipelago. In 2003 a study initiated at Vamizi Island reported 125 species of hard corals (Scleractina) belonging to 42 genera and 14 families **(**Garnier, 2003).

According to CDBTP (2004) the Quirimbas Archipelago contains one of the most extensive, pristine and continuous fringing reefs in the country. Direct pressure from people is low despite existence of artisanal fisheries in the area. The most common species of corals reported are as follow:

- *Echinophora hirsutissima*,
- *Astreopora muriophthalma*,
- *Goniastrea rectiformis*,
- *Porites spp*,
- *Seriatophora hystrix*,
- *Favia stelligera* and
- *Acropora lattistela*.

The rare Indo-Pacific coral reefs occurring in the area include species such as *Acanthastrea ishigakiensis*, *Acropora ocellata*, *Acropora willisae*, *Goniopora tenuidens*, *Montipora peltiformis*, *Porites lichen* and *Turbinaria mesenterina*.

Fishing pressure on these reefs seems to be high (observation by Dr Adriano Macia: in Bandeira et. al. 2007). Destructive fishing methods like small mesh nets, spear gun and line fishing on the corals are of particular concern around this area. The Cabo Delgado Biodiversity Tourism Project is working with the communities in order to reduce these types of impacts (Julie Garnier and Christopher Cox personal communication).

Corals in the Project Area

The location of corals in the Project area is shown in **Figure 5-19**.

Figure 5-19. Corals in the Project area

Selected coral reef habitats were surveyed within the shallow water seismic survey and drilling area to evaluate the species present and general health of the habitat types. Three large representative areas within the shallow water seismic survey and drilling area were selected for ground level site visits (**Figure 5-20**).

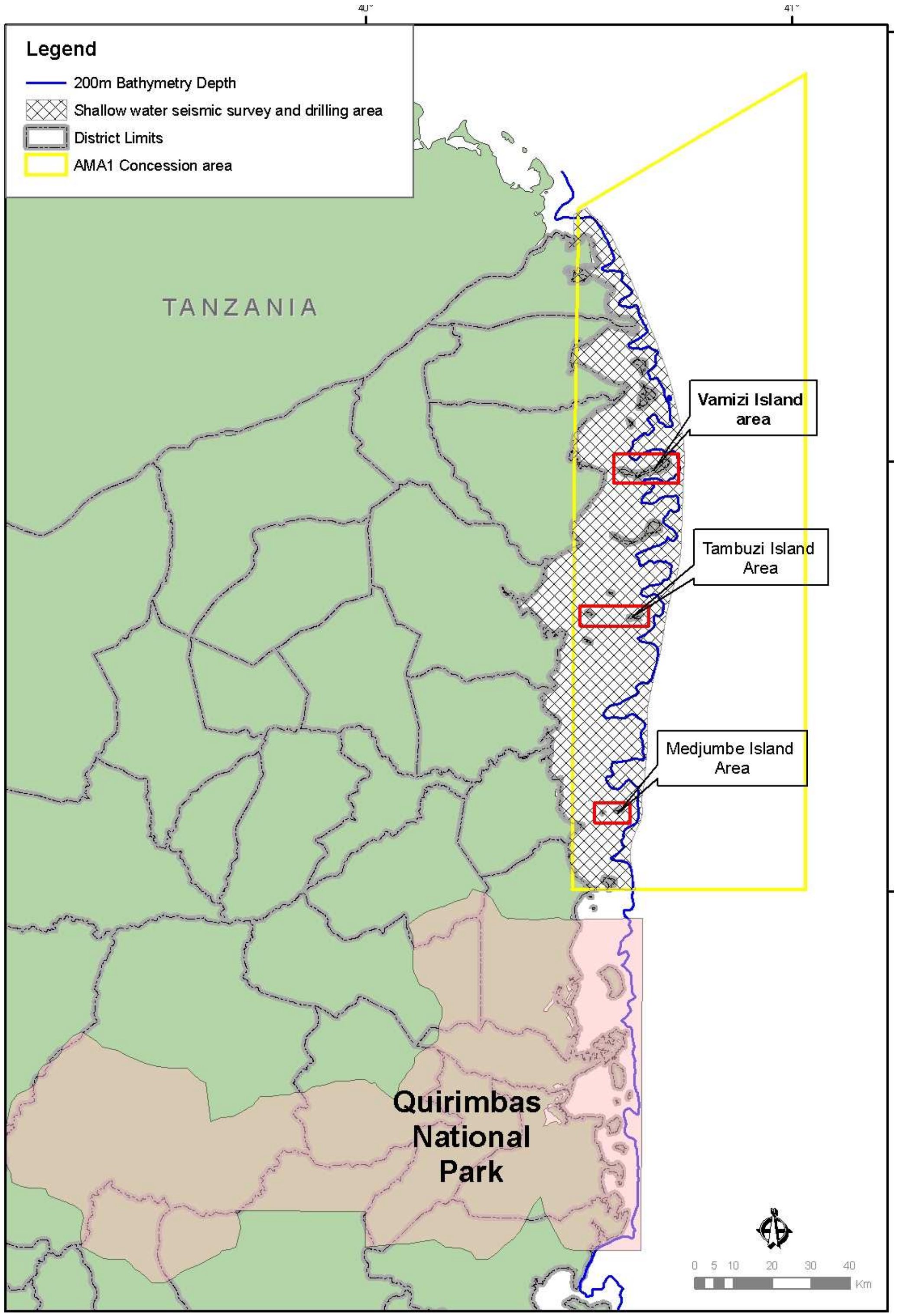


Figure 5-20. Representative areas selected for ground level site visits within the Project area

The following specific coral habitat types within the three areas were identified and surveyed:

- The outer or fringing reef community;
- The “back reef” community from the edge of the reef drop to the exposed shallow water bank surrounding the islands;
- Collections of isolated coral heads and/or patch reefs (coral bommies) growing in sand flats around the islands; and

Stations selected around each of the three island sites included an offshore (eastern) fore-reef station and assorted hard bottom feature stations surrounding the islands. Station locations within the major survey sites are shown in **Figures 5-21**, **5-22**, and **5-23** are are listed in **Table 5-2**.

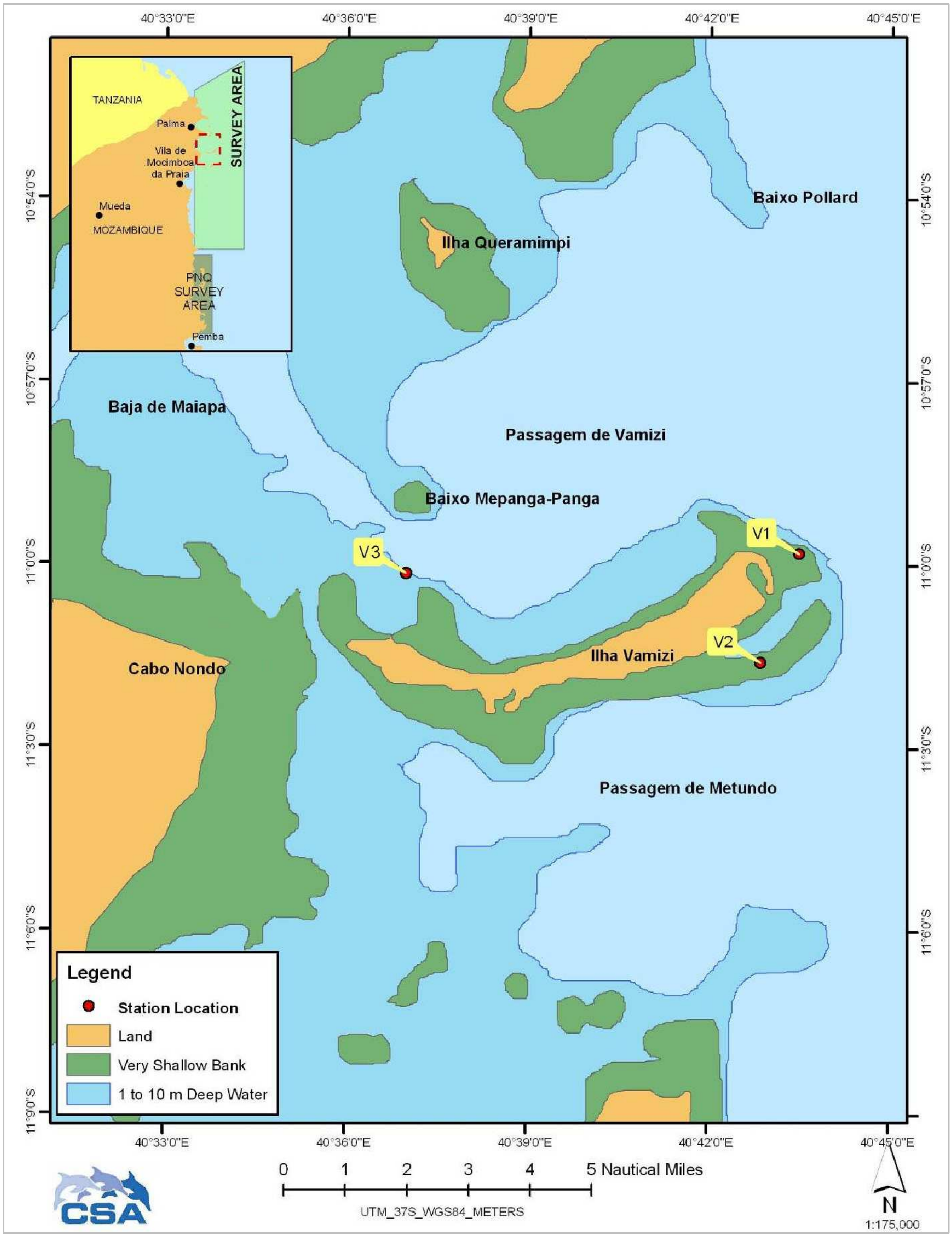


Figure 5-21. Coral survey stations in the Vamizi Island area

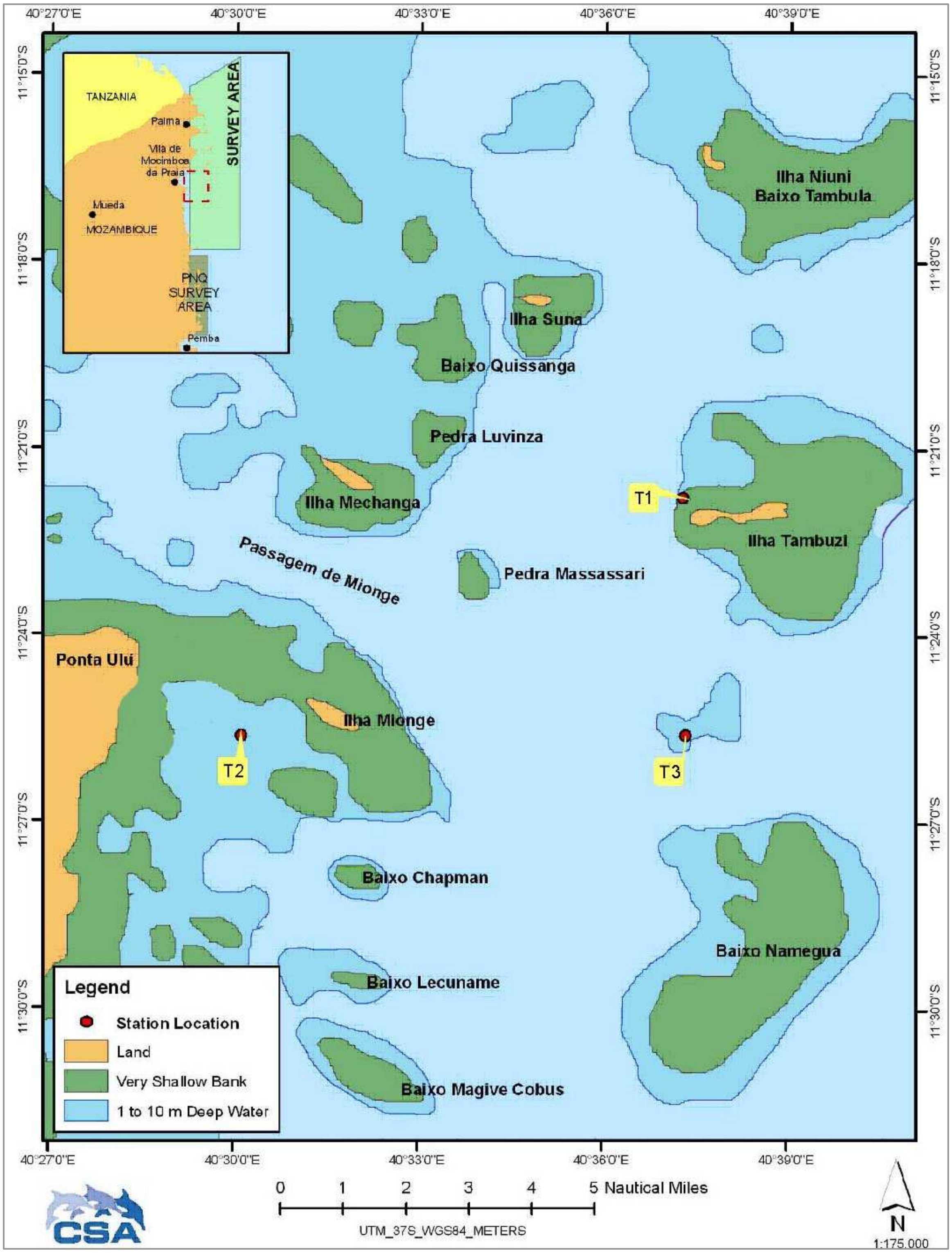


Figure 5-22. Coral survey stations in the Tambuzi Island area

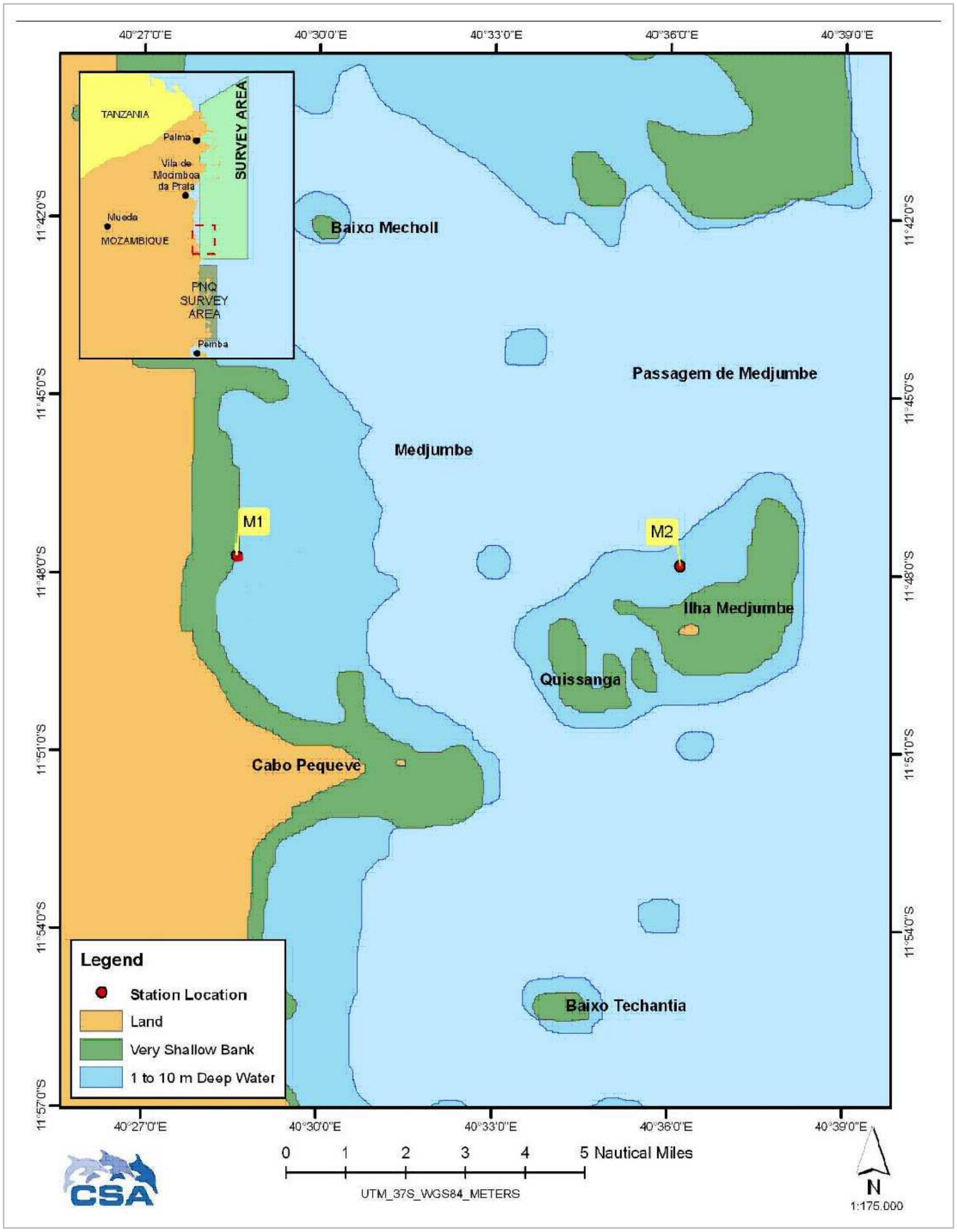


Figure 5-23. Coral survey stations in the Medjumbe Island area

Table 5-2. Areas and respective coral stations surveyed

Area	Station	Location/Description	Latitude	Longitude
Vamizi Island	V1	Eastern fore-reef	10 59.811'S	040 43.491'E
	V2	Southern fringing reef	11 01.594'S	040 42.855'E
	V3	Coral heads and/or patch reefs (coral bommies)	11 00.154'S	040 36.984'E
Tambuzi Island	T1	Very shallow limestone flat	11 21.547'S	040 40.409'E
	T2	Coral heads and/or patch reefs (coral bommies)	11 21.777'S	040 37.276'E
	T3	Nearshore patch reef	11 25.625'S	040 30.106'E
	T4	Offshore low relief hard bottom and seagrass flat	11 25.599'S	040 37.329'E
Medjumbe Island	M1	Near-shore patch reef	11 47.710'S	040 28.601'E
	M2	Coral heads and/or patch reefs (coral bommies)	11 47.842'S	040 36.185'E

Station V1

Station V1 is located off the northeastern tip of the island. It consists of a gentle carbonate hard bottom and sand slope that extended eastward from shore to a vertical wall, or precipice, that dropped from a depth of 12 to 25 m.

The seafloor habitat closest to the island consists of a gently sloping platform covered with carbonate sand. Carbonate outcrops in this area are rare, and these features are sparsely covered with attached biota. The substrate on the adjacent near-shore terrace is covered with exposed carbonate rock and a thriving, high-diversity coral community dominated by stony corals (Order Scleractinia) and octocorals (Subclass Octocorallia).

The vertical surface of the carbonate rock on the offshore wall is covered to a large extent with an unidentified, thin encrusting octocoral. In addition, some hydrocorals (Order Stylasteridae), the stony corals *Tubastraea coccinea* and *T. micrantha*, and a filiform black coral (*Cirrhipathes* sp.) occur. The lower platform, adjacent to the wall, is covered with carbonate sand, scattered sponges (including *Xestospongia testudinaria*), and coral rock rubble. Dominant species observed at Station V1 include the following:

<u>Stony corals (Order Scleractinia)</u>
Montipora digitata
Pocillopora verrucosa
Pocillopora damicornis
Seriatopora spp.
Acropora aspera
Acropora formosa
Acropora humilis
Cycloseris spp.
Fungia sp.
Goniopora spp.
Porites spp.
Favia spp.

Goniastrea spp.
Platgyra spp.
Galaxia spp.
Tubastraea coccinea
Tubastraea micrantha

Octocorals (Subclass Octocorallia)
Lobophytum spp.
Tubipora musica
Sarcophyton spp.
Sinularia spp.

Black corals (Order Antipatharia)
Cirrhipathes sp.

Typical back reef community in the Vamizi Island area

Station V2

Station V2 was located off the southeastern edge of Vamizi Island along a shallow tongue of rocky substrate, bordered to the north by a deeper sandy lagoon and to the south by a pronounced drop-off. The station consists of a number of irregular clusters of coral outcrops on a very gently sloping carbonate sand platform. The out-crop is covered with lush colonies of stony and soft corals. Sponges on these features are conspicuously absent. Dominant species observed at Station V2 include the following:

Stony corals (Order Scleractinia)
Acropora hyacinthus
Acropora formosa
Pavona spp.
Platygyra spp.
Fungia sp.

Pocillopora verrucosa
Pocillopora damicornis
Favites spp.
Porites spp.
Montipora digitata
Turbinaria spp.
Galaxia spp.

Octocorals (Subclass Octocorallia)
Tubipora musica
Sarcophyton spp.
Lobophytum spp.
Sinularia spp.

Station V3

Station V3 consists of a series of large, irregular coral outcrops on a gentle downward sloping sand substrate off the northwest tip of Vamizi Island. The tops of some of the outcrops are emergent during low tide. The outcrops are covered with diverse stony corals, though dominated by one stony coral species (*Acropora humilis*) and alyconacean octocorals. The sandy substrate surrounding the outcrops supports patchy beds of the seagrass *Thalassodendron ciliatum*. Dominant coral species observed at Station V4 include the following:

Stony corals (Order Scleractinia)
Pocillopora verrucosa
Pocillopora spp.
Porites spp.
Acropora humilis
Platygyra spp.

Octocorals (Subclass Octocorallia)
Sarcophyton spp.
Sinularia spp.
Tubipora musica
Lobophyton spp.

Tambuzi Island Site

Three coral stations were surveyed within the vicinity of Tambuzi Island (**Figure 5-22**), including one fringing reef station (T1) and two patch reef stations (T2 and T3).

Station T1

Station T1 is located off the northwestern tip of the island, at the edge of the shallow rock flat. It comprises a series of irregular coral outcrops of medium to high diversity and percent cover. Towards shore, the outcrops grade to a low-relief platform of hard, flat carbonate substrate and coral rubble with approximately 50% coral cover. This platform further grades to a band of mixed rock and sand, with the brown alga *Padina* sp. and diverse alcyonacean (e.g., *Alcyonium* spp.) and nephtheid octocorals attached to exposed rocky substrate. Patchy beds of the seagrass *Cymodocea* spp. also occur within the sandy substrate. Corals recorded at Station T1 include the following:

<u>Stony corals (Order Scleractinia)</u>
Fungia sp.
Halomitra spp.
Acropora formosa
Acropora humilis
Acropora aspera
Pocillopora verrucosa
Pocillopora damicornis
Favia spp.
Symphyllia valenciennesii
Echinopora spp.
Montipora spp.

<u>Algae</u>
Halimeda spp.
Padina spp.
Sargassum spp.

<u>Seagrasses</u>
Cymodocea spp.
Thalassodendron ciliatum

Station T2

Station T2 was located southwest of the island, off Ponta Ulú. The station was positioned within a series of isolated rock outcrops surrounded by a wide band of sandy substrate supporting dense beds of the seagrass *Thallasodendron ciliatum* and the brown algae *Sargassum* sp. The visited outcrop was covered with corals and soft corals, and the top of the outcrop (consisting of living colonies of the stony coral *Acropora* spp.) was exposed at low tide. Surrounding the outcrop and adjacent *T. ciliatum* band was a broad zone of flat, silty sand substrate with patchy, sparse beds of the seagrasses *Halodule* sp. and *Halophila ovalis*. Dominant species observed at Station T2 include the following:

<u>Stony corals (Order Scleractinia)</u>
Seriatopora hystrix
Pocillopora damicornis
Pocillopora verrucosa
Acropora aspera
Acropora formosa
Acropora humilis
Agaricia spp.
Pavona spp.
Fungia sp.
Goniopora spp.
Porites solida
Porites spp.
Favites spp.
Platygyra spp.

Montastraea spp.
Galaxia spp.
Millepora spp.

Station T3

Station T3 was located south of Tambuzi Island, on a shallow bank (Baixo Bower) within Baía Mocímboa da Praia. The station consisted of an area of flat sandy substrate approximately 10 m deep that supports large, dense patches of the seagrass *Thalassodendron ciliatum* and scattered coral outcrops (primarily with the stony coral *Acropora* spp. and diverse soft corals). Dominant species observed at Station T4 included the following:

<u>Stony corals (Order Scleractinia)</u>
Pocillopora damicornis
Pocillopora verrucosa
Porites spp.
Acropora humilis
Platygyra spp.

<u>Octocorals (Subclass Octocorallia)</u>
Tubipora musica
Sarcophyton spp.
Xeniidae
Sinularia spp.
Lobophytum spp.

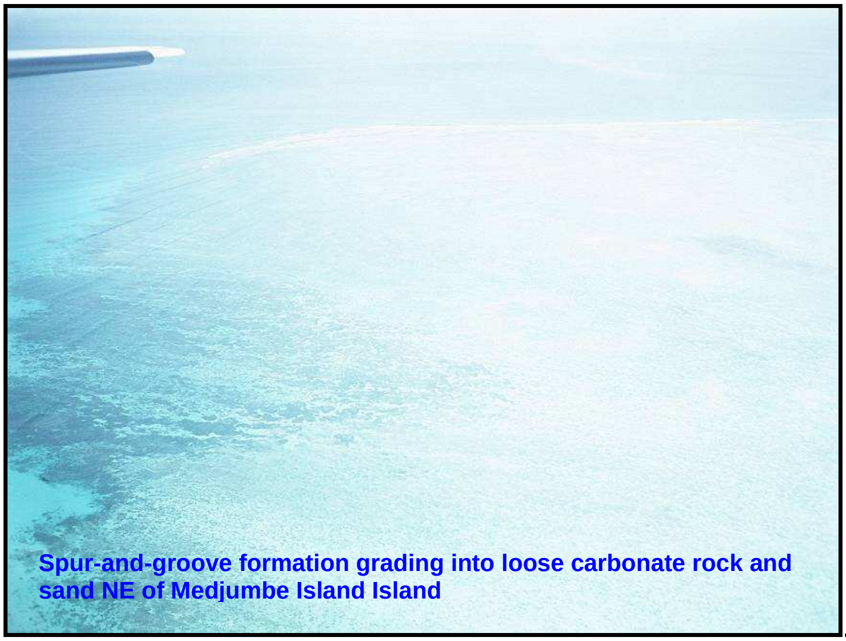

Coral and algal patch reef community in the vicinity of Tambuzi

Medjumbe Island Site

Two stations were visited within the vicinity of Medjumbe Island (**Figure 5-23**), including one fore-reef station (M1), one fringing reef station (M2).

Station M1

Station M1 is located off the northeastern tip of Medjumbe Island, along the offshore edge of a broad, shallow rocky flat that surrounds the emergent island. The inshore area of the station consists of a loose "spur-and-groove" formation of carbonate rock, living coral, and coarse carbonate sand.



Spur-and-groove formation grading into loose carbonate rock and sand NE of Medjumbe Island Island

This grades seaward into a habitat comprising rocky rubble, sandy substrate, and isolated, irregular rock and coral outcrops. It then grades further eastward (and deeper) to an elevated, high-diversity coral and rock platform at depths below 17 m. The dominant species observed at Station M1 included the following:

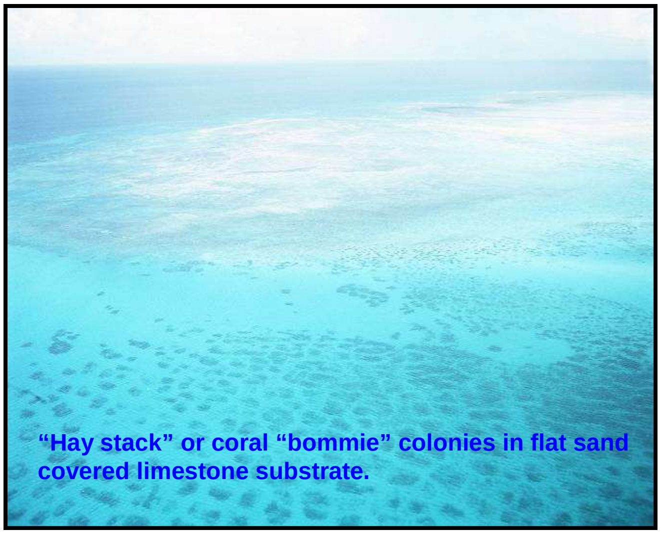
<u>Stony corals (Order Scleractinia)</u>
Pocillopora spp.
Galaxia spp.
Favites spp.
Montastraea spp.
Echinopora spp.
Platygyra spp.
Fungia sp.
Porites spp.
Cycloseris spp.
Acropora formosa
Acropora humilis

Acropora hyacinthus

<u>Black corals (Order Antipatharia)</u>
Cirrhipathes sp.

Station M2

Station M2 was located north of Medjumbe Island. The station includes a series of isolated, rounded coral formations on a flat sand substrate devoid of seagrasses or algae. The "hay stack" or "bommie" formations are often formed by, or are covered with, only a few dominant stony coral species, such as *Porites* spp.


"Hay stack" or coral "bommie" colonies in flat sand covered limestone substrate.

The dominant species observed at Station M2 included the following:

<u>Stony corals (Order Scleractinia)</u>
Pocillopora spp.
Montastraea spp.
Porites spp.
Favia spp.
Platygyra spp.
Galaxia spp.
Montipora spp.
Acropora aspera
Acropora hyacinthus
Acropora humilis
Seriatopora hystrix
Cycloseris spp.
Fungia sp.
Goniopora spp.
Echinopora spp.

Table 5-3 summarizes and compares species observed at each of the 8 coral reef stations surveyed. In all, 32 species of hard corals were observed, in addition to 5 species of soft corals. A comparison of seafloor habitats at stations visited during the survey shows some similarities in the biological communities inhabiting fore-reef and fringing reef areas. The islands consist of calcium carbonate and sand features that lie on much larger submerged platforms or tidal flats. The fore-reef features on the seaward sides of the platforms vary in structure, including structures such as vertical walls, spur-and-groove formations, and solid rocky slopes. However, the dominant epibenthic constituents are predominantly stony corals (Scleractinia) and soft corals (Alcyonacea) of similar species. Fringing reef areas are exposed carbonate features (i.e., topographically complex hard bottom areas or discreet hard bottom features surrounded by sandy substrate, such as coral bommies). Again, dominant epibenthic communities at these stations are similar between sites. Inshore stations, though positioned on mostly sandy substrate, support diverse soft bottom communities. Seagrass species and densities vary greatly in the areas surveyed. This is, in part, a function of distance from shore, seaward exposure, and depth. Many seagrass species on eastern African shores show characterization zones based on specific depths and distances from shore (Bandeira, 2002). Observations made during this survey generally agree with those of Hoguane et. al. (2002) in that these coral habitats support important biodiversity of both commercial and conservational significance.

The reefs surveyed in the Project area Archipelago appear to be very healthy; no evidence of specific coral diseases or bleaching was observed. The reefs visited during this survey effort were minimally disturbed, showing very little natural or anthropogenic damage.

The overall health of these reefs is striking, especially in light of the observed artisanal fishing conducted throughout in the Project area. There appears to be a reduction in larger reef fish, which may have been a product of fishing pressure.

Table 5-3. Coral species recorded at each station in the Project area

Coral species/genera (Lowest Practical Taxonomic Identification)	Vamizi Island Site			Tambuzi Island Site			Medjumbe Island Site	
	V1	V2	V3	T1	T2	T3	M1	M2
Acropora aspera	X			X	X			X
Acropora formosa	X	X		X			X	
Acropora humilis	X		X	X	X	X	X	X
Acropora hyacinthus		X					X	X
Agaricia spp.					X			
Cycloseris spp.	X						X	X
Echinopora spp.				X			X	X
Favia spp.	X			X				X
Favites spp.		X			X		X	
Fungia sp.	X			X	X		X	X
Fungia sp.		X			X			
Galaxia spp.	X	X			X		X	X
Goniastrea spp.	X							
Goniopora spp.	X				X			X
Halomitra spp.				X				
Millepora spp.					X			
Montastraea spp.					X		X	X
Montipora digitata	X	X						
Montipora spp.				X				X
Pavona spp.		X			X			
Platygyra spp.	X	X	X		X	X	X	X
Pocillopora damicornis	X	X		X	X	X		
Pocillopora spp.			X				X	X
Pocillopora verrucosa	X	X	X	X	X	X		
Porites solida					X			
Porites spp.	X	X	X		X	X	X	X
Seriatopora hystrix					X			X
Seriatopora spp.	X							
Symphyllia valenciennesii				X				
Tubastraea coccinea	X							
Tubastraea micrantha	X							
Turbinaria spp.		X						
Lobophytum spp.	X	X	X			X		
Sarcophyton spp.	X	X	X			X		
Sinularia spp.	X	X	X			X		
Tubipora musica	X	X	X			X		
Xeniidae						X		
Cirrhipathes sp.	X						X	

5.2.2.2. Seagrass and Macroalgal Habitats (Sub-Aquatic Vegetation)

The location of the seagrass and macroalgal habitats is shown in **Figure 5.24**.

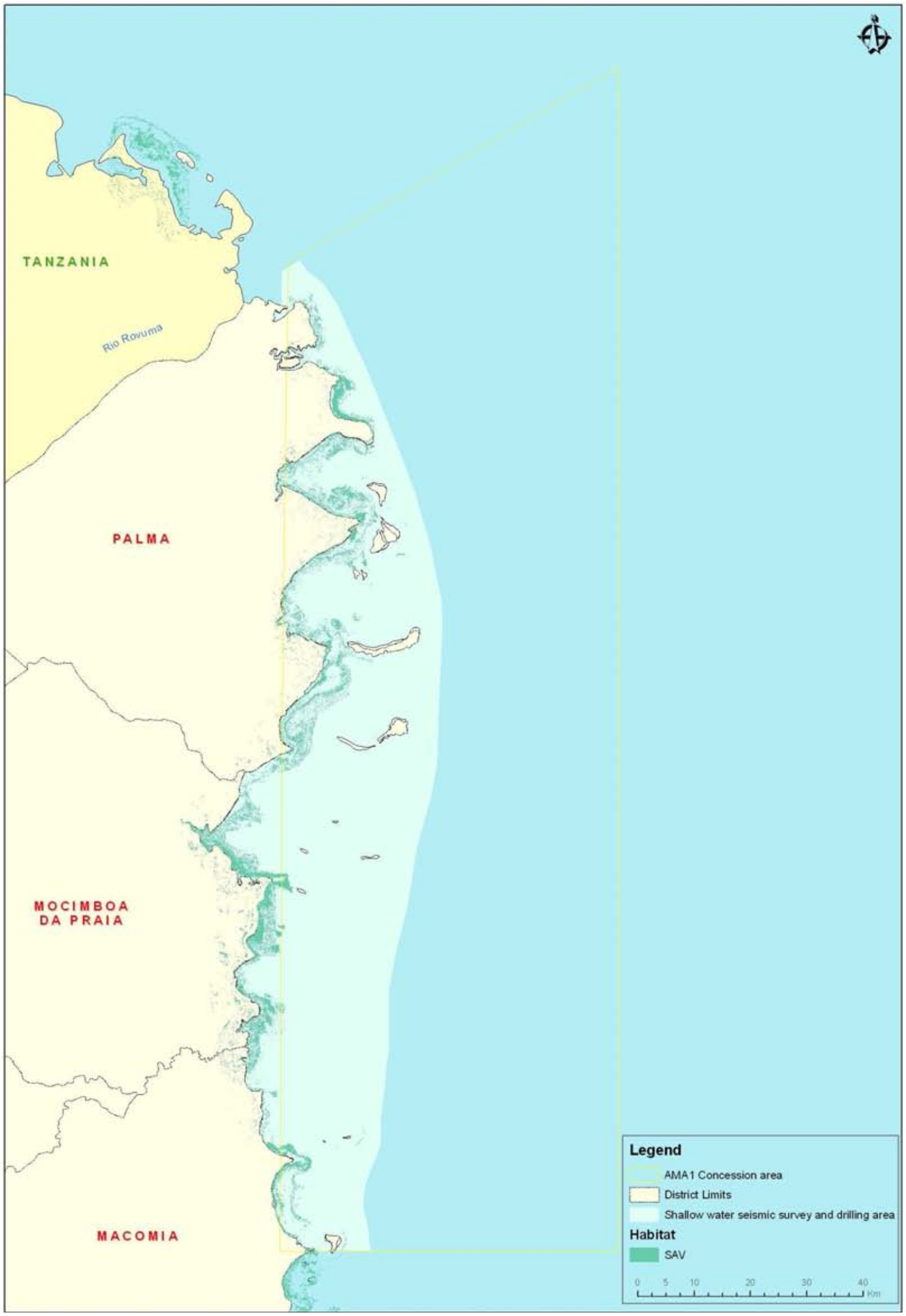


Figure 5-24. Location of seagrass and macroalgal habitats (SAV= Sub-aquatic Vegetation)

Ten species of seagrass belonging to seven genera were recorded along the Cabo Delgado coastline and Quirimbas Archipelago (Whittington *et al.* 2000). Fish species assemblages associated with sea grass meadows are very diverse with 249 species of fish belonging to 64 families recorded for the southern Quirimbas (Whittington *et al.* 2000). Seagrass meadows occur in close association with the fringing coral reefs that form part of the Quirimbas archipelago. They constitute the dominant vegetation in the shallow water ecosystems. The sub-tidal *Enhalus acoroides* and *Thalassodendrun ciliatum* dominate the seagrass beds. There are also small areas of the fine cylindrical seagrass *Syringodium isoetifolium*.

The coastal area is subject to a tidal range of 4.2m, which combined with gently sloping topography leads to the occurrence of extensive intertidal zones. These habitats are suitable for seagrass beds as well as macroalgae assemblages associated with rich fauna. Seagrass beds tend to occur in sheltered waters with suitable substrate (sand/mud) such as embayments (e.g. Mocimboa Bay, Tungue Bay and Quionga Bay).

Selected seagrass beds were surveyed within the shallow water seismic survey and drilling area during the field habitat survey (see section 5.2.2 above) to determine the species present and environmental status. These were carried out in the same three large representative areas as for the coral reef survey viz,. in the vicinity of Vamizi Tambuzi and Medjumbe Islands. Eight seagrass species were recorded during the survey thus representing 80% of the species recorded for the southern Quirimbas Archipelago by Whittington *et al.* (2000). Seagrass and macroalgal species recorded during the habitat survey are shown in **Table 5-4**.

Table 5-4. Seagrass and Macroalgal species recorded at during the habitat survey

Species
Algae
Chaetomorpha crassa
Halimeda sp.
Padina sp.
Sargassum spp.
Seagrasses
Cymnodocea serrulata
Cymodocea spp.
Enhalus acoroides
Halodule sp.
Halophila ovalis
Syringodium isoetifolium
Thalassia hemprichii
Thalassodendron ciliatum

The seagrass beds and macroalgae assemblages play a valuable role by providing food, shelter and serving as nursery grounds for a diversity of commercially exploited species such as fish, crustaceans, gastropods and sea cucumbers. The seagrass beds are important feeding habitats for the green turtle (*Chelonia mydas*).

5.2.2.3. Mangroves

Mangrove forests are well developed along the northern sector of the coast. The mangroves of Rovuma Estuary are the largest and best developed along the northern sector of the coast and occur as a continuous stand across the border into Tanzania. Approximately 7,600 ha of mangroves occur in the Rovuma estuary on the Mozambican side of the border. Patches of mangrove occur on Tecomaji, Rongui and Vamizi Islands with the largest stand on Rongui Island. Large areas of mangroves also occur in Mocimboa da Praia Bay and along the coast south of Mocimboa da Praia.


Channel Mangrove, Mocimboa da Praia


Shoreline Fringing Mangrove, Mocimbia da Praia

Mangrove tree species registered for the northern Cabo Delgado are listed in **Table 5-5**. Their distribution is shown in **Figure 5-25**. Generally, *Sonneratia alba* is the seaward pioneer adapted to the open coastal and coral platforms occupying sites that are deeply flooded every day. *Pemphis acidula* is a beach tree that often is found along the *Sonneratia* fringe. In creek mangroves *Rhizophora mucronata* and *Sonneratia alba* line the canals behind which *Bruguiera gymnorrhiza* and *Xylocarpus granatum* may dominate In drier sites, thickets of *Ceriops tagal* (often stunted) may form broad belts. These may give way to a dwarf *Avicennia marina* zone. Further inland the mangrove is replaced by large expanses of highly saline tidal flats. Succulent herbaceous species such as *Arthrocnemum australasicum, Arthrocnemum indicum,* *Arthrocnemum perenne, Salicornia perriere, Chenolea diffusa* and *Suaeda monoica* occur in these saline areas.

Table 5-5. Tree species occurring in the mangroves of northern Cabo Delgado

Family	Species
Rhizophoraceae	*Rhizophora mucronata* *Ceriops tagal* *Bruguiera gymnorrhiza*
Verbenaceae	*Avicennia marina*
Combretaceae	*Lumnitzera racemosa*
Sonneratiaceae	*Sonneratia alba*
Meliaceae	*Xylocarpus granatum*
Lythraceae	*Pemphis acidula*

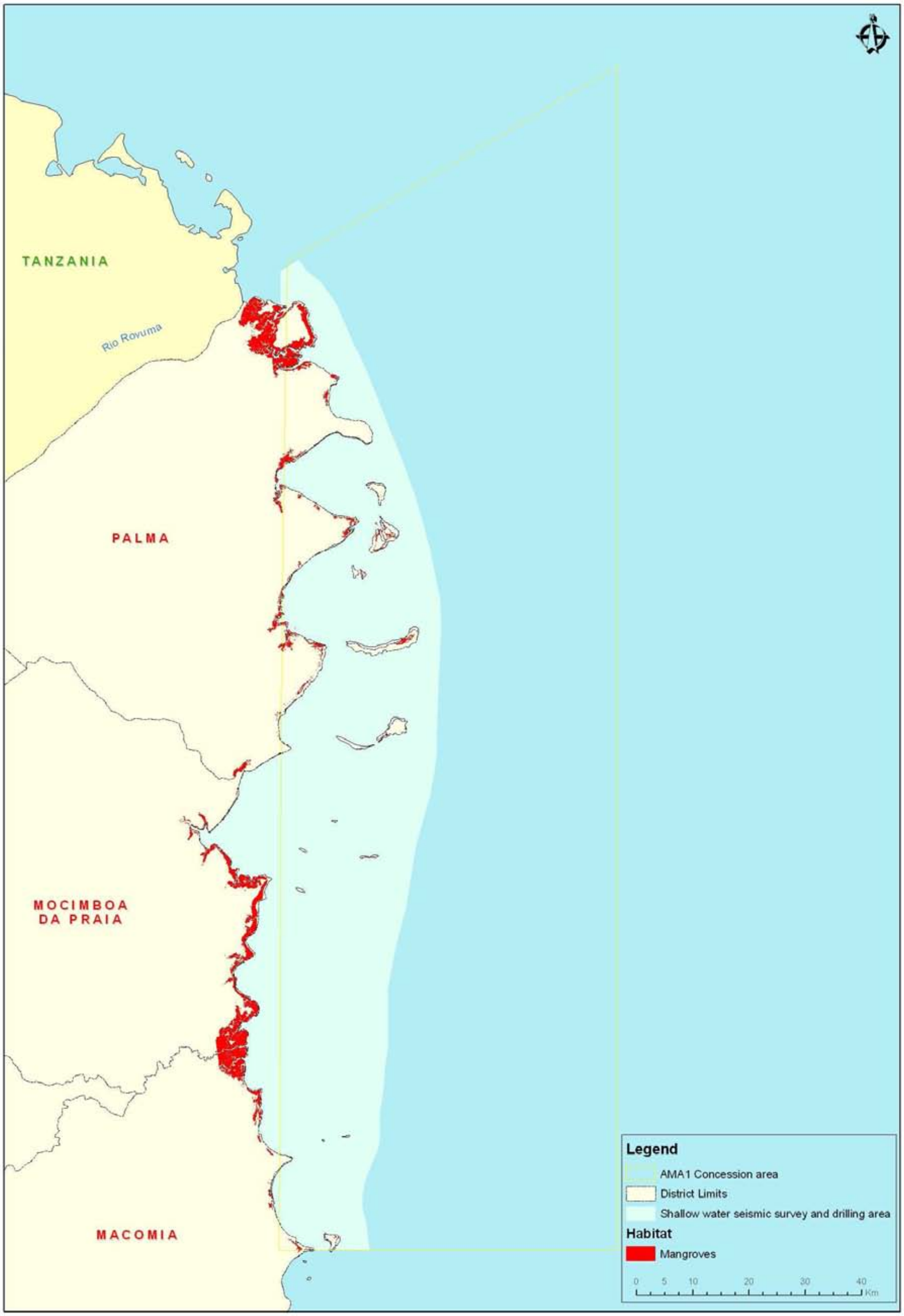


Figure 5.25. Mangrove distribution in the Project area

5.2.2.4. Sandy Beaches

Sandy beaches are located along the coast of Palma, Mocimboa da Praia and Macomia Districts as well as on the off-shore islands. The location of sandy beaches is shown in **Figure 5-26**. All sandy beaches should be considered potential nesting areas for marine turtles. Sandy beaches also provide habitat for a variety of crustaceans, mollusks, snails and polychaetes (see **Table 5-6**).

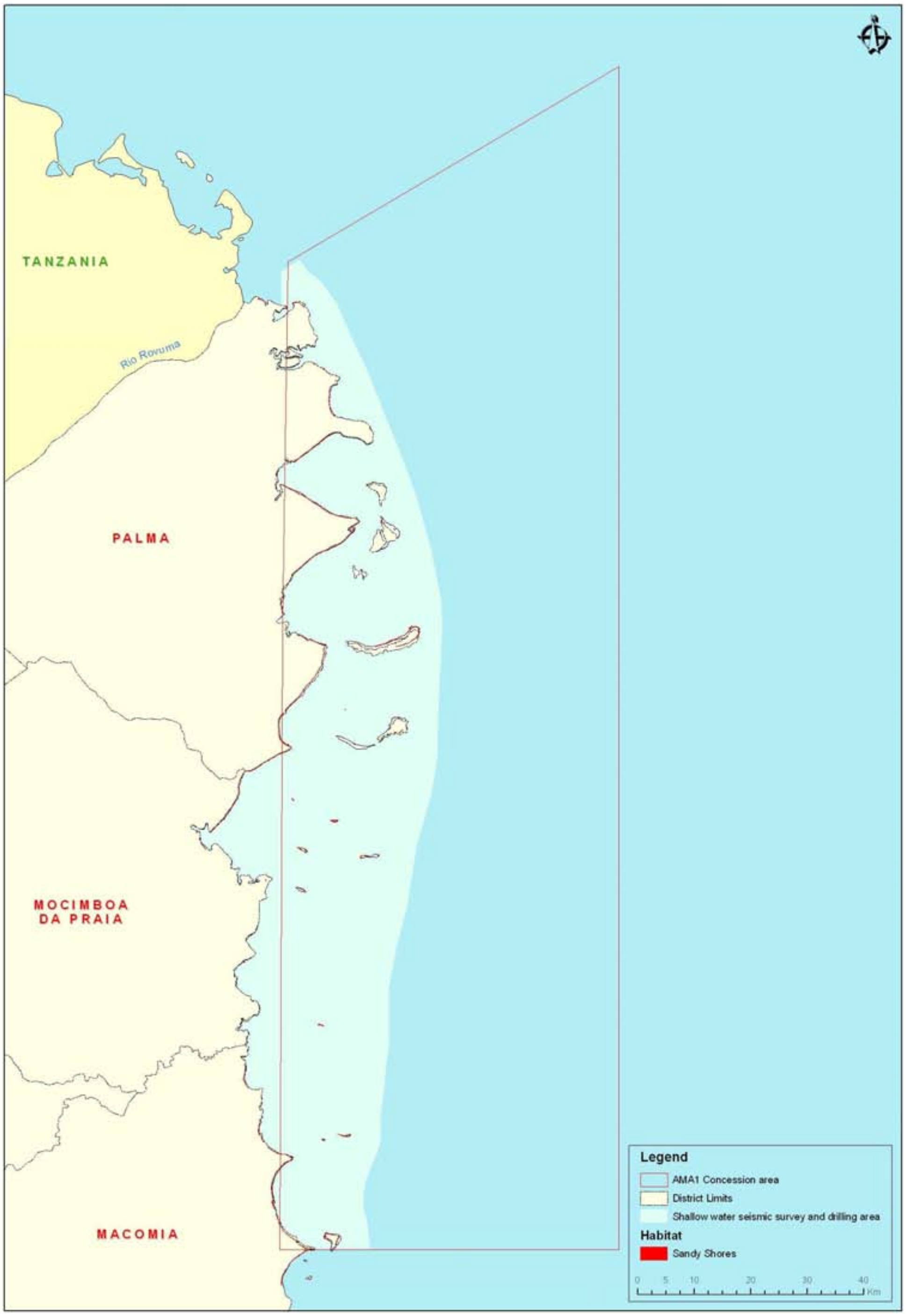


Figure 5-26. Location of sandy beaches in the Project area

Table 5-6. Invertebrate species associated with sandy beaches

Taxonomic Group	**Species**
Crustaceans	*Ocypode sp*. (Ghost crubs) *Dotilla fonestrata* *Macrophthalmus grandidieri* (Sentinel crab)
Mollusks	*Donax faba* (Wedge mussel) *Polynices mammilla* *Nassarius sp.* *Volema sp.*
Polychaetes	*Owenia fusiformis* *Diopatara sp.* *Mesochaetopterus sp.* *Scolelepis squamata* *Cirriformia sp.* *Graviriella sp*.

5.2.2.5. Submerged Rocky Substrate

Submerged rocky substrate occurs throughout the Project area (see **Figure 5-27**). This habitat supports a variety of invertebrate species including starfish, sea urchins, sea cucumbers, brittle stars, crustaceans, mollusks, flatworms and sipunculids. A list of invertebrate species associated with rocky substrates is shown in **Table 5-7**.

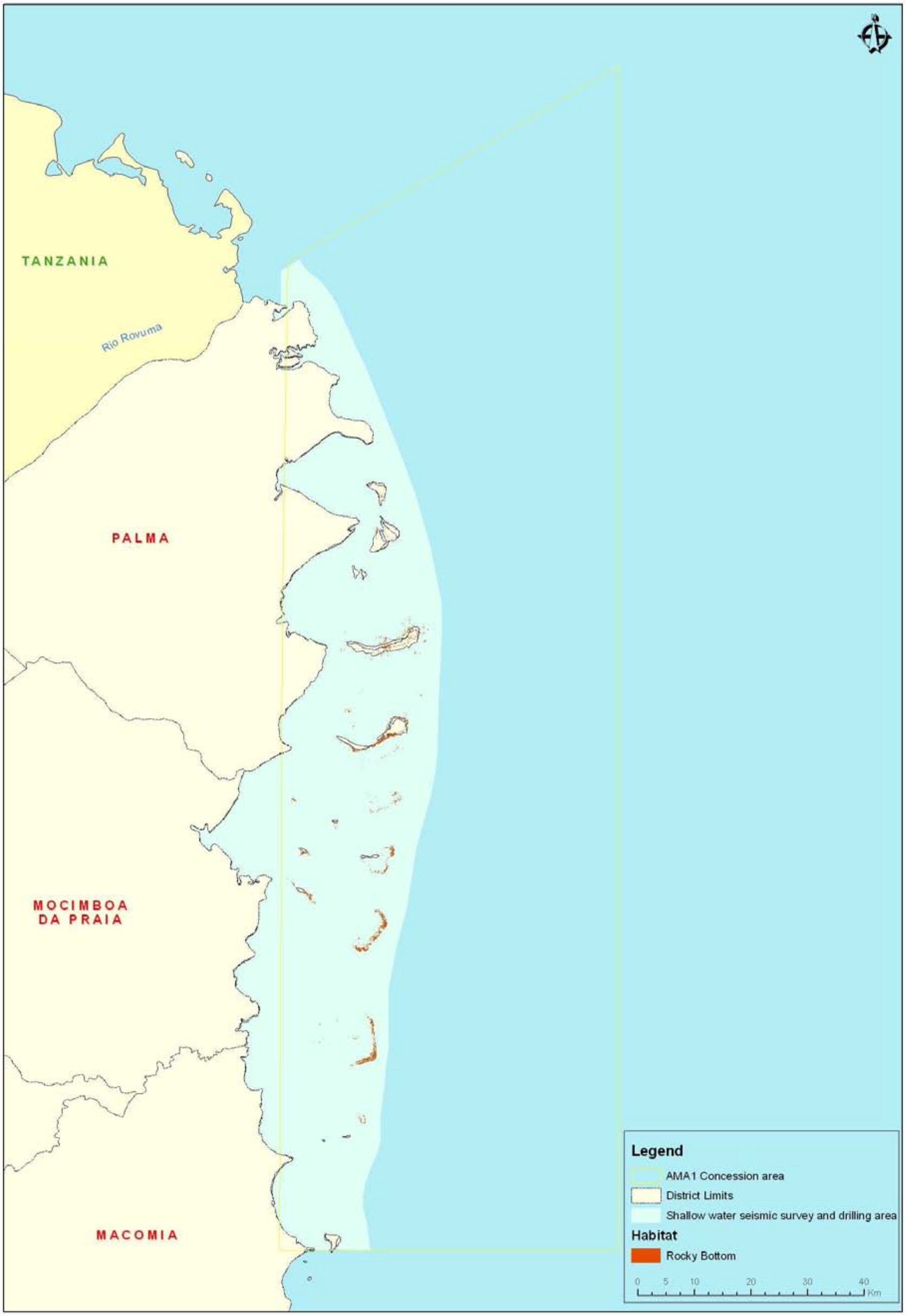


Figure 5-27. Location of rocky substrates

Table 5-7. Invertebrate species associated with rocky substrates

Taxonomic Group	Species
Starfish	*Linckia multiflora* *Asterina burtoni*
Sea Urchins	*Echinometra mathaei*
Brittle Stars	*Ophiactis savignyi* *Macrophiothrix hirsuta* *Ophioleps cinota*
Sea cucumber	*Stolus sp.*
Crustaceans	*Pilumnus spp* *Xantho spp.* *Actaea spp.* *Epixanthus frontalis* *Galathea sp.* *Alpheas sp.* *Gnathophyllum sp.*
Mollusks	*Pinctada negra* *Chlamys sp.* *Lima lima* *Eastonia sp.*

5.2.3. Marine mammals

Overview

The knowledge of species of marine mammals in the Mozambique Channel dates back to the 18th and 19th centuries, during the period of the commercial exploitation of whales based on the records from whaling ships (Wray and Martin 1983).

The first scientific survey of marine mammals along the Mozambican coast was carried out in 1979 by scientists on board the R/F Fridjot Nansen (Saetre, Paula and Silva 1979) which explored the entire Mozambican coast. A number of whale and dolphin species were reported.

More recently, in 1991 and in 2003, two cruises were made along the Mozambican coast, but both were limited to the southern and central regions (the first as far as Quelimane, and the second as far as Mozambique Island) (Findlay *et al*, 1993 and Findlay *et al.* 2004), based on various information gathered sporadically on the waters of the Mozambique Channel (in both Mozambique and Madagascar),

In 2007, an aerial survey of marine mammals and sea turtles undertaken on the continental shelf (from the coast up to 200 metres in depth) in the AMA1 Concession Area, resulted in the observation of 3 species of marine mammals – *Sousa chinensis* in waters near the coast, *Tursiops aduncus* to the east of the islands and a large school of the genus *Stenella*, near Tecomaji island. Additionally, the acoustic and visual monitoring undertaken as part of the seismic survey held in deepwater of Block 1 by AMA1, from January to May 2008, confirmed the occurrence of dolphins (spinner, bottlenose, Risso and melon-headed whale well as several unidentified species), a short-finned pilot whale (*Globicephala macrorhynchus*), a sperm whale (*Physester* *macracephalus*) and a humpback whale (*Megaptera novaeangliae*) (Marine Team Offshore, 2008). The sperm whale is a new recent recording that does not appear on Peddemors *et al. (*1997) list of marine mammals.

The dugong (*Dugong dugon*), occurs in areas near the Mozambican coast, generally in sea grass habitats. Historically this species occurred in the littoral waters of the northern Cabo Delgado coastline but it has not been recorded in the area in recent years. This species is at risk of extinction, and according to recent research is limited mostly to waters near the coast of the Bazaruto Archipelago (Personal Communication, A. Guissamulo).

Species of marine mammals existing in the Project area

According to Peddemors *et al.* (1997), at least 21 species of marine mammals have been recorded in the Mozambique Channel, 17 of which probably occur in the project area (**Table 5-8**.). A sperm whale (*Physester macracephalus*) was recorded during the 2008 marine mammal monitoring program as part of the seismic survey in deepwater of the AMA1 Concession Area carried out during January to May 2008.

Two species (i.e., humpback whale and sperm whale) are listed as Vulnerable (IUCN, 2007).

Table 5-8. Marine mammals in the Mozambique Channel

Common name	**Species**
Baleeen whales	
Humpback whale	*Megaptera novaeangliae***
Minke whale	*Balaenoptera acutorostrata**
Odontocete (toothed) whales and dolphins	
Dolphin	*Delphinus delphis**
Pygmy killer whale	*Feresa attenuata*
Short finned pilot whale	*Globicephala macrorhynchus***
Risso's dolphin	*Grampus griseus***
Pygmy sperm whale	*Kogia breviceps**
Blainville's beaked whale	*Mesoplodon densirostris**
Killer whale	*Orcinus orca*
Melon-headed whale	*Peponocephala electra**
Sperm whale	*Physeter macrocephalus***
False killer whale	*Pseudorca crassidens**
Indian humpback dolphin	*Sousa plúmbea***
Spotted dolphin	*Stenella attenuata**
Striped dolphin	*Stenella coeruleoalba**
Long-snouted spinner dolphin	*Stenella longirostris***
Rough-toothed dolphin	*Steno bredanensis**
Bottlenose dolphin	*Tursiops truncatus***
Long-beaked common dolphin	*Dephinus capensis*
Cuvier's beaked whale	*Ziphius cavirostris**
Sirenians	
Dugong	*Dugong dugon*

* Probably occurs in the project area (Source: Peddemors et al. 1997);
** Occurrence confirmed in the project and surrounding areas (2007 aerial survey: Marine Team Offshore, 2008)

<u>Baleen whales (true whales)</u>

Two species of baleen whale, the humpback whale (*Megaptera novaeangliae*) and the Minke whale (*Balaenoptera acutorostrata)*, occur in the Mozambique Channel. During summer Humpback whales inhabit the southern feeding grounds and in winter they migrate to breeding grounds in coastal tropical waters off Mozambique. (Findlay et al., 1994).

Findlay et al (1994, 2004), conducted two cruises along the Mozambican coast in 1991 and 2003, confirmed that more females with newborn calves predominate in the northern part of Mozambique than in the southern part. The whale numbers were estimated at 1,954 animals in 1991 and close to 6,000 whales in 2003. In the marine region between the Islands of Vamizi and Rongui, in the Quirimbas Archipelago, humpback whales occur between June and November, mostly females with new-born calves, which stresses the importance of this region as a humpback whale breeding ground (Isabel Silva, biologist at Maluane Ltd., 2006). These mother-calf pairs are sensitive to the approach of motor boats used for sports fishing and attempt to avoid the vessels, changing their movements.

During the seismic exploration undertaken from January to May 2008, marine mammal observers reported a single sighting of a humpback whale in the project area (**Figure 5-28** below) (Marine Team Offshore, 2008). This observation was made during a period outside that of the migration of these whales, and requires further investigation.

Despite their distribution close to the coast, humpback whales may cross very deep areas, heading towards the Comoro Islands and Mayotte or to Madagascar. The whales, which move along the coast of Mozambique may often cross the Mozambique Channel at various locations, in order to reach the islands in the middle of the Mozambique Channel or even the Island of Madagascar, where their mating sites are located (Best *et al.* 1998). Often, sounds of solitary individuals making these crossings have been recorded (Best *et al.* 1998).

In the Indian Ocean, the minke whale (*Balaenoptera acutorostrata)*, occurs in two forms which differ in size. These whale species have been observed in the waters of the continental shelf of the Mozambique Channel but are not very well-known. The form that inhabits the North Pacific area is known as *Balaenoptera acutorostrata* subsp.*scammoni*, while a dwarf minke whale, which occurs in the Southern Hemisphere is known as *Balaenoptera acutorostrata* subspecies. The area of the Northern Quirimba Archipelago is at the boundary of these species distribution area and it is possible that the two forms may overlap their distribution. Normally, minke whales rest in areas where the depth is between 20 and 50m.

Despite not being very well-known, it is considered the most common whale and engages in solitary behavior. During the southern summer, it occurs in the Antarctic circumpolar region and in winter it migrates to the region situated between the latitudes of 7ºS and 35ºS. Although it feeds on krill, it also consumes pelagic fishes. Its social structure is complex, with divisions by age, sex and reproductive stage. Its occurrence in the Mozambique Channel is seasonal, mainly between June and November.

<u>Sperm whales</u>

There are three species of sperm whales in the Indian Ocean, namely the sperm whale *(Physester macrocephalus),* the pygmy sperm whale *(Kogia breviceps)* and the dwarf sperm whale *(Kogia simu).* Generally, these species inhabit the deep areas of the continental shelf and of the continental slope. They possess the spermaceti organ in the head, which is filled with liquid wax oil. This organ provides them with buoyancy and the ability to dive deeper (up to several hundred meters).

The *Physester macrocephalus* sperm whale was the target for hunting in the Indian Ocean in the 18^{th} and 19^{th} centuries, which considerably reduced its population. The males exhibit wide migratory movements out to very high (circumpolar) latitudes while the females, with a cohesive social structure, tend to remain in certain areas close to undersea slopes and abysses. They can stay immersed for up to forty minutes, and normally stay on the surface for periods of ten minutes in the interval between dives. Visual and acoustic observations made in between January and May 2008, during seismic exploration in Area 1 of the Rovuma Basin, confirmed the presence of the sperm whale in waters of depths between 500 and 1,000m, near Vamizi Island, close to a deep sea abyss (Figure 5-28 below).

The pygmy sperm whale and the dwarf sperm whale differ slightly in the form of the fin and in the size and number of teeth. Their adult size is 2.7 and 3.2m, respectively. Normally they are solitary or occur in groups reaching six to ten animals. They tend to stay for long periods on the surface of the sea, but have the ability to dive to great depths. Their migratory movement is unknown, as is their abundance. They inhabit the deep waters of the continental shelf and slope.

<u>Killer whales</u>

Two species of killer whales occur in the Mozambique Channel: the killer whale *(Orcinus orca)* and the pygmy killer whale *(Feresa attenuata)*. Their distribution and numbers in the Mozambique Channel and in the project area are not very well-known. The killer whale *(Orcinus orca)* tends to inhabit the circumpolar regions, but during the winter they tend to wander, that is, they do not display a distinct migratory movement and feed off a variety of prey, including other whales, dolphins, sea turtles and fish.

The pygmy killer whale *(Feresa attenuata)* can reach 2.6m, with a pan-tropical distribution, inhabits ocean waters and forms groups of about fifty animals. Its distribution in the Mozambique Channel is unknown, but the species is considered rare and does not carry out any migratory movement, i.e. they occur in the Mozambique Channel during the entire year.

<u>Short-finned pilot whale</u>

The short-finned pilot whale *(Globicephala macrorhynchus),* which can reach up to 7m in size, inhabits tropical waters and occurs in groups of fifteen to fifty animals. In the southern hemisphere, mating occurs in May and births during July – August, occurring in the Mozambique Channel during the entire year. Its diet is dominated by squid. Its status is considered good and the species is abundant, although the numbers are unknown. It does not have a migratory nature, although it wanders. The Marine Team Offshore (2008) reported one sighting of the short-finned pilot whale in waters about 1,000m deep in front of the Bay of Mocimboa da Praia, in January 2008 (**Figure 5-28** below).

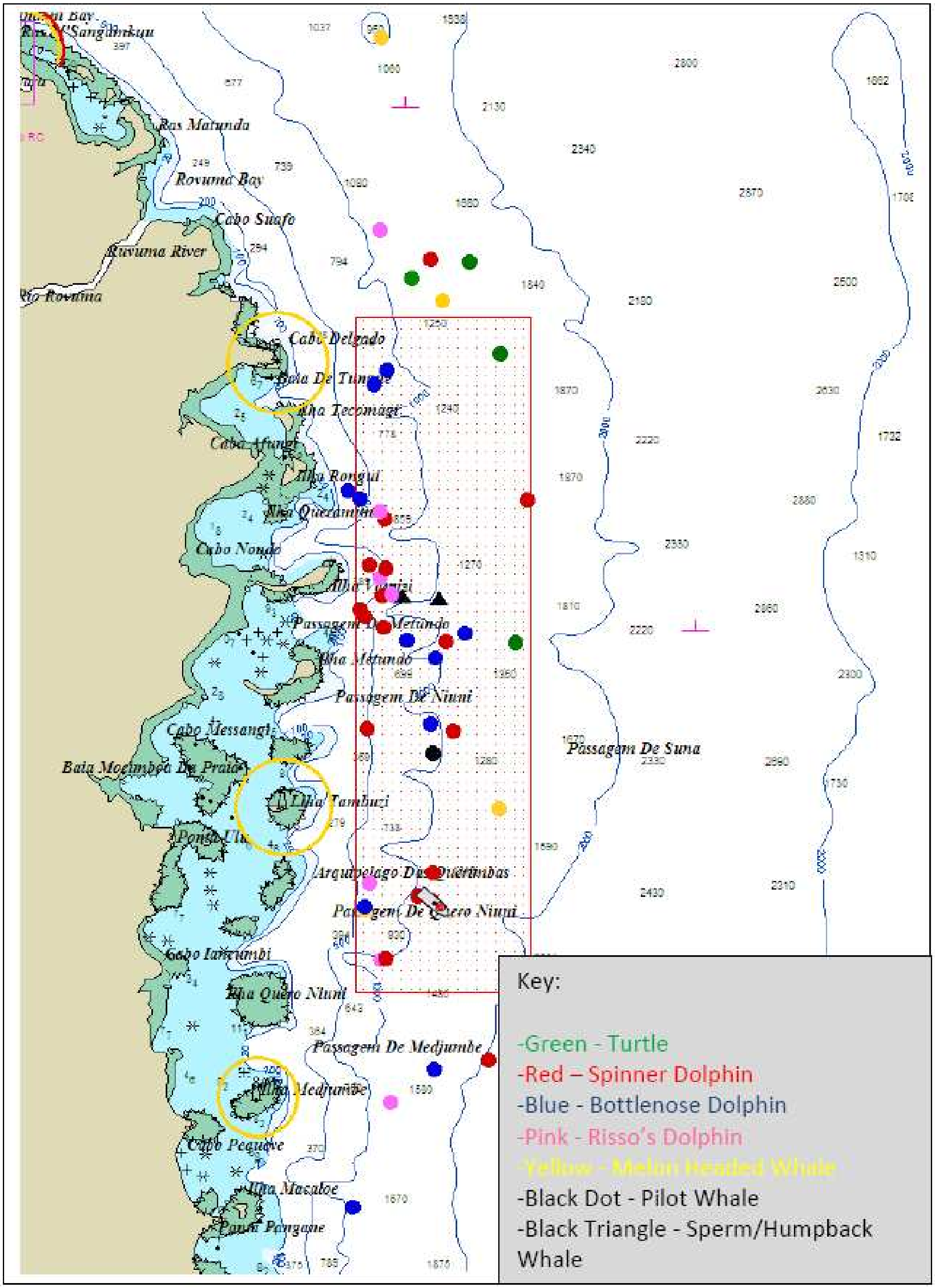


Figure 5-28. Species positively identified by the MMO during seismic survey, from Marine Team Offshore, 2008.

Melon-headed whale

The melon-headed whale *(Peponocephala electra)* has a broad distribution in tropical seas and oceans, but not going beyond latitudes 20°S and 20°N, inhabiting sites where the shelf is narrow and next to the continental slope. It is an extremely gregarious species, with groups that can reach hundreds of animals. It feeds on prey (fishes, squid and crustaceans), which inhabit great depths (1,500m). Its status is not considered critical, although its numbers are not known. It does not have a migratory nature, but its all year occurrence in temperate waters may be associated with its preference for warmer currents. There is no any estimate of the species abundance in the Mozambique Channel.

False killer whale

The false killer whale *(Pseudorca crassidens)* has a broad distribution, and is gregarious (groups normally of ten to twenty individuals) in the coastal regions, up to depths of 1,000m. It feeds on various animals, including other cetaceans, but normally it occurs on the continental slope and prefers cephalopods (squid). Its numbers on the Mozambican coast are unknown. No migratory character is known.

Cuvier's beaked whale

The Cuvier's beaked whale (*Ziphius cavirostris*) can reach a length of 7m, inhabits the cold deep ocean waters of the tropical and temperate regions, in locations with a sharp depth gradient (in abysses). Normally they are solitary or occur in groups of up to seven animals. They feed on squid, fish and some deep-water ocean crustaceans. Their number is unknown, but it is known that the species is very vulnerable to certain types of sound emissions caused by intense industrial or recreational activities (Reeves et al. 2002), and the military (Fernandez et al. (2005); The Antartic and Southern Ocean Coalition (2004). There is no any estimate of the species abundance in the Mozambique Channel.

Blainville's beaked whale

The Blainville's beaked whale (*Mesoplodon densirostris*), which may reach a maximum length of 4.5m, is widely distributed in tropical and warm temperate waters. There is no evidence of them being migratory, and they occur in locations the depths of which range from 500 to 1,500m, and in abysses. They occur in groups of 3 to 5 animals; they may dive for up to 22 minutes and are sensitive to acoustic trauma caused by mid-range sonar that causes severe, diffuse congestion and hemorrhage around the acoustic fat jaw, ears, brain and kidneys (Fernandez et al. 2005, Reeves et al. 2002). There is no estimate of abundance in the Mozambique Channel.

Longman's beaked whale

The Longman's beaked whale (*Indopacetus pacificus*) is a very little known species. The adults grow up to 6 to 9 metres long. The colouring is variable, but dominated by grayish brown tones. The melon organ is well developed and can be white. The beak is relatively long, as is the dorsal fin, which is hooked, and is located on the posterior part of the body. Behind the blowhole the head is a black/dark grey colour. There is just one pair of well developed teeth in adult males. The teeth are inclined forward at the tip of the jaw. The beak has an “abnormal” lateral swelling half way along its length. They occur in cohesive groups of 5 to 20 animals, and sometimes these groups reach a hundred individuals. They expose the beak and the melon above the surface when traveling rapidly. Their blow is low and bushy. Their dives last for 18-25 minutes. They are sometimes seen with short-finned pilot whales and bottlenose dolphins. They occur in tropical ocean waters. They feed on deep sea fish, squid and possibly crustaceans and echinoderms (starfish and sea urchins) from the sea bed. Little is known about their breeding.

<u>Risso’s dolphin</u>

The Risso’s dolphin (*Grampus griseus*) which is less than 4m in length normally has a spotted body. It occurs in the tropical and temperate regions and inhabits very narrow niches on a seasonal basis, with temperatures that vary between 10℃ and 28℃, on the steep continental slopes where the depth reaches 300m. It has no defined migration patterns and feeds on various kinds of cephalopods, mainly at night. They are considered to be abundant in the world but their abundance in the Mozambique Channel is unknown.

<u>Rough-toothed dolphin</u>

The Rough-toothed dolphin (*Steno bredanensis*) occurs in ocean waters of the tropical regions and rarely close to the mainland. However, it may occur close to the islands, the coast of which is situated near the continental slope. It forms groups of ten to twenty individuals, undertakes deep dives and can stay submerged for fifteen minutes. It feeds on fish and cephalopods. It is considered a common and a widely distributed species. Peddemors et al (1997) reported this species in the Mozambique Channel throughout the year.

<u>Long-snouted spinner dolphin</u>

The Long-snouted spinner dolphin (*Stenella longirostris*) inhabits the coastal tropical and subtropical waters, and is most abundant between the tropics, where the water is deeper than 50m. Its migratory character is not known and it forms enormous groups in the ocean regions. They reproduce at any time of the year, although they have a reproductive peak, which varies between the different regions. Normally this species rests during the day, off the islands situated near the marine boundary of the continental shelf, and feeds at night on meso-pelagic prey, which rises to the surface. It is an amply abundant species, which causes no concern for conservation. A group of more than 200 dolphins of this species was seen in the Quirimbas Archipelago on the open sea on the edge of the continental shelf across from the Town of Palma (CSA International, 2007). They are not migratory.

<u>Spotted dolphin</u>

The Spotted dolphin (*Stenella attenuata*) occurs in the tropical and warm temperate oceans, between the latitudes of 40º N and 40º S, inhabiting local coastal waters and in some parts of the world it changes location on a seasonal basis, within a diameter of 200 to 300 nautical miles. It is a gregarious species, forming schools of hundreds to thousands of individuals, containing various social units of twenty individuals of a given age range or reproductive state. It reproduces at any time of the year, with various seasonal peaks. It feeds on small pelagic fish, cephalopods and crustaceans. The global population is estimated at around three million individuals, and it runs no risk of extinction.

Striped dolphin

The Striped dolphin (*Stenella coeruleoalba*) is cosmopolitan, occurring in tropical and warm temperate ocean waters. Peddemors et al (1997) observed only one group of individuals of this species off the Mozambican coast in 1991. They travel in schools which can exceed 100 individuals, with their diet being varied, including pelagic fish and cephalopods. It is a species that is very abundant, occurring in the Mozambique Channel throughout the year.

Bottlenose dolphin

The Bottlenose dolphin (*Tursiops* sp.) is dimorphous: a coastal form, the size of which is normally less than 2.5m, inhabiting the coastal waters out to sites where the depth is no more than 30m *(T. aduncus)* (Figure 5-28) and another oceanic form *(T. truncatus),* whose adult size is larger than 2.5m, which occurs in waters more than 50m deep, on the continental shelf.

The bottlenose dolphin (*Tursiops aduncus*) Photo taken by Angie Gulland

Dolphins of the *T. aduncus* species occur in groups, with an observed average in Maputo Bay of 27 animals (Guissamulo 2006). During the survey undertaken in the waters of the continental shelf of the Quirimbas Archipelago, few groups of these dolphins were noted and the average size of the group was 8.5 animals (CSA International, 2007). A larger number occurred in open waters close to the islands with reefs. Generally speaking, they were relatively rare in relation to other sites in the South of Mozambique.

Little is known about the oceanic form *(T. truncatus),* beyond the fact of it has a more robust body. On the east coast of South Africa, this species exhibits migratory movement following the migration of sardines from the coast of Cape Town out to the coast of Natal Province, during the months of June – July, which is to say, in the winter

(Peddemors and Cockcroft, 1993). In 2006 there were beachings of the oceanic form of dolphins in Zanzibar (around 600 dolphins) (Narriman Jidawi, personal communication 2006) and in 2007 on the Island of Bazaruto 46 dolphins ran ashore (Cockcroft and Guissamulo, 2007), with the causes of these beachings being unknown. However, the group appeared to be dominated by juvenile males, but contained some adult females. A lot of these dolphins were found with empty stomachs or filled with the remains of the digestion of fish and cephalopods.

<u>Indo-Pacific humpback dolphin</u>

The Indo-Pacific humpback dolphin (*Sousa plumbea* or *S. chinensis*) is classified as vulnerable due to its occurrence in places with intense human activity and habitat degradation. It does not have a migratory nature and inhabits the coastal waters associated with mangroves and rocky or coral reefs, in waters that are rarely more than 20m deep.

Its distribution is known within the project area, where it was normally found in the waters between the islands of the Quirimbas Archipelago and the coast of the mainland, with the groups varying from one to ten individuals and the average being four animals (CSA International, 2007). Given its occurrence in shallow waters, it is less susceptible to the action of seismic surveying. It does not normally display seasonal movements (Guissamulo and Cockcroft 2004; Karczmarski 2000). In tropical waters this species apparently tends to occur in smaller areas than in the temperate regions (coast of South Africa) where there are seasonal variations of temperature and of prey availability. The groups observed in Maputo Bay were extremely large when compared with those reported in other areas of its distribution (Guissamulo and Cockcroft, 2004). Peddemors *et al.* 1997 observed this species near the main rivers. It should be noted that these observations were taken from waters of greater depths than those inhabited by this species, due to limitations of the vessel in which the cruise was undertaken. Also, its expansion into distant areas was due to the extension of its habitat next to the large riverine systems.

Humpback Dolphin (Photo: Almeida Guissamulo)

Long-Beaked Common Dolphin

Although Peddemors et al (1997) did not observe this species (*Delphinus capensis*) in the Mozambique Channel, it occurs in Mozambican waters. A school of these dolphins was observed in May 2003 in the area separating the Islands of Vamizi and Rongui (Guissamulo. personal observation) traveling at high speed alongside a passenger and cargo transport vessel, with some members of the school remaining beside this vessel for a period of three minutes. The site where it was observed consisted of deep waters (between 200 and 600m), in one of the abysses situated between these islands. The collection of two crania, one found in the Bay of Sofala and another in Maputo Bay also prove the occurrence of this species in Mozambique.

This species is considered oceanic and in South Africa it carries out migratory movements associated with the migration of sardines (Peddemors *et al.* 1997). However, it is not known if the species is migratory in Mozambique. On the other hand, its status is unknown. It feeds mainly on schools of pelagic fish. Reproduction occurs in summer.

Distribution and Occurrence

The map of the observations of marine mammals obtained during the seismic program in the deep of water Area 1 (see **Figure 5-29**) indicates the position of all marine mammals and turtle detections made from the source vessel in relation to the survey grid. However, it does not identify the species observed. The map shows that dolphin species are widely distributed to the east in the project area and these species probably occur in the shallower waters of the AMA1 concession area. The map also shows sightings and detections of three species of whales and of marine turtles between January and May 2008 (Marine Team Offshore, 2008). Markers refer to the vessel position when the sightings were made and are not indicative of range. Red circles indicate the areas of higher detection frequencies.

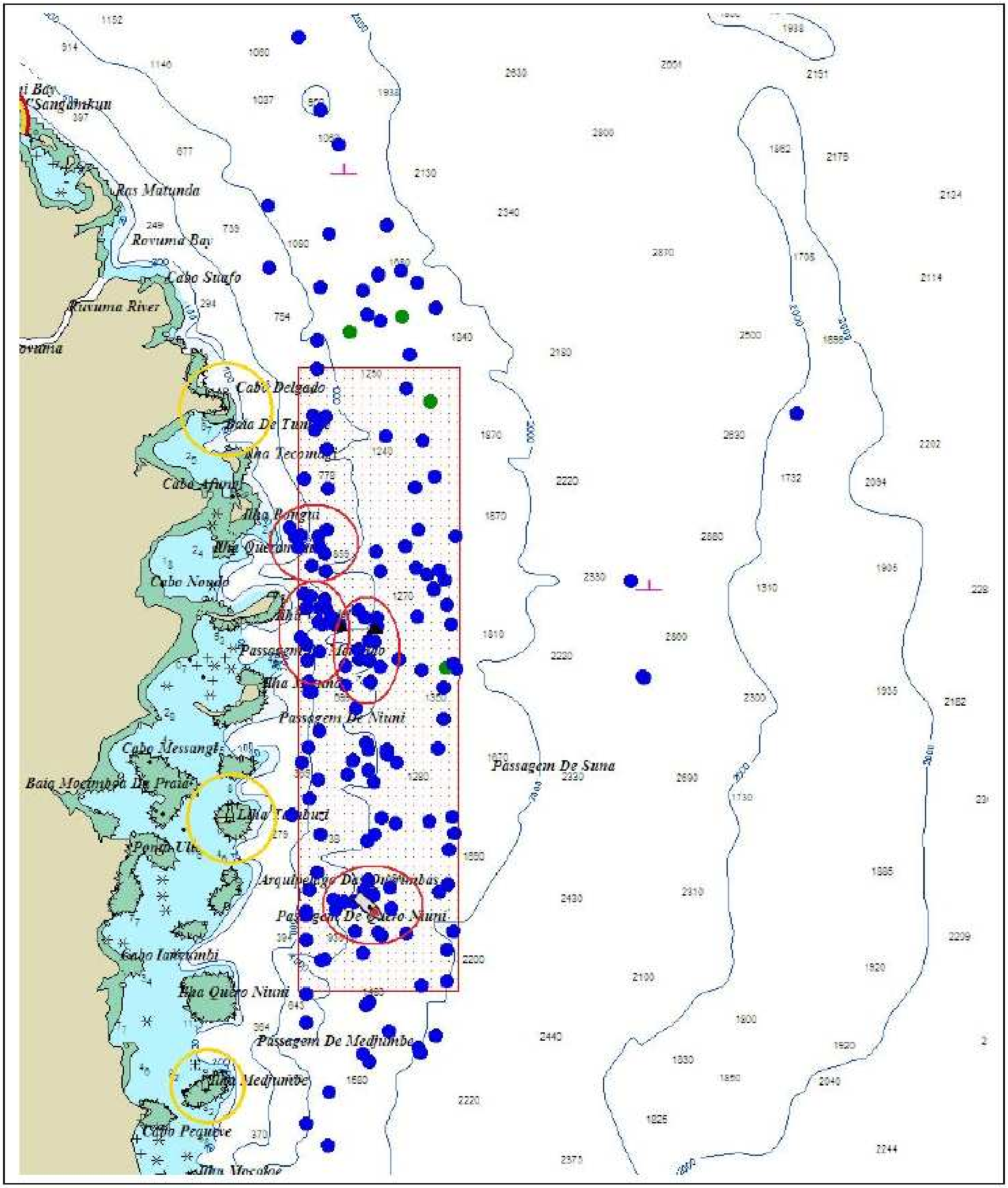


Figure 5-29. Map of all Marine Mammals (blue and red dots) and Turtle Sightings (green dots) and Detections, from the Marine Team Offshore (2008)

The periods of residence of marine mammal species in the Mozambique Channel is shown in **Table 5-9** below.

Table 5-9. Periods of residence of marine mammal species in the Mozambique Channel

Common Name	Speces	Residence	Period
Humpback whale	*Megaptera novaeangliae**	Seasonal	July-November
Minke whale	*Balaenoptera acutorostrata*	Seasonal	July- November
Dolphin	*Delphinus delphis/capensis**	Unknown	All year
Pygmy killer whale	*Feresa attenuata*	All year	All year
Short-finned pilot whale	*Globicephala macrorhynchus**	All year	All year
Risso's dolphin	*Grampus griseus**	All year	All year
Pygmy sperm whale	*Kogia breviceps*	All year	All year
Blainville's beaked whale	*Mesoplodon densirostris*	All year	All year
Killer whale	*Orcinus orca*	Seasonal	
Melon-headed whale	*Peponocephala electra**	All year	
Sperm whale	*Physeter macrocephalus*	All year/ males migratory	All year
False killer whale	*Pseudorca crassidens**	All year	All year
Indian humpback dolphin	*Sousa plúmbea**	All year	All year
Spotted dolphin	*Stenella attenuata**	All year	All year
Striped dolphin	*Stenella coeruleoalba**	All year	All year
Long-snouted spinner dolphin	*Stenella longirostris**	All year	All year
Rough-toothed dolphin	*Steno bredanensis**	All year	All year
Bottlenose dolphin	*Tursiops truncatus**	All year	All year
Cuvier's beaked whale	*Ziphius cavirostris*	All year	All year
Dugong	*Dugong dugon*	Unknown	All year

5.2.4. Marine Turtles

The five species of marine turtles that have been documented to occur along the Mozambican coast are as follows:

1. Green (*Chelonia mydas*);
2. Hawksbill (*Eretmochelys imbricata*);
3. Loggerhead (*Caretta caretta*);
4. Leatherback (*Dermochelys coriacea*); and
5. Olive ridley (*Lepidochelys olivacea*).

All of these species are listed as threatened by the IUCN Red List, with the leatherback turtle and the hawksbill turtle considered critically threatened.

The distribution of the sea turtles in the waters of the continental shelf of the Quirimbas Archipelago was recently documented by CSA (2007). The turtles were four times more abundant in the waters of Quirimbas National Park than on the northern part of the Archipelago, outside of the park. The turtles observed outside of the park were most numerous in the deep waters around the Macaloe and Medjumbe Islands.

Recent studies undertaken by the Maulane Group in conjunction with the London Zoological Society on the islands of Vamizi, Rongue and Macaloe Island, indicate that the green and hawksbill turtles nest on the islands (Hill and Garnier, 2003). Turtle nesting occurs throughout the year. On Vamizi Island turtle nesting peaks in January and August whilst on Macaloe Island the turtles have their nesting peak between November and May.

During the seismic exploration conducted by Anadarko from January to May 2008, marine mammal observers onboard the seismic vessel, made 4 individual turtle sightings in the concession area. Although specific identification was not possible, it was thought that all records were of either Loggerhead Turtle (*Caretta caretta*) or Green Turtle (*Chelonia mydas*). Turtles were mostly seen in the northern area of the concession area (Marine Team Offshore, 2008). Refer to **Figure 5-29** above which summarizes the sighting locations of turtles and marine mammals.

A green turtle was tagged (received a satellite positioning device and named Claudia) by a team from the Zoological Society of London (ZSL) in April 2007 on Vamizi Island (3,8 km from the western boundary of the offshore drilling area), where it had nested. In 2007 Claudia was located on the Kenyan coast. Its course was undertaken along the coast and often in waters shallower than 1,000m deep (see **Figure 5-30**, from the site:http://www.zsl.org/field-conservation/marine-and-freshwater/turtle-tracking.615.AR.html). The greater part of the journey was undertaken in the first twenty days.

The tagging of this turtle occurred as part of the Cabo Delgado Biodiversity and Tourism Project (Maluane), initiated in 1998, as a partnership between ZSL and a group of private individuals, in order to ensure the conservation of the coastal areas in the northern Quirimbas.

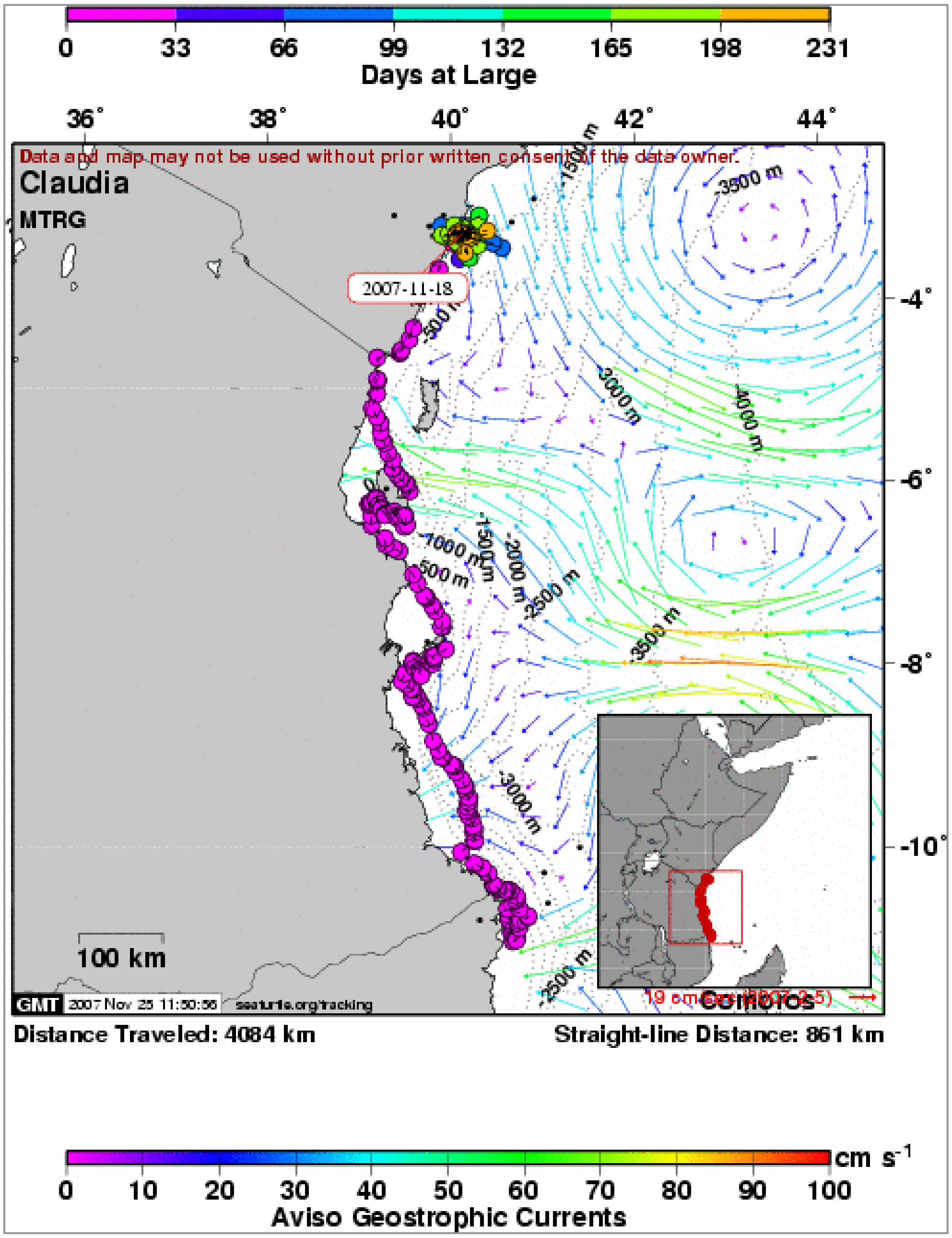


Figure 5-30. Journey of the green turtle Claudia from www.zsl.org

As part of the same project, in May 2008, two new green turtles were tagged after laying nests on Vamizi Island. One of the turtles (named Kiki) laid 3 nests before migrating back to her feeding grounds. She remained close to Vamizi Island venturing no further than around 30 km away from the northern end of the Island. According to the journey, Kiki has traveled within the AMA1 shallow water seismic survey and drilling area (**Figure 5-31** below). It is believed that she could have stayed close in order to lay another nest or two. (http://www.zsl.org/field-conservation/marine-and-freshwater/turtle-tracking,910,AR.html)

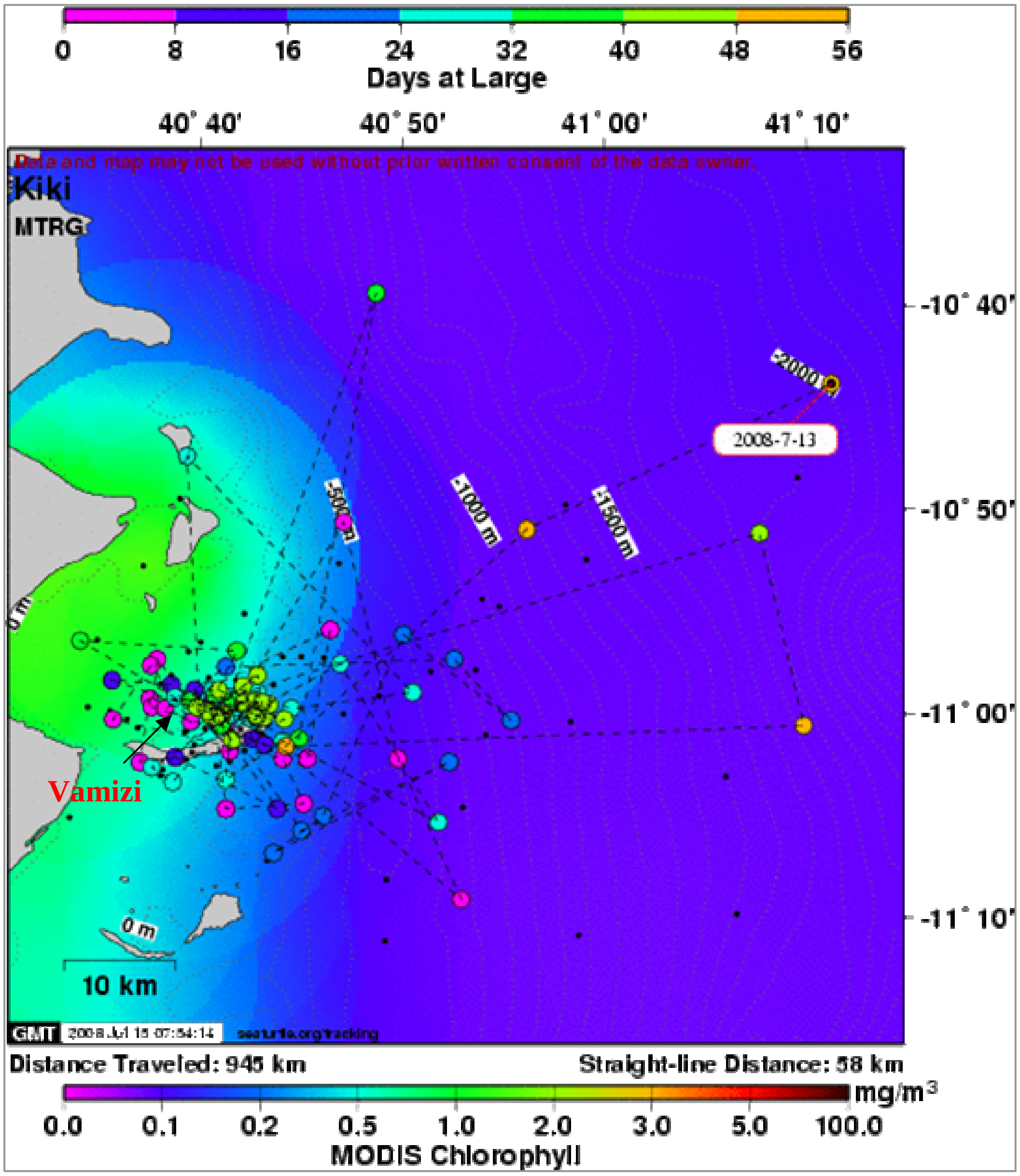


Figure 5-31. Journey of the green turtle Kiki, in the vicinity of Vamizi Island, from www.zsl.org

5.2.5. Fish

Most of the original data on fish in the coastal waters of Mozambique is based on a research survey (both hydrographic and fishing potential) carried out by a joint Mozambican and Norwegian team between August 1977 and June 1978 using the research vessel Dr. Fridtjof Nansen. Additional fish data was acquired from the research survey of the R/V Kattegat carried out between November and December 1978. These data are presented in a comprehensive report prepared by Saetre and Silva (1979). Although the report presents data for the entire Mozambican coast there is relatively less data is available for the northern portion the survey area (north of Angoche) compared to the southern and central sectors. More recently, in 2007, the coastal waters were subject to hydrographic and biological surveys again by the research vessel R/V Fridtjof Nansen. Several sampling stations of the 2007 research are located in and adjacent to the Project area and the results of these surveys provide additional data on fish and water quality along the northern Cabo Delgado coastline.

The flowing categories of fish occur in the Project area:

- Pelagic fish
- Fish associated with coral reefs
- Fish associated with seagrass beds

Data related to fish associated with coral reefs and seagrass beds are based mainly on data derived the Darwin/Frontier Moçambique Quirimba Archipelago Marine Research Programme (April 1996 to December 1997).

1) Small Pelagic Fishes

Small pelagic fish recorded for the mainly scad (De*capterus spp*) and barracuda (S*phyraena spp)*. North of Nacala round scad (*Decaptenus maruadsi*) and ponyfish (L*eiognathus spp*) were recorded for the bottom at 200 m depth. These species probably occur in the coastal water of Cabo Delgado Province. The 1977 R/V Kattegat research survey observed of shoals of scad (probably round scad) near Pemba.

2) Large Pelagic Fishes

Spanish mackerel (S*comberomorus commerson*) have been recorded off Cabo Delgado (Saetre and Silva, 1972). Juvenile Spanish mackerel (2-3 cm in length) were caught off the Cabo Delgado coast in April 1978 during the Dr. Fridtjof Nansen survey indicating a spawning activity for this species during this period of the year.

The *R/V Kattegat* survey recorded several sightings of surface schools of yellowfin tuna (T*hunnus albacares*). Other large pelagic species recorded off Cabo Delgado during the Dr. Fridtjof Nansen survey include dusky shark (C*archorhirius obscuras*) and blackspot shark (*C. sealei*).

According to Impacto and Mark Wood Consultants (2006), a number of pelagic predatory species occur in the coastal waters (*Istiophorus platypterus*), marlin (*Makaira indica*, *M. mazara*, *Tetrapterus angustirostris*, *T. audax*), wahoo (*Acanthocium solandri*), albacore (*Thunnus alalunga*), Yellowfin tuna (*T. albacares*) skipjack tuna (*Katswomus pelamis*), bonitos (*Gymnosarda unicolor*), narrow banded Spanish mackerel (*Scomberomorus japonicus*), swordfish (*Xiphias gladius*), Great barracuda (*Sphyraena barracuda*), Giant trevally (*Caranx ignobilis*) and Blue fin trevally (*Caranx melampygus*).

Marlin, sailfish, wahoo, and dorado are important for sport fishing (between September and April).

Sharks that have been caught in these waters include the bull shark (*Carcharhinus leucas*), blacktip shark (*Carcharhinus limbatus*), hammerhead sharks (*Sphyrna spp.)* and tiger shark (*Galeocerdo cuvier*).

3) Fish associated with coral reefs

Species diversity of fish associated with coral reefs is high. Perreira (2000) has drawn up a check list of reef-associated fishes of Mozambique that lists 601 species comprising 27 families are listed.

Detailed surveys of the southern Quirimbas Islands have been carried out under the auspices of Darwin/Frontier Moçambique Quirimba Archipelago Marine Research Programme. The researchers identified 375 reef-associated fish species from 57 families (**Table 5-10**). The number of reef associated fish species in the northern Quirimbas is likely to be higher.

Table 5.10. Number of species per family of reef fishes recorded for the southern Qurimbas Archipelago Islands (from Whittington *et al.* 1998, Annex A6)

Family	[Common Name	No. of Species
Acanthuridae	Surgeonfishes	22
Antennaridae	Frogfish	1
Anthiinae	Fancy sea basses	3
Apogonidae	Cardinal fishes	10
Aulostomidae	Trumpetfishes.	1
Balistidae	Triggerfishes	12
Belonidae	Needlefish	2
Blenniidae	Blennies	6
Bothidae	Lefteye flounders	2
Caesionidae	Fusiliers	8
Callionymidae	Dragonets	2
Carangidae	Kingfishes	11
Carcharhinidae	Requiem sharks	3
Chirocentridae	Wolf herrings	1
Chaetodontidae	Butterflyfishes	21
Cirrhitidae	Hawkfishes	4
Clupeidae	Herrrings, shads	2
Cynoglossidae	Tonguefishes	1
Dactylopteridae	Flying gunards	1
Dasyatidae	Stingrays	2
Echeneidae	Sharksuckers	2
Engraulidae	Anchovies	1
Entriscidae	Shrimpfish	1
Fistulariidae	Cornetfishes	2
Gerreidae	Mojarras	2
Gobiidae	Gobiies	5
Grammistidae	Soapfishes	1

Family	[Common Name	No. of Species
Haemulidae	Rubberlips and grunters	10
Hemiramphidae	Halfbeaks	3
Holocentridae	Squirrelfishes	8
Kyphosidae	Drummers	1
Labridae	Wrasses	45
Lethrinidae	Emperors	15
Lutjanidae	Snappers	13
Microdesmidae	Wormfishes	1
Monacanthidae	Filefishes	5
Mullidae	Goatfishes	16
Muraenidae	Moray eels	2
Nemipteridae	Threadfin breams	2
Ostraciidae	Boxfishes	2
Pegasidae	Sea moths	1
Pinguipedidae	Sandperches	2
Platacidae	Batfishes	2
Platycephalidae	Flatheads	3
Plotosidae	Catfishes	1
Pomacanthidae	Angelfishes	12
Pomacentridae	Damselfishes	20
Priacanthidae	Bigeyes	2
Rhynchobatidae	Guitarfish	1
Scaridae	Parrotfishes	18
Scombridae	Mackeral	1
Scorpaenidae	Scorpionfishes	6
Serranidae	Groupers	21
Solenostomidae	Pipefishes	1
Siganidae	Rabbitfishes	4
Stegostomatidae	Zebra sharks	1
Syngnathidae	Seahorses	5
Synodontidae	Lizardfishes	2
Teraponidae	Tigerfishes	2
Tetraodontidae	Pufferfishes	13
Tetrarogidae	Waspfishes	1
Triglidae	Searobins.	1
Zanclidae	Moorish idol	1

4) <u>Fish associated with seagrass beds</u>

Gell (1997) identified 195 species of fish from 52 families caught by seine nets and basket traps over seagrass beds. The family Lethrinidae accounted for the largest proportion of fish, 31.5%; Siganidae accounted for 22% and Scaridae represented 11%. There were twenty nine species of wrasse (Labridae) identified, and the family accounted for over 9% of all fish caught.

Although the dominant species varied considerably from day to day and even between hauls, nearly 70% of catch sample by weight were accounted for by the following five species: *Siganus sutor* (Siganidae, 25.1%), *Lethrinus lentjan* (Lenthrinidae, 23.9%), *Leptoscarus vaigiensis* (Scaridae, 8.8%), *Lethrinus variegatus* (Lethrinidae, 8%) and *Gerres oyena* (Gerreidae, 3.5%).

5) <u>A Note on the Coelacanth</u>

The coelacanth (*Latimeria chalumnae*) is a unique fish, and when discovered in 1938 off the coast of South Africa it was regarded as a living fossil. The coelacanth is deep water demersal specie and has been recorded off the Comoros Islands to the east Cabo Delgado Province, to the south off Zambezi Province and to the north off Tanzania. Coelacanths probably occur in marine waters of Cabo Delgado. Several coelacanths have been caught along the Tanzanian coast during the last year, including three in Mnazi Bay-Rovuma Estuary Marine Park, on the border with Mozambique.

An adult coelacanth can grow at least to 180 cm in length and can weigh up to 100 kg. Unlike most fishes which have a gas-filled swim bladder, the coelacanth has a large swim bladder that is filled with fat. Being lighter than the seawater, the fat provides buoyancy. *L chalumnae* is a nocturnal hunter, sheltering in submarine caves by day and foraging at night on squid and other fish species.

Research undertaken so far indicates that coelacanths occur at depths of between 100 and 700m.

The IUCN classifies coelacanths as a Critically Endangered species and is listed on the IUCN Red Lists of Threatened Species.

5.2.6. Seabirds

Nine taxonomic families of seabirds (broadly defined as species that spend a large portion of their lives on or over seawater) are found in both offshore and coastal waters of northern Mozambique (**Table 5-11**). Some species of this group primarily inhabit offshore (continental slope) habitats (e.g., albatrosses, petrels and their allies, boobies and gannets, and tropicbirds). Most Mozambique Channel seabird species, however, inhabit waters of the continental shelf and shelf edge and adjacent coastal and inshore habitats (Newman, 2002; Sinclair and Ryan, 2003).

Two species (wandering albatross and cape gannet) are currently listed by the IUCN as Vulnerable, and two species (Jouanin's petrel and African skimmer) are listed as Near Threatened (IUCN, 2007).

Common and lesser crested terns were the most common seabird sighted along the western edge of the survey area within waters of the continental shelf edge during a 2007 CSA offshore habitat characterization survey (CSA, 2007).

Table 5-11. Seabirds of Northern Mozambique and their current (2007) IUCN listing status (From: Harrison, 1983; Newman, 2002; Sinclair and Ryan, 2003)

Common Name	**Species**	**Local Distribution**	**Seasonality**	**Local Presence**	**IUCN Listing Status**
Albatrosses (Family Diomedeidae)					
Wandering albatross	*Diomedea exulans*	Offshore	n/a	Uncommon visitor	VU
Indian yellow-nosed albatross	*Thalassarche carteri*	Offshore	Winter	Common visitor	n/a
Shy albatross	*Thalassarche cauta*	Offshore	Winter	Common visitor	n/a
			Summer	Uncommon visitor	
Petrels, Shearwaters, and Storm Petrels (Family Procellariidae)					
Great-winged petrel	*Pterodroma macroptera*	Offshore	n/a	Common visitor	LC
Pintado petrel	*Daption capense*	Offshore	Winter	Common visitor	LC
Jouanin's petrel	*Bulweria fallax*	Offshore	n/a	Uncommon visitor	NT
Wedge-tailed shearwater	*Puffinus pacificus*	Offshore	n/a	Infrequent visitor	LC
Flesh-footed shearwater	*Puffinus carneipes*	Offshore	n/a	Uncommon visitor	LC
Cory's shearwater	*Calonectris diomedea*	Offshore	n/a	Common visitor	LC
Audubon's shearwater	*Puffinus lherinieri*	Offshore	n/a	Uncommon visitor	LC
Wilson's storm petrel	*Oceanites oceanicus*	Offshore	n/a	Common visitor	LC
Black-bellied storm petrel	*Fregetta tropica*	Offshore	Winter	Uncommon visitor	LC
Boobies and Gannets (Family Sulidae)					
Cape gannet	*Morus capensis*	Offshore	n/a	Common resident	VU
Masked booby	*Sula dactylatra*	Offshore	n/a	Common visitor	LC
Red-footed booby	*Sula sula*	Offshore	n/a	Uncommon visitor	LC
Tropicbirds (Family Phaethontidae)					
White-tailed tropicbird	*Phaethon lepturus*	Offshore	n/a	Common visitor	LC
Red-tailed tropicbird	*Phaethon rubricauda*	Offshore	n/a	Uncommon visitor	LC
Frigatebirds (Family Fregattidae)					

Common Name	Species	Local Distribution	Seasonality	Local Presence	IUCN Listing Status
Lesser frigatebird	*Fregata ariel*	Offshore/ Coastal	n/a	Rare visitor	LC
Greater frigatebird	*Fregata minor*	Coastal/ Offshore	n/a	Common resident	LC
Gulls, Terns, and Skuas (Jaegers) (Family Laridae)					
Grey-headed gull	*Larus cirrocephalus*	Coastal/ Inland	n/a	Common resident	LC
Lesser black-backed gull	*Larus fuscus*	Coastal/ Inland	n/a	Uncommon visitor	LC
Little tern	*Sterna albifrons*	Coastal/ Inland	n/a	Common visitor	LC
Caspian tern	*Sterna caspia*	Coastal/ Inland	n/a	Common resident	LC
Gull-billed tern	*Sterna nilotica*	Coastal/ Inland	n/a	Rare vagrant	LC
Sandwich tern	*Sterna sandvicensis*	Coastal/ Offshore	Summer	Common visitor	LC
Lesser crested tern	*Sterna bengalensis*	Coastal/ Offshore	Summer	Common visitor	LC
Swift (greater crested) tern	*Sterna bergii*	Coastal	n/a	Common resident	LC
Common tern	*Sterna hirundo*	Coastal/ Offshore	Summer	Common visitor	LC
Sooty tern	*Sterna fuscata*	Offshore	n/a	Uncommon visitor	LC
Whiskered tern	*Chlidonias hybridus*	Coastal/ Inland	n/a	Uncommon resident	LC
White-winged tern	*Chlidonias leucopterus*	Coastal/ Inland	Summer	Common visitor	LC
Lesser noddy	*Anous tenuirostris*	Offshore	n/a	Uncommon visitor	LC
Pomerine jaeger	*Stercorarius pomarinus*	Offshore	n/a	Common visitor	LC
Parasitic jaeger	*Stercorarius parasiticus*	Offshore	n/a	Common visitor	LC
Long-tailed Jaeger	*Stercorarius longicaudus*	Offshore	n/a	Common visitor	LC
Skimmers (Family Rynchopidae)					
African skimmer	*Rhynchops flavirostris*	Coastal/ Inland	n/a	Common resident	NT
Pelicans (Family Pelecanidae)					
Pink-backed pelican	*Pelecanus rufescens*	Coastal/ Inland	n/a	Uncommon resident	LC
Eastern (great) White	*Pelecanus onocrotalus*	Coastal/ Inland	n/a	Common resident	LC

Common Name	Species	Local Distribution	Seasonality	Local Presence	IUCN Listing Status
pelican					
Cormorants (Family Phalacrocoracidae)					
Reed cormorant	*Phalacrocorax africanus*	Coastal/ Inland	n/a	Common resident	LC
White-breasted (great) cormorant	*Phalacrocorax carbo*	Coastal/ Inland	n/a	Common resident	LC

LC = Least Concern; NT = Near Threatened; VU = Vulnerable.

5.2.7. Protected Areas

There are no protected areas under Mozambican regulation within the AMA 1 concession area. The Quirimbas National Park is located 7.8 km from the southern boundary of the Project area, whilst the Mnazi Bay-Rovuma Estuary Marine Park (MBREMP) in Tanzania is located 3 km to the north of the concession area.

The Ministry for the Coordination of Environmental Affairs, under the auspices of the GEF-funded Marine and Coastal Biodiversity Management Project, recently commissioned a study to investigate the possibility of creating a Transfrontier Conservation Area (TFCA) across the Mozambican-Tanzania border to link up with the Mnazi Bay-Rovuma Estuary Marine Park. The study (MICOA, 2007) recommends the creation of a new conservation area in Mozambique (proposed name: the Rovuma/Palma National Reserve). The study also recommends some modifications in the boundaries of the MBREMP to form a contiguous Transfrontier Conservation Area with the proposed conservation area in Mozambique. The limits of the actual and proposed protected areas are shown in **Figure 5-32**.

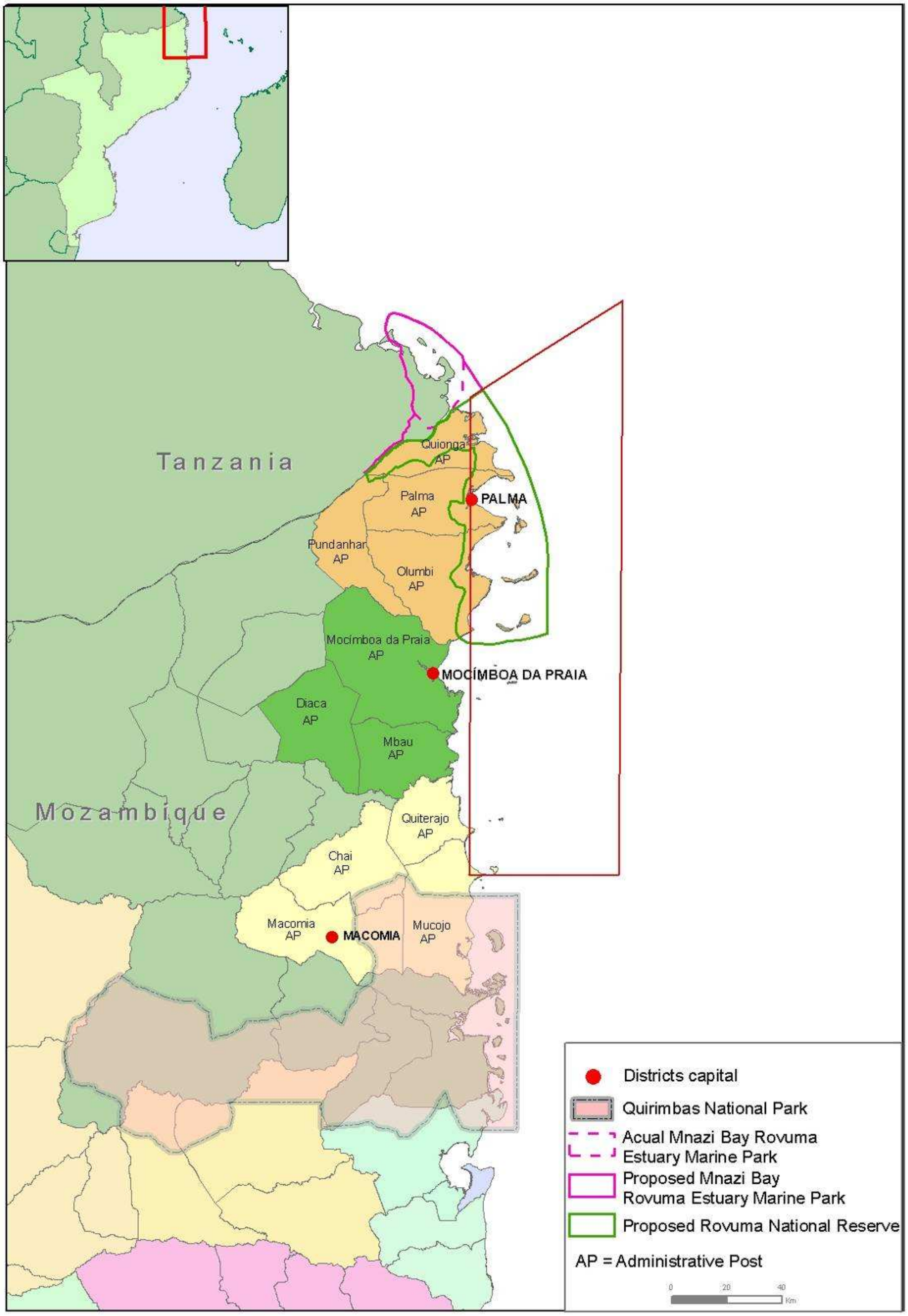


Figure 5-32 Location of actual and proposed conservation areas in relation to the Project area

5.3 DESCRIPTION OF THE RECEIVING SOCIO-ECONOMIC ENVIRONMENT

This section provides an outline of the potentially affected socio-economic environment, by providing a very brief overview of key socio-economic characteristics of the Cabo Delgado Province and the three relevant districts, with detailed descriptions provided on the tourism and artisanal fishing sectors (subsistence and commercial), as these are the activities most likely to be affected by the proposed seismic acquisition.

5.3.1. Geographical layout

As indicated in Section 1, the project area is located in the Cabo Delgado Province in northern Mozambique. While project activities are only to take place offshore, these activities may potentially affect the on-shore socio-economic environment (the mainland as well as the islands of the Quirimbas Archipelago). The study area, therefore, comprises parts of three different districts of the Cabo Delgado Province (**Figure 5-33**), namely, Macomia, Mocimboa da Praia, and Palma. The Cabo Delgado Province has an estimated population of 1,650,270 and covers an area of 82,625 km², with a population density of 19.9 people/km². **Table 5-12** gives an indication as to the population and land area covered by each district.

Table 5-12. Population and geographical size of districts comprising the study area

Area	Population 2005	Size	Population density (people/km²)
Macomia	81,208	4,967 km²	16.3
Mocimboa de Praia	94,197	4,570 km²	20.6
Palma	48,423	3,561 km²	13.6
Total	**233,828**	**13,098 km²**	**---**
Percentage of Province	***14.2%***	***15.8%***	**---**

(INE, 2007)

There are eight islands which fall under the jurisdiction of the Palma District, 10 which fall under the Mocimboa da Praia District, and three which fall administratively under the Macomia District (**Table 5-13**).

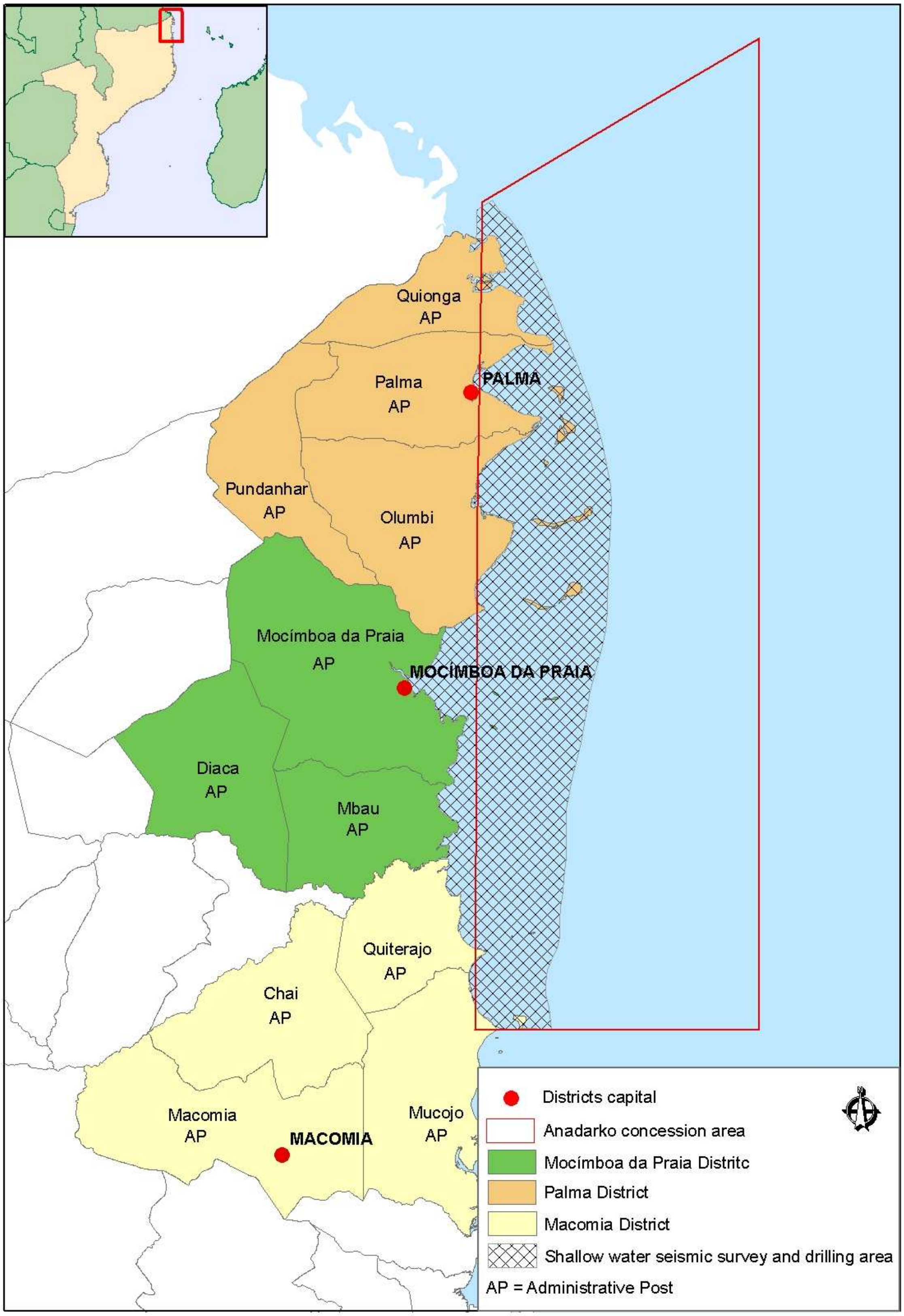


Figure 5-33. AMA1 concession area and shallow water seismic and drilling area in relation to administrative boundaries

Table 5-13. Islands in the study area per district

District	Island
Palma	Quiriamimbi
	Vamizi
	Tecamaje
	Comezi
	Rongui
	Vumba
	Metundo
	Quifuqui
Mocimboa da Praia	Tambuzi
	Muichanga
	Nhonge
	Suavo
	Niuni
	Mejumbe
	Quissanga
	Namadoro
	Muissune
	Quirianhune
Macomia	Macaloe
	Quifula
	Rolas

5.3.2. Institutional and social organisation

<u>Political Structure</u>

The political structure in the study area comprises both formal and traditional authorities, organized in accordance with GOM legislation. The highest level of authority in the Province is the Provincial Governor, who is based in Pemba Cidade (Pemba City). There are 16 districts in the Province, each with the following administrative services:

- District Services of Economic Affairs (Agriculture, Fisheries, Forests, Trade and Industry)
- District Services of District Services of Welfare and Health
- District Services of Education, youth, sport, culture and technology

Other services at distrct level are as follows:

- Planning and Infrastructure
- Fiscal Directorate

- Social Security and labour
- Civil Registration
- Small Scale fisheries development extension station
- Customs and Immigration services
- Police and Public prosecutor

This structure has been recently established under the new Law on Local State Bodies- (Lei dos *Órgãos Locais do Estado*), which stresses the role of the districts in development strategies and implementation of plans. In this approach all activities related to fishing administration, extension and development will be implemented through active district government intervention.

There is a Small Scale Fisheries Development Extension Macomia, Mocimboa da Praia and Palma. Departments such as Tourism and Fisheries have no Government representation at District level, and are governed at the Provincial level.

Each district is headed by a District Administrator, who reports to the Provincial Governor. The Permanent Secretary is the second-in-command to the District Administrator. Each District Administrator coordinates a number of C*hefes dos Posto Administrativos*, who are appointed by the GOM. **Figure 5-34** provides a diagrammatic outline of this institutional structure. *Localidades* are further subdivisions within the authority areas of the *Posto Administrativos,* which fall under *Chefes de Localidade*. Traditional leadership structures known as *Lideres Comunitarios* function below the level of the *Chefe de Posto.* These *Lideres Comunitarios* are appointed according to community criteria, but their position has been formalized through Decree 15/2000, which gives them the authority to make decisions on a range of important community issues.

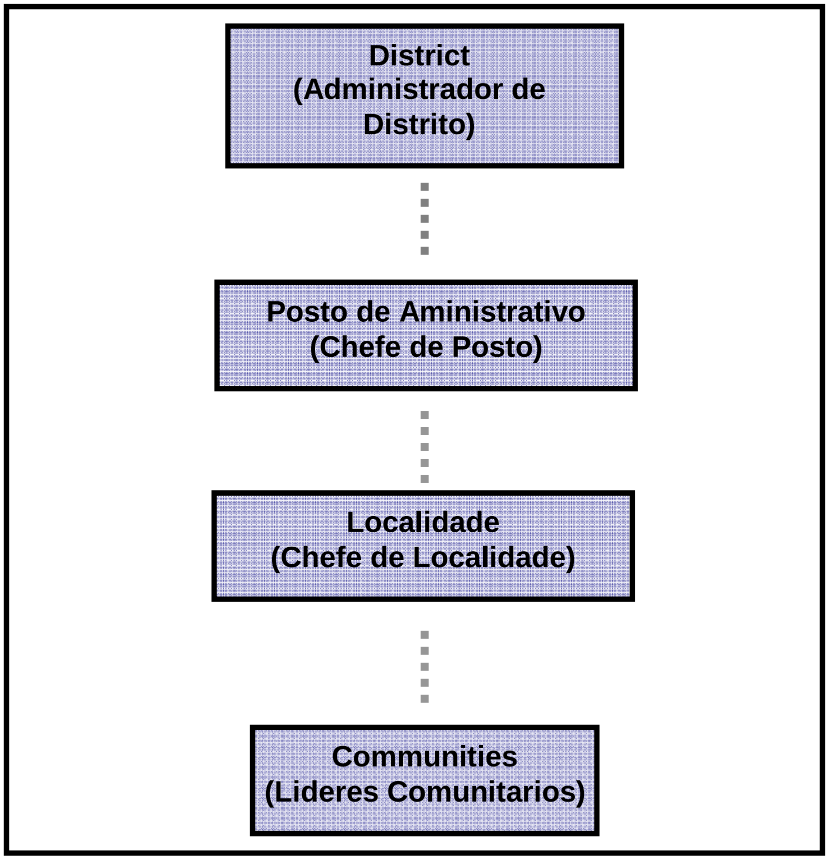


Figure 5-34 Institutional arrangements

Civil society organizations

Very few civil society organizations (CSOs) could be identified in the study area. Reportedly, in the past, more CSOs were active in the area, but most of these groups were dependent on donor funding and once a funding cycle had come to an end, the CSO did too. However, recently, local government started mobilization and extension initiatives which are giving rise to a number of CSOs once again (**Table 5-14**).

Table 5.14 Community based organizations in study area

	Fishers' associations	Agriculture and income generation associations	Fisheries community councils	Finance and credit groups
Palma	6	98	4	4
Mocimboa da Praia	4	22	4	8
Macomia	24	28	3	6
Total	3	148	7	18

Fishers' associations, informal financial services, and the fisheries community councils[7] are the most important CSO's identified in the study area. Most of these groups are funded via local funds (so-called FILLs, which translates as Investment Funds for Local Initiatives), with the aim of income and employment generation. According to local government representatives interviewed, the current CSO strategy has proven successful in that people belonging to CSOs generate and manage their income more effectively when they are organized in associations, rather than on an individual basis. With the technical support from local institutions, these groups have become well organized, with the capacity to generate and manage more profitable businesses.

Social structure

Social structure in fishing settlements varies according to the types of activities practiced, types of fishing activities, level of diversification of income sources, location in relation to the resource base and market, as well as the origin of the households. The owners of the fishing gear belong to a different social class, and are usually wealthy, with a fair amount of socio-economic influence in the community. Similarly, people employed by formal institutions such as teachers, traditional doctors, school headmasters, public service workers, traditional and formal leaders also belong to the different classes. Interestingly, immigrants often belong to the more important social classes. They usually have more access to *modern technologies* and greater investment capital. They earn more income from fishing, as they can fish in the more productive fishing areas, which Mozambican fishers cannot reach.

5.3.3. Demographic characteristics

Cabo Delgado Province

According to the most recent census (2007[8]) the population of Cabo Delgado Province is estimated at 1.63 million, of which 52% are women. The economically active population (15 to 64 years old) comprises approximately 55% of the total population. By far the majority of people (83%) reside in rural areas, leaving only 17% of the population in urban centres.

Districts in the study area

As indicated, the study area falls into three districts (Macomia, Mocimboa da Praia, and Palma), comprising 11 *Posto Administrativos* and 23 *Localidades*.

The total population of the three districts is approximately 223,828 people. **Table 5-12** above outlines the population, area size, and population density of the three districts, while **Table 5-15** gives a breakdown of population figures per *Posto Adminstrativo*.

[8] Not all the information from the 2007 census has been made available yet and, therefore, figures from previous censuses are used where recent information is not yet available.

Data relating to people living on each island is difficult to obtain, as in some cases the data does not exist, and in others, the island population is included with that of a mainland area. As part of the National Population Census of 1997, only Vamizi, Tambuzi, and Muichanga islands (in the study area) were counted separately. Population figures for these three islands are provided in **Table 5-16**.

Table 5-15. Population per District and Posto Administrativo

District	Posto Administrativo	Number of households	Population		
			Male	Female	Total
Macomia	Macomia-Sede	8,191	15,537	16,788	32,325
	Chai	3,941	7,689	8,666	16,355
	Mucujo	6,307	11,199	12,307	23,506
	Quiterajo	2,401	4,646	4,376	9,022
Mocimboa da Praia	Mocimboa -vila	8,500	19,556	21,307	40,863
	Mocimboa-sede	6,632	11,721	12,326	24,047
	Diaca	4,486	8,503	9,285	17,788
	Mbau	2,761	5,646	5,853	11,499
Palma	Palma-sede	6,788	12,879	13,103	25,982
	Olumbe	3,525	6,579	6,161	12,740
	Pundanhar	838	1,636	1,737	3,373
	Quionga	1,867	3,153	3,175	6,328
Total		**56,237**	**108,744**	**115,084**	**223,828**

(INE, 2007 and District Authorities)

Contrary to the National Census, data from the Artisanal Fisheries Census, conducted by the National Institute of Small Scale Fisheries Development (IDPPE) during 2004, suggests that almost all islands are inhabited by fishers living in temporary fishing camps of between 100 and 800 people. According to the IDPPE Census Tambuzi, Vamizi and Muichanga had the highest population numbers (Table 5-16). Migrants from Mocimboa da Praia, Palma, Nampula, and Tanzania inhabit these island camps, which can accommodate as many as 200 households. According to the IDPPE there are approximately 912 of these fishing camps in Cabo Delgado.

Table 5-16. Population and fishers on islands in the study area per district

District	Island	Population (INE census data)	Number of fishers (IDPPE data)
Palma	Quiriamimbi		N/d
	Vamizi	348	> 800
	Tecamaje		< 100
	Comezi		N/d
	Rongui		N/d
	Vumba		< 100
	Metundo		> 300
	Quifuqui		> 200
Mocimboa da Praia	Tambuzi	742	> 300
	Muichanga	52	< 100
	Nhonge		< 100
	Suavo		< 100
	Niuni		< 100
	Mejumbe		< 100
	Quissanga		< 100
	Namadoro		< 100
	Muissune		< 300
	Quirianhune		< 100
Macomia	Macaloe		100 – 200
	Quifula		< 100
	Rolas		< 100

(IDPPE, 2004)

5.3.4. Economic activity and resource use

The majority of the population in the study area are involved in agriculture, fishing, and livestock rearing as key economic activities. Agriculture is the largest of these sectors, and is of specific importance in areas further removed from the coast, although most mainland fishers also practice some form of agriculture. There are two key food and income generation systems in the Cabo Delgado Province:

- The first is composed of dry land farming systems mainly located inland from the study area, and comprises a combination of crop production, livestock rearing, and trading. Rain-fed crop production is susceptible to climatic variability and exposed to risks of prolonged dry seasons. The access to potential markets is poor, and in some areas commercial transactions do not involve money, while in others, Tanzanian currency is used.

- The second system is practiced in the lowland and coastal areas located along the coast and major rivers, such as the Rovuma River. This system consists of a combination of fishing, crop production, livestock rearing, and trading, with fishing being the most important.

The second system is of relevance to the project, as the study area does not include areas of the first.

Artisanal fishing

The SSAFC found that men from the mainland villages in the study area spend approximately 60% of their time catching, processing, and selling fish. Women, who traditionally spend more time on agriculture, spend approximately 40% of their time on these fishing related activities. Soil conditions on the islands are not suitable for agriculture, which is rarely practiced on a larger scale than subsistence vegetable plots. Here, both men and women spend approximately 80% of their time on fishing-related activities.

Artisanal fishing is defined as fishing activities performed by coastal communities, with or without the use of boats (and if used, of which the length is less than 10 m), where the catch is used both for subsistence and commercial purposes. Commercial fishers are defined as fishers who catch fish for the sole purpose of selling, with or without the use of a boat. Subsistence fishing is a noncommercial activity, not for profit generation, but oriented for the procurement of fish for immediate consumption. However, this includes fishers who sell surplus when catch exceeds household demand. However, this is not for profit generation and margins are too small to allow re-investment into fishing gear.

The importance of the role of fishing activities in the livelihoods of people in the study area is further elaborated on in Section 3.6.

Subsistence agriculture

Apart from fishing, subsistence agriculture is the main activity for communities living along the coast. Crops include rice, cassava, millet, maize, sweet potatoes, beans, and coconuts. When possible, two cycles of crops are planted per season. Cultivated areas are situated near villages and near water sources such as rivers, swamps, and lakes. People often have problems with animals such as elephants, antelopes, and baboons raiding and destroying their crops.

On the inhabited islands in the project area, crop production is limited due to poor soil fertility. There are some fields cultivated by residents around the village of Vamizi. There are also some old cultivated areas near the transient fisher camps on the north-eastern and south-eastern sides of the island, and on Rongui and Macaloe Islands, a few areas have also been cleared for crops by transient fishers (Cabo Delgado Biodiversity and Tourism Lda: 2003).

Aquaculture

The Fisheries Master Plan (2008-2017) emphasizes the development of aquaculture in both coastal and interior areas. The Plan also identified suitable and priority areas for aquaculture development in the country, and in Cabo Delgado Province, Pemba, Macomia, and Mecufi were indicated as the most suitable. However, to date, the only form of aquaculture practiced in the Cabo Delgado Province is in the form of seaweed cultivation. The project was initiated in the Messano area (south of Pangane in Macomia district) by a multinational company called Copenhagen Pectin, and later handed over to the Aga Khan Foundation. The seaweed cultivation takes place in water shallower than 6 m deth at high tide and can be located as far as 3 km from the homestead of the "farmer", depending on the bathymetry and coastal configuration. Seaweed is planted, tended to, and harvested during low tide, and seaweed farmers are rarely submerged deeper than hip level. At one stage there were approximately 2,000 households involved in seaweed farming, but according to information obtained during the SSAFC, the project is not fully operational anymore.

Subsistence hunting

In the coastal areas, local communities are mainly fishers, but every village seems to have people who use bows and arrows, or nets, to hunt antelope, small mammals, and birds for meat. Species that are usually not targeted are bushpigs and warthogs, due to religious reasons (Cabo Delgado Biodiversity and Tourism Lda: 2003).´

Use of wild plants

Local communities harvest a large selection of wild plants from their surrounding environment. Some of these, along with their uses, include:

- Wood: firewood, construction, carpentry, tool making.
- Coconut palm leaves: thatching of roofs.
- Bark (especially *Brachystegia* and *Julbernardia* spp): string, rope, and beehives.
- Medicinal plants.
- Gum from *Hymenaea verrucosa*: incense.
- Roots of *Olax dissitiflora*: pounded and used as a white cosmetic face mask.
- Sap of *Hyphaene* palms: palm wine.
- Wild fruits, e.g. *Sclerocarya caffra, Parinari curatellifolia,and Vangueria infausta*.

5.3.5. Tourism and tourism activities in the study area

The Mozambican civil war had an extremely detrimental effect on the tourism industry in the country. In the almost sixteen years since the end of the civil war, a lot of work has been done in order to revive and re-establish the industry. It is, therefore, important to understand the context within which tourism in Mozambique finds itself at present. This section provides background on tourism in Mozambique, the Northern Region, and the study area. The detail provided in the national and regional context is at a level relevant to the project, and does not attempt to provide an exhaustive discussion. However, the local context is based on the information gathered through the baseline surveys as part of TBS and is, therefore, more detailed.

National tourism context

Mozambique is in the early stages of its development as a recognised international tourism destination, and its potential product base remains largely underdeveloped (Ministério do Turismo (MITUR): 2003). This is confirmed by studies conducted by the Instituto Nacional de Estatistica (INE) (National Statistics Institute), together with MITUR, which indicate that the total tourist arrivals nationally during 2001 were 404,100 (INE: 2002). This figure is very low when compared to numbers recorded by other countries in the sub-region, for example 20% less than Tanzania, a country with similar natural characteristics and tourism product lines, but without the proximity and direct road access from South Africa. In comparison, South Africa received six million visitors in 2001 (MITUR: 2004a).

Of the 404,100 tourist[9] arrivals in Mozambique, by far the largest number originated from South Africa (68.3%), followed by Portugal (7.5%), Swaziland (5.9%) and the United Kingdom (UK) (1,5%). The category ‘Other’, i.e. tourists visiting from countries other than the ones mentioned, but with numbers too small to warrant individual mention, comprised 16,7% (INE: 2002). This implies that more than 74% of international tourists to Mozambique are from its two neighboring countries, South Africa and Swaziland, indicating vast room for expansion into the UK and European markets.

Despite its infancy, the tourism sector in Mozambique has been performing well as a prospective investment sector. Tourism accounted for 16% of total investment applications in the country between 1998 and 2002. This makes tourism, with a total investment of US$ 1.3 billion, the third largest sector for investment in Mozambique, after industry (33%) and Energy and Natural Recourses (18%) (MITUR: 2004a).

Recognizing the opportunities for economic growth and job creation through tourism, the GOM created a separate Ministry of Tourism (Ministério do Turismo) (MITUR) in 2000. The responsibility for Conservation Areas, which until then was vested with the Ministry of Agriculture, was transferred to the MITUR in 2001.

National Tourism Policy and Implementation Strategy

The first Mozambican National Tourism Policy was compiled in 1995. This was, however, revised in 2003 through the Tourism Policy and Implementation Strategy (TPIS) (Resolution no. 14 of April 2003). The TPIS provides the platform for the development of the tourism sector in Mozambique. It defines the high-level tourism objectives, identifies the focal points for government intervention, and provides tactical guidelines on how to optimize and make operational its competitive edge. The main objectives of the TPIS are to:

- Develop and position Mozambique as a world-class tourism destination.
- Contribute to employment creation, economic growth and poverty alleviation.

[9] A tourist is defined as an individual spending a finite period of time (more than one night and less than a year) out of his/her usual environment and includes leisure and recreation, business tourists, as well as tourists visiting friends and family (VFR).

- Develop sustainable and responsible tourism.
- Participate in the conservation and protection of biodiversity.
- Preserve cultural values and national pride.
- Enhance quality of life for all the people of Mozambique.

The TPIS identifies 17 Priority Areas for Tourism Investment (PATI), divided into short-term, medium-term, and long-term PATI's. The 'Pemba-Quirimbas Zone' is classified as a short term PATI, and, together with the Ilha de Moçambique Coastal Zone, is the only short term PATI north of Vilanculos (MITUR: 2003).

Strategic Plan for the Development of Tourism in Mozambique (2004 – 2013)

The Strategic Plan for the Development of Tourism in Mozambique (SPDTM) builds upon the TPIS, and serves as the base document for strategic planning processes. It determines the vision for tourism in Mozambique, sets priorities, defines products and markets, and focuses on the PATIs and resources (MITUR: 2004a).

In its SPDTM, MITUR indicates that the vision and strategic planning for tourism in Mozambique can only be achieved realistically in the medium- to long-term. Therefore, the year 2020 has been chosen as the reference-line for the Tourism Vision for Mozambique (MITUR: 2004a).

According to the SPDTM, the Tourism Vision for 2020 is as follows:

- *'By 2020 Mozambique is Africa's most vibrant, dynamic and exotic tourism destination, famous for its outstanding beaches and coastal attractions, exciting eco-tourism products and intriguing culture, welcoming over 4 million tourists a year. Conservation is an integral part of tourism and the combined benefits constitute a significant contribution to National GDP bringing wealth and prosperity to communities across the Country.'*

In order to achieve this vision, the country needs to focus on its resources, which are the inherent strengths of the land, wildlife and natural resources, human resources, man-made, natural, and coastal assets, and natural and cultural heritage, and the tourism attraction value they represent.

One of Mozambique's key resource strengths, highlighted in the SPDTM, is the quality of its beaches and coastal resources, unique to Southern Africa (its so-called 'Blue' product line). This is Mozambique's vast coastline, warm tropical waters, and rich coastal and marine resources. Mozambique should capitalize on this position in product development and marketing, while at the same time conserve and protect its fragile coastal and marine resources as a priority (MITUR: 2004a)

The SPDTM further states that, with regard to tourism markets and product development, Mozambique must concentrate its resources on a few selected markets. Based upon analysis of tourism trends and resource strengths, the following strategic niches have been identified by MITUR (2004a):

- Diving.
- Deep Sea Fishing.
- Hunting.
- Birding.

- Eco-tourism.
- Adventure tourism.
- High-yield 'island' tourism.
- Cultural tourism.

In so doing, Mozambique will aim to actively pursue a mix of target market segments (such as high/medium/low yield, business/leisure, domestic/regional/international), aiming to implement a niche approach towards international markets, focused around the high potential niches of diving, deep-sea fishing, eco-tourism, adventure tourism, birding, cruising, high-yield ´island´ market, and cultural tourism. More mainstream marketing approaches will be used for regional and domestic markets where the main market segments continue to concentrate around sun, sand, sea, and family tourism (MITUR: 2004a).

<u>Mozambique Tourism Anchor Investment Programme</u>

The MITUR, in conjunction with the International Finance Corporation (IFC), has embarked on a project to facilitate the growth of quality tourism investment in Mozambique. The project, called the Mozambique Tourism Anchor Investment Programme (MTAIP), aims to identify, plan, and market key 'anchor' tourism development sites to the investment community, whilst simultaneously clearing the administrative and regulatory constraints to investment. Launched in late 2006, the Anchor Program will run over a three year period (IFC, 2008). On conclusion of the program it will have created:

- Four anchor tourism resorts across the country.
- Approximately 25,000 direct and indirect jobs.
- Approximately US$ 1 billion investment.
- Spin-off business and investment opportunities - the 'anchor effect'.

The implementation of the program is managed jointly by the IFC and the National Tourism Fund (FUTUR), under the auspices of the MITUR. The program is divided into three phases:

- Phase 1: Site selection and detailed program design.
- Phase 2: Development of 'anchor' sites.
- Phase 3: Supply-chain linkages and pro-poor tourism.

Phase 1 was completed in October 2007 and the sites selected include:

- Crusse/Jamali Anchor Site.
  Located in the Nampula Province and includes a number of mainland bays and two small islands a short distance from the Ilha de Moçambique.

- Inhassoro Anchor Site.
  Situated on the mainland overlooking the Bazaruto Archipelago.

- Gilé Anchor Site:

Located in the Gilé Reserve in the Zambezia Province with linkages to two small off-shore islands, Casuarina and Epidendron, approximately 40 km away.

- Maputo Elephant Reserve Anchor Site:
  Situated between Maputo and the South African border and includes a protected area of approximately 800 km².

Thus, the closest project to the study area is located in the Nampula Province, and project activities should not affect it.

<u>Regional context</u>

Mozambique can be divided into three geographical regions, the North (Cabo Delgado, Nampula, and Niassa Provinces), the Centre (Sofala, Manica, Zambézia, and Tete Provinces) and the South (consisting of the provinces of Maputo, Gaza, and Inhambane). Geo-physical characteristics, socio-economic development, and tourism profiles differ between the three regions, and distances between the three regions are significant (with Cabo Delgado Province being in the order of 1,500 km away from Maputo.

As indicated, the study area falls within the Cabo Delgado Province, and is, therefore, located in the Northern Region. This Region is often referred to as Mozambique's relatively unspoilt 'tourism jewel'. It has a deep historical past, rich marine life and the beauty of the Quirimbas Archipelago, the wilderness areas of the Niassa Reserve, and the unique biodiversity of Lake Niassa. All of these aspects have the potential to provide a tourism experience exceptional in both quality and diversity (MITUR: 2003).

The areas of the country visited by tourists appear to be skewed towards the South. Approximately 60% of tourist arrivals were concentrated on Maputo City and the Maputo Province, with the remaining 40% shared by the other 10 provinces (INE: 2002). In 2001, the Provinces of Nampula, Cabo Delgado, and Niassa shared less than 25% of the total registered accommodation units, and less than 10% of total bed nights spent in the country. Some of key reasons for the low number of bed nights are distance, logistics in terms of transport, and poor road infrastructure.

<u>Quirimbas Archipelago as a tourism destination</u>

The Quirimbas Archipelago provides MITUR's so-called 'Blue' product line, and addresses a strategic niche by providing diving, deep sea fishing, eco-tourism, adventure tourism, high-yield 'island' tourism, and cultural tourism.

Despite being in its 'tourism infancy', the Quirimbas Archipelago is rapidly becoming a sought-after international tourism destination. Over the last three years, publications such as the UK London Sunday Times, Condé Nast Traveler, Times (UK), Dive Global, Harpers & Queen (UK), Volta ao Mundo, Paris Match, Observer (UK), and Der Speigel (Germany) have published rave reviews about the archipelago and specific resorts within it. Some of the resorts have been rated as within the top 100 hotels in the world, and among the top 20 international destinations.

According to one of the largest travel agencies in Pemba, there has been a rapid increase in the number of business tourists visiting the Quirimbas Archipelago (when comparing the first four months of 2007 with same period of 2008), while at the same time, numbers of leisure tourists showed only slight variation (**Table 5-17** and **Figures 5-35 to 5-37**). Although the figures in the Table 5-17 are not definitive[10], it provides a certain indication of current tourism trends. As far as the number of leisure tourists is concerned, there appear to be months when the numbers of tourists have decreased between 2007 and 2008. However, seasonality must be borne in mind, e.g. the calendar position of Easter, which usually has a significant influence on March and April bookings. When the totals for March and April combined are compared between the two years, it shows a 26% increase in leisure tourists for these months. Overall, across the four months, there was a 12% increase in leisure tourists.

Based on the figures in **Table 5-17**, it becomes clear that there has been a radical increase in the number of business tourists[11] visiting the area from 2007 to 2008. Again, there are certain months where higher or lower numbers were noted, but the increases per month are all more than 300%, with an overall increase when the four months are compared between 2007 and 2008, of 655%.

The main reason for the extraordinary increase in the number of business tourists can be ascribed to the presence of a number of petroleum exploration companies active in the area. StatoilHydro has established a presence in Pemba and completed their seismic acquisition in 2007, AMA1 and Eni have just completed their respective deep water acquisitions, and Artumas are currently in the process of surveying their on-land area. Business tourism numbers are bound to decrease again after May/June, as all on-going off-shore acquisition would have been temporarily completed or halted due to the restrictions placed on acquisition during the period June to November.

Table 5.17. Number of leisure tourists vs business tourists for the first four months of 2007 and 2008

Year	January			February			March			April		
	Leisure	Business	Total	Leisure	Business	Total	Leisure	Business	Total	Leisure	Business	Total
2007	169	25	**194**	70	0	**70**	45	52	**96**	219	8	**227**
2008	174	171	**345**	55	123	**178**	186	230	**416**	147	118	**265**
Change	+3%	+584%	**+78%**	-21%		**+154%**	+313%	+342%	**+333%**	-33%	+1,375%	**+17%**

10 Albeit from one of the largest, the figures only represent one travel agency's bookings.
11 See definition under previous footnote.

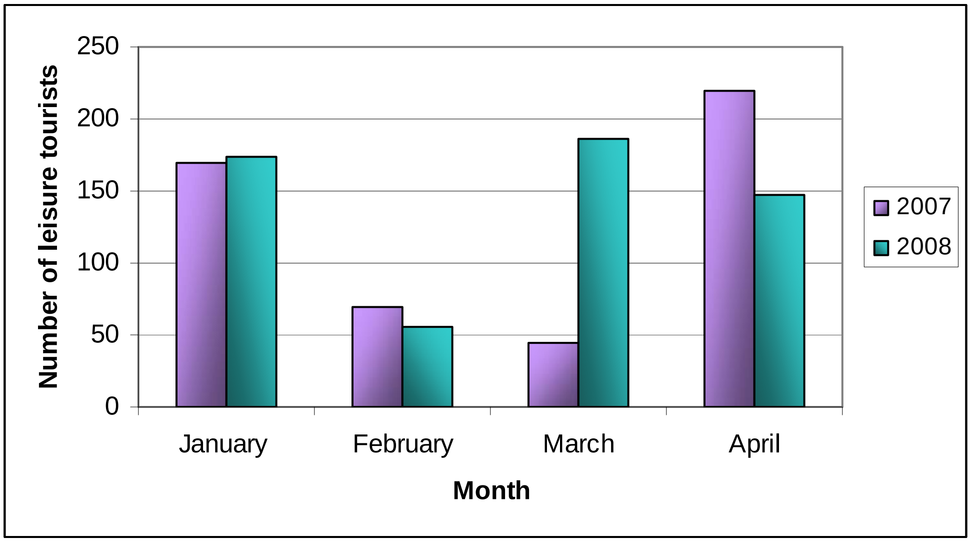


Figure 5-35. Number of leisure tourists for the first four months of 2007 and 2008

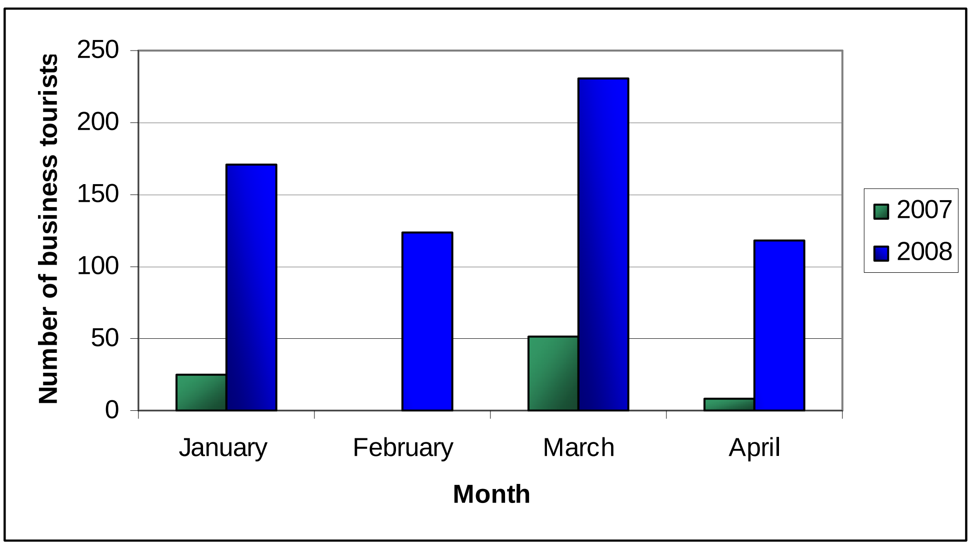


Figure 5-36. Number of business tourists for the first four months of 2007 and 2008

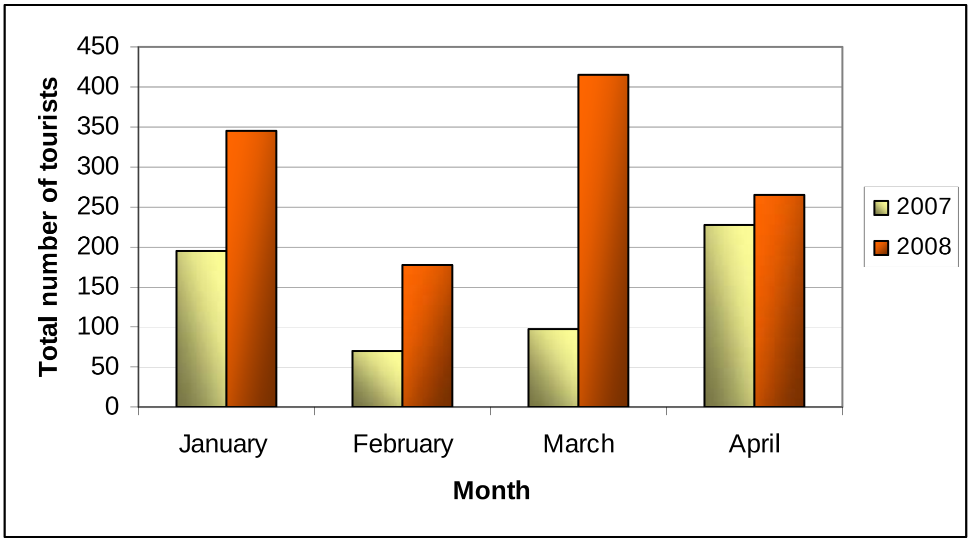


Figure 5.37. Total number of tourists for the first four months of 2007 and 2008

Tourism operators in the study area

Tourism operators in the study area can be divided into two main categories:

- Accommodation Only Operators (AO Operators[12]) - who provide accommodation facilities only. These operators are predominantly based on the mainland.
- Leisure and Accommodation Operators (L&A Operators) - who provide tourism leisure activities, such as diving and sport fishing, as well as accommodation. These operators are predominantly island-based lodge operators.

There are no Leisure Only Operators (LO Operators), providing tourism leisure activities only, e.g. dive charters and fishing charters, in the study area.

Accommodation Only (AO) Operators

Tourism facilities providing accommodation only are very limited in the study area. They are all located either in Mocimboa da Praia or Pangane. These establishments provide accommodation only, with configurations of bed only, bed and breakfast, or full board. **Table 5-18** provides information on AO Operators. There is also a camping ground in Pangane, but it does not provide other formal accommodation. There are no formal accommodation operators in Palma. Although there are a number of establishments calling themselves 'hotels', they are merely restaurant and bar facilities frequented by locals, with no accommodation facilities.

[12] The acronyms for the different types of tourism operators are used for ease of reference.

Table 5-18. Information on AO Operators[13].

Location	Name of operator	Bed nights	Rate/per person (Mtn)[14]	Number of employees	Employee remuneration (Mtn)
Mocimboa da Praia	Pensao Mira-Mar	4	350.00	3	1550.00
	Chez Natalie	9	1850.00	7	1550.00
	Pensão Magido[15]	n/a	n/a	n/a	n/a
Palma	Pensão Residencial Palma	7	500,00 to 750,00	6	1500.00
Pangane	Casa Suk	14	800.00	4	1350.00
	Restaurante/Bar Pangane[16]	1	400.00	2	1300.00

From **Table 5-18** it is clear that there are a limited number of AO Operators in the study area, with a very small number of bed nights available. According to the operators, the average duration of stay for guests is three nights, but a large number of visitors merely pass through, staying a single night. Peak tourist season is largely dependant on the rainy season (November to April), as, at times during the rainy season, it becomes extremely difficult for visitors to reach Mocimboa da Praia and Pangane.

The main countries of origin of guests of AO Operators are Mozambique, Italy, South Africa, and the United Kingdom, with a significant number of guests coming from Mozambique.

<u>Leisure and Accommodation (l&A) Operators</u>

At the time of the study, there were two L&A Operators operational within the study area, namely, the Rani Group and the Maluane Group[17]. The Rani Group currently operates the two island resorts, and the Maluane Group currently has one operational lodge on Vamizi Island, but is in the process of establishing new lodges on Macaloe and Rongui Islands. The location of these resorts is shown in **Figure 5-38**.

[13] Rates quoted in Table 5-19 are for use in this report only and should not be quoted out of context.
[14] Rates quoted in the table were valid for May 2008 and seem to remain fairly fixed throughout the year, with very little seasonal fluctuation.
[15] The whole guesthouse is currently permanently rented by a road maintenance company on a long term rental agreement.
[16] Also provides camping facilities.
[17] It is important to note that there are number of new lodges currently being constructed on some of the islands. These were not operational at the time of the study, and are therefore included in Section 3.4.6 below.

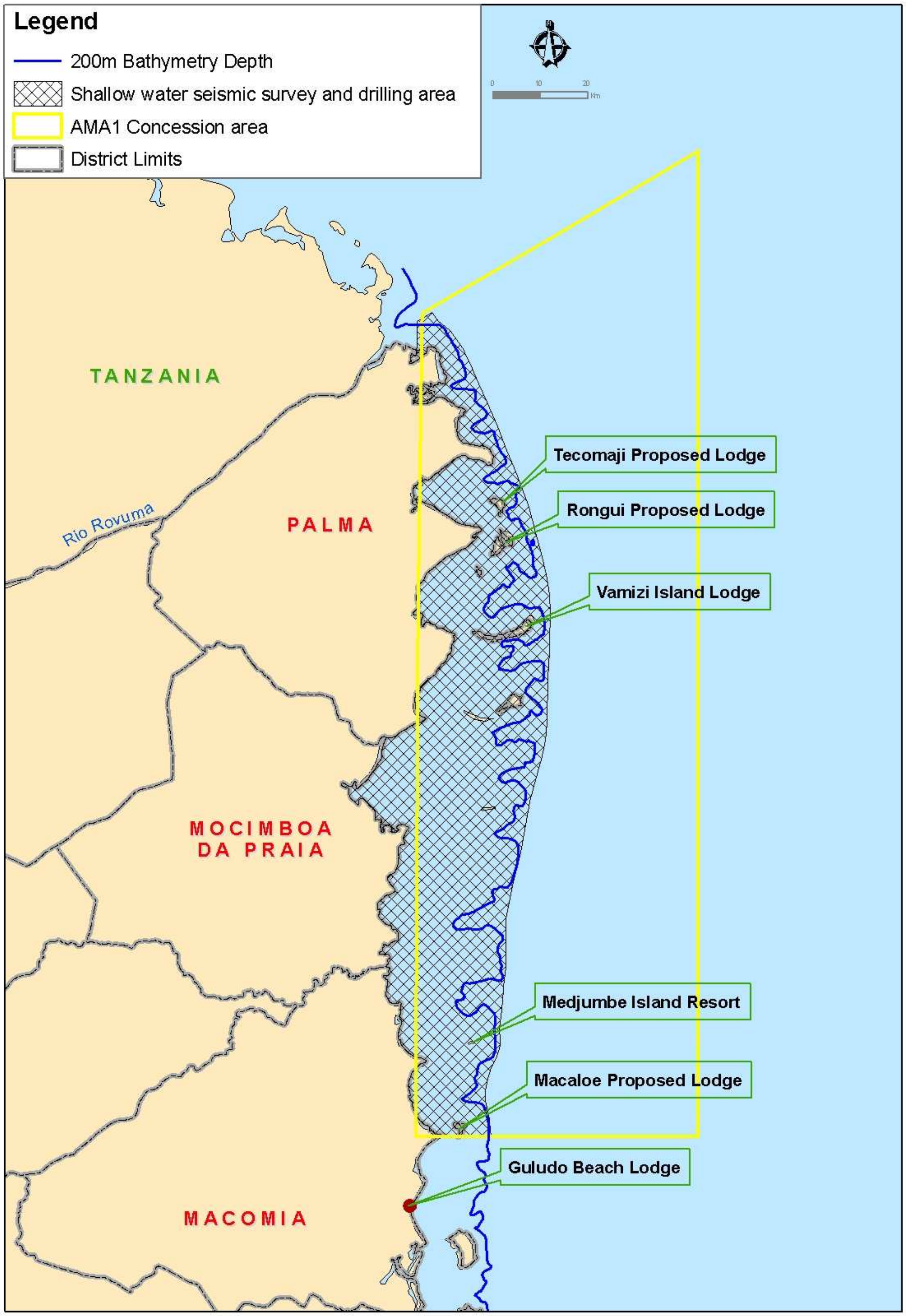


Figure 5-38. Location of actual and porposed resorts

Table 5-19 outlines the number of bed nights and average duration of stay for guests visiting these lodges. According to the operators, peak occupancy seasons are predominantly December to January, and again during March and/or April, depending on where the Easter weekend falls on the calendar. June to November is often less busy than during these two periods, but there are still a fair number of guests. Most of the lodges have not been operational very long e.g. Vamizi Lodge opened in December 2005, and Medjumbe Lodge early in 2006. However, occupancy levels have increased significantly over the past two years, from averages of between 60% and 70% during previous peak seasons, to almost 100% during the most recent season. This is indicative of the Quirimbas becoming a more well known and popular destination, and that operators' marketing strategies are paying off. It would also appear to indicate that the hydro-carbon exploration which has taken place in the area over the past three years, has not had any significant effect on tourism operators to date.

Table 5-19. Bed nights, occupancy and duration of stay at L&A Operators

Operator	Bed nights available	Bed nights per month	Average duration of stay (nights)
Maluane Group	24	720	7
Rani Group	78	2,371	5
Total	**102**	**3,091**	**(Average: 6)**

The main countries of origin of guests visiting L&A facilities are the United Kingdom, Europe (predominantly Italy), South Africa, and Mozambique. South Africans and Mozambicans using these facilities make up a fairly small portion of annual visitors, when compared to the composition of visitors to other parts of the country.

Although all L&A Operators reported steady increases in their occupation numbers, it would appear as if these operators are not affected by the increase in business tourism. A reasonable explanation is that they tend to provide a high-end, luxury retreat, at a level not really required by the average business tourist.

5.3.5.1. Employment, Wages and Local Purchases

Employment, wages, and local purchases are dealt with separately from the preceding discussion, since a number of calculations based on multipliers, as well as certain extrapolations, are made. These are grouped together for ease of comparison.

Based on information provided by L&A Operators, there are a total of 322 people permanently employed and 46 people seasonally employed at their lodges (**Table 5-20**). Approximately 84% of the permanent employees are local, that is from Cabo Delgado Province, and mostly from surrounding villages and settlements. The other 16% comprises Mozambicans from elsewhere in the country, and expatriates.

According to TechnoServe, a Non Governmental Organization (Rose, M. Personal Communication), the average multiplier that is used to calculate indirect employment opportunities for the tourism industry in the area is based on a ration of 1:2, i.e. two indirect employment opportunities for every one direct opportunity. These calculations are done on the total number of employees, regardless of their origin. However, due to the small number of AO Operators, as well as the small scale on which they operate, these are not included in the calculations.

Table 5-20. Direct (permanent and seasonal) and indirect employment provided by L&A Operators at their lodges

Operator	Permanent employees		Seasonal employees	Indirect opportunities[18]	Total (perm +indirect)
	Local employees	Other[19]			
Maluane Group	94	16	25	220	355
Rani Group	130	25	21	310	486
Total	**224**	**41**	**46**	**550**	**841**

According to Techno Serve (Rose, M. Personal Communication), the dependency ratio used for the area can be as high as 1:20. This implies that one salary earned by a local employee could potentially contribute to the support up to 20 people.

Using only the local component of direct permanent employees for the dependency ratio calculation[20], these 224 salaries potentially contribute to the support up to 4,480 people. However, indirect employment opportunities are seen to be predominantly local, thus the 550 indirect employment opportunities are estimated to support up to 11,000 people. Thus, when the numbers of people potentially supported by direct local employees are added to the total number of people potentially supported by indirect employees, it calculates to 15,480 people. This implies that the tourism industry in the study area potentially contributes to the support of up to 15,480 people. However, it is very important to understand that in most instances, these salaries contribute to the support of an individual, but does not become the sole source of the individual it supports' livelihood. Most people in the study area are involved in a range of subsistence agriculture and fishing activities. However, the general population in the study area is poor and formal employment levels are low, and thus, one salary goes a long way to contribute cash support to a number of individuals.

Based on information indicated in **Tables 5-20** and **5-21**, it can be calculated that the number of staff available per bed night is essentially 1:2.6, i.e. 2.6 staff members per guest.

[18] Based on the total number of permanent employees.
[19] 'Other' refers to Mozambicans from elsewhere in the country, as well as expatriates.
[20] Mozambicans from elsewhere in the country may not support the same range of people as locals.

The total amounts reportedly spent annually by L&A Operators on purchases and wages are outlined in **Table 5-21**[21]. This shows that these operators spend approximately US$ 1,166,192.00 in the study area per annum, which implies an average of US$ 97,182.00 per month.

Table 5-21. Total annual local[22] wages and purchases by L&A Operators

Local wages	Local purchases	Total
US$ 1,055,760	US$ 110,432.00	US$ 1,166,192.00

5.3.5.2. Leisure activities provided in the study area

The L&A Operators provide a range of recreational activities to guests. These include:

- Scuba diving and snorkeling.
- Surf- and fly-fishing.
- Game/Offshore sport fishing.
- Whale watching.
- Cultural and historical tours.

<u>Scuba Diving and Snorkeling</u>

Of all the recreational activities, diving and snorkeling will potentially be most affected by the proposed exploration. Snorkeling takes place around the islands, and on reefs and banks in between the islands. According to L&A Operators, the main scuba diving season coincides with the peak tourism season between December and April. An average of three to five dives take place per operator per day, with an average of between four and six divers per dive. The majority of dives take place in water with a depth of less than 20 meters, since depths greater than this are usually limited to advanced divers. **Table 5-22** provides some examples of dive sites and depths in the vicinity of Vamizi and Rongui Islands. **Figure 5-39** outlines some other dive sites in the study area.

[21] The amounts given are aggregated from actual amounts provided by the L&A Operators.
[22] Excluding expatriates and people from elsewhere in Mozambique.

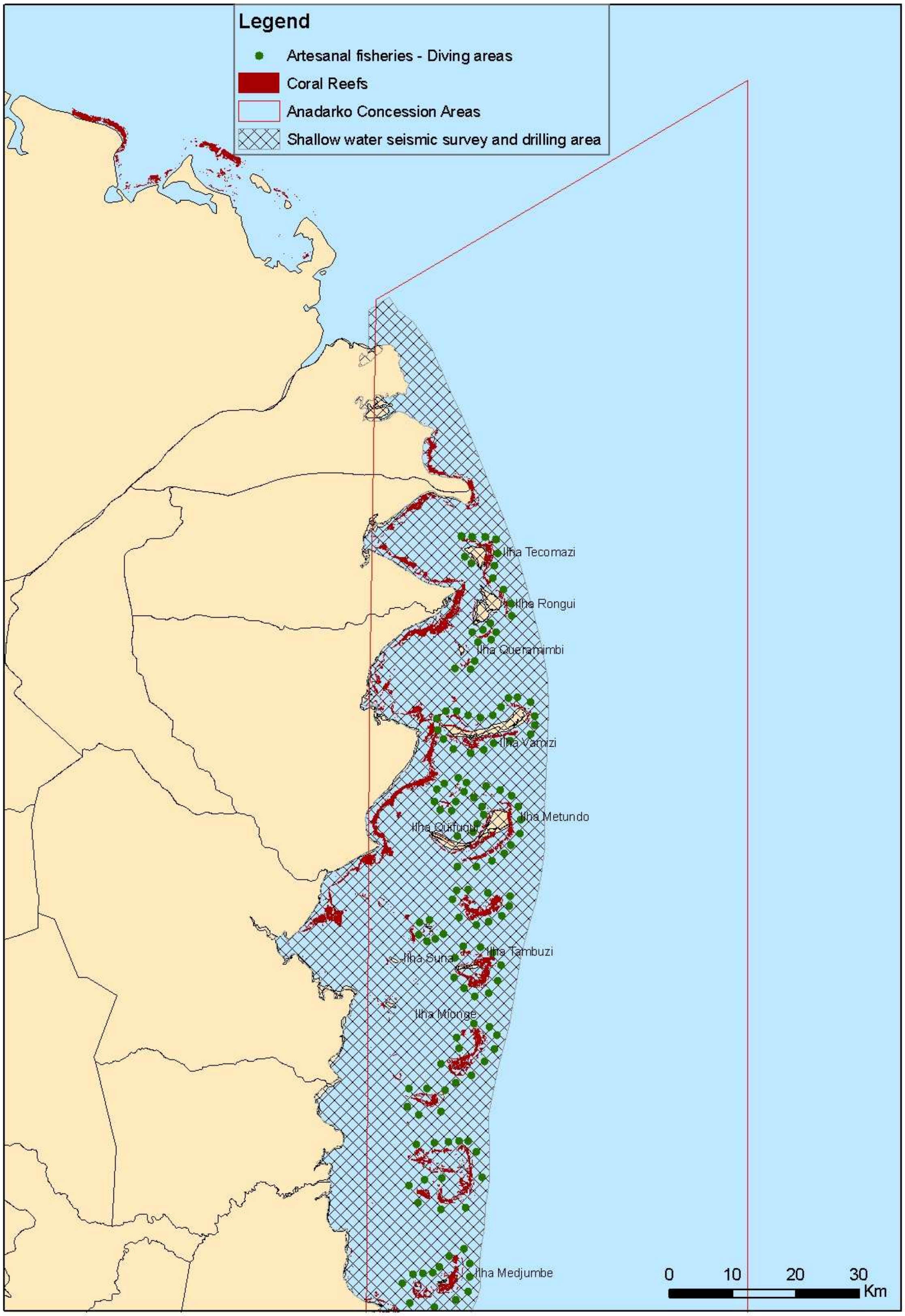


Figure 5-39 Frequented diving and artisanal fishing sites

Table 5-22. Selected dive sites in the vicinity of Vamizi and Rongui Islands

Dive site	Maximum Depth
Makunga	8
Turtle Lounge	14
Skunk Alley	18
Chomnix Express	18
Ponta Papagaio	18
Lettuce Garden	18
Serena's Hills*	25
Hangover*	25
Tuki Point*	35
Cave Wall*	28
The Craic*	35
Neptune's Arm*	35
Wall of China*	35

* For advanced divers only.

<u>Recreational Sport Fishing</u>

All L&A Operators cater for offshore sport fishing. The furthest any of the operators go is to the São Lázaro Bank, approximately 42 km to the east of the mainland (reportedly some of the best sport fishing in the world) (MITUR, 2004b). However, due to the distance and associated costs involved, trips to the São Lázaro Bank are seldom undertaken from the study area.

Most sport fishing activities take place between 3 and 15 nautical miles offshore, with the majority of fishing trips moving in a north/south or south/north direction along the archipelago, rather than far out to sea.

5.3.5.3. Planned Development or Extension

<u>Tourism Operator Developments</u>

As indicated earlier, the tourism industry in the study area is in its infancy. There are numerous developments that are at various stages in the planning process. These include, but are not limited to:

- Quifula Island – An international private developer is currently building six 2-sleeper bungalows on the island, and eight more on the mainland directly opposite the island (just south of Pangane).

- Macaloe Island – The Maluane Group (who operates Vamizi Island to the north of the study area) is planning one of the largest investments in the Quirimbas to date. The aim is to become operational during 2009.

- Vumba Island – A Mozambican private developer is currently building six bungalows, four 2-sleepers and two 4-sleepers, on the island.

- Quisibo Island – A South African-based tourism group is intending to develop tourism facilities on the island, but is still in negotiations with the local inhabitants.

- Mogondula Island – The operator of Ibo Island Lodge has secured a concession for the island, and plans to develop a 20 bed, high-end, luxury lodge.

- Rongui Island – The Maluane Group is also planning a small lodge on Rongui Island. Six bungalows with 12 to 24 beds are planned.

- Tecomaji – A group of South African developers are building a fairly large development, initially with five large luxury chalets (4 to 6-sleepers), with plans to extend this up to 14 luxury chalets.

Completion of developments currently underway on Vumba, Tecomaji, Quifula, and Tambuzi are all aimed at December 2008 or early 2009. Thus, although no more information than the number of bed nights is currently available, these developments could potentially be affected by the drilling project early in 2009.

This implies that by the time the project is implemented, there could be at least an additional 2,250 bed nights per month available on islands in the study area, which would effectively increase the number of available bed nights by more than 60%.

Sale of Island Plots to Private Investors

The Maluane Group has embarked on a unique concept in the study area by making a number of plots on their various islands of operation available for purchase by private investors. Each plot is 2.5 ha in size and all have sea frontage. On each of Vamizi and Rongui Islands, 48 plots have been made available with a further 90 on Macaloe. Plots are valued between US$ 4 million and US$ 5 million. At the time of the study, sales had already started with 10 plots on Rongui and 12 on Vamizi being sold.

5.3.5.4. Tourism Associations

In February 2007, the Cabo Delgado Tourism Association (CDTUR) was established, effectively replacing the Quirimbas Tourism Association (QTA) (established in 2006 by a number of larger tourism operators in the study area). At present CDTUR has in the order of 30 members, including the larger operators, as well as a number of smaller lodges and guesthouses. The main objectives of CDTUR are to promote the province, especially the Quirimbas, as a destination, promote long-term investment, and look after the interests of its members.

5.3.6. Artisanal fisheries and fishing activities in the study area

Fish is the second largest single export from Mozambique, after aluminum, and accounts for 10% to 15% of all exports. It constitutes approximately 1.5% of Gross Domestic Product (GDP). According to World Bank estimates, income from natural resources in Mozambique will increase annually from "…US$30 million to US$67 million until the year of 2015 if development and fiscal policies are effectively implemented." (World Bank: 2005).

Fishing activities in Mozambique can be classified into three categories:

- Artisanal fishing by communities along the coast and around inland water bodies (as outlined under Section 3.4.1). Catches are used for both subsistence and sale (see distinction between subsistence and commercial artisanal fishers under Section 1.3).
- Semi-industrial fishing by intermediate size boats, mainly involved in shallow-water shrimp fisheries offshore, and Kapenta fisheries on Cahora Bassa Dam. Catches are used for both local consumption and export.
- Industrial fishing with larger vessels fishing for shallow water shrimp and fish species in deeper waters. Catches are used mainly for export.

Artisanal fishers yield in the order of 70,000 tons of fish per year, while semi-industrial and industrial fleets yield approximately 11,500 tons and 10,000 tons, respectively.[23] Artisanal fishing provides an important source of animal protein and income, especially to people living close to the coast. As indicated earlier, there are more than 26,000 people involved in artisanal fishing in the Cabo Delgado Province (**Table 5-23** provides a breakdown according to the means of fishing).

Table 5-23. Means of fishing used by artisanal fishers in Cabo Delgado Province

Description	Number	Percentage of total
Fishers using boats	15,875	59%
Fishers without boats	3,399	13%
Artisanal divers	1,399	5%
Collectors/gatherers	6,039	23%
Total	**26,712**	**100%**

(IDPPE: 2004).

Based on more recent studies by the IDPPE (2007), there are approximately 12,130 artisanal fishers in the coastal communities comprising the study area (**Table 5-24**). Of these, 9,044 (almost 75%) are subsistence fishers.

23 The shallow-water shrimp fisheries are, in commercial terms, the most important, with an export of 8,000 tons, and a gross annual value of US$70 million (NORAD, 1999).

Table 5-24. Numbers of artisanal fishers in the study area

District	Total number of fishers	Commercial fishers	Subsistence fishers
Macomia	3,407	881	2,526
Mocimboa da Praia	3,049	678	2,371
Palma	5,674	1,527	4,147
TOTAL	**12,130**	**3,086**	**9,044**

(IDPPE, 2007)

5.3.6.1. Fisheries management and institutional issues

The '*Master Plan for the Fisheries Sector*' (MPFS), compiled by the Ministério das Pescas (MdP) (Ministry of Fisheries) in 1996, set three key objectives for the industry:

- Improvement of the domestic supply of fish, in order to make up for a part of the country's food deficit.
- Increased net foreign exchange earnings for the sector.
- Raised standard of living for the fishing communities.

The legal basis of Mozambican fisheries is provided in the Fisheries Law (Law 3/90) of 1990, by which the regulations of Marine Fisheries (Decree 16/96) was approved in 1996. Flowing from this, the main decrees and resolutions currently in force are:

- Presidential decree 6/2000, concerning the nature, objectives, attributes, and competence of MdP.
- The Fisheries Law (3/90).
- Council of Ministers' Decree 37/90, concerning regulation of fisheries (later amended by Resolution 16/96 for marine fisheries, but still in force for freshwater fisheries).
- Council of Ministers' Decree 11/96, concerning fishery policy and implementation strategy.
- Council of Ministers' Decree 16/96, concerning regulation of marine fisheries.
- Council of Ministers' Decree 51/99, concerning recreation and sport fishing.

In the Cabo Delgado Province the licensing of fisheries is administered by the Provincial Department of Fisheries. It is responsible for the control of the fisheries sector, in collaboration with the Maritime Administration. However, these agencies are poorly represented outside the provincial capital, and incidences of illegal fishing are, therefore, common. In the Quirimbas Archipelago, arrangements for the co-management of fisheries have been introduced in coordination with the Provincial Department of Fisheries, Maritime Administration, and the IDPPE. This implies community and local authority involvement in fisheries and the management of other natural resources. These co-management arrangements have been introduced, based on the concepts outlined in the MPFS. According to this Plan, the fisheries co-management arrangements are headed by the National Fisheries Administration

Commission (NFAC), and implemented at provincial level by the Provincial Co-management Committee (PCC), chaired by the Provincial Directorate of Fisheries. The Fisheries Community Councils (FCC) form the main fisheries social mobilization bodies at community level (**Table 5-25**). The IDPPE is currently managing a project among fishing communities along the coast called *Projecto da Pesca Artisanal Norte Nampula e Cabo Delgado* (PPANCD), which is financed by the African Development Bank. The backbone of the project is provision of IDPPE extension officers, deployed in coastal *Localidades* of the Quirimbas Archipelago, which were instrumental in the establishment of FCCs. **Table 5-26** indicates the number of IDPPE extension officers in the study area, in terms of the *Localidades* where they are active.

In line with the Master Plan, the main aim of the IDPPE project is the mobilization of the fishing communities towards the co-management of fisheries resources in the archipelago. In the process, the FCCs have been established, which are composed of community leaders, fishers using different types of fishing gear, women, and youth residing in fishing villages. The objective of each of these committees is to contribute towards the efficient management of the fishing resources in their respective areas of jurisdiction by, *inter alia*, mobilizing and sensitizing fishers about the need to use fishing material and equipment that enable sustainable use of coastal marine resources.

Table 5-25. Fisheries co-management structure

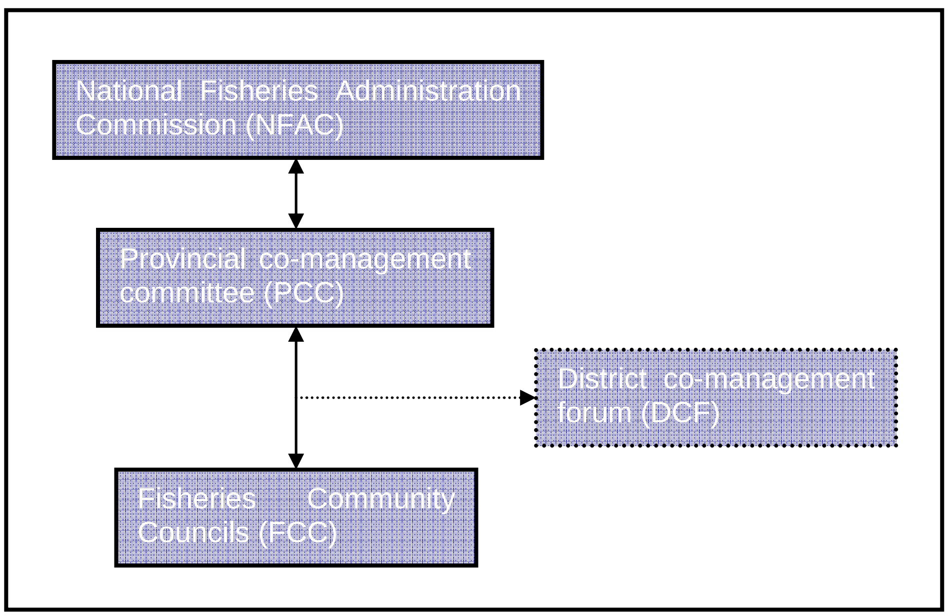


Table 5-26. IDPPE extension officers in the study area

District	Posto administrativo	Localidade	Number of IDPPE Extension officers
Palma	Olumbi	Olumbi	1
	Palma-sede	Palma-sede	2
		Quirinde	1
Mocimboa da Praia	Mocimboa-sede	Mocimboa-sede	2
		Ulo	1
		Malinde	1
Macomia	Mucojo	Pangane	1
		Darumba	1
Total			**10**

5.3.6.2. Fish species caught and catch grading

The most important types of catch traded in the Cabo Delgado Province are fish, octopus (*Octopus spp*), oyster (*Saccostrea cucullata* and *Striostrea margaritacea*), and Sea cucumber (*Holothuria* spp). The fish is classified in First, Second, and Third Grades. First Grade fish can be between 20 cm and 40 cm length and between 0.5 and 4 kg in weight. The most important species in the First Grade group are *Epinephelus spp* and *Cephalopholis spp*, snappers (*Lutjanus spp*), sweetlips *(Plectorinhus spp.*), goatfish (*Parupeneus* spp), grunters (*Pomadasys kaakari*), and rabbit fish (*Siganus* spp). Second Grade fish comprises schad (*Decapterus spp*), fuziliers (*Pterocaesio tile*), barracudas (*Sphyraena* spp), and needlefish (*Ablennes hians*). Sea cucumbers (*holothuria*) are mostly captured by artisanal divers and can be also classified in First, Second and Third Grades. Catch can be sold in four forms, i.e. sun-dried, salt-dried, smoked, and fresh. Some oyster, octopus and sea cucumbers (*holothuria*) are also sold fresh or dried. Salt-drying fish is the most common practice, and also comprises First, Second, and Third Grade species.

A seasonal calendar of the species caught was compiled by the Socio-economic Study of Artisanal Fishing Communities (SSAFC, 2008). It showed that there are species in the study area which are captured at the same volumes through the year. These include fuziliers, needlefish, and rabbit fish (**Table 5-27**). Other species show relatively high catch volumes during the rainy season. August and September were mentioned as being the poorest catch months.

Table 5-27. Seasonal calendar of the most important species captured in the study area

Species			Rainy season				Dry season						Rainy season	
Scientific name	**Portuguese name**	**English name**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**June**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Pomadasys kaakan	Peixe Pedra	Javelin grunter	•••••	•••••	•••••	•••	••	••	••	•	•	•••	•••••	•••••
Caranx hippos	Peixe Xareu	Jack/trevally	•••••	•••••	•••••	•••	••	••	••	•	•	•••	•••••	•••••
Sardinops ocellta	Peixe Sardinhas	Sardines /pilchards	•••••	•••••	•••••	•••	••	••	••	•	•	•••	•••••	•••••
Pterocaesio tile	Peixe Fuzileiro	Fuziliers	•••••	•••••	•••••	•••••	•••••	•••••	•••••	•••••	•••••	•••••	•••••	•••••
Ablennes hians	Peixe-agulha	Needlefish	•••••	•••••	•••••	•••••	•••••	•••••	•••••	•••••	•••••	•••••	•••••	•••••
Siganus spp	Peixe Coelho	Rabbitfish	•••••	•••••	•••••	•••••	•••••	•••••	•••••	•••••	•••••	•••••	•••••	•••••
Sillago	Pescada		•••••	•••••	•••••	•••••	•••••	•••••	•••••	•••••	•••••	•••••	•••••	•••••
Lethrinus. Nebulosus	Peixe Ladrão	Spangled Emperor	•••••	•••••	•••••	•••	••	••	••	•	•	•••	•••••	•••••
Decapeturus	Peixe Carapau	Scadfish	•••••	•••••	•••••	•••	••	••	••	•	•	•••	•••••	•••••
Stegostoma fasciatum	Tubarão	Shark	•••••	•••••	•••••	•••	••	••	••	•	•	•••	•••••	•••••
Panulirus Argus	Lagosta	Lobster	•••••	•••••	•••••	•••	••	••	••	•	•	•••	•••••	•••••
Anemia falciforme	Lula	Squid	•••••	•••••	•••••	•••	••	••	••	•	•	•••	•••••	•••••
Holothuria spp	Holoturias	Sea cucumber	•••••	•••••	•••••	•••••	•••••	•••••	•••••	•••••	•••••	•••••	•••••	•••••
Octopus	Octopus	Polvo	•••••	•••••	•••••	•••	••	••	••	•	•	•••	•••••	•••••
Pyromaia tuberculata	Caranguejo	Crabs	•••••	•••••	•••••	•••	••	••	••	•	•	•••	•••••	•••••
Panulirus Argus	Lagosta	Lobster	•••••	•••••	•••••	•••	••	••	••	•	•	•••	•••••	•••••
	Shrimp		•••••	•••••	•••••	•••	••	••	••	•	•	•••	•••••	•••••
Ancathobatis	Raia	Rays/legskate	•••••	•••••	•••••	•••	••	••	••	•	•	•••	•••••	•••••

(“••••• “ = high catch volumes / ••• = Moderate catch volumes / •• = Low catch volumes / • = Very low catch volumes)

5.3.6.3. Subsistence artisanal fisheries

The main purpose of subsistence artisanal fishers is to obtain the requirements for immediate survival, and not the accumulation of wealth. As indicated, distinction is made between fishers who produce for immediate consumption only, and those who sell the surplus. The first group is mainly composed of women, while the other is composed predominantly of youths and adult men. Although often perceived as an isolated economy, subsistence production interacts with commercial artisanal production through the labor market. For example, subsistence fishers can be employed by commercial artisanal fishers as part-time workers. Thus, changes in the market systems will indirectly affect both commercial and subsistence artisanal fishers.

Gear Types

The majority of subsistence artisanal fishers do not make use of boats in their fishing activities and their fishing gear is mostly very rudimentary. Subsistence artisanal fishers usually operate in areas close to their homes e.g. next to estuaries, and over coral reefs and sand banks. There are, however, subsistence fishers (for example fishers making use of traps or harpoons) who migrate to the islands using the commercial fishing or transport boats.[24] The most important fishing gear used by subsistence artisanal fishers in the study area is outlined in **Table 5-28**.

[24] On average, they may pay the transport in Meticais (15 Mt) or in fish (1.5 kg of fish) per trip. They can remain on the islands for almost a week, fishing or collecting fish resources in the areas around the islands.

Table 5-28. Fishing gear used by the subsistence artisanal fishers in the study area

	Traps	Gamboa	Hand line (no boat)	Harpoon	Collectors	Other	Total
Macomia (Total)	462	39	453	548	1,024		2,526
Women	382	32	-	193	514	-	1,121
Men	80	7	453	355	510	-	1,405
Mocimboa da Praia (Total)	431	94	348	405	1,067	26	2,371
Women	265	34	-	139	219		657
Men	166	60	348	266	848	26	1,714
Palma (Total)	699	279	433	693	2,016	27	4,147
Women	463	52	-	202	841		1,558
Men	236	227	433	491	1,175	27	2,589
Study area (Total)	1,592	412	1,234	1,646	4,107	53	9,044
Women	1,110	118	-	534	1,574	-	3,336
Men	482	294	1,234	1,112	2,533	-	5,655
Total Province	**3,924**	**3,924**	**2,765**	**2,878**	**7,260**	**298**	**21,049**

(IDPPE, 2007) (Preliminary data)

Traps

Approximately 18% of subsistence artisanal fishers in the study area make use of traps. Traps are usually fishing nets used by both men and women. These are often mosquito nets which are used to capture third grade fish, as well as small shrimp. Nets can be purchased at local markets, and cost approximately 250 Mt per length (approximately 6m). Trap fishers operate along the shore line, or in areas close to the coral reefs, estuaries, and mangroves. The SSAFC identified traps in both mainland and island fishing centers.

The most important species captured by trap fishers are outlined in **Table 5-29**. SSAFC observations showed that most of the species indicated in the table were captured in a juvenile state. **Table 5-29** also indicates the market value of the species caught. These fish are caught as mixed bags, and a good day's catch is in the order of 70 kg of fish. Thus, based on the values in **Table 5-29**, a trap fisher can generate between Mt 525.00 and Mt 2,100.00 on a good fishing day, depending on species composition of the catch.

Table 5-29. Main species captured by the traps and their market value

Scientific name	Common name	Market price (Mt/kg)	
		Fresh	Sun-dried
Sardinops ocellta	Sardines /pilchards	7.5	25
Siganus spp	Rabbit Fish	10	30
Lethrinus. Nebulosus	Spangled Emperor	10	30
	Shrimp	12	25

According to the focus groups as part of the SSAFC, the larger traps are up to 20 m to 30 m in length, and an average of six people are involved with such a trap. These are often women, and usually wives of commercial artisanal fishers. In some instances, these groups are even organized as informal associations. In these instances, approximately 60% of the catch is divided among the 'association' members for immediate consumption. The remaining 40% is sold, and the earnings go towards 'association' savings. If the group is not organized as an association, the whole catch is sold, and the income is shared among those involved. The SSAFC found no evidence of earnings being invested for business expansion among these operators.

<u>Harpoons and Hand Lines</u>

Harpoon and hand line fishers comprise 18% and 14% of the total subsistence artisanal fishers in the study area, respectively. Unlike traps, both gear types are used by individuals. No boats are used, and fishers operate along the shore line in waters between 0.5 m and 1 m deep.

Most subsistence hand line fishers are youths, who fish on a part-time basis. No reliable information regarding daily catch could be obtained, but Focus Groups indicated that a good fishing day yields no more than 15 kg of small fishes of mixed species.

Harpoon fishers appear to be more specialized, although their capacity to generate income and investment remains low. Some first grade fish are caught, although the main target species are *Cephalopods*, *Holothuria spp* (Sea cucumbers), and *Pyromaia tuberculata* (Spider crabs). The maximum catch on a good fishing day is estimated at around 20 kg, with most of the catch sold as fresh fish. **Table 5-29** shows the key species caught by subsistence artisanal harpoon fishers, as well as the potential fresh market value of each. Based on the amounts in **Table 5-30**, a harpoon fisher could generate between Mt 240.00 and Mt 1,600.00 per day, depending on the mix of species caught, although it needs to be borne in mind that an individual harpoon fisher is unlikely to catch 20 kg of Sea cucumber in a single day. This means that the maximum daily amount could be lower.

Table 5-30. Selected species captured by harpoons

SCIENTIFIC DESCRIPTION	COMMON NAME	PRICE (MT/KG)
Pomadasys kaakan	Javelin grunter	25.0
Cephalopods	Squid	12
Holothuria spp	Sea cucumbers	80
Decapod crustaceans	Crabs	15

Collectors

Collectors are fishers who do not make use of fishing gear or boats. They mainly operate individually during the low water spring tides (*mare vazante).* In some areas (Macomia and Palma), the collectors tend to be more specialized. Some of them collect mainly crabs, while others collect sea cucumbers and oysters. The sea cucumber and oyster collectors sell their harvest mainly at local markets. However, there are some who transport sun dried sea cucumbers and oysters to the larger towns such as Mocimboa da Praia and Macomia. The maximum catches per type of collector, as well as the price of the catches, are indicated in **Table 5-31**. Based on the amounts outlined in **Table 5-31**, collectors could earn between Mt 300.00 and Mt 4,000.00 per day.

Table 5-31. Catch and market price for collectors.

Catch	Maximum catch on a good fishing day (kg)[25]	Price (Mt/kg)
Sea cucumber	20	200
Oyster	50	8.0
Crabs	15	20

Seasonal livelihoods and dependence on fishing of subsistence artisanal fishers

The livelihood structure of subsistence fisheries is very complex, and although fish is the most important source of animal protein for the majority of coastal communities, they do not generate profits from fisheries, and tend to diversify their livelihoods as much as possible. **Table 5-32** shows some combinations between the main sources of income and other methods of survival among subsistence artisanal fisher households. Although agriculture and fisheries appear to be the most important activities in the study area, there are some differences in terms of the number of alternative activities, and the combination profiles among different occupations.

[25] Values are often higher than those quoted for harpooners, as collectors often process their catch prior to sale, which adds value to the product.

Table 5-32. Combinations of livelihood sources among the subsistence artisanal fisher households

	Palma		Mocimboa da Praia		Macomia	
	Wet season	**Dry season**	**Wet season**	**Dry season**	**Wet season**	**Dry season**
Women						
Agriculture	• • •	• •	• •	• • •	• •	•
Fishing	• • • •	• • •	• • • •	• • • •	• • • • •	• • • • •
Trade	• •	•	• •	• • • •	• •	• •
Livestock			• •	•	•	•
Part-time work	• • •	•				
Men						
Agriculture	• • • •	• •	• •	• •	• •	
Fishing	• • • •	• • • •	• • •	• • •	• • • • •	• • • • •
Trade	• •	• •	• • •	• • •	•	•
Livestock	•	•	•		•	•
Part-time work	• •	• •	• •	• • •		

There are families who practice agriculture even in the dry season, in areas where soil and water is sufficient and suitable for rice cultivation. The number of alternative activities in Macomia (Pangane) is less than that in Mocimboa da Praia and Palma. In Macomia (Quiterajo), there are more people engaged in fishing than in agriculture and trading. Livelihood alternatives in Mocimboa da Praia are dominated by a combination of fishing and trade. Trade has been expanding due to several reasons, i.e. the in-migration of labor employed by local projects (e.g. Artumas's on-shore seismic exploration); the gradual rehabilitation of secondary roads carried out by the local governments, with the support of privately funded projects; and the implementation of micro-finance programs by local government (*Fundos de Iniciativa Locais*). In Palma, fishing is mostly combined with agriculture, since trade is still not well developed in the area.

It is, however, important to take note that high levels of activity diversification do not always imply high levels of productivity of such activities. It merely implies that a strategy is adopted by the households of adding complementary activities to those already practiced. For example, some households who put the same amount of effort into fisheries as in other activities, reported lower incomes from the fishing activity than households who tend to be more specialized in one single activity.

5.3.6.4. Commercial artisanal fishers

There are a total of 3,086 commercial artisanal fishers in the study area, of which 2,341 make use of boats for fishing. Canoes and boats (sail) are the most important type of boat used by this group (**Table 5-33**).

Table 5-33. Commercial fishers according to the type of vessel used

District	Commercial artisanal fishers	Type and number of vessels		
		Canoes	Boats	Other
Macomia	881	685	119	0
Mocimboa da Praia	678	526	178	2
Palma	1,527	617	213	1
TOTAL	**3,086**	**1,828**	**510**	**3**

(IDPPE, 2007)

Less than 1% of the artisanal fishing boats are motorized[26]. The fishing gear most commonly used on boats is (**Table 5-34**):

- Beach seine.
- Gillnets.
- Pursing nets.
- Hand lines.
- Diving for fish.

Table 5-34. Fishing gear used by the commercial artisanal fishers

District	Fishing nets			Other types					Total
	Beach seine	Gillnets	Pursing nets	Cages	Hand lines	Purse seine	Diving	Other	
Macomia	103	132	2	36	529	-	180	2	881
Mocimboa da Praia	148	197	4	28	301	-	106	42	678
Palma	94	164	6	37	505	2	750	63	1,527
Total study area	**345**	**493**	**12**	**101**	**1,335**	**2**	**1,036**	**107**	**3,086**

(IDPPE, 2007)

[26] There are 10 motorized boats in the study area, among which 7 are in Mocimboa da Praia, 2 in Macomia, and 1 in Palma (IDPPE, 2007).

Each gear type usually belongs to one or more adult males who do not often go to sea themselves. They remain on land, selling their fish and other commodities, while their workers go fishing. There are also operators who rent out their equipments (boat or fishing gear) to other fishers. In these cases, the owners of the fishing equipment are paid daily in cash (Meticais) or catch.

Fishing Net Users

As indicated above, commercial artisanal fishers using fishing nets use three types of gear, i.e. beach seine, gillnets, and pursing nets. Almost all fishing net operators (99%) use boats (*lanchas*). The area most commonly fished with nets is between the islands and mainland. A very small number of pursing nets are operated on the open sea side of the islands.

Beach seine and pursing nets operators can employ between seven and 17 people per gear type, while gillnets employ less than seven people (**Table 5-35**). Each fishing unit is composed of two distinct social groups, i.e. the owners of the fishing boats/gear, and the workers.

Table 5-35. Average number of workers per fishing gear type

	Permanent	Part time	Total of averages per gear
Beach seine	17	5	22
Gill net	7	3	10
Pursing net	10	2	12

(SSAFC, 2008).

Beach seine gear is operated from the islands, as well as from mainland fishing centers. Vamize, Quifuke, Tambuze, Muichanga, Kirianhune, and Macaloe are the most important islands for fishing net users.

Beach seine, gillnets, and pursing nets fishing units generally comprise crew members which include the owner, a fishing master, and regular team members. Teams for pursing net operations are almost the same as that for the beach seine fishing units, although for pursing net operations there are a number of divers involved in fish identification and fish location, prior to the setting of the nets. Recent studies on beach seine indicate that crew members generally remain with one specific fishing net throughout the season, and will not move between nets or work two or more nets simultaneously (Wilson, 2007).

The salaries paid to the workers in all net uses are calculated on a daily basis, after the fishing operation, and usually according to the formulas presented in **Box 2.**

Box 2 – Payment of fishing teams

Beach seine fishing is usually done by a specialized crew which includes the owner, the fishing master, and a team. The composition of a pursing net team is very similar. However, there are a number of specialized divers who specialize in fish identification during the fishing operation. The payment to the workers involved with these types of fishing gear is made on a daily basis, upon completion of the fishing operation. In most instances, the following formula is applied.

1) $S_{owner} = Q_{kg} \times 50\% - S_{master}$

2) $S_{master} = \frac{Q_{kg} \times 50\%}{3}$

3) $S_{crew} = Q_{kg} \times 50\%$

The following is represented in these formula:

- S_{owner} = payment to the owner.
- S_{master} = payment to the master.
- S_{crew} = payment to the crew.
- Q_{kg} = quantity of catch per day.

Therefore, after landing the catch, 50% of the day's catch (Q_{kg}) will be handed to the crew. The remaining 50% will be divided into three parts, from which one part (one-third) will be handed to the fishing master, while the remaining two-thirds remain with the owner of the gear. Where the owner is renting part of his equipment, e.g. a boat, 50% of his takings will be handed across to the owner of the equipment.

It is not an easy task to establish the type of catch for commercial artisanal fishing nets, since most of the nets targets mixed catches. However, in general, pursing nets target mainly First Grade fish, while gillnets target First as well as Second Grade fish. Beach seine mainly targets Second and Third Grade fish.

Diving for Catch

The IDPPE (2007) estimated a total number of 1,404 divers in Cabo Delgado, 1.036 (74%) of which are in the study area (**Table 5-36**). Divers use spears/harpoons made by local craftsmen from a variety of steel and iron rods.

Table 5-36. Diving and hand lines for fishing.

Gear type	Macomia	Mocimboa da Praia	Palma	Total
Hand lines	529	301	505	1,335
Diving	180	106	750	1,036
Total	**709**	**407**	**1,255**	**2,371**

(IDPPE, 2007)

There are two types of divers in the study area, i.e. those who dive from boats and those who do not. The latter group is more concentrated in the mainland fishing centers, and the former operates around the islands. Small canoes are used to reach target areas. Divers dive in water up to 40 meters deep, although it is by far the minority who dive down to these depths. Divers target predominantly First Grade fish, although divers may also capture rays, shrimps, lobsters, crabs, squid, sea cucumber, and octopus.

5.3.6.5. Fishing areas and movement of fishers

Fishing areas

Table 5-37 shows the fishing areas reported by the commercial artisanal fishers during the survey conducted as part of the SSAFC. The majority of these fishers (41%), fish in what is defined as the 'coastal area' (**Figure 5-40**). However, there are also a considerable number of fishers who reported fishing in the open sea (35%). Almost 23% of the respondents fish in both areas.

Table 5-37. Fishing areas according to the SSAFC survey

	Fishing areas				
Gear type	**Open sea**	**Coastal**	**Both**	Other[[27]	**Total**
Beach seine	3%	70%	9%	100%	32%
Gill net	8%	2%	5%	0%	5%
Pursing net	39%	6%	27%	0%	23%
Hand line	26%	5%	43%	0%	21%
Dive for fishing	24%	7%	16%	0%	15%
Cages	0%	10%	0%	0%	4%
Ratio to total	**35%**	**41%**	**23%**	**1%**	**100%**

[27] Fishing takes place in estuaries close to the Rovuma River.

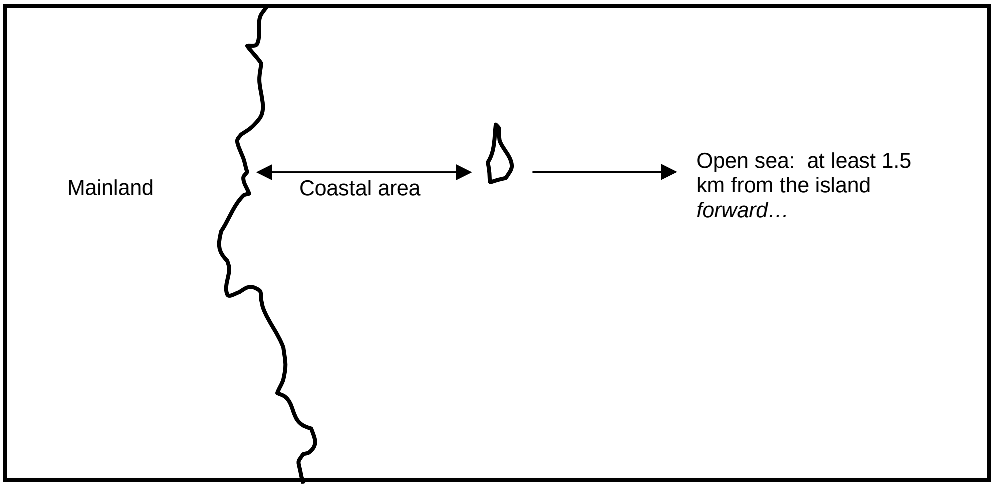


Figure 5-40. Diagram indicating coastal and open sea as used in the study

This definition of ‘coastal’ and ‘open sea’ was used by the SSAFC during focus group discussions, to clarify some of the areas and depths indicated above. According to the focus groups, some divers dive in the direction of the open sea, but, at the furthest, not more than 1.5 km from the islands. Divers predominantly dive around the islands, and in other specific areas between the islands and the mainland. Beach seine activities mainly take place close to the islands, estuaries, or on some coral reefs. Both the questionnaire survey and focus groups confirmed that pursing nets and hand lines operated from boats are used in the open sea up to a maximum of 6 nautical miles from the islands. The areas around the islands and between islands and mainland are the most important fishing areas for all artisanal fishers.

Tables 5-38 to 5-40 outline the names of the most important fishing areas in the study area. The movement of fishers between these areas is variable. Some fishers from Kirianhune and other islands often fish in the same area for five to six days per week. The decision of where to fish is made according to the number of fishers operating in the same area at the same time, early catch success rate in an area, and wind speed and direction. If a boat operates in an area for a number of days and the number of other vessels in the area starts to gradually increase, the first vessel is likely to move off to another area. Diving for fish and fishing with hand lines are less influenced by these factors. Divers and hand liners fish during the journey, and if the catch is very good, may return to the fishing center even before arriving at the originally intended fishing area.

Table 5-38. Fishing areas in Palma

Most important fishing areas	Specific coral reef or banks	
	Name of coral reef or bank	Specific location
Kirinde influential area	Manhani Corals	
	Shalati corals	
	Gongo coastal area	Gongo
Palma-sede area	Palma-sede coastal area	Palma-sede
	Iwango banks	
	All island-associated areas	
Nauyene bank	Nauyene bank	Near Lalane (after Olumbi in direction to south part)
Farol coral reefs	Farol coral reefs	Farols Vilage
Nsangues associated areas	Nsanges coral reef	Close to Nsangue Ponta area
Kifuque, Muitundo and Kissangulo Islands areas	same name	Around the islands with same name
Olumbi associated areas	Nawieni Bank	Close to Nondo or between Nondo and Vamizes area
	Chalas Bank	
	Mbuto coral reef	
	Chamba cha Roque coral	between Olumbi and Vamize/kissungulu

	reef	wa nkunga island
	namiambolhe coral reef	
	Naupanhas Coral reef	
Paquissangas Bank	Paquissangas Bank	
Mbangas coral reef	Mbangas coral reef	Front of Monjanes area
Mbwizi (mainland)	The corals identified are close to the shore line	
Tecamalhi Island	Tekamalhi coral reefs	Around Tekamalhi
Ngambo (mainland)	No alternatives	
Nsemo (bank),	Iwangos bank	Near Nsengo
Quiramimbi Island	Quiramimbi coral reefs	Near Quiramimbi island
Vamize Island	Vamizes coral reefs	Around Vamize
	Iwala Bank	West Vamize
Nondos Bank	Nondos Bank	Near Nondo fishing center
Muivumbas Island,	Muivumbas Island,	
Quissungure (bank)	Quissungure (bank)	
Nkifuke (Island)	Nkifuke (Island)	

Table 5-39. Fishing areas in Mocimboa da Praia

Most important fishing areas	Specific coral reef or banks	
	Name of coral reef or bank	Specific location
Tembuzi Island	Tchungulomo, Buona, Massassale, Matabula, Wantumbuluko	Coral reefs asociated to the Tambuze and Nhonge Islands
	Tembuzes bank	Around Tambuzes Island
Nsemo, Mutondo, Nkizinguite, Fungo-zimo, Muizala, Nelo, Namacula, Sinhala, Macanhe,	No alternatives	Coral reefs associated to Nabage and Ulo areas
Insisissi coral reefs		Kirianhnune Island
Kirianhune (Island)	Kabacar Bank – northeast Kirianhune	
	Nanguo coral reefs – northwest Kirianhune	

Table 5-40. Fishing areas in Macomia

Most important fishing areas	Specific coral reef or banks	
	Name of coral reef or bank	Specific location
Mitaca (or Quiterajo-sede area)	Coral reefs: Kifumbula, Nangalu, Muapota, Muamba Nkati-Kati	No more than 3 miles from coastal line area in Quiterajo
Near Mnlamba area	Coral reefs: Coral reefs: Ndolima and Ndevo	
Muabota area	Coral reefs: Muapota, Muamba Nkati-Kati	

Nunumba area	Coral reefs: Tchala, Kutanke, Kumizinga, Kubacari, Lufinga, Tcholoe, Chumi-chitoto, Tchumi Kikulo	No more than 3.5 miles from coastal line area in Nunumba side
	Messalo stuarine area	Near Messano River
Near Macaloe Island	Coral reefs: Massassa, Ntomas, Nquissanga, Palavi, Ncomaga, Kwela, Kiungo,	
		Distant from Medjumbi Island: 3.5 miles
Kifula Island	Kifula Island	
Melingani area	Mabangue 1 e 2, Ngongolo, Fungo ya Wala, Oibo	
Massassa bank	Massassa bank	East Matemo
		Near Medjumbi Island
		Kwela bank

5.3.6.6. Duration of fishing trips and depths fished

Fishers from the mainland traveling to the islands depart early in morning (around 02h00) from their base fishing centers. The average trip from the mainland to the islands is between 2.5 to 3 hours. A trip from the to the furthest fishing areas is on average between 4 and 6 hours outward bound, and another 4 or 6 hours for the return trip. The fishing operation itself also takes between five and six hours, depending to the weather. Fishers often stay over on the islands for at least one night in order to prepare for the trip to a fishing area, or to rest on the return trip. Hand liners and pursing nets operators also fish during the night.

On average, beach seine activities take place in waters between 5 m and 7 m deep, while the maximum depth for pursing nets is around 100 meters (depending on the size of the net). There are a small number of pursing nets in the study area (mostly owned and operated by Tanzanians) which can operate at depths of up to 200 meters (**Table 5-41**). Hand line fishers fish in waters with a maximum depth of 200 meters. Divers seldom exceed 30 m, and only a few very skilled divers are able to do this.

Table 5-41. Average maximum and minimum water depths where fishing takes place

Gear type	5 – 20 m	21 – 50 m	51 – 100 m	101 – 200 m	201 – 400 m
Beach seine	61%	29%	14%	16%	0%
Gillnets	6%	6%	5%	5%	0%
Pursing nets	1%	27%	54%	54%	7%
Hand lines	4%	2%	23%	25%	93%
Dive for fish	17%	35%	4%	0%	0%
Cages	11%	1%	0%	0%	0%
Total ratio	*35%*	*24%*	*19%*	*8%*	*13%*

5.3.6.7. Movement and migration of fishers

The movement and migration of fishers can be classified as follows (**Figure 5-41**):

- From Tanzania, to the study area.
- From Nampula and other Mozambican provinces, to the study area.
- From the mainland fishing centers in the study area, to the islands.

Focus groups highlighted two types of Tanzanian fishers, i.e. legal, those who arrive in the study area via local ports, and those who are illegal and make their way into the study area via sea routes. The first group includes traders, fishers, and/or people who want to start businesses in Mozambique, which occurs more frequently during the dry season. The latter group primarily consists of fishers and fish traders. They move mainly on or around the islands, using several different types of fishing gear, and are commonly seen as violating the local rules. This situation, and the fact that they often have large boats and better fishing gear, often leads to conflict with the local fishers.

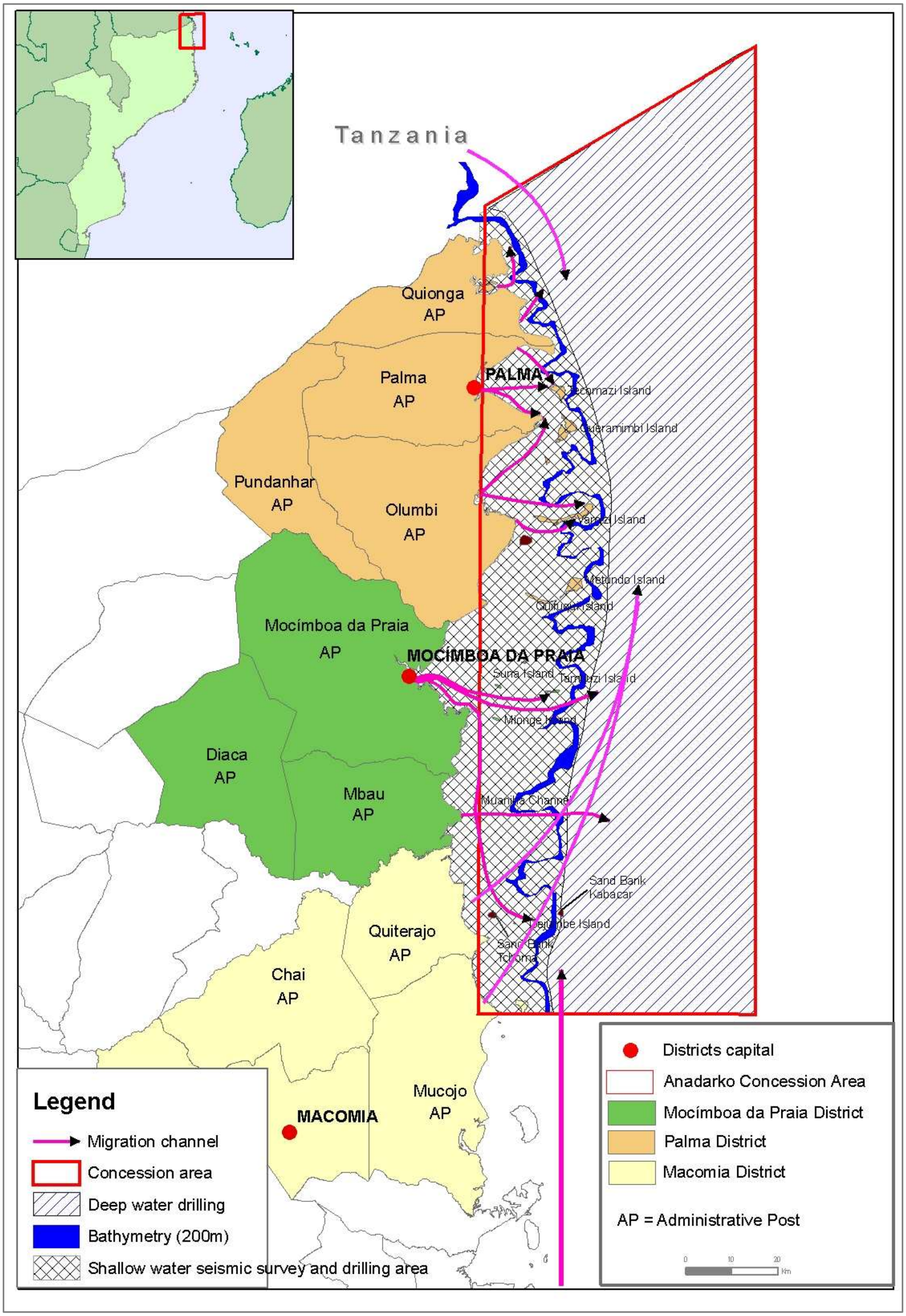


Figure 5-41. Movement of artisanal fishers in the study area

Generally, fishers from Nampula spend more time on the islands. They may stay away from their homes for up to a year, and some even travel with their families or marry locals.

Movements from the mainland to the islands are the most important and clear forms of geographical movements which occur throughout the year, but with greater frequency during the rainy season when the catches are relatively high. In Palma the most important islands are Tecamalhi and Vamizi Islands; in Mocimboa da Praia, Kirianhune and Tembuzi Islands, and in Macomia the most important areas are Medjumbi and Macaloe. Fishers also use these islands as bases, and stay in fishing camps for short periods while fishing around other islands.

No evidence was found through the SSAFC of fishers moving from the islands to fish along the mainland coast. The relatively high productivity of the fishing grounds in the islands appears to be the reason for this.

5.3.6.8. Value adding and fisheries supporting activities

The most important value adding activity in the area is the processing of fish. In Cabo Delgado, there are approximately 1,102 people engaged in fish processing, most of whom are based in Palma (**Table 5-42**). Although a large part of the daily catch is consumed, sold, or bartered fresh to local and neighboring communities and nearby urban settlements, a portion is also preserved by sun drying, smoking, and salt drying. When compared to the rest of the province, the 468 processors in the study area comprise approximately 42% of the overall number of processors in the Province. The artisanal fisheries census conducted by the IDPPE during 2007 (IDPPE, 2007) indicated that approximately 14% of the processors identified in Cabo Delgado are women. However, only 6% of processors surveyed during the SSAFC are women. This is due to the fact that women in this area are also potentially involved in other activities, which may consume most of their time.

Table 5-42. Processors by gender and district

Processors	Macomia	Mocimboa da Praia	Palma	Total
Male	119	119	203	441
Female	0	18	9	27
Total	**119**	**137**	**212**	**468**

(IDPPE, 2007)

Salt-drying is the most common practice, and is divided into First, Second and Third Grade species. Drying reduces almost two-thirds of the fish's weight i.e. three kilograms of fresh fish would produce one kilogram of processed fish. However, processing increases the shelf life of the fish product, e.g. salt-dried products can last up to five months.

The supporting industry to the fishing sector provides boats, nets, and other inputs, such as fishing line. Of these, the boat building industry is the most important in the study area. No updated statistical data regarding supporting fishing industries was available at the time of the study. According to the IDPPE (2004), there were 103 master boat builders and 66 apprentices in the districts comprising the study area (**Table 5-43**). These masters and apprentices are based in fishing villages that are equipped with the infrastructure for boat building

Table 5-43. The number of master and apprentice boat builders in the study area per district

District	Masters	Learners	Total
Palma	40	42	82
Mocimboa da Praia	28	16	44
Macomia	35	8	43
Total in the study area	**103**	**66**	**169**

IDPPE, 2004.

There are no community-based suppliers of fishing inputs in the study area, although articles such as fishing line, cotton, hooks, and others, are sometimes sold at local informal markets. The main sources of inputs are located in Pemba, Nacala, Nampula, Maputo, and even as far afield as Tanzania and Malawi. Fishers in the northern part of the study area (Palma) predominantly buy their inputs from Tanzania and Nampula.

5.3.6.9. Fish markets, trading and income from fishing

Fish markets

Most of the fish from the study area are sold in the main towns to consumers and intermediaries. In Palma, the most important market is Palma-sede, with the secondary markets at Olumbi and Quirinde/Quinga. In Mocimboa da Praia, the most important market is Mocimboa da Praia-sede. There are also markets in Malinde and Luxete, but these are much less competitive than the market at Mocimboa da Praia-sede. In Macomia, the district capital is located approximately 80 km in-land from the coast and, thus, almost all fish landed at fishing centers (e.g. Pangane and Quiterajo) is sold to intermediaries who transport it to Macomia-sede and Pemba (approximately 250 km). Some intermediaries operate in Pangane, and buy fish from the primary producers and serve it at local restaurants, or transport it to Pemba and other large markets.

In the study area, the demand for fish is higher in district capital towns (due to the strong presence of Tanzanian traders) than in the secondary markets, because the most important fish buyers are usually concentrated in the main towns due to the better conditions (better roads, electricity, and telecommunication). Access to the secondary markets such as Quirinde, Luxete, and Olumbi is poor, and there is no electricity for fish storage. Generally, fish sold in most of the mainland markets come from the islands. Traders from these areas prefer to travel to the islands to purchase fish to sell at mainland sites. They can remain on the islands for up to three days, or until they purchase enough fish.

Trading in fish

Fish supply and demand are determined by the dry and rainy season cycles, type of product, location of the market, and the level of development of boat landing sites. Fishers indicated that during the rainy season (see **Tables 5-27** and **5-32**) the catches are substantially higher than in the dry season. However, although profits in the rainy-wet season seem to be much lower, due to supply variations, prices do not vary too much along the year. Also, during the rainy-wet season, fish commodities demand has been reported as relatively lower, compared to the dry season. The problem is the local road infrastructure, which for large parts of the rainy season becomes almost impassable. This then prevents bulk traders from accessing fishing villages, and single traders from selling fish in the interior.

Fish traders can be grouped into two main categories, i.e. fishers selling to consumers, and fishers selling to traders. Sale to consumers takes place at the landing sites where fishers bring in the catch after a fishing trip, and occurs at all the fishing centers. The catch sold usually consists of fresh fish, octopus, rays, and lobsters. Sale to traders includes the same type of catch, but is found more on the islands. Traders from the mainland frequently travel to the islands to purchase fish. These traders then either process the fish on the island, or take it back to the mainland for selling as fresh or processed fish. Buyers from Tanzania frequent Mocimboa da Praia and buy large quantities of dried fish, which are taken back to Tanzania by road or boat.

In Palma, the largest buyer of first and second grade fish, as well as sea cucumbers, squids, crayfish and octopus, is the Complexo Pesqueiro de Palma (CPP). Constructed in 2002 as part of a joint programme between IDPPE and the Spanish Government, the CPP buys in the order of 70% of fish landed in Palma-sede and neighboring fishing centers such as Maganja, Quiwia, Manhenahele, Vamizi and other islands. The CPP has the necessary cooling and freezing facilities to store fish, which then get sold in Pemba, Nampula, and even Maputo. There are also a substantial number of informal traders which also form an important link between the islands and the mainland.

<u>Income from fishing</u>

Prices of fresh and processed fish are determined by grade, based on size and weight. Average prices in the study area that are paid to the fishers for fresh fish range between 15.00 Mtn and 100.00 Mtn per kg (**Table 5-44**). However, some differences were found between the price received by intermediaries who sell their product in the main towns, and those who sell fish at the secondary markets. Prices may have doubled or tripled by the time the product reaches the main urban centers. Price will also vary according to the season of the year, but the variation is not significant enough for a detailed discussion. On the islands, where fish is mostly sold by the fishers to intermediaries from the mainland fishing centers, the price corresponds to that presented in the first column of **Table 5-44**. No intermediaries sell their products in these areas. In the Mocimboa-sede and Palma-sede markets, there are primary producers who sell their catch to consumers at intermediaries' prices, if the intermediaries are also selling their products at the same time.

Table 5-44. Average price (in Meticais) at landing site per kg for commercial fisheries

Type of fish	Price per kg received by primary producers	Price per kg received by intermediates in main towns	Price per kg received by intermediates in secondary towns
Fresh fish			
❑ Grade one	15	42.5	33.2
❑ Grade two	15	25.4	20.3
❑ Grade three	15	18.5	17.7
Dried/salted fish			
❑ Grade one	45	80.5	67
❑ Grade two	37	50.3	45.6
❑ Grade three	15	37.5	30.2
Shrimp			
❑ Grade one	60.5	67.1	67.1
❑ Grade two	30.6	47.5	47.5
❑ Grade three	10.1	30.8	30.8
Squid			
❑ Fresh	15	20.0	19
❑ Dried	35.0	69.2	59
Octopus			
❑ Fresh	15	35.0	30
❑ Dried	30	40.5	37
Shark	20	35	25
Ray	15	20	15
Crabs	15	20.5	18
Lobster	100	160	90

No overall district-level data regarding economic performance of artisanal fishers is available. One of the most recent studies was made under the Projecto da Pesca Artisanal em Nampula e Cabo Delgado (PPANCD) project from IDPPE. This study concluded that, on average, artisanal fishers households are very poor. However, it identified three different socio-economic groups, namely: boat and gear owners, employees, and fish collectors. "Among these groups, the boat and gear owners held the highest mean annual household income while for the lowest category it was either the employees or fish collectors" (IDPPE, 2006). However, income levels of households of collectors and fishers without boats have not been assessed. The study also does not present any quantitative estimate of income per fishing.

Rousselot (2005) on the fisheries in Quirimbas National Park is one of the few references to the approximate income of Macomia's fishers. This study noted that the beach seine owners earned a gross income of approximately US$ 200.00 per month in the dry season, while their workers earned almost US$ 40.00 per month during the same period. Analysis of these estimates and other assumptions, suggests that the owner's household incomes can reach an annual gross income of US$ 2,050, especially those who sells fish to areas near to (semi) urban centers. The employees might earn a gross value of US$ 650.00 per annum. The hand line fishers might earn a gross income of approximately US$ 60.00 per month, with an annual average of US$ 750.00, according to the interviews.

Field results from the SSAFC provide a more updated gross income per day, per type of fishing gear (**Table 5-45**), as well as an indication of the potential daily profit to the owner of the gear, once expenses such as workers' wages and running costs have been deducted (**Table 5-46**).

Table 5-45. Gross daily income from different types of fishing gear using sailing boats on a good fishing day

	Beach seine	Pursing nets	Gillnets	Hand lines	Cages
Maximum catch per day (kg)	250	222	100	59	19
Price of catch (Mtn/kg)	15.0	22.0	20.0	20.0	15.0
Value of catch per day[28]	Mtn 3,750.00 (US$ 155.60)	Mtn 4,884.00 (US$ 202.65)	Mtn 2,000 (US$ 82.89)	Mtn 1,180 (US$ 48.96)	Mtn 285.00 (US$ 11.80)

Table 5-46. Potential profit estimates per gear type on a good fishing day

	Beach seine	Pursing nets	Gillnets	Hand line	Cages
Net profit per kg/day	Mtn 1.70	Mtn 2.61	Mtn 3.55	Mtn 18.07	Mtn 14.66
Total potential profit on good fishing days	Mtn 425.00 (US$ 17.60)	Mtn 579.00 (US$ 24.02)	Mtn 355.00 (US$ 14.70)	Mtn 1,066.00 (US$ 44.20)	Mtn 279

The only gear used by the small number of motorized vessels in the study area, is pursing nets. **Table 5-47** outlines the gross daily income, as well as potential profits on good fishing days, from the use of pursing nets on motorized vessels.

Table 5-47. Gross daily income from pursing nets on motorized vessels on a good fishing day

Item	Values
Maximum-average catch per good day (kg)	2,667 kg
Price of catches (Mt/kg)	Mtn 21/kg
Gross income per day	Mtn 56,007.00 (US$ 2,323.94)
Net profit (Mt/kg/day)	Mtn 4.10
Total net profit	Mtn 10,934.70 (US$ 453.72)

[28] For the purposes of currency conversions in this study, an exchange rate of 1 US$ to Mtn 24.1 was used.

5.3.7. Other Socio Economic Features

5.3.7.1. Mocimboa de Praia Port

Only one port for commercial shipping (Mocimboa da Praia which is classified as a tertiary port) is located in the Project area. The layout of the port is shown in **Figure 5-42**. The number of vessels using the port is low averaging less than two vessels per month (see **Table 5-48**). According to the Maritime Delegate for Mocímboa da Praia the main cargo shipped at the Port are wood, fuels and vegetable oils.

Figure 5-42. Layout of Mocimboa de Praia part

Table 5-48. Movement of ships in the Port of Mocímboa da Praia during 2007

YEAR	2007 12 month period	Monthly average Or 2007
Number of ships	16	1.3

Source: Maritime Branch/Customs Branch of Mocímboa da Praia

Commercial Salt Pans

Thirteen registered salt pans occur along the coast in the Project area. The location of the salt pans is shown in **Figure 5-43**. Most of the salt pans are operated by families or fishermen for home consumption and local sale as the quality of the salt is poor.

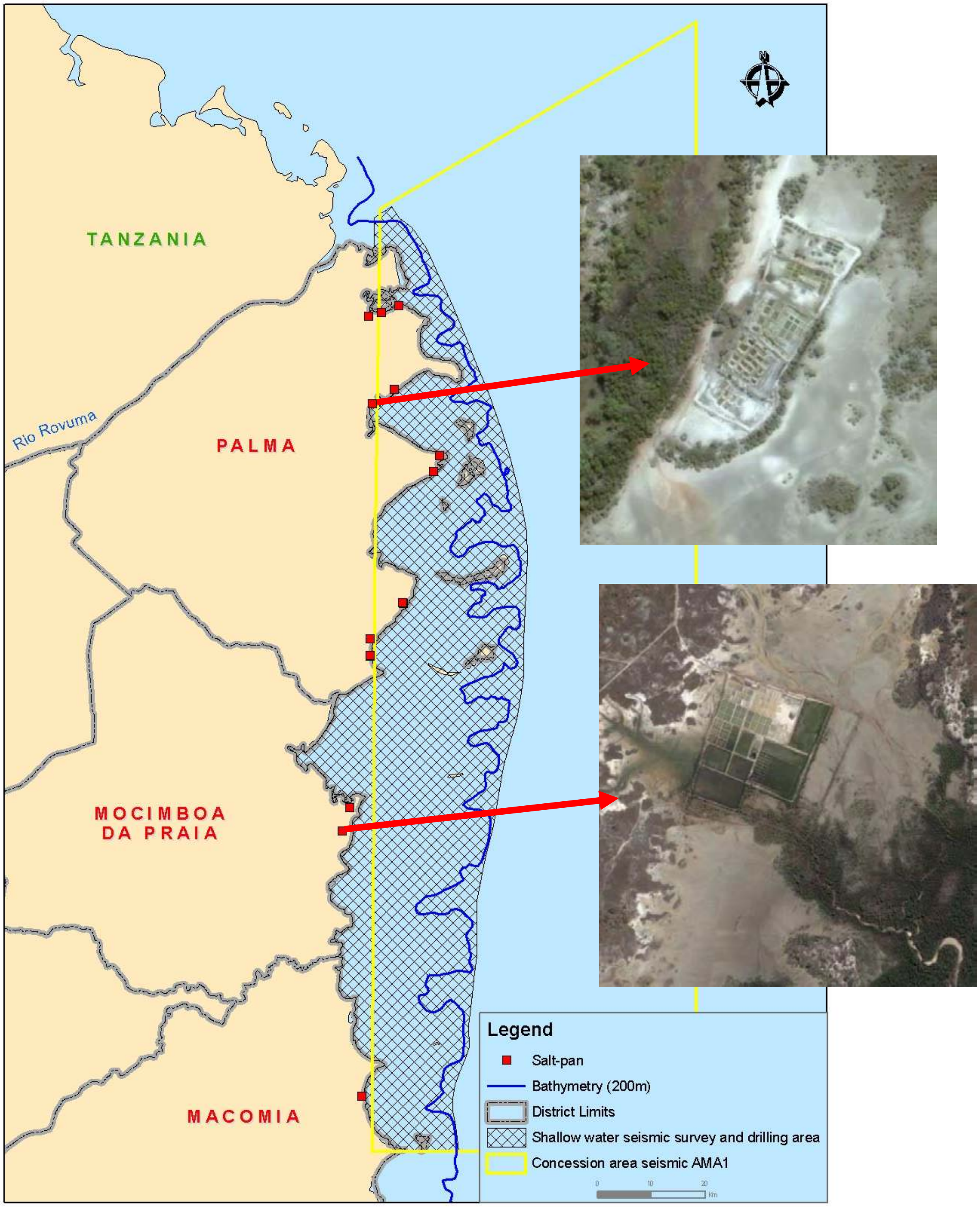


Figure 5-43. Location of salt pans in the Project area

Chapter 6

ENVIRONMENTAL IMPACT ASSESSMENT

Chapter 6

ENVIRONMENTAL IMPACT ASSESSMENT

6.1 METHODOLOGY FOR ASSESSING IMPACTS

6.1.1 General Methodology

The overall Project comprises five separate "sub-Projects" as described in Chapter 2 (Project Description): For the purposes of the Environmental Impact Assessment two of the sub-Projects have identical impacts (*viz.,* 2D and 3D seismic surveys using ocean bottom cables) and these are discussed together in this Chapter. Impacts are evaluated for the following sub-Projects:

1. Two dimensional (2D) seismic surveys using shallow water streamers, which send sound waves directed downwards from a seismic vessel;

2. 2D and 3D seismic surveys using ocean bottom cables;

3. 3D seismic surveys using individual (autonomous) receivers that are placed on the sea floor; and

4. Drilling

The impact assessment process, in the first instance, identifies the activities associated with each of the sub-projects above that could interact with the environment.

In parallel, the key biological, physical and human components of the project area described in Chapter 5 (Biophysical and Socioeconomic Description of the Study Area) that could be affected by the activities of each sub-project are identified. These are summarized in **Table 6-1**.

Table 6-1. Environmental Components

Category	Environmental Component	Importance
Air	Air Quality	Link to human and animal and plant health Link to climate change
Water	Water quality	Link to fauna and flora, population, fishing, tourism and recreational activities
Ecology and Biodiversity	Mangroves	Biodiversity value Breeding/nursery value
	Seagrass beds	Biodiversity value Breeding/nursery value
	Coral reefs	Biodiversity value Breeding/nursery value Links to tourism, recreational activities and artisanal fisheries
	Marine mammals	Biodiversity value
	Turtles	Biodiversity value
	Fish	Biodiversity value; link to artisanal fishing, tourism and recreational activities
	Protected Areas	Biodiversity value Conservation value (Quirimba National Park)
Human Environment and Economic Activities	Population	Living conditions
	Artisanal fisheries	Living conditions
	Coastal Industries	Local economy
	Tourism	Income generation and employment

The potential positive and negative impacts resulting from each of the sub-project activities were predicted. These predicted impacts were then evaluated using a significance ranking process.

An outline of the impact assessment procedure is as follows:

- Identification of the key project activities;
- Identification of the environmental components;
- Impact identification;
- Impact evaluation; and
- Significance ranking

6.1.2 Environmental Aspects

The environmental aspects of the five sub projects is based on an analysis of the five sub-project activities and are listed in **Tables 6-2** to **6-5** below.

Table 6-2. Environmental Aspects related to two dimensional (2D) seismic surveys using shallow water streamers

Sub-Project Component (2D seismic surveys using streamers)	**Environmental Aspect**
Equipment mobilization	Movements of vessels and equipment from international waters to the Project area
Seismic Program	Seismic Survey (separate seismic sound source, separate recording vessel using streamers etc)
	Production/emission of solid, liquid, gaseous wastes
Decommissioning	Movements of vessels and equipment from the Project area to international waters.
Non-routine Events	Leaks and spills
	Collision with other vessels

Table 6-3. Environmental Aspects related to 2D and 3D seismic surveys using ocean bottom cables

Sub-Project Component (2D and 3D seismic surveys using bottom cables)	**Environmental Aspect**
Equipment mobilization	Movements of vessels and equipment from international waters to the Project area
Seismic Program	Seismic Survey (separate seismic sound source, separate recording vessel, laying of bottom cables, removal of bottom cables etc.)
	Production/emission of solid, liquid, gaseous wastes
Decommissioning	Movements of vessels and equipment from the Project area to international waters.
Non-routine Events	Leaks and spills
	Collision with other vessels

Table 6-4. Environmental Aspects 3D seismic surveys using individual (autonomous) receivers that are placed on the sea floor

Sub-Project Component (3 D seismic surveys using autonomous receivers)	Environmental Aspect
Equipment mobilization	Movements of vessels and equipment from international waters to the Project area
Seismic Program	Seismic Survey (separate seismic sound source, separate recording vessel, emplacement of autonomous receivers, removal of autonomous receivers etc)
	Production/emission of solid, liquid, gaseous wastes
Decommissioning	Movements of vessels and equipment from the Project area to international waters.
Non-routine Events	Leaks and spills
	Collision with other vessels

Table 6-5. Environmental Aspects Drilling Sub-Component

Sub-Project Component (Drilling)	Environmental Aspect
Equipment mobilization	Movements of vessels and equipment from international waters to the Project area
Drilling Program	Drilling
	Waste (solid, liquid, gaseous) Management
Decommissioning	Well abandonment
	Movements of vessels and equipment from the Project area to international waters.
Non-routine Events	Leaks and spills
	Blowout
	Fire and explosions
	Collision with other vessels

These environmental aspects may affect the physical, biological or socio-economic environment within or outside the study area.

6.1.3 Environmental Components

For the purpose of evaluating environmental impacts, the receiving environment is divided into Environmental Components (EC). An EC is be defined as any part of the environment or society that is considered important by the developer, operator, general public, or any non-governmental or governmental organization involved in the assessment process.

Inherent to the identification of a particular environmental component is the understanding that preservation of the component is desirable. However, it is recognized that some ECs may be considered to have greater importance than others, and therefore a simple evaluation of each EC is made to determine its relative importance. The EC characterization represents the sensitivity of the receptor to potential impacts together with any local, national or international designations, where appropriate. This importance rating is classified as Very Low, Low, Medium, High or Very High (**Table 6-6**), and ensures that the more important ECs are afforded a greater weighting in the impact evaluation process.

Table 6-6. Environmental Component Categorization

EC CATEGORISATION	VL	L	M	H	VH
Increasing environmental and social value and/or fragility	→				

The environmental components for the proposed project are listed by category in **Table 6.7** together with the assigned EC value and a description of why the EC is important.

Table 6-7. Environmental Component (EC) Categorization

Category	EC	EC Categorization	Why is it Important?
Air	Air quality	Medium	Health implications on neighboring communities. Ecological implications for neighboring areas. Cumulative impacts in combination with other industries in the region.
Water	Marine water quality	High	Indirect impacts to marine wildlife and human users of the sea. Cumulative impacts in combination with other industries in the region.
Ecology and Biodiversity	Mangrove forest	High	Impacts on an important breeding/ nursery area and habitat for a variety of bird species, crustaceans, fish, and mollusks.
	Corals	High	Impacts on these will affect breeding and feeding grounds of a vast array of animal species. Indirect impacts on the livelihoods of the local populations as corals are important habitats for fishes and invertebrates harvested by artisanal fishers along the reef line. Indirect impacts on the local tourism industries through impacts on the recreational activities such as scuba diving and snorkeling. Impacts on the conservation value.

Category	EC	EC Categorization	Why is it Important?
	Seagrass beds	High	Impacts on these will affect breeding and feeding grounds of a many fish, mollusk and crustacean species. Indirect impacts on the livelihoods of the local populations as sea grass beds are important as nursery areas for the juvenile life stages of fishes and invertebrates harvested by artisanal fishers along the reef line. Impacts on the conservation value.
	Marine Mammals	High	Marine mammals are important for their biodiversity value and conservation status in the project area.
	Turtles	High	Marine turtles are important for their biodiversity value and conservation status in the project area. They are protected under Mozambican law.
	Fish	High	Important for biodiversity. Very important source of protein and income generation
	Deep Water Macrobenthic[1] Communities (echinoderms, mollusks, crustaceans, etc)	Low	Deep water macrobenthic communities are important in the biological processes of the sea floor, food chain and biodiversity.
	Protected Areas	Very High	Very important due to their intrinsic conservation value.
Human Environment and Economic Activities	Population and local economy	High	High population density along coast that depend directly or indirectly on the coastal/marine resources for their livelihoods.
	Artisanal Fisheries	Very High	Numerous fishing centers along the mainland and on islands. Impact on an important source of protein and income generation in the project area for local fishers.

[1] Only relevant for drilling

Category	EC	EC Categorization	Why is it Important?
	Tourism	High	Impact on Mozambique's economy as the northern Quirimbas Archipelago is considered to be one of the most important tourism areas due to its pristine nature, rich marine life and unique biodiversity.
	Coastal industries	Low	Impact on local economy, for industries located on the shoreline *viz.,* salt pans and small ports

6.1.4 Impact Evaluation Process

The impact evaluation will be conducted using the following criteria and compliant with Decree 45/2004 (Mozambican EIA Regulation):

- Nature of impact – negative or positive (beneficial);
- Magnitude (Intensity) of impact – Describes the quantity of the resource potentially affected by the project activity (i.e., very small, small, moderate, large and very large)
- Extent of impact – an assessment of the geographic extent of an impact (i.e., site specific, local, regional, national, or trans-boundary);
- Duration of impact – how long the impact would last (i.e., will effects be short term, medium term, long term, or permanent);
- Type of Impact: Direct or Indirect. When the resource is affected directly by the activity, it is considered to be a direct impact. When the resource is affected through another resource that has been previously affected by the activity, it is considered to be an indirect impact.
- Cumulative. Cumulative effects may be considered significant if an impact is added to existing or future similar impacts.
- Reversibility. An impact is considered reversible when the affected resource can revert to its previous state. An impact is considered irreversible when the affected resource can not return to its previous state.
- Probability of occurrence – very unlikely, unlikely, probable, or highly likely/certain.

The impact evaluation will be conducted using two sets of criteria *viz.,* basic and supplementary.

<u>Basic Criteria</u>:
Magnitude;
Spatial extent; and
Duration.

The impact **Magnitude** is measured on q scale from one to five corresponding to the following descriptions: very small (1), small (2), moderate (3), large (4), and very large (5).

The **Spatial Extent** of an impact is allocated one of the following categories:

Very Small (1) – local scale impact in the immediate area of the activity

Small (2) – local impact in the study area
Moderate (3) – regional scale impact
Large (4) – national scale impact
Very Large (5) – trans-boundary impact

The **Duration** of an impact is described by one of the following categories:

Very Short (1) – less than one year
Short (2) – one to five years
Moderate (3) – six to ten years
Long (4) – greater than ten years / duration of the project's lifetime
Very Long (5) – permanent

The Basic Impact Index is obtained by averaging the three values assigned to Magnitude, Spatial Extent and Duration (rounded up), to obtain a whole number between 1 and 5 (**Table 6-8**).

Table 6-8. Basic Impact Index

BASIC IMPACT INDEX	VL	L	M	H	VH
Average of Magnitude, Spatial Extent and Duration	1	2	3	4	5

Supplemental Criteria:

- Type of Impact
- Cumulative
- Reversibility

Type of Impact: Direct or Indirect. When the resource is affected directly by the activity, it is considered to be a direct impact. When the resource is affected through another resource that has been previously affected by the activity, it is considered to be an indirect impact.

Cumulative Effects Cumulative impacts result from a combination of a proposed project's impacts and those from other existing or future, developments. Cumulative impacts also include situations where two or more potential impacts from a single project, while individually insignificant, could produce more severe impacts when considered together. Cumulative effects are evaluated using the following parameters:

Nil – No effect
Low – unlikely to contribute to a cumulative effect
Medium – likely to contribute to a cumulative effect
High – highly likely/certain to contribute to a cumulative effect

Reversibility: An impact is considered reversible when the affected resource can revert to its previous state. An impact is considered irreversible when the affected resource can not return to its previous state. Reversibility is assessed as follows:

Reversible – likely to be reversible in the medium term. Reversible impacts are assigned a value of Low or Medium.

Irreversible – likely to be irreversible. Irreversible impacts are assigned a value of High.

The Total Impact Index is a combination of the basic and supplementary criteria. The Total Impact Index will be equal to the Basic Impact Index, except where one or more of the supplementary criteria are High or both are Medium. In this case the Total Impact Index will be increased to the next category.

6.1.5 Impact Significance Assessment

The final impact significance (adverse or beneficial) is the result of the combination of the Total Impact Index and the Environmental Component categorization. These results in one of the following impact significance classifications: Insignificant (IN), Minor (MI), Moderate (MO) or Major (MA).

Table 6-9. Impact Significance

	Total Impact Index				
EC Categorization	VL	L	M	H	VH
VL	IN	IN	MI	MI	MO
L	IN	MI	MI	MO	MO
M	MI	MI	MO	MO	MA
H	MI	MO	MO	MA	MA
VH	MO	MO	MA	MA	MA

Table 6-10 defines the impact significance as assessed above.

Table 6-10. Definition of the Impact Significance

Impact Significance	Description
Beneficial	Likely to cause some enhancement to the environment or socio-economic benefits.
Insignificant	No changes or changes that are unlikely to be noticed or measurable against background activities.
Minor	Minimal adverse effects on environmental resources, which will not require any modification in project plans or specific mitigation measures.
Moderate	Significant. Project activity will have measurable effects on environmental resources. These impacts may require modifications to the project design and/or implementation of effective mitigation measures.
Major	Severe. Will have a major effect on environmental resources. Such potential impacts may represent fatal flaws in the project and will require modifications to the project design and implementation of mitigation measures.

To complement the impact significance assessment each impact is evaluated in terms of its probability of occurrence. Some impacts, while severe if they occur, are highly unlikely to take place. This is especially true for non-routine events.

The **probability** of occurrence for a particular event can be categorized as follows:

Very unlikely – remote chance of occurrence within the lifetime of the project
Unlikely – Unlikely to occur during the lifetime of the project
Probable – likely to occur at least once during the lifetime of the project
Highly likely/certain – will occur one or more times during the lifetime of the project

Tables 6-18, 6-19, 6-20 and **6-21** provide a summary of impact evaluation for routine events and non-routine for seismic surveys and for drilling respectively. The values assigned for each Environmental Component (see **Table 6-8** above) are given in these summary Tables. Then systematically, for each EC and each impact, the methodology above was applied to derive the significance of the impact.

6.1.6 Impact Identification

The identification of impacts utilizes the Environmental Aspects and the Environmental Components in the form of a matrix to identify the impacts that could be originated by a certain activity. **Tables 6-11, 6-12, 6-13** and **6-14** present the results of that identification where Environmental Aspects and Environmental Components are shown in rows and columns respectively for each sub-project and the impacts (unmitigated) are shown as a highlight where a certain Environmental Aspect potentially affects an Environmental Component.

Table 6-11. Impact Identification Matrix for 2D seismic survey using streamers

Environmental Aspects		Physical Environment		Ecology and Biodiversity							Human Environment & Economic Activities			
		Air Quality	Water Quality	Mangroves	Corals	Seagrass	Marine Mammals	Turtles	Fish	Protected Areas	Population	Artisanal fisheries	Tourism	Coastal industries
Equipment mobilization	Vessel movements													
Seismic program	Seismic survey (sound)													
	Waste management													
Decommissioning	Vessel movement to international water													
Non-routine events	Leaks & Spills													
	Collision with other vessel													

Table 6-12. Environmental Impact Identification Matrix for 2D and 3D seismic survey using ocean bottom cables

Environmental Aspects		Physical Environment		Ecology and Biodiversity							Human Environment & Economic Activities			
		Air Quality	Water Quality	Mangroves	Corals	Seagrass	Marine Mammals	Turtles	Fish	Protected Areas	Population	Artisanal fisheries	Tourism	Coastal industries
Equipment mobilization	Vessel movements													
Seismic programm	Seismic survey (sound)													
	Laying of bottom cables													
	Waste management													
Decommissioning	Vessel movement to international water													
Non-routine events	Leaks & Spills													
	Collision with other vessel													

Table 6-13. Impact Identification Matrix for cables 3D seismic survey using autonomous receivers

Environmental Aspects		Physical Environment		Ecology and Biodiversity							Human Environment & Economic Activities			
		Air Quality	Water Quality	Mangrove	Corals	Seagrass	Marine Mammals	Turtles	Fish	Protected Areas	Population	Artisanal fisheries	Tourism	Coastal industries
Equipment mobilization	Vessel movements													
Seismic program	Seismic survey (sound)													
	Emplacement of autonomous receivers													
	Waste management													
Decommissioning	Vessel movement to international water													
Non-routine events	Leaks & Spills													
	Collision with other vessel													

Table 6-14 Impact Identification Matrix for drilling operations

Environmental Aspects		Physical Environment		Ecology and Biodiversity								Human Environment & Economic Activities			
		Air Quality	Water Quality	Mangroves	Corals	Seagrass	Marine Mammals	Turtles	Fish	Deep Water Macrobenthos	Protected Areas	Population	Artisanal fisheries	Tourism	Coastal industries
Equipment mobilization	Vessel movements	■	■										■	■	
Drilling	Drilling	■	■	■	■	■							■	■	■
	Waste management									■					
Decommissioning	Well abandonment		■												
	Vessel movement to international water		■										■	■	
Non-routine events	Leaks & Spills	■	■		■	■	■	■	■		■	■	■	■	■
	Blow out	■	■	■	■	■	■	■	■		■	■	■	■	■
	Fire and explosion	■	■									■	■	■	■
	Collision with other vessels	■	■										■	■	

6.2. IMPACT ASSESSMENT

Environmental impacts can affect one or more Environmental Components (ECs) directly or indirectly, or cumulatively. This section describes impacts predicted as the result of environmental aspects for seismic surveys (Section 6.2.1) and for exploratory drilling (Section 6.2.2) and are grouped by EC to clarify how each environmental component can be impacted, particularly by the cumulative effect of one or more environmental aspects.

Mitigation measures are presented in Chapter 7.

Impacts from routine events and for non-routine events for seismic survey are summarized in **Tables 6-21** and **Table 6-22** respectively of Section 6.3.1.

Impacts from routine events and for non-routine events for drilling are summarized in **Tables 6-23** and **Table 6-24** respectively of Section 6.3.2.

With regards to impact assessment for shallow water seismic surveys and for drilling, the following factors should be taken into consideration:

- The overall seismic survey is a temporary activity (not more than three months) and the presence of the seismic vessels at any one location will be very short (only a few days) before moving to a new location;
- The drilling program is an exploratory activity;
- Well locations are still undecided;
- The duration of the drilling activity is temporary (up to 3 months per well).

6.2.1. Impact Assessment for Seismic Survey

Impact-producing factors associated with the proposed seismic survey program include sound pressure waves produced by the seismic sound source and physical impacts to benthic habitats from the deployment and recovery of receiver bottom cables and individual receivers.

The distribution of acoustic energy or sound fields generated during a seismic survey varies depending on the route (direction) of the survey vessel, size and number of compressed air sources, water depth, and aspects of the seafloor such as topography and sediment size.

Three of these seismic surveys techniques involve the placement of some type of seismic receivers, either cable or autonomous single unit receptors, on the seafloor. The placement and retrieval of these cable arrays on sensitive habitats could result in physical damage to biological communities.

The environment affected by the activities is divided into three different sections:

- Physical and chemical environment: air and water
- Biological environment: sensitive habitats and fauna
- Socioeconomic environment: Population and local economy, artisanal fisheries and tourism

6.2.1.1. Impact Assessment for Routine Operations (Seismic Surveys)

PHYSICAL ENVIRONMENT

AIR

Potential Impact 1: Reduction in air quality due to project emissions

Air pollutants that will be emitted during the project include carbon dioxide (CO_2), nitrogen oxides (NOx), sulfur oxides (SOx), carbon monoxide (CO), volatile organic compounds (VOC's) and particulate matter (PM10). These combustion products may cause atmospheric pollution and contribute to greenhouse gases and ozone depletion (and consequently to climate change).

The primary sources of these pollutants are the diesel engines that power the seismic vessels and support vessels, generators and other equipment required for the project.

Table 6-15 provides the estimated fuel requirements for the duration of seismic survey.

Table 6-15. Full consumption for the seismic survey

Equipment	Horsepower/ Engine	Number of Engines	Operation Days	Fuel Use (m^3)
Seismic Survey				
Source Vessel	250	2	90	90
Recording Vessel	212	2	90	90
Floating Accommodation vessel	1 x 139 1 x 120	2	90	135
Supply Vessel 1	2 x 300	2	30	75
Supply Vessel 2	212	2	90	45
Total				435m^3

The total fuel consumption is 435m^3 for the duration of the seismic operations. This amount will release approximately 1160 metric tonnes of CO_2 to the atmosphere during the 90 operation days. According to the website of the Energy Information Administration, which shows the Official Energy Statistics from the US Government (http://www.eia.doe.gov/pub/international/iealf/tableh2co2.xls), the project will contribute 0,0111% of the yearly total Mozambique emissions; 0.00044% of the total Africa emissions and 26.32×10^{-6}% of the total World emissions resulting from the consumption of petroleum (using the latest figures available:2005).

Based on these calculations air pollutant emissions from seismic survey vessels will not have a significant impact on air quality due to the release of combustion gases. Onshore air quality is not expected to be significantly affected. **Therefore the impact can be considered insignificant.**

WATER

Potential impact 2: Contamination of the waters around the seismic vessel and accommodation barge due to deck drainage and bilge water

Deck drainage

Deck water includes drainage water from precipitation, sea spray or routine operations such as deck and equipment cleaning. This water could contain small amounts of oils, solvents, cleaners or other similar products that can reduce marine water quality.

Bilge water

The seismic vessels for shallow waters have very shallow draft and bilge areas are thus small. As operations will mainly be during daylight hours the vessels will return to the accommodation barge each evening and transfer any bilge water to holding tanks for transfer to shore for disposal.
The impact on water quality from deck drainage and bilge water will be insignificant.

Potential Impact 3: Water contamination around the seismic vessel and accommodation barge from the discharge of sewage

As per the Project Description (Chapter 2) it is estimated that $90m^3$ of sanitary wastes will be produced throughout the 90 operation days.

The waters in the vicinity of the discharge location may be temporarily affected and become organically enriched. However, the volumes of the discharge are very low when compared to the total volume of the sea water in the location where they will be discharged, and the maritime currents will ensure the necessary natural dispersion of the discharges.

The impact of the discharge of sanitary wastes is minor.

Potential impact 4: Reduced water quality due to the discharge of solid wastes

The day-by-day operations on board the seismic vessel will generate wastes that, if mishandled or wrongly deposited, can cause impacts in the vicinity of the seismic acquisition.

Table 6-16 shows the estimated solid wastes to be produced during the seismic survey .

Table 6-16. Estimated Solid Wastes generated during the seismic survey

Waste stream	Amount (in kg)
Paper	80 kg
Plastic	80 kg
Glass	180 kg
Metal scrap	180 kg
Oily rags	180 kg
Metal drums	9 units (40.5kg total)
Aerosol cans	22.5 kg

In view of these relatively small quantities the potential impact can be considered minor.
BIOLOGICAL ENVIRONMENT

The impact analysis considers two types of impact:

i. Acoustic impacts: the acoustic impacts will be the same for every activity since all of them will have a sound source that will emit sound pressure waves; and

ii. Physical impacts: mainly related to seismic activities that involve ocean bottom cables

MANGROVES

Potential impact 5: Impacts of sound pressure waves on mangroves

Extensive mangrove formations occur along the Palma, Mocimboa da Praia and Macomia coastline as well as on several of the islands within the Project area (see Section 5.2.2.3). Mangroves provide habitat for a variety of bird species, crustaceans, fish and mollusks, and are also important as nursing and breeding grounds.
Mangroves and their associated vegetation are not sensitive to the sound pressure waves generated by seismic sound sources. However fauna living in mangroves may be affected.

Sessile invertebrates associated with mangrove aerial root systems (e.g., sponges, hydroids, etc.) may derive some protection from the aerial roots and should not be in direct proximity of the discharging air guns (physical impact). Generally, they also are not sensitive to the sound pressure waves generated by seismic sound sources. (McCauley, 1994)[2]

Benthic infauna is sheltered by the sediments in which they live. Motile epifaunal invertebrates may be damaged by extremely high sound pressure waves in the very near-field of the seismic sound source (Andriguetto-Filho et. al., 2005). However, it is assumed that motile epifaunal invertebrates will move away from these intense sound pressures before serious damage is done.

Thus, the impact on mangroves is considered minor.

Potential impact 6: Impacts of retrieval and deployment of bottom cables/autonomous receivers on mangroves

Deployment and retrieval of fixed bottom cables will likely result in physical damage to mangroves especially on aerial roots. The sessile invertebrates associated with mangrove aerial root systems will likely be affected by this activity.

The impact is considered of moderate significance.

SEAGRASS BEDS AND MACROALGAE

Potential Impact 7: Impacts of sound pressure waves on seagrass beds and macroalgae

As with coastal mangroves, seagrass beds and macroalgae communities occur in the shallow waters near to the islands. Seagrass beds and macroalgal assemblages play a valuable role by providing food and shelter and serving as nursery grounds for diverse,

[2] McCauley, R.D. 1994. Environmental implications of offshore oil and gas development in Australia – seismic surveys. Australian Institute of Marine Science, Townsville, Queensland. 121 pp.

commercially-exploited species, such as fishes, crustaceans, gastropods, and sea cucumbers

Seagrass beds and macroalgae are not sensitive to the sound pressures generated from seismic surveying. Sessile invertebrates living on sediments within seagrass beds or on the seagrass blades themselves are not known to be sensitive to seismic sounds.

Benthic infauna living within the sediments stabilized by seagrass root systems are well protected from seismic sound source pressure waves. Motile epifaunal invertebrates using the seagrass beds for shelter may be impacted by seismic sound pressure waves if they are very close to the sound source, but this would happen only in very shallow water.

Thus, the impact is of minor significance.

<u>Potential impact 8: Impacts of retrieval and deployment of bottom cables/autonomous receivers on seagrass beds</u>

The deployment and retrieval of bottom cable or autonomous receivers may physically impact the seagrass beds through crushing and/or uprooting the seagrass. Also, sediments will be suspended into the water column. However, in comparison to the seasonal disturbance of sediments by storms, the temporary mobilization of sediment by cable-laying is not considered significant (ERM, 2006). The sessile invertebrates living on sediments within seagrass beds or on the seagrass blades themselves are likely to be similarly affected.

The impact of this equipment mobilization on the seagrass and associated sessile invertebrates is of minor significance.

CORAL REEFS

<u>Potential Impact 9: Impacts of sound pressure waves on coral reefs and associate fauna</u>

Coral reefs are some of the more sensitive habitats found in the Mozambique area. Coral reefs occur in all of the project area and include stony corals (Order Scleractinia), octocorals (Subclass Octocorallia), black corals (Order Antipatharia), as well as other taxa (e.g., sponges, diverse motile invertebrates, and reef-associated fishes).

The coral colonies themselves that define coral reefs are not sensitive to the sound pressure waves generated by seismic sound sources. Macroalgae and sessile invertebrates such as sponges and octocorals growing on and around coral colonies are similarly not affected by seismic sound.

Many fish species and motile invertebrates associated with the coral habitats may be affected by seismic sound. Rather than being able to move away from the habitat, they will move deeper into the habitat framework as sound pressures increase.

Woodside Energy Ltd. has recently completed a comprehensive, real-time study on the effects of seismic activities on Scott Reef, Western Australia. While the results have not yet been published in a peer-reviewed journal, the results were presented at the 2008 Australian Petroleum Exploration and Production Association (APPEA). This study involved the following activities:

- Sound exposure level mapping
- Fauna mortality monitoring
- Coral damage monitoring
- Verification of specific acoustic impacts to fish
- Behavior of tropical maring fish
- Fish diversity and abundance

As of this writing, the data from this work continues to be evaluated. However, the following conclusions were reported at the conference:

- No damage to coral assemblages
- Only minor, short-term changes in fish behavior
- No impacts on fish hearing
- No changes in fish diversity or abundance

In view of the complexity of coral habitats and their biological importance the unmitigated impacts on coral assemblages are considered to be moderate.

<u>Potential impact 10: Impacts of retrieval and deployment of bottom cables/autonomous receivers on coral reefs</u>

Of concern with regards to coral reefs is the physical damage that may be caused by cable-laying activities. Due to the sensitivity (in particular of corals) and the high ecological importance of these habitats, any damage or disturbance will, thus, impact reef-building in this habitat.

The significance of this unmitigated impact is moderate.

FAUNA (MARINE MAMMALS, TURTLES AND FISH)

<u>Potential Impact 11: Impacts of sound pressure waves on marine mammals</u>

Whale and dolphin species occurring in the project area can be divided into baleen whales and toothed whales and dolphins. There is no recent evidence of the presence of dugongs in the project area.

Underwater seismic sand can have direct impacts in marine mammals, with the potential to cause physical or physiological damage, or indirect impacts which may interfere in basic activities such as feeding and reproduction.

The behavior of seismic sound in the marine environment

Seismic sound sources use a burst of compressed air to create an acoustic pulse. The seismic vessel will be equipped with multiple compressed air sources. The far-field pressure generated by a multiple compressed air sources is substantially greater than that of an individual compressed air source, but is also strongly angle-dependent relative to the array axis. An array of 30 multiple compressed air sources may have a zero-to-peak source level of 255 dB re 1μPa @ 1m (~56 bar·m) in the vertical direction. This apparently high value for the source level can lead to erroneous conclusions about the impact on marine mammals (and other marine organisms) as peak source levels for seismic survey sources are usually quoted relative to the vertical direction. However, due to the directional dependence of the radiated sound field, source levels off to the sides of the array are generally lower. Thus, although most of the sound energy propagates downward toward the seafloor some of the sound does propagate laterally (see **Figure 6-3**).

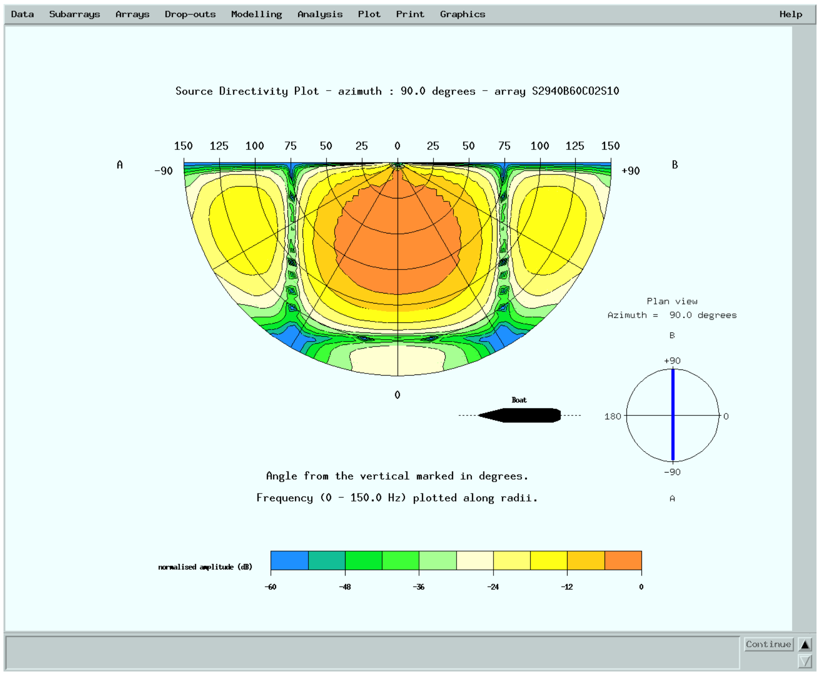


Figure 6-1. Example of a source directivity plot for sound energy released from a seismic sound source (From CSA and Impacto, 2007)

A detailed description of seismic source levels and propagation is provided in Volume III of the EIS Report (Jasco, 2008; Assessment of Underwater Noise).

The Acoustic Modeling for shallow waters (see Volume III of the EIS Report) shows that acoustic energy from the seismic exploration sources in waters less than 50m deep diminishes rapidly with horizontal distance from the source (see **Figure 6-4**).

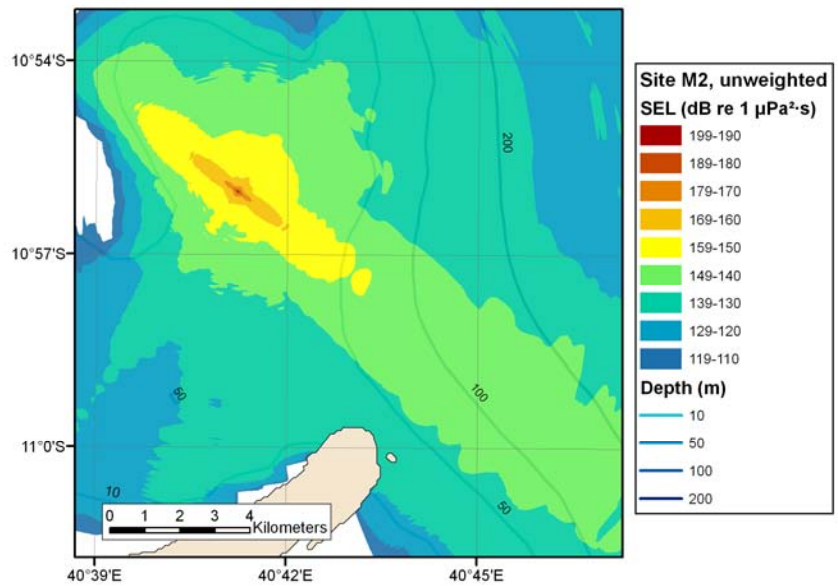


Figure 6-2. Example of a predicted sound exposure level (SEL) arising from operation of multiple compressed air sources at approximately 5 km north of Vamizi Island

This high-energy sound has the potential to harm marine animals, particularly if they swim immediately beneath the source. While death or serious injury is unlikely, marine mammals (as well as marine turtles and fishes) may experience temporary or permanent auditory trauma if they are very close to a seismic sound source operating at full power. Beyond a few hundred meters laterally from the source, auditory trauma is unlikely, but behavioral effects (e.g., avoidance) may result. The biological importance of such behavioral responses is not well understood.

Responses of marine mammals to the influence of seismic exploration

Potential impacts of seismic surveys on marine mammals have been reviewed extensively (Richardson et al., 1995; Davis et al., 1998; Gordon et al., 1998; High Energy Seismic Survey [HESS] Team, 1999; Stone, 2003; Continental Shelf Associates, Inc., 2004). The key findings are as follows:

- There have been no documented instances of deaths or physical injuries to marine mammals from seismic surveys.
- There is a risk of temporary or permanent auditory trauma within a range of a few hundred meters of a typical seismic sound source. This range depends on a variety of factors, including the size and configuration of the array, water depth, receiver depth, seafloor characteristics, and the density structure of the water column.
- Behavioral responses have been observed in many instances, primarily in mysticetes (baleen whales, including the humpback whale). However, the biological importance of such behavioral responses to underwater noise has not been determined (Ocean Studies Board, 2003).

While the risk of auditory trauma depends on proximity to and length of time in the proximity of the sound source, behavioral responses may occur at distances of many kilometers and are not necessarily predictable from the loudness of the sound source. Also, behavioral responses may vary depending on factors such as the age and status of the animal, the type of activity it is engaged in, and the social context (McCauley et al., 2000).

Baleen whales, such as humpback whales, are believed to have good hearing in the low-frequency range produced by seismic surveying, meaning the noise would seem loud to them. Toothed whales and dolphins generally are thought to be less sensitive to low-frequency noise. However, behavioral responses to seismic survey noise have been observed in both groups.

Dugong hearing has not been studied, but some data are available for a related species, the West Indian manatee. According to Gerstein et al. (1999), hearing thresholds range from about 0.4 to 46 kHz, but the frequency range of best hearing is between 6 and 20 kHz. Similar ranges were reported by Mann et al. (2005). Therefore, most of the low-frequency noise from seismic surveys probably would be below the best hearing range of dugongs.

Auditory Trauma

It is known that with terrestrial mammals, exposure to high levels of sound can cause a temporary elevation of the hearing threshold known as temporary threshold shift (TTS) (Richardson et al., 1995). Prolonged or repeated exposure to sound levels sufficient to induce TTS without recovery time eventually leads to permanent threshold shift (PTS), or permanent hearing loss.

Finneran et al. (2002) conducted TTS experiments with one dolphin and one white whale exposed to sounds generated from a seismic source. TTS was observed in the white whale after exposure to single impulses with a sound exposure level (SEL) of 186 dB re 1 $\mu Pa^2 \cdot s$. The white whale's hearing returned to normal within 4 minutes of exposure. No TTS was observed in the dolphin at an SEL of 188 dB re 1 $\mu Pa^2 \cdot s$. These experiments involved single pulses; animals exposed to multiple pulses would be expected to experience TTS at lower SELs, but this has not been quantified. Acoustic modeling for shallow water carried out for this EIA (Jasco 2008) indicates that a SEL of 180 dB re 1 $\mu Pa^2 \cdot s$ could occur within 160 and 240m of the array center. At this range, the array cannot be approximated as a point source, and the actual received sound level at any given point will depend on the proximity to larger or smaller individual seismic sources.

This criterion is based on sound pressure level (SPL) rather than energy (e.g., SEL is an energy unit). Acoustic modeling indicates that an SPL of 180 dB re 1 µPa (rms) could extend to about 500 m from the array center. Including a 5 dB correction for uncertainty in the model predictions, the 180 dB range would extend the distance to about 850 m from the array center.

This is most applicable to mysticetes (baleen whales), which are believed to have good low-frequency hearing. Odontocetes (toothed whales and dolphins) are probably at less risk for auditory trauma because of the high hearing threshold (i.e., poor hearing) of odontocetes in the frequency range less than 200 Hz, where most of the energy from seismic pulses is concentrated (Goold, 1996). Dugongs probably also are at relatively low risk, as their frequency range of best hearing is believed to be between 6 and 20 kHz (Gerstein et al., 1999).

Auditory Masking

Auditory masking occurs when sound signals important to a marine mammal (e.g., sounds associated with echolocation, communication, and environmental sounds cues) are blocked or interfered with (Richardson et al., 1995). In the case of seismic surveys, the potential masking noise consists of a pulsed form with a low cycle rate (approximately 10%, or a 1-

sec disturbance in every 10 sec of ambient noise). Davis et al. (1998) considered the effect of masking resulting from marine seismic operations to be of little consequence due to the low cycle rate of seismic pulses relative to continuous sounds, such as ship noise.

Behavioral Effects

A number of studies have documented behavioral effects of marine mammals in response to seismic surveys (Richardson et al., 1995; McCauley et al., 2000; Stone, 2003; Holst et al., 2006; Miller et al., 2006). However, it is unclear how the behavioral changes may affect the mammals' long-term health (Ocean Studies Board, 2003).

Stone (2003) reported that during seismic surveys in United Kingdom waters, several dolphin species were seen less frequently when seismic sound sources were firing than when they were not firing. In addition, baleen whales, killer whales, and all of the small odontocetes were farther from large source arrays during periods of active operation than when the sources were silent. In general, from these data, small odontocetes showed the strongest avoidance response to seismic activity, with baleen whales and killer whales showing some localized avoidance, pilot whales showing few effects, and sperm whales showing no observed effects. Different groups of cetaceans may adopt different strategies for responding to acoustic disturbance from seismic surveys (Stone, 2003).
Baleen whales are believed to hear well in the low frequency range and have been observed to increase their distance from the source, change their orientation, and sometimes remain nearer to the surface in response to sounds produced by seismic surveying. For example, McCauley et al. (2000) reported that humpback whales began avoidance maneuvers at 5 to 8 km from an operating sound source array and maintained a standoff range of 3 to 4 km. McCauley et al. (2000) concluded that this observation suggests localized avoidance of the operating seismic vessels. Similar results have been reported for other baleen whales (Richardson et al., 1995).

McCauley et al. (2000) reported observations of adult humpback whales engaging in percussive behavior, such as tail slapping, during seismic surveys. This behavior is typically shown by breeding males competing for females and can produce very high sound levels. It has been suggested that males may perceive the loud sounds that seismic survey pulses produce as competing males (McCauley et al., 2000).

Mother/calf behaviors, such as suckling, may be more susceptible to acoustic disturbance. McCauley et al. (2000) suggested potential avoidance ranges of 7 to 12 km by nursing animals (based on results of single trials scaled to 3-D array measurements), but noted that these might differ in different sound propagation conditions. As discussed in Chapter 5 (Baseline Description) humpback whales migrate along the coast of Mozambique to mate, calve, and nurse their young, primarily from July to December.

The U.S. National Marine Fisheries Service (NMFS) currently uses a criteria of 160 dB re 1 µPa (rms) as a criterion for behavioral harassment of marine mammals. The equivalent SEL is about 155 dB re 1 $\mu Pa^2 \cdot s$. The acoustic modeling indicates that marine mammals could be exposed to levels of 150 dB (which is somewhat lower than the NMFS criteria) at distances of between 3 and 10.6 km from the source array. However, behavioral responses are not necessarily predictable from the loudness of the sound source and may vary depending on factors such as the age and status of the animal, the type of activity it is engaged in, and the social context (McCauley et al., 2000).

There are no reports of dugong response to underwater noise. However, studies of a related species, the West Indian manatee, indicate that the animals responded to approaching boats by orienting towards deeper channel waters and increasing their swimming speed when boats were within approximately 25 to 50 m (Nowacek et al., 2004). Research by Mann et al. (2007) indicates that manatees are capable of localizing sounds underwater, including those produced by boats. There are no reports of responses to seismic survey noise.

In conclusion, therefore, without mitigation, seismic surveys could produce temporary or permanent auditory trauma to marine mammals. Although humpback whales are the main concern, several other IUCN-listed whales can occur in the area (sperm whales, blue whales, fin whales, and sei whales). However, the risk is limited mainly to within a few hundred meters around the sound sources and can be minimized through mitigation measures during seismic surveys (see Chapter 7).

Behavioral responses, such as avoidance (or in some cases, approach to operating sound sources), can be expected to occur within many kilometers of an operating array. While the biological importance of behavioral changes is not well understood, the consequences probably are not significant under most circumstances (McCauley et al., 2000; Continental Shelf Associates, Inc., 2004). If surveys were conducted during the humpback whale calving/nursing season, avoidance behavior could have a greater potential for disrupting normal activities during a critical life stage.

Based on this the impact of sound pressure waves in marine mammals can be considered of moderate significance.

Potential impact 12: Impacts of retrieval and deployment of bottom cables/autonomous receivers on marine mammals

The retrieval and deployment of bottom cables/autonomous receivers will have minimal impacts on marine mammals. **The impact will be insignificant.**

Potential Impact 13: Impacts of sound pressure waves on marine turtles

In contrast to marine mammals, relatively little is known about sea turtle hearing ability or their dependency on sound (passive or active) for survival cues. Only two species, loggerhead and green sea turtles have undergone any auditory investigations. The anatomy of the sea turtle ear does not lend itself to aerial conduction; rather, it is structured for sound conduction through two media: bone and water (Békésy, 1948; Lenhardt, 1982; Lenhardt and Harkins, 1983).

Auditory testing and behavioral studies show that turtles can detect low-frequency sounds (Ridgway et al., 1969; Bartol et al., 1999). Most common sound frequencies produced by seismic sources overlap with the frequency range where turtle hearing is most sensitive (100 to 700 Hz). It is likely that sea turtles would be able to hear seismic survey noise for a considerable distance from the source and possibly experience some disturbance.

Auditory Trauma

All sea turtle species are assumed to be at some risk for auditory trauma, although hearing data are only available for loggerhead and green turtles. Hatchling sea turtles are probably at minimal risk for noise impacts. These animals inhabit seaweed mats and debris floating on the sea surface. Due to the attenuation pattern of seismic arrays, seismic noise levels would be lowest in near-surface waters.

Because sea turtles remain submerged much of the time (Eckert et al., 1986, 1989; Keinath and Musick, 1993), they may be passed over by seismic arrays and, therefore, exposed to the highest sound levels, which are directed downward. Although the sound levels produced by seismic sound sources are not likely to kill a sea turtle (even at close range), they could result in auditory trauma.

In the absence of criteria for auditory trauma in sea turtles, the criteria for marine mammals will be assumed to apply. The criterion for TTS from a single pulse would be an SEL of 186 dB re 1 $\mu Pa^2 \cdot s$; turtles could be exposed to this level within about 150 m of the array center.

Behavioral Effects

McCauley et al. (2000) exposed sea turtles to seismic sound pulses and found that they began to noticeably increase their swimming activity and, at higher exposure levels, began to show more erratic swimming patterns, possibly indicative of them being in an agitated state. They suggested that sea turtles displayed a general “alarm” response at an estimated 2-km range from an operating seismic vessel and behavior indicative of avoidance occurred at an estimated 1-km range.

Holst et al. (2006) reported on the results of turtle observations during seismic surveys at various locations. Sea turtles showed localized avoidance during large- and small-source surveys. The mean closest point of approach for turtles was smaller during non-seismic than seismic periods (i.e., 139 m versus 228 m for large-source surveys and 120 m versus 285 m for small-source surveys).

There are no formal criteria for behavioral responses in sea turtles. The U.S. National Marine Fisheries Service (NMFS) currently uses 160 dB re 1 µPa (rms) as a criterion for behavioral harassment of marine mammals. Acoustic modeling indicates that animals could be exposed to these levels at distances of between 6 km and 12 km from the source array. Based on the preceding discussion of limited turtle responses to seismic survey noise, the 160 dB criterion would appear to greatly overestimate the extent of behavioral impacts in sea turtles and is not considered applicable.

Disruption of Nesting and Hatchling Behavior

The seismic surveys will be conducted during the sea turtle nesting season and could affect the behavior of nesting females or emerging hatchlings. Both noise and lights could be a factor.

According to the discussion in Chapter 5 (Baseline Description), the green and hawksbill turtles nest on the several of the islands (Hill and Garnier, 2003). Turtle nesting occurs throughout the year. On Vamizi Island turtle nesting peaks in January and August whilst on Macaloe Island the turtles have their nesting peak between November and May.

Sea turtles nest in sandy beaches and therefore will be insulated from seismic sound or acoustic energy during their nesting activity. Sea turtles en-route to sandy beaches to nest may be affected by the seismic sound pressure waves and move away from the beaches.

In conclusion, without mitigation, seismic surveys could produce temporary or permanent auditory trauma to sea turtles, all of which are listed by the IUCN as endangered or critically endangered and are protected under Mozambican law. However, the risk is limited mainly to within a few hundred meters around a sound source array and can be minimized through mitigation measures during seismic surveys (see Chapter 7).

Thus, sound pressure waves may affect marine turtles. The significance of this unmitigated impact is moderate.

Potential impact 14: Impacts of retrieval and deployment of bottom cables/autonomous receivers on marine turtles

The retrieval and deployment of bottom cables/autonomous receivers will have minimal impacts on marine turtles. **The impact will be insignificant.**

Potential Impact 15: Impacts of sound pressure waves on fish (other than coral fish)

In the event of fish being in close proximity to the sound source, it is possible that pathological trauma or mortality will occur. Assessment of the pathological effects of sound pressure waves on fish species have usually involved the exposure of captive or caged fish to nearby sound sources (see McCauley, 1994 and Turnpenny and Nedwell, 1994).

Larval fishes and fish eggs inhabiting mangroves, seagrass beds may be disrupted by sound pressure waves in the very near field (Booman et. al., 1996). Juvenile fishes can also be damaged or killed by the high sound pressure waves generated by the seismic sound sources (Dalton, 2007). Their ability to move away and avoid the sound sources is less than adult fishes.

For adult fishes, the intense sound in the range of those produced during seismic operations can damage sensory epithelia of the hearing system or rupture the swim bladder (Popper et al., 2005). However they can swim away of the seismic source before serious damage is caused. Reef fish, being territorial, will move deeper into the habitat framework, being more exposes than pelagic species.

Given the general high mobility of fish it is assumed that the majority of fish species would avoid seismic noise at lower levels than where pathological injury or mortality would occur. However, possible injury or mortality could occur on initiation of a sound source at full pressure in the vicinity of fish at received levels of over about 180 dB re 1_Pa, or where reproductive, territorial or feeding behaviour override a flight response to seismic survey sounds (for example, fish associated with reefs) or in extreme shallow.

The significance of this unmitigated impact is considered moderate.

Potential impact 16: Impacts of retrieval and deployment of bottom cables/autonomous receivers on fishes

The retrieval and deployment of bottom cables/autonomous receivers will have minimal on fishes. **Therefore the impact is insignificant**

SOCIO-ECONOMIC ENVIRONMENT

POPULATION AND LOCAL ECONOMY

Potential Impact 17: Social conflicts due to the presence of foreign workers

The seismic survey vessels and crews are highly specialized and will be mobilized from outside Mozambique. The vessels will have onboard provisions; however, an escort vessel will be designated to bunker the fuel and supplies from Pemba when needed, while one or more other escort vessels continue to ensure there are no obstacles in the survey vessel's path. Half the crew will be rotated approximately every three weeks through Pemba via helicopter and international flights to Johannesburg, South Africa.

Apart from these workers, a total of 2 to 3 crew personnel, Anadarko representatives and observers will be directly involved in the seismic activities, and will be based in Pemba for the duration of the project.

The presence of foreign workers can pose a risk in terms of health impacts of transferable disease. Communicable diseases pose a significant public health threat worldwide. Diseases of most concern during the project are sexually-transmitted diseases (STDs), such as HIV/AIDS. Expatriate workers with relatively large amounts of money could potentially result in an increase in prostitution and in an increase on STDs. The mobile nature of these workers means STDs could be carried to other locations when the workers return home.
For those working on the seismic vessels, due to their short presence in Pemba (maximum one night), **the potential for social conflicts and an increase in STD prevalence is considered to be of minor significance.**

For those based in Pemba for the duration of the project, **the potential for social conflicts and an increase in STD prevalence is considered to be of minor significance.**

<u>Potential Impact 18: Increased revenue due to the presence of the crew in Pemba</u>

The presence of the workforce in Pemba may lead to a limited increase in expenditure in the local hotels, restaurants and markets. Crew members and families may even visit local tourist attractions available in the region.

The presence of the workforce would therefore result in a small, temporary, economic boost and impacts are therefore considered to be positive.

ARTISANAL FISHERIES

Effects of the safety zones on artisanal fishing

<u>Potential impact 19: Temporary loss of access to fishing grounds and associated loss of catch – off-shore commercial artisanal fishers</u>

According to the findings of the SSAFC, the majority of commercial artisanal fishers in the study area fish in the coastal area, i.e. between islands and the mainland, between the islands, and not further than 1.5 km to the east of the islands. This is due to distances, rough sea conditions further out, and the generally poor condition of the boats. As **Figure 6-5** indicates, a significant amount of artisanal activity is concentrated around reefs, banks, and shallower parts of the study area. **Figure 6-6**, in turn, shows the movement of fishers travelling to fishing grounds within the seismic survey area. Thus, commercial artisanal fishers may temporary lose access to certain fishing grounds when the seismic vessel is in proximity to the fishing area, or catch days may be disrupted by the approaching seismic vessel.

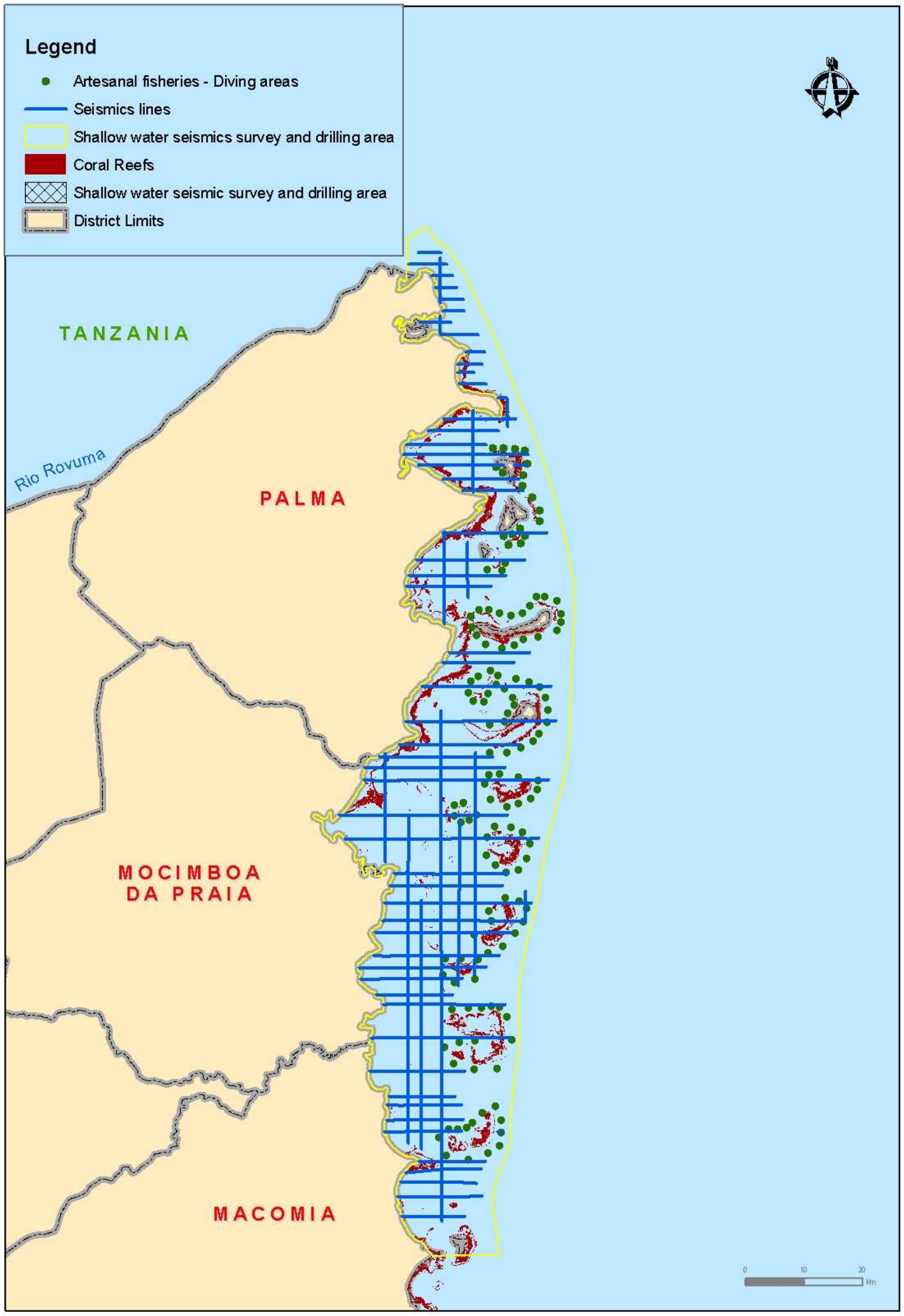


Figure 6-3. Frequented diving and artisanal fishing sites in relation to the proposed seismic lines

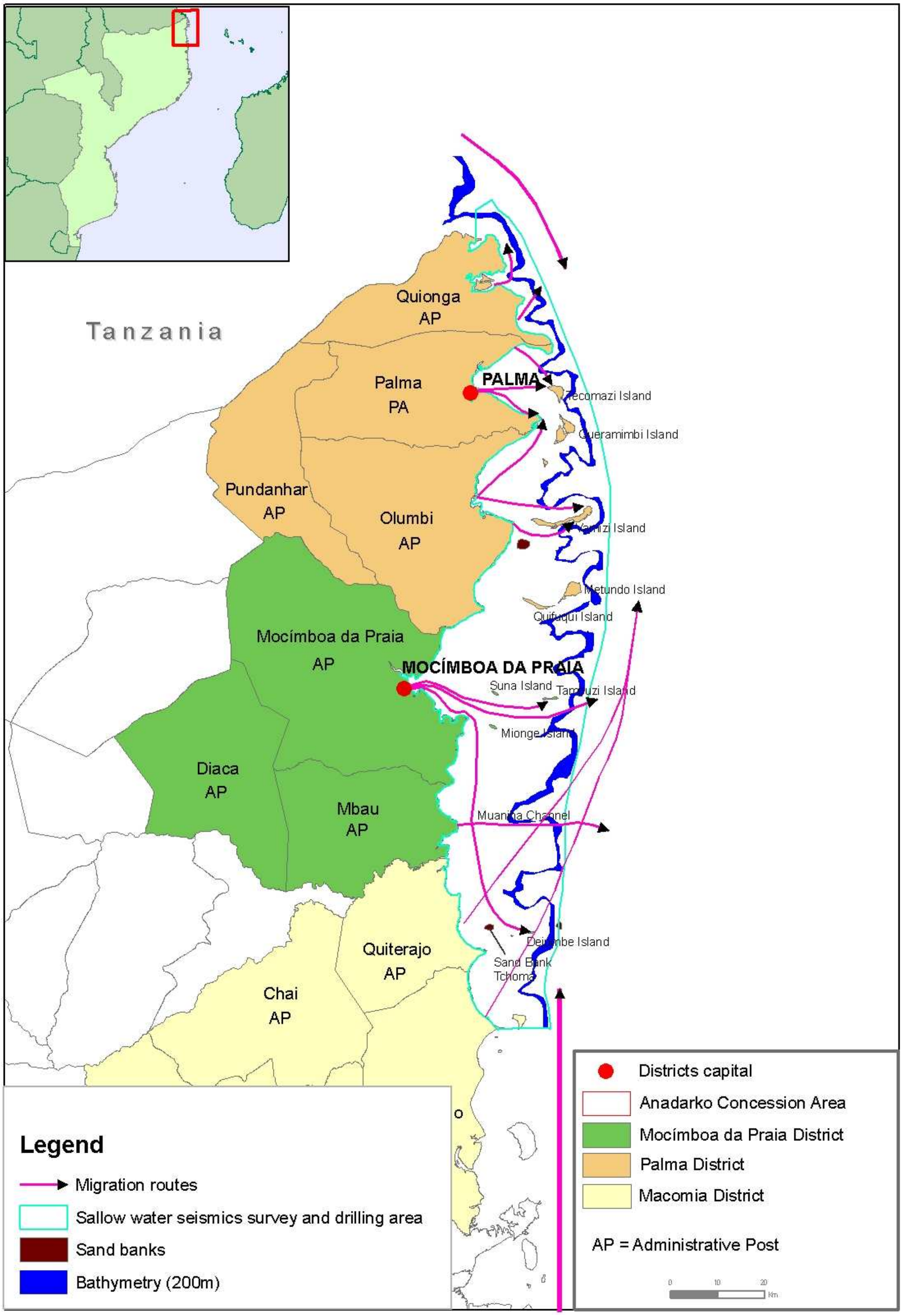


Figure 6-4. Movement of artisanal fishers in the study area

The effect on commercial artisanal fishers operating off-shore will be temporary (no more than two days at a time), and, in all likelihood, will only potentially affect the number of fishers who intended to fish in the affected area on a particular day. As indicated above, most fishers have alternative fishing grounds, or in the case of artisanal divers and hand line fishers, alternative sources of income in the form of trade.

The significance of this impact is minor

Potential impact 20: Temporary loss of access to fishing grounds and associated loss of catch – subsistence and commercial artisanal fishers operating from the shoreline

Subsistence artisanal fishers comprise approximately 70% of artisanal fisher sector in the study area. They do not make use of boats, and their activities are limited to the very shallow areas close to the shore line. Fishers using harpoons and hand lines do so in water around 1 m deep, and fishers using traps can do so in water up to 5 m deep. These fishers are more area bound, and not as mobile as their counterparts using boats.

According to the current seismic transect layout, very few of the most western points of the transects are in water depths less than 5 m, and none of the lines in close proximity to the islands pass through water of less than 5 m deep either. Thus, if the current seismic transect layout is followed, effects on subsistence artisanal fishers should be limited. However, the laying of bottom cables (whether 2D or 3D) in areas where water depth are below 2 m, could affect these fishers' access to certain fishing grounds. Similarly, commercial artisanal fishers using beach seine gear predominantly operate in water depths of less than 20 m, but they do so from the shore, banks, or reefs. Beach seine comprises 51% of fishing net operators in the study area. They could also lose access to fishing grounds while the cables are in place. However, at the time of the SSAFC and the SIA, the potential areas where bottom cables would be laid had not been determined yet by the proponent, and it was also not known how long cables would be in place at any given location. Thus, it becomes difficult to attempt to quantify the potential effect that these cables could have on subsistence and commercial fishers' access to fishing grounds.

Access to fishing grounds for certain subsistence artisanal fishers and beach seine operators may be affected by the laying of 2D and/or 3D bottom cables, although the exact duration of this impact could not be determined at the time of the study. The total size of the area where bottom cables would be used, as well as the duration of access being affected, would determine the overall rating of the impact.

Beach seine fishers will, however, be able to continue fishing on the some beach where OBCs are laid although they would have to move a short distance (say 100m) away from the site of the OBC were laid.

The impact is considered of minor significance

- NOTE -

For the most part, impacts on subsistence artisanal fishers and commercial artisanal fishers operating from the shoreline are related to the use of bottom cables in water depths less than 2 m. Thus, if bottom cables are not used as part of the acquisition program, or only used in very confined areas, impacts on these fishers could be minimal.

Effects of changes in fish behavior and movement on artisanal fishing

Potential impact 21: Temporary decreased catch volumes in certain areas - off-shore commercial artisanal fishers

Artisanal fishers catch reef fish when fishing over coral reefs as well as pelagic demersal fish and squid. Most artisanal fishers are poorly equipped to catch deep water fish, and the condition of their boats does not allow them to venture too far off-shore.

As indicated in preceding sections, seismic acquisition could have a temporary disruptive effect on the behavior patterns and movement of fish. According to the Sensitivity Analysis and Fish Study conducted by CSA (CSA, 2008a and 2008b), the changes in behavior in reef fish should not continue for longer than one day after the seismic vessel has passed. Pelagic and demersal species would tend to move away from the sound source, but these fish are not site bound and move about as a matter of course. However, a more recent study on the Woodside Scott Reef Study in Australia concluded the reef fish began to feed and behave normally within 20 minutes of a seismic vessel passing as recommended in the Communication Plan.

Although the seismic activity may not affect fish behavior or fish population to any great extent, artisanal fishers will not be able to fish in an area for a period of up to two days because of the presence of the seismic vessel as indicated in the Communication Plan . **The significance of the impact is moderate**

Potential impact 22: Temporary decreased catch volumes in certain areas - subsistence and commercial artisanal fishers operating from the shoreline

According to CSA's Sensitivity Analysis and the Fish Study (CSA, 2008a and 2008b), and discussion with specialists (Viada, S. Personal communication), if habitat is not destroyed or disrupted during the laying and retrieving of bottom cables, fish should return to areas where bottom cable activity took place, within two days. This statement assumes that buffer zones outlined in the Sensitivity Analysis (CSA, 2008a) are implemented and adhered to. Thus, for approximately two days after bottom cable operations have ceased in a specific area, subsistence artisanal fishers and commercial artisanal fishers operating from the shoreline could experience decreased catch volumes.

If no habitat disruption or destruction takes place, fish could return to areas where bottom cables were used within two days after operations have ceased.

This impact is considered of moderate significance.

- NOTE -

It is important to bear in mind that due to loss of access to fishing areas, together with decreased catch volumes, subsistence artisanal fishers and commercial artisanal fishers operating from the shoreline in a specific area, could be affected for a much longer period, depending on the duration of bottom cable operations. Since these fishers are less mobile and, therefore, less likely to be able to access alternative fishing areas, the impact ratings (prior to, and after mitigation) used here, take cognizance of this.

Effects on the safety of artisanal divers

Potential impact 23: Effects on physical safety and health of divers due to sound source pulses

The Diving Medical Advisory Committee (DMAC) (London) for diving operations in deep water (according to DMAC, at depths greater than 10 meters) with a seismic source array with capacities less than 4,400 cu. in. (DMAC 12 – November 1979) recommend a safety zone of 1,500 meters for divers.

The US Navy's Permissible Exposure Limit (PEL) guidelines (http://www.surtass-lfa-eis.com/DiverStudies/index.htm) for diver exposure to their SURTASS LFA sonar provide three sound level thresholds:

- 157 dB – no physiological evidence of damage to test divers was observed;
- 148 dB – 2% of the test divers reported aversion reaction to the sounds; and
- 145 dB – a 3 dB 'safety margin' applied to the 148 dB threshold.

Two of the sites (M1 and S1) for underwater acoustic modeling for shallow waters were at depths less than 20 m (Site M1 = 15m and Site S1 = 10m) – see Volume III of this EIA, Specialist Study No. 1 (JASCO Report; Assessment of Underwater Noise: EIA for Shallow Water Exploration Seismic survey and Exploration Drilling Operations in the Rovuma Offshore Area 1, Mozambique. Appendix B, pp. 44-46). From these data, a PEL value of 150 dB is considered, since JASCO applied a safety margin ('uncertainty factor') of 3 dB to their radii data. The 95th percentile radii, defined as the radius of a circle which encompasses 95% of the grid points whose value is equal to or greater than the threshold value, for a sound level of 150 dB at the two modeled sites are shown in the table below.

Table 6-17. Summary of 95% safety radii for two shallow water acoustic modeling sites. The 95% safety radii of the 150-dB Sound Exposure Level (=160-dB Root-Mean-Square) isopleths have been estimated from SEL values, with addition of an uncertainty factor of 3 dB.

Table 6-17. Summary of 95% safety radii for two shallow water acoustic modeling sites

Site Number	Bottom Depth (m)	95th Percentile Radius (km) for a Sound Level of 150 Db (SEL)
M1	15	2.4
S1	10	1.8

From these modeling results, it is recommended that a 2.4 km safety radius be implemented for divers within the shallow waters of the AMA-1 Rovuma Concession Area. It is also recommended that seismic survey mitigation measures include soft-start (ramp-up) procedures, the presence of a Liaison Officer on the chase vessel to locate divers in the survey area and the prior communication with artisanal and recreational divers as laid out in the Communication Plan.

Since diving for catch forms a part of the livelihoods of artisanal fishing communities, the emphasis is on the safety of the divers, rather than the nuisance effect as in the case of recreational divers.

The majority of artisanal fishing activities require the operators of the gear to submerge below the water surface at some point during the operations, whether it's an inherent part of the operation, such as specie spotting while using pursing nets, or *ad hoc* events such as diving down to retrieve hooks or nets snagged or coral or rocks. The enforcement of the 2.4 km safety zone around the seismic vessel ensures for the safety of such fishers.

Should bottom cable acquisition be done, the presence of an additional chase vessel is important, because the actual seismic vessel would be slightly further off-shore than the area where the cables have been laid, and the safety zone would need to be enforced.

This effect will be temporary, in all likelihood, and will only potentially affect a small number of divers at a time.

The unmitigated impacts of seismic sound on divers are considered to be major.

Effects on the livelihoods of artisanal fishers

<u>Potential impact 24: Temporary loss of income and effects on food security</u>

As indicated in the SSAFC, the income generated from fishing activities by artisanal fishers is limited, and they work on very small profit margins, or on a purely subsistence basis. The potential disruption of catches and catch volumes may, therefore, lead to a temporary loss of income, not only for individual subsistence fishers and owners of the boats or fishing gear, but also for the 'workers', who are paid in fish, and whose income is, thus, directly related to the volume caught. Decreased catch volumes may affect artisanal fishers, in that they may not only experience a loss of income, but also that an important part of their diet and food security may also be affected.

As indicated above, according to the current seismic transect layout above (**Figure 6-5**), none of the most western points of the transects are in water depth less than 5 m and none of the lines in close proximity to the islands pass through water of less than 5 m deep. Thus, if the current seismic transect layout is followed, and no acquisition, whether with streamers or bottom cables, takes place in water shallower than 5 m, the income and food security of more than 70% of artisanal fishers in the study area[3] would not be affected by the exploration. However, if the transects are extended into shallower water and if bottom cable acquisition is conducted in water less than 2 m deep, this would change significantly.

Artisanal divers are not solely dependant on their catch as their only source of livelihood. The SSAFC indicates that, due to the unpredictability of weather conditions that can

[3] Subsistence artisanal fishers.

sometimes make diving virtually impossible for days, artisanal divers typically have other sources of livelihoods, such as informal trading.

This effect will be temporary and the significance of the impacts on income and food security would be largely dependant on the final seismic transect plan and the use, or not, of bottom cables in shallow water.

The significance of the impact is minor.

Effects on first order fish traders and their livelihoods

Potential impact 25: Temporary reduction in fish volumes available for purchase and resale

A temporary reduction in catch for fishers implies that there may be a temporary reduction in fish stocks available for traders to buy and sell. Local markets may experience shortages, and single traders may not be able to get sufficient volumes together to justify long trips to the study area. However, first order traders are predominantly supplied by commercial artisanal fishers and, as indicated in preceding sections, impacts on catch among these fishers would not be severe. Also, fish traders are usually supplied by a number of fishers, not all of whom fish in the same areas. Therefore, it is not anticipated that there would by any significant effect on fish volumes available for sale by first order fish traders.
This effect would be temporary, although it may lead to some temporary loss of income for first order fish traders. **The significance of the impact is minor.**

TOURISM

Recreational diving and snorkeling activities

Potential impact 26: Temporary loss of access to dive sites due to safety zone around the seismic vessel

According to the information provided by dive operators, recreational diving predominantly takes place around the islands of Mejumbe and its associated reefs, and Vamizi and Rongui and their associated reefs. The current seismic plan takes cognizance of these areas and no transects are currently located over these dive sites. If is, therefore, unlikely that access to dive sites could be affected due to the enforcement of the safety zone around the vessel during the actual seismic acquisition.

However, it is important to note that while the vessel maneuvers between transects in “non-acquisition mode”, that is, the sound sources are not in operation, the hydrophones are still in position and trail behind the vessel. Thus, the safety zone will still be in place even when the vessel is not on a predetermined transect, which could potentially disrupt diving activities. However, it is not possible to attempt to quantify the additional duration.

The expected potential effect on diving operations due to the safety zone around the seismic vessel will be limited to vessel maneuvers close to dive sites, and temporary.

The impact is considered of minor significance.

<u>Potential impact 27: Physical safety and health of divers due to seismic sound source pulses</u>

The effect on recreational divers would be similar to the effect on artisanal divers (Potential Impact 23 above) and a safety zone of 2.4 km of no diving would need to be maintained around the seismic sound source vessel and dive sites. A number of transects of the current seismic design occur within the 2.4 km of the dive sites. These should be adapted, in order to accommodate the safety principle.

The significance of the impact, if unmitigated by the safety zone is major.

<u>Potential impact 28: Discomfort of divers due to sound pulses generated by the seismic sound source</u>

One of the greatest draw cards and selling points of the Quirimbas Archipelago as a tourism destination is its isolation and remoteness. Divers visiting the archipelago do so to experience a high level of undisturbed wilderness, which is not possible in other, more populated tourist areas, and these visitors are prepared to pay for the experience. As the numbers of divers per day outlined earlier shows, there are a fairly small number of divers in the water on any given day. Considering this dive quality, and the reputation of the Quirimbas Archipelago as a wilderness diving destination, industrial noise, audible above ambient ocean noise levels, could potentially be intrusive and would be negatively received by divers.

Ambient noise in the ocean originates from a variety of sources, over bands of frequencies ranging up to 100 kHz. The major sources of ambient oceanic noise are related to wind and distant shipping. Other sources include rain, oceanic turbulence, sea life, tides, waves, volcanic eruptions, non-industrial seismic activity, and molecular agitation (heating and cooling). Deep ocean background noise attributable to shipping, ranges from 82 to 87 dB ref 1µ Pa (Continental Shelf Associates, Inc.: 1996).

Ambient reef noise levels measured at sites off Hawaii had a broadband, peak frequency of 1.9 kHz, and had a mean SPL of 107 dB ref 1µ Pa (Boyle and Tricas: 2006). Off Lizard Island in the Great Barrier Reef, levels of broadcast reef sound (broadband 80–4000Hz) were predicted to be 107–109 dB re 1µPa (Leis and Lockett: 2005). Based on this, it can be assumed that the general level of background noise on a reef or in shallow water habitats similar to those of the Quirimbas Archipelago would be in the 107 to 109 dB re 1µPa range.

Data from a seismic survey done in shallow water off the Yucatan Peninsula, Mexico provide some perspective on the perceived loudness of the received sound. In the survey, a diver 3.5 km from the survey vessel reported the sound in the water was barely noticeable (Barton, P., J. Diebold, and S. Gulick: 2006). This survey was conducted over a shallow water (<30 m) limestone carbonate bank, similar to the inshore waters of the Quirimbas Archipelago.

Sound levels which are approximately 20 dB higher than ambient levels, may become audible to the average recreational diver, although experienced divers may detect sounds above ambient at lower levels.

Based on the results of the acoustic modeling done by JASCO Research (JASCO Research, 2008) sound levels would abate to below 130 dB within approximately 10 km of most of the shallow water modeled sites(**Figure 6-7**). Although the sound propagation from these modeled sites towards deeper water was stronger, there are no dive sites in the deeper water.

Conservatively, given that there are no interruptions or problematic weather conditions, and depending on the final 'acquisition plan', all transects within a 10 km radius from a dive site could be completed in two days. If surveying takes place at night as well, it could reduce the day-time exposure periods significantly.

The time during which sound levels generated by the seismic survey would be audible above ambient noise levels to the average recreational diver is conservatively estimated as approximately two to three days at the commonly visited dive sites within the study area.

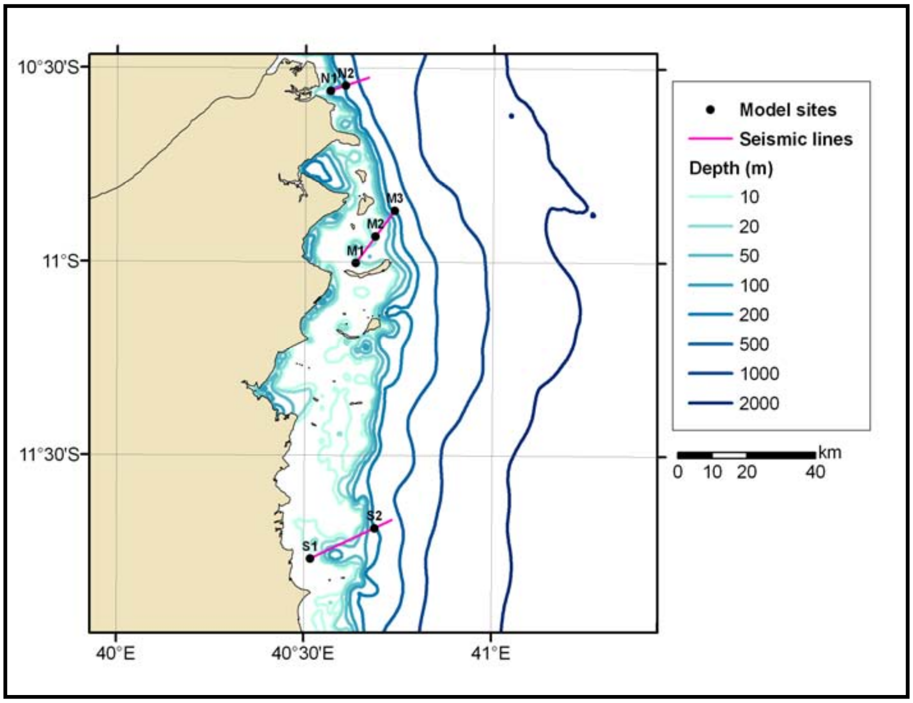


Figure 6-5. Position of points used for seismic modeling

The significance of the impact is moderate

Effects on recreational fishing activities

<u>Potential impact 29: Temporary loss / delayed access to recreational off-shore fishing grounds due to movements of the seismic vessel</u>

Recreational off-shore sport fishing activities also take place largely amongst the islands or a short distance east of them. However, L&A Operators indicated that they do conduct fishing excursions further out to sea, as far out as 12 nautical miles (approximately 22 km) to the east. Fishing activities may be temporarily affected by the safety zone in force while the seismic survey vessel is operating. This may also lead to a temporary delay in access to fishing grounds, the duration of which would determine the intensity of the impact. However, the seismic vessel will be travelling at approximately 5 knots (9.6 km/h), and delays would therefore be short, lasting less than 30 minutes, while the fishing boats wait for the seismic vessel to pass, or go around it. Also, off-shore sports fishing activities conducted by individual L&A Operators are not restricted to specific fishing areas. Fishing areas are spread out across the study area, and are usually some distance apart. Also, there are only approximately 14 recreational fishing boats used by L&A Operators in the study area, which makes the probability of a recreational fishing vessel coming into contact with the seismic vessel low.

The temporary loss (delay) of access to fishing areas due to the presence of the seismic vessels will have a short duration, and should not affect the fishing experience of recreational fishermen significantly. **Therefore the significance of the impact is minor**.

<u>Potential impact 30: Reduced off-shore sports fishing experience due to changes in fish behavior and movement, potentially leading to decreased catches</u>

Behavioral responses and the susceptibility of fishes to auditory trauma varies greatly due to the wide differences in hearing capability and morphologies among fish species, and at close range, seismic sounds mainly evoke a startle response (i.e., movement away from the source of the noise), and changes in schooling behavior. The Sensitivity Analysis conducted by CSA (CSA, 2008a) indicated that this may occur with regards fish over emergent hard substrates and sand and mud substrates, i.e. the fish may move away from the affected area. Over shallow and emergent coral communities, as well as deep water coral communities, visitors from deeper water (predominantly pelagic fishes) will move away, but reef fish species may move deeper into the habitat framework.

Habituation of fishes to the noise is suggested by the fact that behavioral changes are observed to cease during the exposure period, sometimes within minutes of commencement of surveying.

In general, subtle behavioral changes in fishes may be expected to occur at received peak pressures of 160 dB re 1 μPa, and peak pressures of 180 dB or higher may cause noticeable changes in behavior (Chapman and Hawkins 1969; Pearson, W., J. Skalski, and C. Malme: 1992; Skalski, J., W. Pearson, and C. Malme: 1992). For example, Pearson et al. (1992) studied the effects of seismic sounds on rockfish behavior, and noted that at received levels of 180 dB re 1 μPa, animals appeared to be alarmed and either aggregated more tightly, descended, or ascended in the water column. The lowest level causing any observed behavioral change was 161 dB. A return to pre-exposure behaviors was noted within 20 to 60 minutes.

Although none of this provides conclusive evidence for the Quirimbas, the avoidance behavior and changes in feeding patterns of fish may potentially lead to decreased catches by off-shore sports fishers in areas where seismic acquisition has taken place recently. Thus, if an assumption is made that off-shore sport fishing access to specific fishing areas will be disrupted for a day due to the safety zone (again the conservative principle is applied), and that changes in fish movement and behavior will last for a further day, the potential exists that disruption of these activities in specific areas may have an effective duration of two days.

The potential effect on sport fishermen catches could have duration of two days, if combined with the effect on access or delays in accessing fishing areas (conservatively estimated at one day). **Thus the impact is of minor significance**.

Effects on Cetacean (whales and dolphins) sightseeing excursions

Potential impact 31: Reduced quality of sightseeing, due to mammal movement away from the area of exploration activities

The U.S. National Marine Fisheries Service (NMFS) currently uses a criterion of 160 dB re 1 µPa (rms) for behavioral harassment assessment of marine mammals. The equivalent SEL is about 155 dB re 1 $\mu Pa^2 \cdot s$. Acoustic modeling indicates that marine mammals could be exposed to these levels within about 6.2 to 13.6 km of the sound source. However, behavioral responses are not necessarily predictable from the loudness of the sound source, and may vary depending on factors such as the age and status of the animal, the type of activity it is engaged in, and the social context (McCauley, 1994).

According to L&A Operators, Cetacean sightseeing excursions predominantly take place between July and November. Although dolphins are spotted all year round, no specific dolphin excursions usually take place within the survey period. Should the seismic survey period coincide with this peak season, it could significantly affect these excursions.

The impact is considered of minor significance.

Visual/aesthetic effects on tourists, especially on the islands

Potential impact 32: Visual disturbance caused by the seismic vessel

For a person of 1.82 m (6 feet) tall, the visible horizon when standing at sea level, is approximately 2.86 nautical miles (approximately 5.3 km)[4] away (http://boatsafe.com/tools/horizon.htm). The superstructure of the seismic vessel at bridge level is approximately 10 m from the sea level[5]. When the same formula is extended to include an object on the horizon, it implies that the vessel should start to become visible above the horizon when it is at a distance of 9.46 nautical miles (approximately 17.5 km offshore from the islands).

On a number of transects, the seismic vessel would be within approximately 3 km from the islands, and the vessel would definitely be visible from shore. However, these would be fairly short periods, as long as the vessel keeps moving when this close to the islands. Should the vessel have to stop for bad weather or any other reason, in close proximity to the islands, the intensity of the effect could increase.

The potential visual intrusion or disturbance created by the seismic vessel will be limited to short periods, and would be at a sufficient distance away from the islands not to have a significant impact. **The significance of the impact is minor.**

Economic effects on the tourism industry in the study area

[4] The distance to the horizon in nautical miles = 1.17 times the square root of your height of eye.

[5] The radar tower is higher than the superstructure, but this height has not been used in calculations, as the tower structure is thin and unobtrusive and will hardly be visible as it crests the horizon.

<u>Potential impact 33: Potential loss of revenue to tourism operators</u>

As indicated above, a diving safety zone of 2.4 km will be maintained around the seismic vessel. Also, the sound generated during the seismic survey will be audible above ambient sea noise levels for a number of hours at a time at certain dive sites, as the seismic vessel moves past. There could, therefore, be a number of days during which diving cannot take place due to potential effects on the safety and comfort of recreational divers.

The majority of visitors to the islands do so to dive, and the majority of the L&A Operators' packages include a number of dives. These operators, therefore, run the risk of potential patrons canceling bookings if they are informed that their diving experience could be affected, or patrons arriving on existing bookings and demanding part of their money back because of the effects of seismic survey activities.

There would be a number of days that diving could potentially be disrupted, be it for safety or comfort reasons, although only for specific and limited periods. **The significance of the impact is moderate**

<u>Potential impact 34: Potential loss of income (in terms of wages and purchases)</u>

Due to the potential loss of revenue by L&A Operators, there is a possibility of a loss of wages (direct and indirect) and purchases, since operators may be spending less on wages and purchases. However, the period of potential loss of revenue would be limited, and if tourism operators are compensated for any proven losses it should not affect wages, although purchases could decrease slightly due to a smaller number of guests.

It is unlikely that loss of revenue by L&A Operators would lead to a loss of employment. It may still, however, have a limited effect on purchases, since fewer guests would require fewer goods. **The impact significance is minor.**

<u>Potential impact 35: Effects on the sale of island plots to private investors</u>

According to the Maluane Group, sales of island plots to private investors are underway, due to an active marketing campaign, which has reportedly generated quite significant international interest. However, since the process was only initiated fairly recently, at the time of the study, only approximately 12% of available plots had been sold. The seismic acquisition, could potentially negatively affect interest in, and sales of, islands plots. However, the seismic vessel would only be in close proximity to the three islands on which plots are available for sale for limited periods, and since it is a normal ocean-going vessel, it may not even draw notice from potential investors. This could slow down the rate of sales of island plots and negatively effect income from the sale of plots. **The impact significance will be minor.**

Effects on the image of the Quirimbas Archipelago as a medium/high-end tourism destination.

<u>Potential impact 36: Effects on the 'island paradise' image</u>

Although the tourism industry in the Quirimbas Archipelago is in its infancy, it is growing rapidly, and is already a sought-after international destination in the high-end tourism market. Tourists visiting the resorts in the study area are predominantly from the UK and Europe. Lodges in the Quirimbas capitalise on the theme of unspoilt wilderness and luxury holidays in a tropical island paradise. Diving, recreational fishing, and whale watching are integral parts of their branding. Branding becomes very important when targeting a high-end market with consumers who like to think that they are visiting a unique area for a unique experience. If the “unique experience” image is not sustained, this patronage could easily go elsewhere. The potential effect of the proposed seismic exploration on the image of the Quirimbas is strongly dependant on how activities associated with the survey are managed, and how lodges deal with the issues around diving. Also, due to the extended seismic, drilling, and other exploration related activities which have been taking place in Archipelago over the past three years, the proposed shallow water seismic exploration is but one of a number of activities which could have an effect on the Quirimbas Archipelago’s image.

However, specifically related to this project, bad diving experiences due to seismic sound, or inability to dive on certain days, could result in negative perceptions about the Quirimbas among divers and guests. Experiences at destinations are shared by fellow tourists by word of mouth and tourism orientated websites, which are fast becoming a very powerful medium. International tourism agencies responsible for bookings and the marketing of resorts may also become apprehensive as to the quality of the tourism experience which they can guarantee their client, and deliberately or unintentionally spread negative perceptions into the market.

Potential effects of a change in the image of the area as a tourism destination may be a decrease in occupation levels, decreased revenue to operators, and decreased spending, which may lead to direct, as well as indirect, job losses. This may have a longer term impact on the socio-economic environment, and also stems from more than one source, i.e. the current activities of all five concession holders in the Rovuma block.

However, when viewed against the increasing occupation levels, as well as the large number of new and planned developments in the Quirimbas Archipelago, it also indicates that the hydrocarbon exploration which has been taking place in the area over the past three years has not had any significant effect on the image to date.

The impact significance will be moderate.

Effects on planned and future tourism developments in the Quirimbas Archipelago

<u>Potential impact 37: Suspension of planned and future investment</u>

There is substantial additional new investment planned in the Quirimbas Archipelago, with a number of existing tourism operators also planning extensions to their current facilities. This number has increased over the past two years, and developers do not seem perturbed by the potential development of offshore oil or gas resources.

Completion of developments currently underway on Vumba, Tecomaji, Quifula, and Tambuzi are all aimed at December 2008 or early 2009.

This implies that by the time the project is implemented, there could be at least an additional 2,250 bed nights per month available on islands in the study area, which would effectively increase the number of available bed nights by more than 60%.

It would, therefore, appear that hydrocarbon exploration has not had a significant effect on planned future investment to date.

The significance of the impact is moderate during the exploration phase due to the temporary nature of the activity.

6.2.1.2. Impact Assessment for Non-Routine Events (Seismic Survey)

The potential non-routine events associated with seismic survey operations are mainly related to small diesel spills during bunkering and collisions with other vessels. Collision with other vessels can result in diesel spills.

Small diesel spills can have impacts on all environmental components described above.
The effects of diesel oil spills on marine ecosystems are described in more detail under the non-routine drilling events in Section 6.2.2.2. below.

A fire/explosion could occur on the seismic vessel or support vessels. The impacts of a fire or explosion are largely concerned with the risks for human population but there will also be temporary and localized impacts on air quality.

PHYSICAL ENVIRONMENT

AIR

<u>Potential Impact 1: Reduced air quality due to the evaporation of VOCs from diesel spills</u>

A diesel spill would affect air quality through the evaporation of volatile compounds, but only within the immediate vicinity of the spill. Dissolution, dispersion, biodegradation, and photo-oxidation would also act on select components of the diesel. Given the relatively small volume of diesel released under this accident scenario, coupled with rapid dissolution, dispersion, evaporation, and, to a lesser extent, photo-oxidation, only very localized air quality impacts would be realized. No impact to coastal areas would be expected.
The impact is insignificant.

<u>Potential Impact 2: Reduced air quality due to a fire/explosion</u>

In the unlikely event of a fire/explosion on the seismic vessel or the support vessels, the release of combustion products such as CO2 and particulate matter to the atmosphere may occur. A fire/explosion will result in the release of combustion products such as CO_2 and particulate matter. Thus, air quality in the vicinity of the fire/explosion may be affected.

The significance of this impact is minor.

WATER

<u>Potential impact 3: Reduced water quality due to accidental diesel spills</u>

Potential accidents during a seismic activity may include spills of reduced volumes of bunkers during the fuel supply operations to the seismic vessel. Initially, the vessel will bunker at the mobilization point; while the additional bunkering will take place at the sea through transference of bunkers from a support vessel to the seismic vessel.

If spills do occur, they will probably be minor and the potential impacts will be of short duration.

Therefore the impact will be of minor significance.

BIOLOGICAL ENVIRONMENT

MANGROVES

Potential Impact 4: Effects on coastal mangroves due to diesel spills

Oil spill effects on mangroves have already been described while discussing spill impact during drilling. When spilled on water diesel oil spreads very quickly to a thin film. When small spills do strand on the shoreline the oil tends to penetrate porous sediments quickly but are also washed off quickly by waves and tidal flushing. No shore cleanup is usually needed. As long as only small scale diesel spills can be expected the **significance of such an accident is minor.**

SEAGRASS AND MACROALGAE

Potential Impact 5: Effects on seagrass beds and macroalgae due to diesel spills

For spilled diesel fuel, minimal toxicity to sea grasses is expected due to hydrocarbons being readily dissolved, dispersed, and evaporated, depending upon proximity of sea grass beds to spill location.

Impact can be considered minor

CORAL REEFS

Potential Impact 6: Effects on coral reefs due to diesel spills

Impacts of spill on coral reefs have been analyzed in detail when identifying impacts of accidents while drilling operations. Smaller diesel fuel spill don't have persistent effects and diesel tends to quickly evaporate. **Impact can be considered minor**

FAUNA

MARINE MAMMALS

Potential Impact 7: Effects on marine mammals due to diesel spills

Marine mammals are less vulnerable than seabirds to fouling by oil and they can be affected by diesel spill within the first few days. Symptoms from acute exposure include irritation to the eyes and lungs, lethargy, poor coordination and difficult with breathing. **Impact can be classified as minor**

MARINE TURTLES

Potential Impact 8: Effects on marine turtles due to diesel spills

Adult and juvenile turtles can survive and, through their swimming ability, avoid oil slicks. The most vulnerable stage in the turtle life cycle is if an oil slick reaches beaches where hatchlings are about to emerge and migrate to the sea. It is probable, although not specifically proven, that the presence of an oil slick will disorientate the hatchlings. This may lengthen their exposure to predators on the beaches and/or interfere with their swimming abilities. Hatchling survival is not high in any case (Bjorndal, 1982) and any increased mortalities can be reflected in the overall population.

The potential impacts of a small diesel spill are significantly reduced (relative to crude oil impacts) because the smaller spill volume and weathering of the diesel fuel will limit the surface area of the spill and overall effects on sea turtles that may be present. **Impact can be classified as minor.**

FISH

<u>Potential Impact 9: Effects on fish due to diesel spills</u>

Pelagic fish (adults, larvae) mortalities as a result of oil spills are limited in size and have not translated into measurable effects on fish stocks. However, local mortalities especially in fish larvae and fish eggs can occur but direct observation of this is apparently rare (Baker et al., 1990).
Toxicity effects on fishes, with localized mortality to fish eggs and larvae can be possible on major spills. Smaller spill volume and weathering of the diesel fuel will limit the areal extent of the spill and overall effects on local fish populations. **Impact can be classified as minor**

SOCIOECONOMIC ENVIRONMENT

POPULATION

<u>Potential Impact 10: Effects on population due to diesel spills</u>

Effects on human populations are related to potential health hazards as well as economic losses, such as those associated with the temporary loss of fishing grounds.

The local population may be affected because they depend upon coastal and marine resources for subsistence. If water quality is affected, coastal and marine resources may be affected and that will reduce the source of food and income for the local population. Some health problems could also arise within the communities living in the vicinity of the spill as a result of contaminated foods and through odor and atmospheric pollutants evaporating from the spill. It is important to highlight that petroleum hydrocarbons are potentially carcinogenic and can cause severe dermatitis.

However due to the temporary nature of the impact and small quantities involved in the spill, the impact is considered of minor significance.

<u>Potential Impact 11: Effects on population due to fire/explosions</u>

In the unlikely event of a fire/explosion on the seismic vessel or the support vessels, the release of combustion products such as CO2 and particulate matter to the atmosphere may occur.

It is highly unlikely that the fire or explosion would directly affect local population (i.e., fatalities through burning from an explosion) unless the vessel was in port. However, a fire may force hydrocarbons and debris into the air to settle on the surface of the ocean or on nearby islands or land. These falling materials may cause damage to infrastructure, crops or livestock. In addition, air contaminants may cause respiratory ailments if settlements occur in within a few kilometers of a large fire/explosion.

The significance of the impact is moderate to major dependent on the proximity to areas of human habitation or ports.

ARTISANAL FISHERIES

Potential Impact 12: Effects on artisanal fisheries due to diesel spill

An oil spill can lead to mortality, tainting of fish rendering products unmarketable, altering of habitats (affecting availability and/or recruitment), and oiling of gear leading to increased maintenance or replacement costs. **However due to the temporary nature of the impact and small quantities involved in the spill, the impact is considered of minor significance.**

TOURISM

Potential Impact 13: Effects on tourism due to diesel spill

The attraction of the Quirimbas Archipelago for tourists is due, at least partially, to its image as un-spoilt, and this could be negatively affected for a long period, if not permanently, by an oil spill.

However due to the temporary nature of the impact and small quantities involved in the spill, the impact is considered of minor significance.

6.2.2. Impact Assessment for Drilling

The main potential bio-physical and socio-economic impacts associated with exploratory drilling are the following:

- Localized impacts on air quality;
- Localized impacts on water and sediment quality;
- Localized, physical impacts on habitats associated with locating the drilling rig on the substrate (sea grasses and coral communities);
- Localized, behavioral and physical impacts to marine mammals and sea turtles from drilling operations and vessel traffic associated with drilling operations;
- Interruption of artisanal fisheries due to the safety zone around the drilling rig;
- Interference with the tourism activities in the area (safety zone and aesthetic impacts); and
- Water contamination by potential hydrocarbon spills and subsequent impacts on marine fauna and socio-economic activities.

The exploratory drilling will be conducted by a jack-up rig as described in Chapter 2 (Project Description). As mentioned in section 2.3.1 the rig will be configured for no discharge in shallow water except for treated deck drainage (in compliance with MARPOL). ***The following drilling impact assessment will reflect this pre-condition when addressing the impacts related to discharges.***

6.2.2.1. Impact Assessment for Routine Operations (Drilling)

PHYSICAL ENVIRONMENT

AIR

Potential Impact 1: Reduction in air quality due to use of fuel for routine operations

During routine operations (diesel engines, drilling, support vessels, helicopters, etc) fuel (mainly diesel) will be used. Air pollutants that will be emitted during the project include carbon dioxide (CO_2), nitrogen oxides (NOx), sulfur oxides (SOx), carbon monoxide (CO), volatile organic compounds (VOC's) and particulate matter (PM10). The primary sources of these pollutants are the diesel engines that power the drilling rig and support vessels, generators and other equipment required for the project. These generators will be operational 24 h a day.

Emissions from combustion of aviation fuel will also result from helicopter activities although these will be minor. These combustion products may cause atmospheric pollution and contribute to greenhouse gases and ozone depletion (and consequently to climate change).

Fuel consumption is estimated at 12.7m^3 per day for the drilling rig (Jack-up) and 6.3m^3 for the supply vessel[6]. This corresponds to a total of 20m^3 fuel consumption per day, releasing about 53.2 metric tonnes of CO_2 per day. During 90 days (maximum time for drilling each well) approximately 1800m^3 of fuel will be used releasing 4788 metric tonnes of CO_2.

According to the website of the Energy Information Administration, which shows the Official Energy Statistics from the US Government (http://www.eia.doe.gov/pub/international/iealf/tableh2co2.xls), the project (each well site) will contribute 0,25% of the yearly total Mozambique emissions; 0.0011% of the total Africa emissions and 0.0000436% of the total World emissions resulting from the consumption of petroleum (using the latest figures available:2005).

The contribution of these emissions to air is very low in relation to total global emissions and is unlikely to have a significant effect on local air quality.

Impacts as a result of a reduction in air quality and contribution to the green house gases are therefore considered to be of minor significance.

Potential Impact 2: Reduction in air quality due to flaring of wells

Flaring during drilling will be minimal during routine operations; however, in the event of a successful well, testing will be carried out at some point after drilling. Typically testing will be carried out over a 2-4 day intermittent[7] period per well with expected test rates in the range of 5000 barrels (795m^3) of oil/day being flared (i.e. in total 10,000 barrels or 1500m^3).

This is slightly less than the amount of fuel being burnt during routine operations of the drilling rig and support vessel (*viz* 1800m^3). Due to the short duration of testing these

[6] During the first 5-7 days of operations, supply vessels will be traveling every day. Afterwards, probably 2.5 trips per week.

[7] The well testing will not occur during 2-4 days consecutive. There will be flowing and shut-in intervals.

emissions are unlikely to have a significant impact on local air quality and the contribution the impact classification is the same as above.

WATER

Potential impact 3: Reduced water quality due to the discharge of solid wastes (excluding drilling muds and cuttings)

The day-by-day operations on the rig the seismic vessel will generate wastes that, if mishandled or wrongly deposited, can cause impacts in the vicinity of the rig.

Several types of solid waste will be generated during drilling including paper, plastics and glass (see **Table 6-18**). Drilling cuttings comprises the most important waste stream (in terms of amount) and these are discussed separately below.

Table 6-18. Estimated solid wastes produced during drilling operations (based on 180 days and 92 people on board)

Waste stream	Amount
Paper	2.50 ton
Plastic	1.62 ton
Glass	0.60 ton
Metal scrap	76.5 ton
Batteries	0.21 ton
Plastic drums	0.48 ton
Oily rags	92.15 ton
Metal drums	3 ton
Cement	3.15 ton
Drilling cuttings	1,430 m^3
Aerosol cans	0.09 ton

The unmitigated impacts associated with solid waste disposal on water quality are considered to be moderate

Potential Impact 4: Reduced water quality due to the discharge of drilling muds and cuttings

An estimated total of 1,430m^3 of drilling cuttings will be produced during the drilling operations (**Table 6-18** above).

Shallow water

There will be **no discharge** of drilling muds and cuttings to the shallow waters as defined by this project. Drilling muds and cuttings will be stored in barges and taken to deeper water to be discharged meeting the criteria internationally established for these activities. For reference, an explanation of the potential impacts of drilling muds and cuttings is provided in Volume III of the EIA Report.

However when drilling the initial hole section prior to setting the first structural casing and well head some cuttings may be generated and discharged in the immediate vicinity of the well. Plans are to jet or pile the casing into the sea floor. In this case there will be no well cuttings extruded to the seafloor. If jetting is not possible due to hard substrate then using a 26" bit and 42" hole opener the well will be drilled to the structural casing depth (40 m below the sea floor). In this case a small amount of cuttings (approximately 40 m^3) will be extruded to the sea floor and this will settle on the surface of the seabed immediately around the hole. These cuttings will not be contaminated with WBM or SBM, but a fluid will be present to help to drill the first section. This fluid is normally seawater-based spud mud.

This disposal will cause limited turbidity and contamination load, primarily close to the seafloor with little effects on the water column. **Therefore the impact can be considered minor.**

Disposal in Deep water

The main routine drilling activities that impact in water quality are the disposal of drilling muds and cuttings. Two types of drilling muds can possibly be used during the proposed exploratory drilling in the shallow waters of Area 1; water-based muds (WBMs) and/or synthetic-based muds (SBMs) as discussed in Chapter 2 (Project Description).

Water quality could potentially be affected in two ways through the disposal of drilling muds and cuttings *viz* increased turbidity and contamination.

Water-based muds for use in the offshore oil and gas industry comprise mainly seawater (approximately 75 %) with the addition of barite and bentonite to control mud density. Other compounds are added as necessary to achieve the desired properties for a particular situation (OGP, 2003). WBMs are generally used to drill the upper portions of a well where conditions are less demanding on the properties of the mud. WBMs are also relatively cheap compared to other mud types and are generally considered to be the least toxic of the drilling muds (Patin, 1999). However, WBMs do contain heavy metals in the barite component, which have the potential to pollute the marine environment should they be discharged.

Crecelius *et al.* (2007) conducted a study to investigate if metals contained within the low-metal barite used in water-based drilling fluids dissolve readily into seawater or the pore-water of marine sediments. The laboratory tests indicated that mercury and other trace metals are not released in significant quantities into seawater or pore-water, and concluded the following:

> "Mercury (Hg), cadmium (Cd), copper (Cu), lead (Pb) and zinc (Zn) are the primary metals of marine environmental concern in barite because these metals can, in some situations, be enriched by more than an order of magnitude compared to marine sediment. In addition, the USEPA water quality criteria for these metals are relatively low. A relatively small amount of these five metals in barite are soluble in seawater in the pH range of 7.3 to 8.3. During one week exposure of barite in seawater, less than 1 percent of the Cu, Hg and Pb, 3 percent of the Zn, and 15 percent of the Cd dissolved from the barite. Because low-metal barite releases little of these metals to seawater, it is not likely that low-metal barite will cause environmental effects to organisms living in the water column."

Neff (2005) summarized the fate and effects of water-based drilling muds. When WBMs and cuttings are discharged to the ocean, the larger particles and flocculated solids, representing about 90% of the mass of the mud solids, form a plume that settles quickly to the bottom. The remaining 10% of the mud solids mass, which consist of fine-grained unflocculated clay-sized particles and a portion of the soluble components of the mud, forms another plume in the upper water column that drifts with prevailing currents away from the platform and is diluted rapidly in the receiving waters. In well-mixed ocean waters, drilling muds and cuttings are diluted by 100-fold within 10 m of the discharge and by 1,000-fold after a transport time of about 10 minutes at a distance of about 100 m from the platform. Because of the rapid dilution of the drilling mud and cuttings plume in the water column, harm to communities of water column phytoplankton and animals is unlikely and has never been demonstrated.

In deeper portions of a well, or where deviated drilling is required, WBMs are often not able to provide the requisite properties to drill efficiently and safely. In these cases, non-aqueous drilling fluids (NADFs) are used. NADFs include oil-based muds (OBMs) and SBMs. Historically, OBMs were used and comprised crude oil, oil products and other mixtures of organic substances. However, due to environmental concerns over the use of OBMs, many countries prohibited their use and this lead to the development of alternative drilling fluids, which comprised less toxic synthetic components in place of the diesel and other oil products traditionally used (Patin, 1999). Synthetic components include esters, paraffins and olefins and are generally less toxic due to reduced concentrations of aromatic compounds. They are also less persistent in the environment (OGP, 2003). The SBMs expected to be used during this exploratory drilling program are Group III NADFs. These fluids are characterized by a polyaromatic hydrocarbon (PAH) content of less than 0.001 % and a total aromatic content of less than 0.5 % (OGP, 2003).

Due to the increased cost of SBMs and environmental considerations, SBMs are recovered to the rig for recycling. This recycling process involves separating the muds from the cuttings using vibrating screens known as shale shakers. Some drilling fluids will remain adhered to the cuttings but the majority will be separated by the shale shakers and returned to the drilling fluid system, which will be continuously re-circulated, while the cuttings will be discharged to the sea.

The impacts on the water column from the discharge of SBM cuttings are generally considered to be negligible due to the following (OGP, 2003):

- Low solubility of synthetic fluids in seawater;
- Low water column dispersion and residence time due to rapid settling; and
- Drilling discharges are intermittent and transient.

The specific constituents of the drilling muds (especially SBM) to be used during this drilling program are specified in Chapter 2 (Project Description).

WBM (muds and cuttings) or SBM cuttings from the shallow water wells will be transported to deep waters and discharged via spreading on the sea surface. The WBM (muds) discharge will be diluted and dispersed over a wide area, with solids distributed as a thin veneer over a large area of the sea floor. WBM cuttings will release small amounts of muds into the water column as a result of these muds adhering to the larger cuttings particles. Similarly, the release of SBM cuttings will result in cuttings “clumping” as the individual solids tend to adhere to one another and therefore sink more rapidly. However, significant amounts of SBM will not be released into the water column.

WBM muds and cuttings discharges will produce localized turbidity within the water column, which will disperse and dilute rapidly at a rate dependant upon ambient oceanographic conditions. Impacts to water quality from either WBM (muds and cuttings) or SBM cuttings will be minor and of short duration. Once discharges cease, normal water quality conditions will return within minutes to hours.

The location of the disposal sites will comply with distances specified by MARPOL and will be based on the mud/cutting dispersion modeling to be conducted for deep water drilling.
For WBM it is expected that two trips per day will be needed to dispose of the mud and cuttings into deep water. For SBM, the number of boat trips to discharge cuttings in deeper waters will be a function of the geometry of the wells, the rate at which cuttings are generated, and the volume of storage aboard the rig. It is expected that during the first week a boat will be transporting cuttings every 4-6 hours and towards the end of the drilling, the boat will mobilize once every two days.

For deep waters the impacts on water quality are considered to be minor.

<u>Potential Impact 5: Reduction in water quality due to deck drainage, bilge water and sewage discharge</u>

Deck Drainage

Deck water includes drainage water from precipitation, sea spray or routine operations such as deck and equipment cleaning. This water could contain small amounts of oils, solvents, cleaners or other similar products that can reduce marine water quality.

Bilge

With regard to water from the machinery space, small quantities of hydrocarbons such as diesel from the engines, lubricants, and grease used onboard the drilling rig have the potential to contaminate the water column.

Sewage

Sewage includes grey and black water from showers, toilets and kitchen facilities, which, if discharged into the sea untreated, can pose an organic and bacterial load on natural degradation processes. Because many marine micro-organisms (e.g. bacteria) metabolize sewage, it could lead to a local rise in bacterial levels in the water and consequent increased demand for oxygen. If discharge occurs close to the coast in shallow water, the rapid proliferation of bacteria and algae utilizing the effluent as a nutrient source can cause anoxic conditions, which can diminish the biodiversity of an area.

The unmitigated impact from these sources will be moderate

<u>Potential Impact 6: Reduction in water quality due to disposal of kitchen wastes</u>

A significant of kitchen ease (food residues) will be produced during the drilling operations. Kitchen wastes comprising food residues are generally readily consumed and biodegraded in the marine environment and as such is not deemed to pose a risk to water quality.

Impacts due the disposal of food waste are therefore considered to be minor.

<u>Potential Impact 7: Reduction in water quality due to the disposal of produced water (from well testing)</u>

The fluids produced during the test will be run through a three-phase separator where gas, oil and water will be segregated and metered. Produced hydrocarbons (oil and gas) will be flared through a burner boom, and produced water, if any, will be discharged. **It is therefore considered that impacts due to discharge of produced water will be of minor significance.**

BIOLOGICAL ENVIRONMENT

MANGROVES

Potential Impact 8: Impacts of waste disposal (including muds and cuttings) on the coastal mangroves

Discharges from drilling operations may smother mangrove aerial roots. Sessile invertebrates (i.e., sponges, hydroids, etc.) and benthic infauna associated with mangrove may also be smothered by discharges. Mangrove forests are adapted to periodic influx of sediments and increased turbidity. Natural dispersive properties (currents, winds, and waves) will also act to disperse and dilute drilling discharges. Minor increases in sediments and turbidity that accompany cuttings discharges would have minimal effect.

However, as mentioned under Potential Impact 3 the only potential cuttings discharge in shallow water may be from drilling the initial hole section. All other drilling muds and cuttings will be taken to deep waters to be discharged.

Impacts on coastal mangroves due to waste disposal or cuttings discharge from the initial drill are therefore considered to be minor to moderate dependent on the proximity of the well habitat.

SEAGRASS AND CORAL COMMUNITIES

Potential Impact 9: Effects of the installation of a jack- up rig on seagrass and coral communities

During the positioning of the jack-up rig on location, shallow water communities such as seagrasses and coral reefs within the drilling rig footprint may be destroyed.

When using jack-up, direct disturbance of habitat in the contact area and direct mortality of sessile seabed organisms would be expected where the legs contact the seafloor. If sensitive marine habitats, such as corals and seagrass beds are impacted as a result of the mooring of the jack-up, significant impacts would be expected. However, as described in the Project Description, prior to the mobilization and depending of the water depth, AMA1 will evaluate the appropriate methodology (use of side scan sonar, video cameras, or divers) to conduct a site reconnaissance prior to emplacement of the rig.

Unmitigated physical damage on these habitats can go from minor to major significance depending on the proximity to seagrass and coral communities.

Potential Impact 10: Effects of disposal of drilling muds and cuttings on coral reefs and seagrass beds from the initial drill hole.

Coral communities reefs are some of the more sensitive habitats found in the shallow water areas of the AMA 1 concession area.

The only potential cuttings discharge in shallow waters will be from the initial hole section prior to setting the first structural casing and well head. All other cuttings and drilling muds will be taken to deep water by barge to be discharged.

The distance from the discharge location and the amount of discharged solids accumulating depend primarily on current speed and water depth. In low-energy, shallow water environments, much of the cuttings from the first drill section may settle on the bottom within

10 to 20 m of the discharge location (NRC, 1983). Discharges from drilling operations may smother corals, macroalgae, and sessile invertebrates associated with this habitat

Discharges from drilling operations may also smother seagrasses and algal communities, including associated sessile invertebrates and benthic infauna. Benthic infauna within the deposition area from the cuttings discharges would be smothered.

The volume of discharged material from the first drill section is relatively small and the significance of the impact will go from minor to moderate depending on the proximity of the well to these habitats.

SHALLOW WATER MACROBENTHIC ORGANISMS

<u>Potential Impact 11: Effects on benthic macrofauna due to the discharge of drilling muds and cuttings</u>

Benthic macrofauna maybe associated with sandy and muddy substrates in shallow waters. These may include both sessile and non-sessile invertebrates.

As per Potential Impact 3 the only potential cuttings discharge in shallow waters will be in the initial hole section. All other cuttings and drilling muds will be taken to deep water by barge to be discharged.

Thick accumulations may result from the release of cuttings and seawater-based spud mud during the initial well interval before the marine riser is set. These materials will bury and smother benthic organisms around the wellbore. This increase in sedimentation, possibly resulting in burial or smothering, is the main impact of concern to benthic communities. Monitoring programs have shown that drilling impacts on benthos are minor and localized within a few hundred meters of the wellsite (EG&G Environmental Consultants, 1982; NRC, 1983; Neff, 1987; Continental Shelf Associates, Inc., 2006).

The significance of the impact will be minor.

DEEP WATER MACROBENTHIC ORGANISMS

<u>Potential Impact 12: Effects on deep water benthic macrofauna due to the discharge of drilling muds and cuttings in deep waters</u>

With the no discharge pre-condition in shallow water, drilling muds and cuttings will be taken to deep waters and will be spread at the sea surface. It is unlikely that this spreading will occur at the same spot each time.

For this drilling operation, only WBM and SBM will be utilized. No oil based muds will be used. As SBMs are largely biodegradable organic compounds, deposition of SBM cuttings with adhering SBM mud on the seabed is likely to increase the biological oxygen demand in the underlying sediment. This can lead to anoxic conditions as the organic components of the mud are oxidized. This consumption of available oxygen in the sediments can lead to changes in the benthic systems until the drilling fluid has been sufficiently degraded to allow the re-establishment of the natural biota (OGP, 2003).

In water depths greater than 200 m, sensitive areas such as coral reefs and seagrass beds do not exist. Furthermore, studies in the Norwegian North Sea have shown that where only

WBMs and SBMs have been used (as opposed to the more toxic OBMs), the discharges of the cuttings associated with these fluids have little or no effect on benthic fauna more than 250 m from the well (OGP, 2003). **In view of the deep water location (and associated lack of seagrass beds and corals) it is considered that these impacts will be of minor significance at this stage.**

FAUNA (MARINE MAMMALS, TURTLES, FISH AND SEABIRDS)

Potential Impact 13: Impacts due to the disposal of muds and cuttings on fauna through increased turbidity and contaminant load

Shallow water

Potential disposal of cuttings in shallow water is only related to the initial section of the well (refer to Potential Impact 11). This disposal will cause limited turbidity and contamination load, primarily close to the seafloor with little effects on the water column. **Impacts on marine mammals, turtles, fish and seabirds due to this disposal are very unlikely and can be considered insignificant.**

Deep water

Drilling muds and cuttings will be taken to deep waters for discharge via surface spreading. The potential impacts on water quality have been discussed under Potential Impact 4. Any reduction in water quality could lead to secondary effects on marine fauna in terms of morbidity or mortality, or simply displacement from preferred feeding or nesting areas. A description of the potential impacts on the fauna is provided below.

Marine mammals

Impacts to the water column environment from WBM muds and cuttings and SBM cuttings discharges are minor due to the intermittent and spreading nature of the discharges. Drilling mud solids do not increase to high concentrations in the water column, are diluted quickly (depending upon ambient currents), and affect only small parcels of water. Periodic, minor increases in the turbidity and suspended particulate material concentrations in the upper water column during muds and cuttings discharges are unlikely to have an environmentally significant effect on marine mammals. Marine mammals that may swim through the WBM discharge plume are unlikely to be adversely affected by the plume (Ayers, 1994).

Sea Turtles

The impacts to the water column environment from WBM muds and cuttings and SBM cuttings discharges are minor for the reasons mentioned above. Sea turtles that may become entrained in or swim through the WBM discharge plume are unlikely to be adversely affected by the plume.

Fish

Hurley and Ellis (2004) identify the following impacts to fish from WBMs and WBM cuttings discharges:

- Fish health: Studies on organic condition indices and energy reserves indicate little potential for toxicity beyond 1 to 2 km from rig sites (Cranford et al., 2001). For the Canadian EEM data, no fish health effects were observed for any of the tested species across all reviewed sites. Interpretation of these indices requires consideration of the mobility of fish species, the relevant scales of environmental change and exposure to other stressors. For highly mobile species, the degree of exposure is unknown. There are few dose-response experimental studies linking body burdens of chemicals to effects. A combination of measures, including biochemical and/or histopathological indicators of chemical stress, was recommended to provide an appreciation of the degree and severity of any potential health effects (Mathieu, 2002).

- Fish taint: Taint was not detected for any of the fish species tested within the Canadian EEM programs.

As explained above impacts to the water column environment from WBM muds and cuttings and SBM cuttings discharges are minor. Periodic, minor increases in the turbidity and suspended particulate material concentrations in the upper water column during muds and cuttings discharges are unlikely to have an environmentally significant effect on fish species present in the vicinity of the drill rig.

Seabirds

Seabirds diving in the vicinity of the discharge plume are expected to experience negligible impacts upon foraging and prey availability. WBM muds and cuttings and SBM cuttings discharges will be intermittent and of short duration. Total surface area affected by a discharge plume will be extremely small relative to available foraging area. Periodic, minor increases in the turbidity and suspended particulate material concentrations in the upper water column during WBM muds and cuttings discharges are unlikely to have an environmentally significant effect on seabirds. Similarly, only negligible impacts to seabirds are predicted from SBM cuttings discharges.

Due to the fact that the SBM cuttings discharged from the vessel will rapidly fall through the water column, it is not considered that a significant reduction in water column quality will occur.

Given the ability of marine mammals, turtles, fish and seabirds to move away from areas they find unfavorable, it is considered that any impacts from contaminants or increased turbidity due to the disposal of drilling muds and cuttings will be minor for deep waters.

<u>Potential Impact 14: Impacts on marine fauna due to deck drainage, bilge water disposal and sewage discharge</u>

The potential impacts related to untreated discharges from deck drainage, bilge water and sewage are discussed under Potential Impact 5.

Impacts on marine fauna due to the discharge of deck wash, bilge water and sewage are considered to be moderate.

<u>Potential Impact 15: Impacts on marine fauna due to disposal of kitchen wastes</u>

A significant amount the solid food waste that will be produced during project activities, Thse are discussed under Potential Impact 6.

Impacts on marine fauna are considered to be minor.

Potential Impact 16: Impacts of noise on marine mammals, turtles and fish

Various impacts can result from noise emissions during well drilling. These include behavioral changes and masking or interference of acoustic communication.

The noise spectrum may range between 0.016 and 0.2 kHz, with tonal reception levels between 167 and 171 dB re 1 µPa @ 1 m (Richardson *et al*, 1995; Evans & Nice, 1996). However, the SASOL EIA prepared for the Offshore Exploration Project in Blocks 16 & 19 (ERM, 2006), indicates 1.2 Hz - 5Hz and 119 – 127 dB re 1 µPa @ 1 m as the frequency and sound pressure, respectively, of noise from drilling (fixed platform). For comparison the noise produced by seismic sound sources airguns is usually around 260 dB re 1µPa @ 1m with wide-band frequency components mostly concentrated in the 20-250 Hz range.

Noise emitted underwater during drilling operations is highest for drill-ships and semi-submersibles, followed by bottom-founded rigs such as jack-ups and drill barges. Noise produced by drill ships is similar in range to some supply vessels and fishing trawlers (ERM, 2006).

The impact of the noise produced during the drilling of the exploration wells depends on the following factors:

- background environmental noise;
- the transmission conditions of the receiving environment; and
- the proximity of animals and their capacity to detect sound frequencies.

Marine animals are already naturally exposed to sounds produced by the wind, waves, rain, echolocation produced by cetaceans, and noise produced by tectonic activities. Sounds from anthropogenic origin (e.g. boats, airplanes) also occur along the Mozambican coast, including in the project area.

Most of the sounds produced during drilling are continuous and of low frequency. The effects of this noise on false whales, seals and dolphins may be considered negligible. Only the true whales (the humpback whale occurs in the project area) are susceptible to medium and low frequency and may react negatively (Davis *et al*, 1990). In this case, these cetaceans will react by moving away, avoiding proximity to the source of noise. In fact, these marine mammals have good detection capacity and mobility to avoid sound disturbance.

It should be noted that the noise from boat movements is more intense and significant than that produced by drilling activities and that marine mammals are more tolerant to noise generated by stationary objects (such as those produced during drilling) than mobile objects (Richardson et al. 1995).

Sea turtles are considered to be less sensitive to noise than marine mammals and the sound levels expected during the drilling program suggests that the impact on turtles as well as fish is not likely to be significant.

Noise duration will be temporary (with a maximum duration of 90 days per well). The noise will be produced directly by the drilling activities and by the support ship movements (engines/maneuvers), but is unlikely to be of sufficient amplitude to cause significant impacts to marine fauna. **Impacts of noise on marine fauna are therefore deemed to be of minor significance.**

HUMAN ENVIRONMENT AND ECONOMIC ACTIVITIES

POPULATION AND LOCAL ECONOMY

Potential Impact 17: Social conflicts due to the presence of foreign workers

All rigs are self-contained with a highly trained and specialized crew. The drilling rig for this program will have a crew working on a 28 days rotation (estimated number of workers at the rig is 92). A helicopter will transfer the crew from the vessel to Mocimboa da Praia, From there the crew members will fly back to Pemba and then off to their home country. Apart from these workers, there will be expatriate workers (approximately 20) in Pemba for the duration of the project.

The presence of foreign workers can pose a risk in terms of health impacts of transferable disease. Communicable diseases pose a significant public health threat worldwide. Diseases of most concern during the project are sexually-transmitted diseases (STDs), such as HIV/AIDS. Expatriate workers with relatively large amounts of money could potentially result in an increase in prostitution and in an increase on STDs. The mobile nature of these workers means STDs could be carried to other locations when the workers return home.

For those working on the drilling rig, due to their short presence in Pemba (maximum one night), **the potential for social conflicts and an increase in STD prevalence is considered to be of minor significance.**

For those based in Pemba for the duration of the project, **the potential for social conflicts and an increase in STD prevalence is considered to be of moderate significance.**

Potential Impact 18: Increased revenue due to the presence of the crew in Pemba

The presence of the workforce in Pemba may lead to a limited increase in expenditure in the local hotels, restaurants and markets. Crew members and families may even visit local tourist attractions available in the region.

The presence of the workforce would therefore result in a small, temporary, economic boost and impacts are therefore considered to be positive.

ARTISANAL FISHERIES

Potential Impact 19: Temporary loss of access to fishing grounds and associated loss of catch due to exclusion zones

According to the findings of the Socio-economic Study of Artisanal Fishing Communities (SSAFC)[8], the majority of commercial artisanal fishers in the study area fish in the coastal area, i.e. between islands and the mainland, between the islands, and not further than 1.5 km to the east of the islands. This is due to distances, rough sea conditions further out, and the generally poor condition of the boats. A significant amount of artisanal activity is concentrated around reefs, banks, and shallower parts of the study area.
Fishing activities may be temporarily affected by the 500m safety zone around the drill rig (the drill rig itself will occupy an area of $9600m^2$). The drill rig would be fixed at specific points for a certain period of time (90 days per well). This means that fishers will temporarily lose access to approximately 1.2 km^2 of fishing grounds. Viewed against the total area of

[8] Socioeconomic field study and report commissioned under this EIA

AMA1 shallow water exploration area of 3712 km², it is a very small area. This may extend the travel time and distance to certain fishing grounds. The drill rig would be fixed at specific points for a certain period of time (90 days per well).

Fishing areas are spread out across the study area, and are usually some distance apart. This may extend the travel time and distance to certain fishing grounds. The effect on commercial artisanal fishers operating off-shore will be temporary. Most fishers have alternative fishing grounds, or in the case of artisanal divers and hand line fishers, alternative sources of income in the form of trade. **Impacts on artisanal fisheries as a result of the drilling rig exclusion zone are therefore considered to be of minor significance.**

Potential Impact 20: Temporary catch decrease due to fish displacement and restrictions on fishing

Artisanal fishers catch reef fish and, in the cases where the boats venture into the deeper waters east of the reefs, pelagic fish, squid and demersal fish. Most artisanal fishers are poorly equipped to catch deep water fish and the condition of their boats does not allow them to venture too far offshore.

The free-swimming ability of fish enables them to move away from areas that they find unfavorable, but due to the small zone that is likely to be affected by a reduction in water quality, it is not anticipated that fish will be displaced sufficiently so as to affect artisanal fishers.

The drilling rig will produce low-frequency noise. This noise spectrum may range between 0.5 and 1.2 kHz with pressure levels between 119 and 127dB re 1 µPa @ 1 m (ERM, 2006). Noise will also be produced by the supply vessels which is of a lower frequency than that produced by the rig.

The ability of fish to move away from areas that they find unfavorable and the relatively low amplitude of the anticipated noise levels, it is not anticipated that fish will be displaced sufficiently to render them unobtainable. **Impacts on artisanal fishing grounds as a result of fish displacement are therefore considered to be of minor significance.**

Potential Impact 21: Effects on physical safety and health of divers due to sound generated by drilling activities

As indicated above, noise generated by drilling activities is only slightly higher than ambient ocean and reef noise levels. Also, a safety zone of 500m will be enforced around the drill rig, which is the same area as recommended for safety purposes around the seismic vessel, which generates higher noise levels. Again, diving for catch forms a part of the livelihoods of artisanal fishing communities, and thus, the emphasis here is on the safety of the divers, rather than the nuisance effect as in the case of recreational divers.

Ambient noise in the ocean originates from a variety of sources over bands of frequencies ranging up to 100 kHz. The major sources of ambient oceanic noise are related to wind and the noise made by ships. Other sources include rain, oceanic turbulence, sea life, tides, waves, volcanic eruptions, natural seismic activity, and molecular agitation (heating and cooling). Deep ocean background noise attributable to shipping ranges from 82 to 87 dB ref 1µPa @1m (Continental Shelf Associates, Inc.: 1996).

Impacts of the effects of noise during drilling on artisanal fishery divers are therefore considered to be insignificant.

Effects on the livelihoods of artisanal fishers

Potential impact 22: Temporary loss of income and effects on food security

As indicated in the SSAFC, the income generated from fishing activities by artisanal fishers is limited, and they work on very small profit margins, or on a purely subsistence basis. The potential disruption of catches and catch volumes may, therefore, lead to a temporary loss of income, not only for individual subsistence fishers and owners of the boats or fishing gear, but also for the 'workers', who are paid in fish, and whose income is, thus, directly related to the volume caught. Decreased catch volumes may affect artisanal fishers, in that they may not only experience a loss of income, but also that an important part of their diet and food security may also be affected.

Artisanal divers are not solely dependant on their catch as their only source of livelihood. The SSAFC indicates that, due to the unpredictability of weather conditions that can sometimes make diving virtually impossible for days, artisanal divers typically have other sources of livelihoods, such as informal trading. **This impact is of minor significance.**

TOURISM

Recreational diving and snorkeling activities

Potential Impact 23: Temporary loss of access to dive sites due to presence of the drill rig and the safety zone around the rig

For safety reasons, vessel movement and some other activities may be restricted from operating in an area closer to the drilling rig. A 500m safety zone will be created around the rig, in which vessel movement and diving will be prohibited. If a recreational dive site is located within this safety zone it could lead to the temporary loss of access to those sites for a period of up to three months. Also, tourism operators may not want to dive at certain sites, even if it is outside the safety zone, due to the visual impacts of the drilling operation.

The expected potential effect on diving operations due to the safety zone around the drill rig can only be properly quantified and assessed once potential drill sites have been identified. However, and in following the precautionary principle, the potential worst case scenario, i.e. where diving sites are located within the 500m safety zone is used here. Should a potential drillsite be selected that precludes the tourism operator from utilizing a favored diving location. **This impact is of major significance.**

Potential Impact 24: Physical safety and health and discomfort of divers due to sound generated by the drilling operations

One of the greatest attractions of the Quirimbas Archipelago as a tourism destination is its isolation and remoteness. Divers visiting the archipelago do so to experience a high level of undisturbed wilderness, which is not possible in other, more populated tourist areas. As the numbers of divers per day outlined earlier (Section 5.3.5.2) shows, there are a fairly small number of divers in the water on any given day. Considering this dive quality, and the reputation of the Quirimbas Archipelago as a wilderness diving destination, industrial noise, audible above ambient ocean noise levels, could potentially be intrusive and would be negatively received by divers.

Ambient reef noise levels measured at sites off Hawaii had a broadband, peak frequency of 1.9 kHz, and had a mean SPL of 107 dB ref 1µPa (Boyle and Tricas: 2006). Off Lizard Island in the Great Barrier Reef, levels of broadcast reef sound (broadband 80–4000Hz) were predicted to be 107–109 dB re 1µPa (Leis and Lockett: 2005). Based on this, it can be assumed that the general level of background noise on a reef or in shallow water habitats similar to those of the Quirimbas Archipelago would be in the 107 to 109 dB re 1µPa range.

Based on the sound levels generated by drilling operations provided above, sound levels would be approximately 12 to 18 dB higher than ambient levels. This fairly small increase indicates that an average recreational diver should not be able to distinguish the drilling noise above ambient noise levels, especially when diving outside of the 500m safety zone. **This impact is, therefore, insignificant.**

Effects on recreational fishing activities

<u>Potential Impact 25: Temporary loss / delayed access to recreational off-shore fishing grounds due to the presence of the safety zone around the drill rig</u>

Fishing activities may be temporarily affected by the 500m safety zone around the drill rig. This may extend the travel time and distance to certain fishing grounds. The drill rig would be fixed at specific points for a certain period of time. Fishing areas are spread out across the study area, and are usually some distance apart. Thus, tourism operators should be able to plan fishing excursions with cognizance of drilling sites.

The temporary loss (delay) of access to fishing areas due to the presence of the drill rig should not affect the fishing experience of recreational fishermen significantly. **Therefore the impact will be of minor significance.**

<u>Potential Impact 26: Reduced off-shore sports fishing experience due to changes in fish behavior and movement, potentially leading to decreased catches</u>

The drilling rig will produce low-frequency noise. This noise spectrum may range between 0.5 and 1.2 kHz with pressure levels between 119 and 127dB re 1 µPa @ 1 m (ERM, 2006). Noise will also be produced by the supply vessels. The sources of noise will be from the vessel engines, and during vessel maneuvering alongside the jack-up. Noise from these offshore fishing boats themselves will also contribute to any impacts attributed to vessel noise.

The ability of fish to move away from areas that they find unfavorable and the relatively low amplitude of the anticipated noise levels, it is not anticipated that fish will be displaced sufficiently to render them unobtainable. **The impact will be of minor significance.**

Effects on Cetacean (whales and dolphins) sightseeing excursions

<u>Potential Impact 27: Reduced quality of sightseeing, due to mammal movement away from the area of exploration activities</u>

Mammals could move away from the area of exploration activities if feeling uncomfortable due to noise. The impacts of noise in cetaceans were addressed above potential impact 16.

However, behavioral responses are not necessarily predictable from the loudness of the sound source, and may vary depending on factors such as the age and health the animal, the type of activity it is engaged in, and the social context (McCauley, 1994).

According to Leisure & Accommodation (L&A) Operators, cetacean sightseeing excursions predominantly take place between July and November Although dolphins are spotted all year round, no specific dolphin excursions usually take place within the drilling period. Should the drilling period coincide with this peak season, it could affect these excursions.

Most of the sounds produced during drilling are continuous and of low frequency. The effects of this noise on false whales, seals and dolphins may be considered negligible. Only the true whales (the humpback whale occurs in the project area) are susceptible to medium and low frequency and may react negatively (Davis *et al*, 1990). In this case, these cetaceans will react by moving away, avoiding proximity to the source of noise. In fact, these marine mammals have good detection capacity and mobility to avoid sound disturbance.

It should be noted that the noise from boat movements is more intense and significant than that produced by drilling activities and that marine mammals are more tolerant to noise generated by stationary objects (such as those produced during drilling) than mobile objects (Richardson et al. 1995).

Therefore the impact can be considered insignificant.

Visual/aesthetic effects on tourists, especially on the islands

<u>Potential impact 28: Visual disturbance caused by the drilling operations</u>

The platform of the jack-up drill rig will be approximately 300ft (91.44m) above the water line, and will occupy a surface area of approximately 9,600 m^2 above the waterline. Using the same assumptions and formulas as in Section 4.1.4.1, this implies that the drill platform would be visible from approximately 42 km for a person of 1.82 m (6 feet) tall, when standing at sea level.

There will be no test flaring during the drilling of the exploration wells. However, should gas pockets be struck during the drilling process, and flaring is required, it could significantly increase the visible distance of the drilling rig, by day, and especially at night. The duration of any flaring during drilling will be short.

The potential visual intrusion or disturbance created by the drilling operations can only be properly quantified and assessed once potential drill sites have been identified. Thus, a scenario of the drill rig being located closer than the visible horizon to the location of tourism operations is assessed here for illustrative purposes, as the impact rating would grow more severe, the closer drill sites are located to tourism operations. **Impact significance will go from minor to major**.

Economic effects on the tourism industry in the study area

<u>Potential impact 29: Potential loss of revenue to tourism operators</u>

The majority of visitors to the islands seek an unspoiled destination for relaxation and leisure including diving. These operators, therefore, run the risk of potential patrons canceling bookings if they are informed that drilling activities will be taking place close to the island or their diving experience could be affected, or patrons arriving on existing bookings and demanding their money back because of the effects of the drilling activities. **This impact is of minor to major significance depending on the proximity of the rig to the island. This is linked to the potential visual impact on no. 29 above.**

<u>Potential impact 30: Potential loss of income (in terms of wages and purchases)</u>

Due to the potential loss of revenue by L&A Operators, there is a possibility of a loss of wages (direct and indirect) and purchases, since operators may be spending less on wages and purchases. However, the period of potential loss of revenue would be limited to the time the drilling rig is on location, and if tourism operators are compensated for any proven losses, it should not affect wages. Purchases could decrease slightly due to a smaller number of guests.

It is unlikely that loss of revenue by L&A Operators would lead to a loss of employment. It may still, however, have a limited effect on purchases, since fewer guests would require fewer goods. **The impact significance is minor.**

Potential impact 31: Effects on the sale of island plots to private investors

According to the Maluane Group, sales of island plots to private investors are underway, due to an active marketing campaign, which has reportedly generated quite significant international interest. However, since the process was only initiated fairly recently, at the time of the study, only approximately 12% of available plots had been sold. The proposed drilling activities, could potentially negatively affect interest in, and sales of, islands plots. The presence of a drilling platform within visible distance from any of these islands could potentially deter investors from purchasing land on the islands. This could slow down the rate of sales of island plots and negatively effect income from the sale of plots.

As indicated earlier, the potential visual intrusion or disturbance created by the drilling operations can only be properly quantified and assessed once potential drill sites have been identified. Thus, a scenario of the drill rig being located closer than the visible horizon to the location of tourism operations is assessed here for illustrative purposes, as the impact rating would grow more severe, the closer drill sites are located to tourism operations. **The impact significance will go from minor to major.**

Effects on the image of the Quirimbas Archipelago as a medium/high-end tourist Destination

Potential impact 32: Effects on the 'island paradise' image

Although the tourism industry in the Quirimbas Archipelago is in its infancy, it is growing rapidly, and is already a sought-after international destination in the high-end tourism market. Tourists visiting the resorts in the study area are predominantly from Europe. Lodges in the Quirimbas capitalize on the theme of unspoilt wilderness and luxury holidays in a tropical island paradise. Diving, recreational fishing, and whale watching are integral parts of their branding. Branding becomes very important when targeting a high-end market with consumers who like to think that they are visiting a unique area for a unique experience. If the "unique experience" image is not sustained, this patronage could easily go elsewhere. The potential effect of the proposed drilling on the image of the Quirimbas is strongly dependant on how activities associated with the survey are managed, and how lodges deal with the issues around diving. Seismic and other exploration related activities have been taking place in the Archipelago over the past three years. This proposed shallow water exploration and drilling project extends the activities which could have an effect on the Quirimbas Archipelago's image.

However, poor diving experiences specifically related to this project could result in negative perceptions about the Quirimbas among divers and guests. Experiences at destinations are shared by fellow tourists by word of mouth and tourism orientated websites, which are fast becoming a very powerful medium. International tourism agencies responsible for bookings and the marketing of resorts may also become apprehensive as to the quality of the tourism experience which they can guarantee their client, and deliberately or unintentionally spread negative perceptions into the market.

Potential effects of a change in the image of the area as a tourism destination may be a decrease in occupation levels, decreased revenue to operators, and decreased spending, which may lead to direct, as well as indirect, job losses. This may have a longer term impact on the socio-economic environment, and also stems from more than one source, i.e. the current activities of all five concession holders in the Rovuma block.

However, when viewed against the increasing occupation levels as well as the large number of new and planned developments in the Quirimbas Archipelago, it also indicates that the hydrocarbon exploration which has been taking place in the area over the past three years has not had any significant effect on the image to date.

The impact significance will be moderate.

Effects on planned and future tourism developments in the Quirimbas Archipelago

<u>Potential impact 33: Impacts on planned and future investment</u>

There is substantial additional new investment planned in the Quirimbas Archipelago, with a number of existing tourism operators also planning extensions to their current facilities. This number has increased over the past two years, and developers do not seem perturbed by the potential development of off-shore oil or gas resources.

Completion of developments currently underway on Vumba, Tecomaji, Quifula, and Tambuzi are all aimed at December 2008 or early 2009.

This implies that by the time the project is implemented, there could be at least an additional 2,250 bed nights per month available on islands in the study area, which would effectively increase the number of available bed nights by more than 60%.

It would, therefore, appear that hydrocarbon exploration has not had a significant effect on planned future investment to date.

The significance of the impact is moderate during the exploration phase due to the temporary nature of the activity.

NAVIGATION

<u>Potential Impact 34: Interference with maritime traffic</u>

The rig will be mobilized to site under tow by a vessel in open navigable seaways. The movement of the drilling rig to the drilling site may cause interference with maritime traffic, especially the national and regional cabotage shipping, as well as from private yachts that call at the Port of Pemba and Quirimbas archipelago. The present navigation routes along the Mozambique Channel pass through the AMA 1 Concession Area but outside the project area at distances that range from 15 to 35 nautical miles (27-63km) off the coast of Mozambique. It should be noted that international traffic passes outside the AMA1 Concession Area.

The drilling rig will remain stationary at specific coordinates for up to 90 days during each well operation. A safety exclusion radius of 500m around the rig will be maintained during that time.

In shallow waters traffic is almost inexistent and no formally established routes for maritime traffic would be traversed and it is not anticipated that it will have adverse effects of other maritime traffic in the region.

Impacts on other maritime traffic in the region due to the presence of the rig are therefore considered to be insignificant.

6.2.2.2. Impact Assessment for Non-Routine Events (Drilling)

The potential non-routine events associated with offshore drilling operations are:

- Leaks and Spills;
- Fires and explosions;
- Collisions with other vessels; and
- Blow outs.

Of these potential incidents, blowouts releasing large volumes of crude oil are likely to create the most significant impacts. Such an event, while extremely unlikely to occur, could result in extensive negative impacts should the released hydrocarbons enter nearshore waters and coastline habitats. Other potential spills during a drilling operation include diesel fuel releases from the rig or support vessels. Large diesel spill events are also highly unlikely, and spills in most cases would involve much lower volumes than a blowout. The potential impacts of these incidents will be discussed below.

For the majority of the environmental components, the impacts of fires and explosions or vessel collisions are those associated with the spillage of hydrocarbons and impacts are therefore similar to leaks and spills or blowouts.

An introduction to the non-routine events is provided below, following which the potential impacts on the environmental components are discussed.

Leaks and Spills

For drilling operations a barge storing 3000m^3 of diesel will be anchored near Mocimboa da Praia. A catastrophic accident (such as an explosion on the barge) could potentially result in a very large spill, with the 3000m^3 being spilled into the sea. However the probability of a catastrophic event of this nature is highly unlikely.

A more likely scenario will be a minor diesel-fuel spill that may occur during bunkering to the drilling rig from a supply vessel. Anderson and LaBelle (2000), in their compilation and assessment of U.S. and worldwide spill statistics, identified 19 506 minor spills categorized as between 0 and 1.0 bbl on the U.S. Outer Continental Shelf (OCS) during the period from 1985 to 1999 for all exploration and development operations, with a spill rate of 3,357 and an average spill size of 0.07 bbl. Spill rate was based on the number of spills per billion barrels of oil (Bbl) handled, applicable primarily to oil production but also relevant to exploratory activities. Similar analyses for slightly larger spills, ranging between 1.1 and 9.9 bbl, identified 434 spills during the same period, a spill rate of 74.7, an average spill size of 3.2 bbl, and a median spill size of 2.8 bbl. Historical spill data for these small-volume spills, which would include the diesel spill scenario considered in this analysis, indicate that a spill of 1 to 2 bbl is likely. Measures will be implemented to prevent spills during fuel transfer. Contingency plans are prepared to deal with all hydrocarbon spill scenarios .

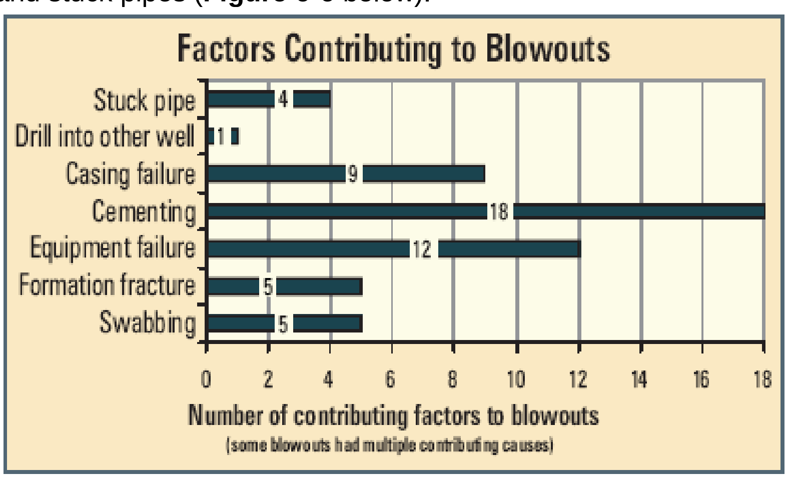
Blowouts

Offshore oil and gas exploration and development has the potential for minor to severe releases of oil, natural gas, condensate, and formation water (e.g., from a blowout). A blowout is an uncontrolled flow of reservoir fluids or gas into the wellbore and, very occasionally, to the surface. A blowout may consist of saltwater, oil, gas, condensate, or a mixture of these, depending upon the reservoir being drilled. During drilling, all wells are equipped with a blowout preventer (BOP), a special assembly of high-pressure valves fitted to the top of a well to prevent high pressure oil or gas from escaping.

Blowouts are rare events and most do not result in spills. Statistics from offshore drilling in the U.S. Gulf of Mexico provide a reasonable basis for evaluating spill risk. According to Holand (1997), the average blowout frequency for exploration drilling in the U.S. Gulf of Mexico is 0.00593 blowouts per well drilled, or one blowout per 169 exploration wells drilled. Similarly, the US Minerals Management Service (MMS) Safety and Environmental Management Program (SEMP) blowout incident rate for 1992 to 2006 was approximately 1 blowout every 387 wells drilled (MMS, 2007).

Historically, most blowouts have not resulted in oil spills; of 151 well blowouts in the Gulf of Mexico from 1971 to 1995, only 18 (12%) resulted in oil spills. The total volume released from all of these spills was 1 000 bbl of crude oil and condensate (MMS, 2001). Between 1964 and 1999, almost all offshore spills (94%) from drilling- and production-related operations on the U.S. OCS were less than or equal to 1 bbl in size (Anderson and LaBelle, 2000). Taken together, the historical data indicate that a blowout occurring and resulting in an oil spill of any size is very unlikely (less than 0.1 %). The probability of a blowout resulting in a large oil spill is even lower.

According to the MMS (2007), the main factors contributing to blowouts are leaks behind casing flows after cementing; equipment failure; casing failure; formation fracture; swabbing; and stuck pipes (**Figure 6-6** below).



Source: MMS (2007)

Figure 6-6. Factors contributing to blowouts

Despite the fact that blowouts resulting in spills are rare events, should they occur, they are likely to result in water pollution due to the spillage of muds, chemicals and hydrocarbons. Potential impacts can range from minor to major, depending on the magnitude of the blowout and the location of the rig. From 1992 – 2006 in the Gulf of Mexico, environmental impacts due to blowouts were negligible (MMS, 2007).

Fires/explosions

A fire/explosion could occur on the rig, barge or support vessels, particularly where it involves hydrocarbons that could ignite causing a fire or explosion. The impacts on the environment of a fire or explosion are largely concerned with the risks for human population but there will also be a localized impact on air quality.

Vessel Collisions

Vessel collisions may occur between the rig and the support vessels, between the support vessels and other third party vessels and/or between the rig and other third party vessels.

The most common causes of such accidents are related to unsafe work practices, including vessels not being seaworthy; use of improper and/or poorly maintained equipment; inadequate crew training in maritime safety procedures and equipment operations; and violation of rules.

Collision with other vessels is a highly unlikely event but could result in spills of diesel fuel and/or other products, including hazardous substances that the vessels may be transporting.

Effects on Environmental Components

The effects of non-routine events are largely concerned with the spillage/release of hydrocarbons. This can be associated with a diesel spill during transfer or vessel collision or the release of crude oil during a blowout. Fires or explosions are also likely to result in the release of hydrocarbons and can also have an effect on localized air quality. The effects of these events on the environmental components (with the exception of air quality, which includes fires/explosions) are therefore focused on hydrocarbon releases.

In order to assess the potential impacts on the environmental components, it is important to understand the fate of oil spills in the marine environment, which involves a series of complex processes whose progression, duration, and impact depend upon several key parameters, including:

- oil composition;
- release characteristics (e.g., release rate, surface or subsurface location); and
- ambient oceanographic conditions.

In general, an oil spill is influenced by mechanisms of physical transport (i.e., spreading, drifting, dissolution, emulsification, photo-oxidation, adsorption, and subsequent sedimentation) and biological activity (i.e., microbial biodegradation) **(Figure 6-7**).

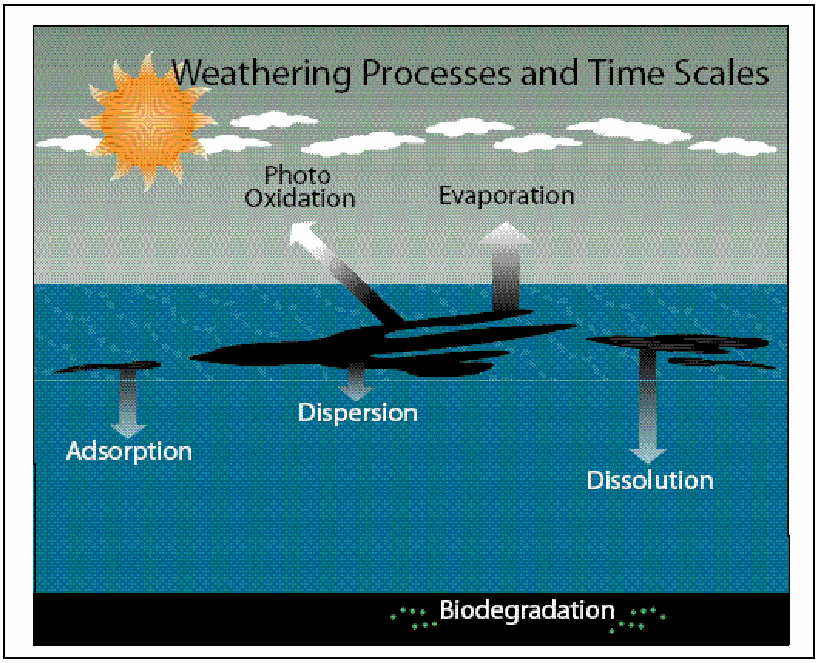


Figure 6-7. Weathering processes affecting oil spilled into the marine environment (From: National Oceanic and Atmospheric Administration, 2006).

Spreading characteristics are affected by uniform and non-uniform currents, winds, and waves. As oil is released over time, these mechanisms physically break up the slick; droplets are formed, then disperse, and resurface. Historically, the thickness of an oil spill "slick" has been estimated by dividing volume/area (Mackay and Chau, 1986; Lunel and Lewis, 1993a,b; Lewis et al., 1995a,b; Walker et al., 1995; Brandvik et al., 1996; Brown et al., 2000). Spill measurements indicate that oil does not spread uniformly, but is irregular in shape and thickness – generally elongated in the direction of the wind, often composed of thick "patches" (>1 mm) and thinner "sheens" (<0.01 mm). Ross (1997) gives a general rule of thumb: 90% of spill volume is contained in 10% of its area (National Research Council [NRC], 2005).

Under a blowout scenario, oil is released at depth, forming a plume that discharges into the marine environment near the seafloor. Once the plume surfaces from a sub-sea blowout, oil and entrained water will spread radially in a surface layer (Fannelop and Sjoen, 1980). The resulting oil slick will be significantly thinner than those produced by oil spilled directly on the surface. Natural gas may also be associated with oil. If gas is present in the formation, gas bubbles released during a blowout will affect plume buoyancy. In deeper water, ambient currents and water column density stratification will cause the gas bubbles and larger oil droplets to separate from the remainder of the plume and ascend as individual (or small groups of) droplets and bubbles (Socolofsky and Adams, 2002) Because droplet rise-velocity depends on diameter, the larger oil droplets will reach the surface sooner and closer to their source than smaller droplets (i.e., fractionation [NRC, 2005]), which would lead to a substantially longer and thinner plume than would be produced by a surface oil spill.

Under the diesel fuel spill scenario, fuel would be released at the sea surface. Unlike the blowout scenario where released crude oil forms a subsurface buoyant plume, diesel fuel released onto the ocean surface forms no subsurface plume. Diesel oil is much lighter than water (i.e., specific gravity ~0.85, compared to 1.03 for seawater) and therefore cannot sink. However, it is possible for diesel fuel to be physically mixed into the water column by wave action, forming small droplets that are carried and kept in suspension by currents. An accidental release of diesel fuel will rapidly spread and thin. Refined products such as diesel fuel contain higher proportions of lighter fractions (e.g., C2-C10 compounds) than crude oil and are more susceptible to spreading and mixing.

Diesel is generally more toxic to marine organisms than crude oil as has been shown by many toxicity tests such as shown in the table below[9]. One of the main reasons is that diesel is more water soluble than crude oil and therefore tends to release toxic components into the water column more readily than crude oil.

Diesel is also more volatile than crude oil which results in higher concentrations of VOC´s in the air as compared to most crude oils.

The **Table 6-19** below demonstrates some of differences in toxicity of different petroleum types.

Table 6-19. Acute toxicity of fuel oil and crude oil to different species and life stages of marine animals (From: Neff, 1987)

Organism	Material Tested	LC_{50}*(mg/l)
Finfish	No. 2 Fuel Oil[10]/Kerosene	90-550
Larvae and eggs	No. 2 Fuel Oil/Kerosene	0.1-4.0
Pelagic crustacea	No. 2 Fuel Oil/Kerosene	5-50
Benthic crustacea	No. 2 Fuel Oil/Kerosene	5-50
Bivalve molluscs	No. 2 Fuel Oil/Kerosene	30,000-40,000
Other benthic invertebrates	No. 2 Fuel Oil/Kerosene	5-50
Finfish	Fresh Crude Oil	88-18,000
Larvae and eggs	Fresh Crude Oil	0.1-100
Pelagic crustacea	Fresh Crude Oil	100-40,000
Benthic crustacea	Fresh Crude Oil	56
Bivalve mollusks	Fresh Crude Oil	1,000-100,000
Other benthic invertebrates	Fresh Crude Oil	100-6,000
*The concentration calculated to kill 50% of the test organisms in a specified period of time.		

While spreading and drift are important physical processes, other mechanisms affect the fate of spilled oil or petroleum products, including evaporation, dissolution, photo-oxidation, biodegradation, water-in-oil emulsification (mousse formation), dispersion of whole oil droplets into the water column (entrainment), interaction of dissolved and dispersed components with suspended particulate material (SPM), uptake by organisms, and stranding on shorelines (NRC, 1985, 1989, 2003).

Evaporation is the single most important and rapid of all weathering processes (McAuliffe, 1989). The NRC (2005) notes that weathering losses can account for the loss of 20% to 50% of many crude oils, 75 % or more of refined petroleum products, and 10% or less of residual fuel oils (Butler, 1975; Butler et al., 1976; NRC, 1985, 2003). The NOAA (2006) indicates that more than 90 % of the diesel in a small spill incident into the marine

[9] Diesel is a component of crude oil representing carbon molecules in chains in the C_{12} – C_{20} range
[10] No. 2 fuel oil is a designation for diesel

environment is either evaporated or naturally dispersed into the water column within hours to several days. Photochemical generation of additional polar products (e.g., resins, carboxylic acids, ketones, aldehydes, alcohols, and phenols) with low hydrophilic-lipophilic balance (HLB) values that remain in the oil phase also can lead to the formation and stabilization of water-in-oil emulsions with greater water content.

The potential impacts of hydrocarbon spills on the various environmental components are discussed in the following sections. There are many different types of oil; therefore each oil spill is different depending on the type of oil accidentally released into the environment. Each oil spill will have a different impact on sensitive resources and the surrounding environment depending on the following:

- Type of oil spilled – physical and chemical characteristics of oil, susceptibility to evaporation, emulsion formation, dispersion, etc., and degree of oil weathering that occurs prior to contact;
- Spill location – distance from sensitive resources;
- Species present – temporal (e.g., seasonal presence, migrants), spatial (i.e., distribution, tendency to occur in schools, herds, etc.), and behavioral characteristics (e.g., species-specific response to oil); and
- Timing of breeding cycles and seasonal migrations.

In general, direct oil effects typically include smothering, toxicity from ingestion and/or inhalation, increased levels of hydrocarbons in water and air, and areal exclusion. Indirect impacts include adverse effects on prey organisms and/or destruction of habitat.

PHYSICAL ENVIRONMENT

Air Quality

Potential Impact 1: Reduced air quality due to hydrocarbon release

An oil spill would affect air quality in the vicinity of the oil slick by introducing volatile organic compounds (VOCs) through evaporation. Emissions would not last long due to rapid volatilization of hydrocarbons. Evaporation is also greatest within the first 24 hours. The more toxic, light aromatic, and aliphatic hydrocarbons are lost rapidly by evaporation and dissolution (NRC, 1985; Payne et al., 1987). Evaporated hydrocarbons are degraded rapidly by sunlight through photo-oxidation. Biodegradation of oil on the water surface and in the water column by marine bacteria and fungi initially removes the n-alkanes and subsequently the light aromatics. Other components are biodegraded more slowly. Photo-oxidation attacks mainly the medium and high molecular weight polycyclic aromatic hydrocarbons of a spill. The extent and persistence of impacts would depend on meteorological and oceanographic conditions at the time. Little or no impact on air quality in coastal areas would be expected.

A diesel spill would also affect air quality through the evaporation of volatile compounds, but only within the immediate vicinity of the spill. Dissolution, dispersion, biodegradation, and photo-oxidation would also act on select components of the diesel. Given the relatively small volume of diesel released under this accident scenario, coupled with rapid dissolution, dispersion, evaporation, and, to a lesser extent, photo-oxidation, only very localized air quality impacts would be realized. No impact to coastal areas would be expected.

In the unlikely event of hydrocarbon release, it is probable that the air quality in the immediate vicinity of the incident will be reduced due to evaporation of hydrocarbons but this will be short term.

The significance of a hydrocarbon release on air quality will go from minor to moderate depending on the volume and volatility of the spill.

Potential Impact 2: Reduced air quality due to a fire/explosion

In the unlikely event of an explosion on the rig or any of the vessels resulting in the uncontrolled escape of hydrocarbons during the drilling activity there is the potential to cause short-term, localized air pollution. A fire/explosion will result in the release of combustion products such as CO_2 and particulate matter. Thus, air quality in the vicinity of the fire/explosion may be affected.

The significance of this impact is minor.

Water Quality

Potential Impact 3: Reduced water quality due to hydrocarbon spills

An hydrocarbon spill of either crude oil or diesel fuel would affect marine water quality by increasing hydrocarbon concentrations due to dissolved components and small oil droplets. Natural weathering processes are expected to rapidly remove the diesel fuel from the water column and dilute the constituents to background levels. Similarly, the lighter fractions of crude oil will weather, while more complex compounds will persist. The highly evaporative and dispersive *components* of a medium crude oil are expected to result in its ready dispersal into the water column.

The significance of a crude oil or diesel spills will go from minor, for small[11] spills, to major for large[12] spills should the spilled material escape containment and therefore release soluble components into the water column over a larger area.

BIOLOGICAL ENVIRONMENT

MANGROVES

Potential Impact 4: Effects on coastal mangroves due to hydrocarbon spills

Extensive mangroves occur along the coastline and on several islands in the Project area.

Mangroves are particularly sensitive to oil and are primary areas for protection (International Petroleum Industry Environmental Conservation Association [IPIECA], 1993). Oil spills have been reported to kill mangroves in Nigeria, Indonesia, Panama, Kenya, Puerto Rico and other areas (Thorhaug, 1992). Experimental studies and field observations show that the impact of oil spills on mangroves can be divided into two phases:

1. Short-term mortality phase, attributed to coating with fresh oil and probably to the aromatic hydrocarbon content; and
2. Longer-term effects of weathered oil becoming incorporated into the sediment, inhibiting the growth of seedlings and larger plants (Volkman et al., 1994).

[11] Small spill: That can be dealt locally with all spilled materials contained at this spill site.
[12] Large spill: That would escape containment and require rapid mobilization of equipment not available in the region (ie, an international oil spill response company)

While experts agree that oil causes physical suffocation and toxicological/physiological impacts, researchers disagree as to the relative contributions of each mechanism, which may vary with type of oil and time since the spill (Proffitt, 1997; Hoff, 2002). Snedaker et al. (1997) have suggested that several mangrove species can tolerate or accommodate exposure to moderate amounts of oil on breathing roots.

Hoff (2002), in an analysis of mangrove oiling effects and remediation, addressed both acute and chronic impacts, and summarized a broad range of effects ranging from stress to mortality (**Table 6-20**). Oil-impacted mangroves may suffer yellowed leaves, defoliation, and tree death. More subtle responses include branching of pneumatophores, germination failure, decreased canopy cover, increased rate of mutation, and increased sensitivity to other stresses.

Table 6-20. Acute and chronic responses of mangrove forests to oil spills (From: Lewis, 1983 and Hoff, 2002).

Stage	Observed Impact
Acute	
0-15 days	Death of birds, fishes, invertebrates
15-30 days	Defoliation and death of small (<1 m) mangroves Loss of aerial root community
Chronic	
30 days – 1 year	Defoliation and death of medium (<3 m) mangroves Tissue damage to aerial roots
1 year – 5 years	Death of larger (>3 m) mangroves Loss of aerial roots Regrowth of roots; occasionally deformed Recolonization of oiled areas by new seedlings
1 year – 10 years	Reduction in litterfall Reduced reproduction Reduced seedling survival Death or reduced growth of recolonizing trees Increased insect damage
10 – 50 years	Complete recovery

Oil slicks enter mangrove forests when the tide is high and the oil can be deposited on the aerial roots and sediment surface as the tide recedes. This commonly leads to a patchy distribution of the oil and its effects such as patches of dead trees, etc. It appears, however, that mangroves are not killed by oil spills which do not sink into the root systems, but only oil the bark of trees at high tide (Thorhaug, 1992).

The organisms among and on the mangrove trees can affected in two ways. Firstly, there may be heavy mortalities as a direct result of the oil. For example, oil may penetrate burrows in the sediments killing crabs and worms, or coat mollusks on the sediment surface and aerial roots. Secondly, dead trees lead to loss of habitat (IPIECA, 1993). The physical effects of oiling (e.g., covering or blocking of specialized tissues for respiration or salt management) can be as damaging to mangroves as the inherent toxicity of the oil (Hoff, 2002). Research is inconclusive – some studies indicate that mangroves can tolerate some coating without apparent damage, while others identify physical effects of oiling as the most serious mechanism.

Volkman et al. (1994) in a scientific review of the impacts of oil spills, give recovery times of low energy intertidal communities, such as mangroves, as being about 10 to 15 years after the spill. Five years after the Bahia las Minas (Panama) spill[13], oil remaining in mangrove sediments continued to adversely affect root survival, canopy condition, and growth rates of mangrove seedlings in oil-deforested gaps. Six years after the spill, surviving forests fringing deforested areas showed continued deterioration of canopy leaf biomass (Burns et al., 1993). Persistence of oil residues from 5 to over 20 years is reported.

The oiling of mudflats and mangroves could have severe negative impacts for species populations and community structure. Due to the dependence of some commercially fished resources in the region on estuaries, e.g., pink shrimp, the socioeconomic consequences could be equally severe.

The significance of a crude oil or diesel spill go from minor, for small spills, to major for large spills that exceed local containment and migrate into these mudflat and/or mangrove areas.

SEAGRASS AND CORAL COMMUNITITES

Potential Impact 5: Effects on coral reefs and seagrass beds due to oil spills

Corals

Coral reefs are some of the more sensitive habitats in the shallow waters of the Project area. Spilled oil can come into contact with coral reefs in a number of ways. Because oil is less dense than water, it tends to float over reefs, although there is dispersion and dissolution of portions of crude oil into the water column. However, some reef areas are exposed to the air during low tides and, when coupled with an oil spill, could experience direct contact with oil, resulting in smothering.

Another mechanism involves waves breaking on the reefs and shoreline, creating droplets of oil that are distributed into the water column and come into contact with the corals. As corals secrete mucus, especially when stressed, the droplets can easily stick to them, but may subsequently be shed with the mucus. In some areas with high dust loadings and/or high particle content of the water column, oil can combine with mineral particles and sink, and these oily particles may affect the corals. The whole process of weathering (including evaporation and effect of sunlight) can also cause oil to sink and come into contact with deeper corals.

Various physiological effects of oil exposure to coral reefs have been documented, as summarized by the National Oceanic and Atmospheric Administration (NOAA) (2001), including:

- Tissue death (Johannes et al., 1972; Reimer, 1975; Neff and Anderson, 1981; Wyers et al., 1986);
- Impaired feeding response (Reimer, 1975; Lewis, 1971; Wyers et al., 1986);
- Impaired polyp retraction (Elgershuizen and de Kruijf, 1976; Neff and Anderson, 1981; Knap et al., 1983; Wyers et al., 1986);
- Impaired sediment clearance ability (Bak and Elgershuizen, 1976);
- Increased mucus production (Peters et al., 1981; Wyers et al., 1986; Harrison et al., 1990);

[13] On April 27, 1986, 75,000 – 100,000 barrels of medium weight crude oil spill from a refinery near Bahia las Minas, Panama.

- Change in calcification rate (Birkeland et al., 1976; Neff and Anderson, 1981; Dodge et al., 1984; Guzmán et al., 1991, 1994);
- Gonad damage (Rinkevich and Loya, 1979; Peters et al., 1981);
- Premature extrusion of planulae (Loya and Rinkevich, 1979; Cohen et al., 1977);
- Larval death (Rinkevich and Loya, 1977);
- Impaired larval settlement (Rinkevich and Loya, 1977; Te, 1991; Kushmaro et al., 1996; Epstein et al., 2000);
- Expulsion of zooxanthellae (Birkeland et al., 1976; Neff and Anderson, 1981; Peters et al., 1981);
- Change in zooxanthellae primary production (Neff and Anderson, 1981; Cook and Knap, 1983; Rinkevich and Loya, 1983); and
- Muscle atrophy (Peters et al., 1981).

Oil reaching coral reefs will be subject to weathering, dispersal, and dissolution. Due to the relatively large volumes associated with a blowout, crude oil is expected to be more persistent in the environment than a smaller diesel fuel spill. Diesel fuel will quickly undergo weathering, dispersal, and dissolution. Distance and transport time, and the degree of oil weathering that may occur are critical elements in assessing impact. With relatively short transport times (i.e., estimated at 3 to 17 hours), crude oil weathering will be highly dependent upon physical mechanisms of weathering (e.g., wind and wave action enhancing dissolution and transport of floating crude oil) and the relative percentage of VOCs (i.e., spill fractions susceptible to evaporation and/or dissolution). Tidal cycle may also influence degree of subsurface exposure for both crude oil and diesel fuel.

Seagrass

Seagrass beds and macroalgal assemblages play a valuable role by providing food and shelter and serving as nursery grounds for diverse, commercially-exploited species, such as fishes, crustaceans, gastropods, and sea cucumbers. Seagrasses are important feeding habitats for the endangered dugong (*Dugong dugon*) and green turtle (*Chelonia mydas*).

For spilled diesel fuel, minimal toxicity to seagrasses is expected due to hydrocarbons being readily dissolved, dispersed, and evaporated, depending upon proximity of seagrass beds to spill location. For the larger crude oil spill, seagrass beds could be coated and smothered, causing mortality. Lighter fractions of crude oil may also result in toxicity to seagrasses and associated fauna (e.g., juvenile fishes and invertebrates).

The significance of a crude oil or diesel oil spill on these important shallow water macrobenthic communities goes from minor, for small spills, to major for large spills that exceed local containment and migrate over these areas in such quantities that lead to toxic concentration of the soluble components reaching the seagrass and/or coral habitats.

FAUNA- MARINE MAMMALS, MARINE TURTLES; FISH AND SEABIRDS

<u>Potential Impact 6: Effects on marine mammals, turtles, fish and seabirds due to oil spills</u>

Marine Mammals

Marine mammals may be exposed to oil in several ways, including inhalation of hydrocarbon vapors, direct contact between oil and the skin, ingestion of oil droplets or contaminated prey, and fouling of baleen plates (Geraci and St. Aubin, 1987; Geraci, 1990; Loughlin, 1996). Whales and dolphins can apparently detect oil slicks on the sea surface, but do not always avoid them; Scholz et al. (1992) have seen various whale and dolphin species surfacing in oil slicks. Whales (e.g., humpback, fin, right, and minke) and bottlenose dolphins have been observed to swim through oil slicks without apparent deleterious effects. Because cetaceans apparently do not avoid oil slicks, they may be vulnerable to inhalation of hydrocarbon vapors.

Effects of oil spills on marine mammals depend on the level of exposure and potential for ingestion or inhalation. Direct oiling of whales and dolphins is not considered to be a serious risk as their skin contains a resistant dermal shield that acts as a barrier to toxic petroleum compounds (Scholtz et al., 1992). Cetacean skin is highly impermeable to oil and is not seriously irritated by brief exposure to environmentally-realistic amounts of oil (Geraci, 1990). However, if a cetacean surfaces directly within a slick of fresh oil, it may inhale hydrocarbon vapors, possibly leading to irritation and congestion of the lungs and bronchi. Absorption of volatile hydrocarbons through the lungs can lead to liver damage and may be a greater hazard to cetaceans than ingestion of oil or oil-contaminated prey (Geraci, 1990). Vapor concentrations of volatile hydrocarbons may be high enough just above a fresh slick (particularly if the oil is a light crude, a condensate, or a light or middle distillate fuel) to cause systemic damage for a few hours after a spill.

There is no evidence that ingestion of oil as droplets or contaminated prey represents a significant risk to baleen and toothed cetaceans. Fouling of the baleen feeding apparatus of baleen whales has not been observed; if it does occur, it is probably transitory and not debilitating. Preferred prey items are not likely to be sufficiently contaminated to pose a significant health risk to cetaceans.

Direct and indirect impacts of either crude oil or diesel fuel upon these highly mobile animals are liable to be very short term and insignificant on the regional scale. Should a crude oil spill reach dugong coastal habitat in large volumes, the potential exists for longer term exposure if oil becomes trapped in embayments. Diesel fuel is not likely to reach dugong habitat.

Turtles

Sea turtles usually do not avoid contact with oil either on the sea surface or onshore, and may even seek out and ingest tar balls (Odell and MacMurray, 1986; Lohoefener et al., 1989). If a sea turtle does encounter a large oil slick on the sea surface, there is a high probability that the turtle will suffer injury or possible death (Lutcavage et al., 1995, 1997). A loggerhead turtle was observed to surface repeatedly within an oil slick for more than an hour in the western Gulf of Mexico (Lohoefener et al., 1989). Leatherback sea turtles, in particular, may ingest tar balls, mistaking them for their preferred prey of gelatinous zooplankton.

All species and life stages of sea turtles are vulnerable to injury from encounters with oil. Oil can adhere to the body surface and cling to the nares, eyes, and upper esophagus of sea turtles, causing contact dermatitis (Lutcavage et al., 1995). Mucus membranes around the eyes, nose, and mouth may become irritated and damaged by oil contact. Short-term contact with or ingestion of the oil may cause significant changes in respiration, blood chemistry, energy metabolism, and diving behavior. Salt gland function has also been shown to be inhibited immediately after oil exposure, returning to normal within several weeks following exposure. In the field, these responses to oil would cause a variety of sub-lethal physiological effects that may lessen the ability of the turtle to cope with normal environmental stresses. Inhalation of hydrocarbon vapors may cause respiratory pathology and systemic toxicity.

Adult and juvenile turtles can survive and, through their swimming ability, avoid oil slicks. The most vulnerable stage in the turtle life cycle is if an oil slick reaches beaches where hatchlings are about to emerge and migrate to the sea. It is probable, although not specifically proven, that the presence of an oil slick will disorientate the hatchlings. This may lengthen their exposure to predators on the beaches and/or interfere with their swimming abilities. Hatchling survival is not high in any case (Bjorndal, 1982) and any increased mortalities can be reflected in the overall population.

The potential impacts of a crude oil spill on turtle populations inhabiting the region may be significant, including both contact at sea and on nesting beaches. The potential for impact from a small diesel spill are significantly reduced (relative to crude oil impacts) because the smaller spill volume and weathering of the diesel fuel will limit the surface area of the spill and overall effects on sea turtles that may be present.

Fish

Pelagic fish (adults, larvae) mortalities as a result of oil spills are limited in size and have not translated into measurable effects on fish stocks. However, local mortalities especially in fish larvae and fish eggs can occur but direct observation of this is apparently rare (Baker et al., 1990).

Demersal, near-shore, and estuarine stocks, especially those species feeding on the sediment surface (e.g., soles and some Mugil [mullet] species) may suffer mortalities through ingesting contaminated sediments. This has been observed on the Brittany coast where plaice (*Pleuronectes platessa*) were adversely affected for at least two years by the Amoco Cadiz tanker oil spill.

Fish species of intertidal and shallow sub-tidal sites affected by oiling showed no clear effects from the JESSICA tanker oil spill in the Galapagos (Gelin et al., 2002); increases in the density of several fish taxa (as well as increases in algal, sea urchin, and hydroid populations) were detected adjacent to the wreck, and were probably caused by Jessica-associated disturbance.

Fishes are mobile and can move out of an impacted area. However, the overall habitat range can be significantly decreased, leading to major implications for the fish populations as a whole. An oil spill, therefore, can have a major negative impact upon these near-shore and shallow water species. Crude oil exposure may be expected to result in toxicity effects on fishes, with localized mortality to fish eggs and larvae also possible. Similar effects may be expected following exposure to diesel fuel, although the smaller spill volume and weathering of the diesel fuel will limit the area extent of the spill and overall effects on local fish populations.

Seabirds

Seabirds are conspicuous victims of oil pollution in the sea. Birds are affected through fouling of plumage and resulting hypothermia, direct ingestion of oil, reduced reproductive success, and physical disturbance associated with spill cleanup operations. Even moderate oiling can lead to death, mainly due to reduced thermoregulation and/or insulation. Direct observations of bird mortalities through oil spills probably only reflect 10 % at most of the actual mortalities (Donnet, 1982 cited in Volkman et al., 1994). These effects are expected to be similar for both crude oil and diesel fuel, although the number of birds affected by a small diesel spill will be small because of the short time diesel remains on the water surface. Experience noted by NOAA (2006) following hundreds of small diesel spills in Alaska is that few birds are directly affected by diesel spills from fishing vessels.

Mozambique's seabird and shorebird populations are, therefore, vulnerable to oil spills (crude and diesel), which may have a high negative impact on individual birds. If crude oil was to reach the estuaries of Mozambique, this high negative impact may extend to the population level.

The significance of a crude oil or diesel spill go from minor, for small spills, to major for large spills that exceed local containment and migrate into areas where these important faunal components are exposed to the spilled material.

PROTECTED AREAS

Potential Impact 7: Effects on protected areas due to an oil spill

Hydrocarbon spills that occur in the drilling areas may be transported to sensitive habitats that are critically important for coastal marine mammals (dolphins and dugongs), sea turtles and sea birds. These habitats are sandy beaches, corals, sea grasses and mangroves and the extent of the damage would depend on the size, type and duration of the spill, currents and wind direction.

Although it is not within the AMA1 concession or the boundary of the currently proposed drilling project, the Quirimbas National Park (QNP) lies directly to the south (7.8km) of the study area with a very small portion of the proposed buffer zone falling within the AMA1 Concession Area. The QNP includes the southern-most 11 islands of the Quirimbas Archipelago, as well as a large portion of the mainland. The marine protected portion of the QNP covers 1361km^2 and is one of the largest marine protected areas in Africa.

The Mnazi Bay-Ruvuma Estuary Marine Park (MBREMP) in Tanzania is located 3km to the north of the AMA1 Concession Area while a very small portion of the Proposed Rovuma National Reserve occurs within the drilling area. These protected areas could be significantly affected by a major spill event such as an oil well blowout.

Should spilled oil reach more sensitive areas (Sandy beaches, mangroves, seagrass beds and coral reefs), the impacts are likely to be significant due to their vulnerability and high ecological value as well as their importance to the local tourism sector and their protection status.

The impacts of a hydrocarbon release on coastal features such as mangroves, corals and seagrass beds have been discussed. Ecological protected areas are usually designated due to their biodiversity value or vulnerability and as such are likely to be significantly affected by a hydrocarbon release that reaches the shore.
The significance of a crude oil or diesel oil spill on these intrinsically valuable sensitive and protected areas goes from minor for small spills, to major for large spills that spread beyond local containment and extend into the sensitive areas.

SOCIO-ECONOMIC ENVIRONMENT

POPULATION

Potential Impact 8: Effects on population due to hydrocarbon spills

Effects on human populations are realized through potential health hazards as well as economic losses, such as those associated with the temporary loss of fishing grounds.

The local population may be affected because they depend upon coastal and marine resources for subsistence. If water quality is affected, coastal and marine resources may be affected and that will reduce the source of food and income for the local population. Some health problems could also arise within the communities living in the vicinity of the spill as a result of contaminated foods and through odor and atmospheric pollutants evaporating from the spill. It is important to highlight that petroleum hydrocarbons are potentially carcinogenic and can cause severe dermatitis.

An indirect impact would be a loss in trade and market confidence as the local people and restaurants may be unwilling to purchase marine products from the local fisherman.

Prohibitions may be imposed on fishing and harvesting marine products after a spill in order to regain market confidence as well as to protect fishing and collection equipment from damage. This would seriously impact the livelihoods of the local population, who depend upon the marine resources.

The intensity and duration of the impact of hydrocarbon spills on the local population is dependent on the type (crude oil or diesel) intensity and volume of hydrocarbons spilled into the environment. Impacts could be short term; however, there is a potential for recovery time to take longer (e.g. 5 years or more), if the impact's magnitude is large. Also, it should be noted that if local communities depend upon the coastal and marine resources for living, even a short-term impact could be significant due to the vulnerable socio-economic status of these communities and their inability to fish in different areas.

The significance of a crude oil or diesel oil spill go from minor, for small spills, to major for large spills that exceed local containment and migrate into areas where exposure to the population cannot be avoided.

Potential Impact 9: Effects on population due to fire/explosions

In the unlikely event of a fire/explosion on a rig or any of the vessels, the release of combustion products such as CO2 and particulate matter to the atmosphere may occur. For a large fire/explosion (e.g., resulting from a well blow out when accumulated hydrocarbons may ignite) the initial shock waves may be felt a few kilometers away.

It is highly unlikely that the fire or explosion would directly affect local population (i.e., fatalities through burning from an explosion). For the rig a 500m security zone around the rig will be established. However, the fire may force hydrocarbons, sand, grit and drilling fluids up into the air to settle on the surface of the ocean or on nearby islands or land. These falling materials may cause damage to infrastructure, crops or livestock. In addition, air contaminants may cause respiratory ailments if settlements occur in within a few kilometers of a large fire/explosion and temporary evacuation may be required.

The significance of the impact is minor to major contingent upon the proximity to inhabited areas or port.

ARTISANAL FISHERIES

Potential Impact 10: Effects on artisanal fisheries due to a hydrocarbon spill

Artisanal fishing in the Quirimbas Archipelago is mainly in and around the island reefs, extending occasionally into the deepwater up to 13 km east. Artisanal fishers catch reef fishes and, in cases where boats venture into deeper waters east of the reefs, pelagic fishes, squid, and demersal fishes.

An hydrocarbon spill can lead to mortality, tainting of fish rendering products unmarketable, altering of habitats (affecting availability and/or recruitment), and fouling of gear leading to increased maintenance or replacement costs. The larger the spill, the more extensive its impacts – more area is potentially affected, and there is a longer presence in the environment. Under the crude oil spill scenario, the potential for a much larger volume of oil will be released. Furthermore, crude oil is not expected to weather as quickly as a smaller diesel spill. Thus, crude oil impacts may be expected to extend further and last longer than those from diesel spills.

The intensity and duration of a reduction in fish yields as a result of hydrocarbon spills is dependent upon the type, intensity and volume of hydrocarbons spilled into the environment. A decrease in catch volume and limited access to fishing grounds farther a field could result in significant impacts.

The significance of a crude oil or diesel spill will go from minor, for small spills, to major for large spills that exceed local containment and cover multiple hectares of sea surface such that artisanal fishers cannot access the area and/or soluble components reach quantities in the water column that lead to tainting.

TOURISM

Potential Impact 11: Effects on tourism due to a hydrocarbon spill

The impacts of a major spill on the tourism industry could be very significant. Lodges would have to close during the clean-up period, and depending on the volumes that reached the shore, the effects could be long term. Also, near-shore coral reefs and other sea life upon which tourism operators depend for recreation for their guests could be seriously impacted. Oil spills preclude leisure activities such as swimming, sailing, fishing, angling and snorkeling and diving until the area is cleaned. This can take from days to weeks depending upon the specific parameters of the spill event.

Loss of revenue due to closure or disrupted activities could have a significant effect on the local economy. The attraction of the Quirimbas Archipelago for tourists is due, at least partially, to its image as un-spoilt, and this could be negatively affected for a long period, if not permanently, by a hydrocarbon spill.

The significance of a crude oil or diesel oil spill go from minor, for small spills, to major for large spills that extend beyond local containment and affect access to beaches, diving spots, etc.

COASTAL INDUSTRIES

Potential Impact 12: Effects on coastal industries due to a hydrocarbon spill

The most important activities developed by the micro-industries in the coastal region of the study area are maize flour mills, cashew processing, carpentries, cold-storage timber-exploration unities, salt pans and furniture manufacture. Forty-one percent of these industries are located in Mocimboa da Praia, while 34 % were found in Macomia. Aquaculture is still developing.

The industries that are likely to be affected are the salt pans and potential aquaculture projects due to their location and usage of sea water.

The salt pans are all located along the coast (less than 2 km from the shore line) and they may employ a maximum of 10 workers, but are not currently marketing the product. However, should a spill occur, a ban could be imposed during clean-up, affecting the local population that consumes the salt.

If such a spill occurred once the salt is being marketed, the salt could potentially become contaminated. That would render the salt unsalable. An indirect impact would be a loss in trade and market confidence as the local people and restaurants may be unwilling to purchase salt from the local salt industries.

Regarding potential aquaculture projects, it should be stated there that should these be developed, they are very likely to be affected by hydrocarbon spills and the consequences could be severe.

Seaweed farming has been developed under the AGA KHAN Project in the district of Macomia (*Pangane, Messano, Lumwamwa, Naunde and Kirimize).* The seaweed farms are located between 0 to 3 miles from the coast, depending on the coastal configuration, but not farther than the 6 m isobath. During 2007, approximately 1,400 households were involved in Macomia (≈ 800), Quissanga and Pemba.

As the method used for seaweed production is artisanal, hydrocarbon spills would damage the sticks, strings and nylon line used to produce seaweed as well as the seaweed itself because it would be using contaminated sea water for the culture, which would then affect its trade and export, rendering an economic loss to the company and the country (through export).

It should be noted that the aquaculture of seaweed has currently been suspended by AGA KHAN Foundation. It is not known when production is likely to resume.

The significance of a crude oil or diesel spill go from minor, for small spills, to major for large spills that exceed containment and reach areas where these coastal industry activities are occurring.

6.3. SUMMARY OF IMPACT EVALUATION

6.3.1. Seismic Survey

Unmitigated impacts from routine events and for non-routine events for seismic surveys are summarized in **Tables 6.21** and **Table 6.22** respectively.

Table 6-21. Summary of impact evaluation from routine events (seismic survey)

No.	EC	EC category	Impact	Magnitude	Spatial extent	Duration	Type	Cumulative	Reversibility	SIGNIFICANCE	Probability
PHYSICAL AND CHEIMICAL ENVIRONMENT											
1	AIR	MEDIUM	Reduction in air quality due to project emissions	Very small	Very small	Very short	Direct	Medium	Reversible	INSIGNIFICANT	Certain
2	WATER	HIGH	Water contamination around the seismic vessel and accommodation barge due to deck drainage and bilge water	Very small	Very small	Very short	Direct	No effect	Reversible	MINOR	Unlikely
3			Water contamination around the seismic vessel and accommodation barge from the discharge of sewage	Very small	Very small	Very short	Direct	No effect	Reversible	INSIGNIFICANT	Unlikely
4			Reduced water quality due to the discharge of solid wastes	Small	Very small	Very short	Direct	No effect	Reversible	MINOR	Unlikely
BIOLOGICAL ENVIRONMENT											
5	MANGROVES	HIGH	Impacts of sound pressure waves on mangroves	Very small	Very small	Very short	Direct	No effect	Reversible	MINOR	Very unlikely

No.	EC	EC category	Impact	Magnitude	Spatial extent	Duration	Type	Cumulative	Reversibility	SIGNIFICANCE	Probability
6			Impacts of retrieval and deployment of bottom cables/autonomous receivers on mangroves	Very small	Very small	Very short	Direct	No effect	Reversible	MODERATE	Certain
7	SEAGRASS BEDS	HIGH	Impacts of sound pressure waves on seagrass beds and macroalgae	Very small	Very small	Very short	Direct	No effect	Reversible	MINOR	Very unlikely
8			Impacts of retrieval and deployment of bottom cables/autonomous receivers on seagrass beds and macroalgae	Very small	Very small	Very short	Direct	No effect	Reversible	MINOR	Certain
9	CORAL REEFS	HIGH	Impacts of sound pressure waves on coral reefs	Very small	Very small	Very short	Direct	No effect	Reversible	MODERATE	Very unlikely
10			Impacts of retrieval and deployment of bottom cables/autonomous receivers on coral reefs	Very small	Very small	Very short	Direct	No effect	Reversible	MODERATE	Certain
11	MARINE MAMMALS	HIGH	Impacts of sound pressure waves on marine mammals	Very small	Very small	Very short	Direct	No effect	Reversible	MODERATE	Certain
12			Impacts of retrieval and deployment of bottom cables/autonomous receivers on marine mammals	Very small	Very small	Very short	Direct	No effect	Reversible	INSIGNIFICANT	Very unlikely

13	MARINE TURTLES	HIGH	Impacts of sound pressure waves on marine turtles	Very small	Very small	Very short	Direct	No effect	Reversible	MODERATE	Certain
14			Impacts of retrieval and deployment of bottom cables/autonomous receivers on marine turtles	Very small	Very small	Very short	Direct	No effect	Reversible	INSIGNIFICANT	Very unlikely
15	FISHES	HIGH	Impacts of sound pressure waves on fishes	Very small	Very small	Very short	Direct	No effect	Reversible	MODERATE	Certain
16			Impacts of retrieval and deployment of bottom cables/autonomous receivers on fishes	Very small	Very small	Very short	Direct	No effect	Reversible	INSIGNIFICANT	Very unlikely
SOCIOECONOMIC ENVIRONMENT											
17	POPULATION AND LOCAL ECONOMY	HIGH	Social conflicts due to the presence of foreign workers	Very small	Very small	Very short	Indirect	Low	Reversible	MINOR	Probable
18			Increased revenue due to the presence of the crew in Pemba	Very small	Very small	Very short	Indirect	Low	Reversible	POSITIVE	Certain
19	ARTISANAL FISHERIES	VERY HIGH	Temporary loss of access to fishing grounds and associated loss of catch – off-shore commercial artisanal fishers	Very small	Very small	Very short	Direct	No effect	Reversible	MINOR	Probable

20			Temporary loss of access to fishing grounds and associated loss ofcatch – subsistence and commercial artisanal fishers operating from the shoreline	Very small	Very small	Very short	Direct	No effect	Reversible	MINOR	Probable
21			Temporary decreased catch volumes in certain areas - off-shore commercial artisanal fishers	Very small	Very small	Very short	Direct	No effect	Reversible	MODERATE	Probable
22			Temporary decreased catch volumes in certain areas - subsistence and commercial artisanal fishers operating from the shoreline	Very small	Very small	Very short	Direct	No effect	Reversible	MODERATE	Probable
23			Effects on physical safety and health of divers due to sound source pulses	Large	Very small	Very short	Direct	No effect	Reversible	MAJOR	Probable
24			Temporary loss of income and effects on food security	Very small	Very small	Very short	Indirect	No effect	Reversible	MINOR	Probable
25			Temporary reduction in fish volumes available for purchase and resale	Very small	Very small	Very short	Indirect	No effect	Reversible	MINOR	Unlikely
26	TOURISM	HIGH	Temporary loss of access to dive sites due to safety zone around the seismic vessel	Very small	Very small	Very short	Direct	No effect	Reversible	MINOR	Probable

27			Physical safety and health of divers due to seismic sound source pulses	Large	Very small	Very short	Direct	No effect	Reversible	Major	Probable
28			Discomfort of divers due to sound pulses generated by the seismic sound source	Small	Small	very short	Direct	No effect	Reversible	MODERATE	Probable
29			Temporary loss / delayed access to recreational off-shore fishing grounds due to movements of the seismic vessel	Very small	Very small	Very short	Indirect	No effect	Reversible	MINOR	Probable
30			Reduced off-shore sports fishing experience due to changes in fish behavior and movement, potentially leading to decreased catches	Very small	Very small	Very short	Indirect	No effect	Reversible	MINOR	Probable
31			Reduced quality of sightseeing, due to mammal movement away from the area of seismic vessel	Very small	Very small	Very short	Indirect	No effect	Reversible	MINOR	Probable
32			Visual disturbance caused by the seismic vessel	Small	Very small	Very short	Indirect	No effect	Reversible	MINOR	Probable
33			Potential loss of revenue to the tourism operators	Small	Very small	Very short	Indirect	No effect	Reversible	MODERATE	Probable
34			Potential loss of income (in terms of wages and purchases)	Small	Very small	Very short	Indirect	No effect	Reversible	MINOR	Unlikely

35			Effects on the sale of island plots to private investors	Small	Very small	Very short	Indirect	No effect	Reversible	MINOR	Unlikely
36			Effects on the 'island paradise' image	Moderatel	Moderate	Short	Indirect	No effect	Reversible	MODERATE	Improbable
37			Suspension of planned and future investment	Moderatel	Moderate	Short	Indirect	No effect	Reversible	MODERATE	Improbable

Table 6-22. Summary of impact evaluation from non-routine events (seismic surveys)

No.	EC	EC category	Impact	Magnitude	Spatial extent	Duration	Type	Cumulative	Reversibility	SIGNIFICANCE	Probability
PHYSICAL AND CHEMICAL ENVIRONMENT											
1	AIR	MEDIUM	Reduction in air quality due evaporation of VOCs from a diesel spill	Small	Very small	Very short	Indirect	Low	Reversible	INSIGNIFICANT	Unlikely
2			Reduced air quality due to a fire/explosion	Small	Very small	Very short	Direct	Low	Reversible	MINOR	Unlikely
3	WATER	HIGH	Thin film of diesel produced on the sea surface Temporary toxicity in water column	Small	Very small	Very short	Direct	Low	Reversible	MINOR	Unlikely
4	MANGROVES	HIGH	Temporary film on the shoreline affecting trees and associated fauna	Small	Very small	Very short	Direct	Low	Reversible	MINOR	Unlikely
5	SEAGRASS BEDS AND MACROALGAE	HIGH	Direct contact can affected sea grasses seaweeds and associated fauna.	Small	Very small	Very short	Direct	Low	Reversible	MINOR	Unlikely

No.	EC	EC category	Impact	Magnitude	Spatial extent	Duration	Type	Cumulative	Reversibility	SIGNIFICANCE	Probability
6	CORAL REEFS	HIGH	Direct contact can affect corals and fishes	Small	Very small	Very short	Direct	Low	Reversible	MINOR	Unlikely
7	MARINE MAMMALS	HIGH	Exposure to diesel and fouling can affect animals	Small	Very Small	Very short	Direct	Low	Reversible	MINOR	Unlikely
8	MARINE TURTLES	HIGH	Exposure to diesel and fouling can affect animals	Small	Small	Very short	Direct	Low	Reversible	MINOR	Unlikely
9	FISH	HIGH	Exposure to diesel and fouling can affect animals	Small	Small	Very short	Direct	Low	Reversible	MINOR	Unlikely
10	POPULATION	HIGH	Effects on population due to diesel spills	Large	Small	Very short	Indirect	Low	Reversible	MINOR	Unlikely
11			Effects on population due to fire/explosions	Large	Small	Very short	Direct	Low	Reversible	MODERATE TO MAJOR	Unlikely
12	ARTISANAL FISHERIS	VERY HIGH	Effects on artisanal fisheries due to diesel spill	Large	Small	Very short	Indirect	Low	Reversible	MINOR	Unlikely

No.	EC	EC category	Impact	Magnitude	Spatial extent	Duration	Type	Cumulative	Reversibility	SIGNIFICANCE	Probability
13	TOURISM	HIGH	Effects on tourism due to diesel spill	Large	Small	Very short	Indirect	Low	Reversible	MINOR	Unlikely

6.3.2. Drilling

Impacts from routine events and for non-routine events for drilling are summarized in **Table 6-23** and **Table 6-24** respectively.

Table 6-23. Summary of impact evaluation from routine events (drilling)

No.	EC	EC category	Impact	Magnitude	Spatial extent	Duration	Type	Cumulative	Reversibility	SIGNIFICANCE	Probability
BIOPHYSICAL ENVIRONMENT											
1	AIR	MEDIUM	Reduction in air quality due to use of fuel for routine operations	Very small	Very small	Very short	Direct	Medium	Reversible	MINOR	Certain
2			Reduction in air quality due to test flaring of wells	Very small	Very small	Very short	Direct	Medium	Reversible	MINOR	Certain (if well testing is undertaken) Very unlikely (if no well testing is undertaken)
3	WATER	VERY HIGH	Reduced water quality due to discharges of solid wastes (excluding drilling muds and cuttings)	Small	Very small	Very short	Direct	No effect	Reversible	MODERATE	Unlikely
4a) (Shallow water)			Reduced water quality due to the discharge of drilling muds and cuttings	Very small*	Very small	Very short	Direct	No effect	Reversible	MINOR	Probable
4b) (Deep water)				Small	Small	Very short	Direct	No effect	Reversible	MINOR	Certain
5			Reduction in water quality due to deck drainage. Bilge water and sewage discharge	Small	Very small	Very short	Direct	No effect	Reversible	MODERATE	Unlikely

* Potential impacts related to drilling of the initial hole section before the marine riser is in place

6			Reduction in water quality due to disposal of kitchen wastes	Very small	Very small	Very short	Direct	No effect	Reversible	MINOR	Unlikely
7			Reduction in water quality due to the disposal of produced water	Small	Very small	Very short	Direct	No effect	Reversible	MINOR	Very unlikely
8	MANGROVE	HIGH	Impacts of waste disposal (including muds and cuttings) on the coastal mangroves	Very small*	Very small	Very short	Direct	No effect	Reversible	MINOR TO MODERATE	Very unlikely
9	SEAGRASS AND CORAL COMMUNITIES	VERY HIGH	Effects of positioning a jack-up rig on seagrass and coral community	Very small	Very small	Very short	Direct	No effect	Reversible	MINOR TO MAJOR	Probable
10			Effects of disposal of drilling muds and cuttings on coral reefs and seagrass beds	Very small*	Very small	Very short	Direct	No effect	Reversible	MINOR TO MODERATE	Unlikely
11	MACROBENTHOS		Effects on shallow water benthic macrofauna due to the discharge of drilling muds and cuttings	Very small*	Very small	Very short	Direct	No effect	Reversible	MINOR	Very unlikely

* Potential impacts related to drilling of the initial hole section before the marine riser is in place

12	DEEP WATER MACROBENTHOS	LOW	Effects on deep water benthic macrofauna due to discharge of drilling muds and cuttings	Small	Small	Short	Direct	No effect	Reversible	MINOR	Certain
13a) Shallow water	FAUNA (FISH, MARINE MAMMAL, MARINE TURTLE)	HIGH	Impacts due to the disposal of muds and cuttings on fauna through increased turbidity and contaminant load	Very small*	Very small	Very short	Indirect	No effect	Reversible	INSIGNIFICANT	Very unlikely
13b) Deep water				Very small	Very small	Very short	Indirect	No effect	Reversible	MINOR	Probable
14			Impacts on marine fauna due to deck drainage, bilge water disposal and sewage discharge	Small	Very small	Very short	Indirect	No effect	Reversible	MODERATE	Unlikely
15			Impacts on marine fauna due to the disposal of kitchen wastes	Very small	Very small	Very short	Direct	No effect	Reversible	MINOR	Very unlikely

* Potential impacts related to drilling of the initial hole section before the marine riser is in place

16			Impacts of noise on marine mammals, turtle and fish	Very small	Very small	Very short	Direct	Low	Reversible	MINOR	Probable
SOCIOECONOMIC ENVIRONMENT											
17	POPULATION AND LOCAL ECONOMY	MEDIUM	Social conflicts due to the presence of foreign workers	Very small	Very small	Very short	Indirect	Low	Reversible	MINOR TO MODERATE	Probable
18			Increased revenue due to the presence of the crew in Pemba	Very small	Very small	Very short	Indirect	Low	Reversible	POSITIVE	Certain
19	ARTISANAL FISHERIES	HIGH	Temporary loss of access to fishing grounds and associated loss of catch due to exclusion zones	Very small	Very small	Very short	Direct	No effect	Reversible	MINOR	Probable
20			Temporary catch decrease due to fish displacement and restrictions on fishing	Very small	Very small	Very short	Indirect	No effect	Reversible	MINOR	Probable
21			Effects on physical safety and health of divers due to sound generated by drilling activities	Very small	Very small	Very short	Indirect	No effect	Reversible	INSIGNIFICANT	Unlikely
22			Temporary loss of income and effects on food security	Very small	Very small	Very short	Indirect	No effect	Reversible	MINOR	Probable

23	TOURISM	HIGH	Temporary loss of access to dive sites due to the presence of the drill rig and the safety zone around the rig	Very small	Small	Very short	Direct	No effect	Reversible	MINOR to MAJOR (If close to a dive site) t	Probable
24			Physical safety and health and discomfort of divers due to sound generated by the drilling operations	Very small	Very small	Very short	Indirect	No effect	Reversible	INSIGNIFICANT	Unlikely
25			Temporary loss/delayed access to recreational offshore fishing grounds due to the presence of the safety zone around the rig	Very small	Very small	Very short	Direct	No effect	Reversible	MINOR	Probable
26			Reduced offshore sports fishing experiences due to changes in fish behavior and movement, potentially leading to decreased catches	Very small	Very small	Very short	Indirect	No effect	Reversible	MINOR	Unlikely
27			Reduced quality of sightseeing, due to mammal movement away from the area of exploration activities	Very small	Very small	Very short	Direct	No effect	Reversible	INSIGNIFICANT	Unlikely

28			Visual disturbance caused by the drilling operations	Small	Very small	Very short	Direct	No effect	Reversible	MINOR TO MAJOR***	Probable
29			Potential loss of revenue to tourism operators	Small	Very small	Very short	Indirect	No effect	Reversible	MINOR TO MAJOR	Probable
30			Potential loss of income (in terms of wages and purchases)	Small	Very small	Very short	Indirect	No effect	Reversible	MINOR	Unlikely
31			Effects on the sale of island plots to private investors	Small	Small	Very short	Indirect	No effect	Reversible	MINOR TO MAJOR	Unlikely
32			Effects on the "island paradise" image	Moderate	Moderate	Short	Indirect	No effect	Reversible	Moderate	Unlikely
33			Suspension of planned and future investment	Moderate	Moderate	Short	Indirect	No effect	Reversible	Moderate	Unlikely
34	NAVIGATION	VERY LOW	Interference with maritime traffic	Very small	Very small	Very short	Direct	No effect	Reversible	INSIGNIFICANT	Very unlikely

*** Dependent on the distance between the rig and the tourism location

Table 6-24. Summary of impact evaluation from non-routine events (drilling)

No.	EC	EC category	Impact	Magnitude	Spatial extent	Duration	Type	Cumulative	Reversibility	SIGNIFICANCE	Probability
BIOPHYSICAL ENVIRONMENT											
1	AIR	MEDIUM	Reduced air quality due hydrocarbon release	Small	Very small	Very short	Direct	Low	Reversible	MINOR TO MODERATE*	Unlikely
2			Reduced air quality due to fire/explosions	Small	Very small	Very short	Direct	Low	Reversible	MINOR	Very unlikely
3a	WATER	HIGH	Reduced water quality due to diesel oil spills	Large	Moderate	Short	Direct	Moderate	Reversible	Small[14] – MINOR Large[15] - MAJOR	Very unlikely
3b			Reduced water quality due to crude oil spills	Large	Moderate	Short	Direct	Moderate	Reversible	Small – MINOR Large - MAJOR	Very unlikely
4a	MANGROVE	HIGH	Effects on coastal mangroves due to diesel oil spills	Large	Moderate	Very short	Direct	Moderate	Reversible	Small – MINOR Large - MAJOR	Very unlikely
4b			Effects on coastal mangroves due to crude oil spills	Large	Moderate	Very short	Direct	Moderate	Reversible	Small – MINOR Large - MAJOR	Very unlikely

* Depending on the volume and volatility of the spill. Generally diesel is more volatile than crude.

14 Small spill: That can be dealt locally with all spilled materials contained at this spill site
15 Large spill: That would escape containment and require rapid mobilization of equipment not available in the region (i.e., an international oil spill response company)

No.	EC	EC category	Impact	Magnitude	Spatial extent	Duration	Type	Cumulative	Reversibility	SIGNIFICANCE	Probability
5a	SEAGRASS AND CORAL COMMUNITIES	VERY HIGH	Effects on coral reefs and seagrass beds due to diesel oil spills	Large	Moderate	Moderate	Direct	Low	Reversible	Small – MINOR Large - MAJOR	Very unlikely
5b			Effects on coral reefs and seagrass beds due to crude oil spills	Large	Moderate	Moderate	Direct	Low	Reversible	Small – MINOR Large - MAJOR	Very unlikely
6a	FAUNA (FISH, MARINE MAMMAL; MARINT TURTLE),SEABIRDS)	HIGH	Effects on marine mammals, turtles, fish and seabirds due to diesel oil spills	Large	Moderate	Short	Direct	Moderate	Irreversible	Small – MINOR Large - MAJOR	Very unlikely
6b			Effects on marine mammals, turtles, fish and seabirds due to crude oil spills	Large	Moderate	Short	Direct	Moderate	Irreversible	Small – MINOR Large - MAJOR	Very unlikely
7a	PROTECTED AREAS	VERY HIGH	Effects on protected areas due to a diesel oil spill	Large	Small	Moderate	Direct	Moderate	Reversible	Small – MINOR Large - MAJOR	Very unlikely
7b			Effects on protected areas due to a crude oil spill	Large	Small	Moderate	Direct	Moderate	Reversible	Small – MINOR Large - MAJOR	Very unlikely
SOCIOECONOMIC ENVIRONMENT											
8a	POPULATION	LOW	Effects on population due to diesel oil spills	Large	Moderate	Short	Indirect	Low	Reversible	Small – MINOR Large - MAJOR	Very unlikely
8b			Effects on population due to crude oil spills	Large	Moderate	Short	Indirect	Low	Reversible	Small – MINOR Large - MAJOR	Very unlikely

No.	EC	EC category	Impact	Magnitude	Spatial extent	Duration	Type	Cumulative	Reversibility	SIGNIFICANCE	Probability
9			Effects on population due to fire/explosions	Large	Moderate	Short	Direct	Low	Reversible	MODERATE	Very unlikely
10a	ARTISANAL FISHERIES	HIGH	Effects on Artisanal fisheries due to a diesel oil spill	Large	Moderate	Short	Direct	Low	Reversible	Small – MINOR Large - MAJOR	Very unlikely
10b			Effects on Artisanal fisheries due to a crude oil spill	Large	Moderate	Short	Direct	Low	Reversible	Small – MINOR Large - MAJOR	Very unlikely
11a	TOURISM	HIGH	Effects on tourism due to a diesel oil spill	Large	Moderate	Short	Direct	Low	Reversible	Small – MINOR Large - MAJOR	Very unlikely
11b			Effects on tourism due to a crude oil spill	Large	Moderate	Short	Direct	Low	Reversible	Small – MINOR Large - MAJOR	Very unlikely
12a	COASTAL INDUSTRIES	VERY LOW	Effects on coastal industries due to a diesel oil spill	Very small	Very small	Very short	Direct	Low	Reversible	Small – MINOR Large - MAJOR	Very unlikely
12b			Effects on coastal industries due to a crude oil spill	Very small	Very small	Very short	Direct	Low	Reversible	Small – MINOR Large - MAJOR	Very unlikely

Chapter 7

ENVIRONMENTAL MITIGATING MEASURES AND RESIDUAL IMPACTS

Chapter 7

ENVIRONMENTAL MITIGATION MEASURES AND RESIDUAL IMPACTS

The majority of impacts associated with the seismic and drilling programs are considered to be minor to insignificant (with few exceptions) provided that mitigation measures are implemented.

Potential (unmitigated) moderate to major impacts associated with seismic surveys in shallow waters include underwater seismic sound on marine mammals, marine turtles and divers.

With regard to exploratory drilling in shallow waters, it should be noted that drilling operations are designed for no discharge of drilling muds or cuttings in shallow waters. The drilling impact assessment and mitigation reflect this pre-condition when addressing the impacts related to these discharges.

Potential (unmitigated) major impacts associated with drilling include potential impacts of positioning of a drilling rig on corals and seagrass, potential impacts of a major hydrocarbon spill on components of the biological and socio-economic environments and potential visual impacts on tourism activities.

Adherence to environmental operating procedures described in this report, in conjunction with adherence to the Environmental Management Plan (of Volume II-Part B) will result in the reduction of adverse environmental impact to a minimum. Nevertheless, close attention should be paid to the prevention of non-routine events and prevention of impacts on water quality. Avoidance of these impacts will result in the reduction or elimination of impacts to other Environmental Components.

Mitigating measures and residual impacts anticipated for the AMA1 seismic program proposed for the shallow waters of Area 1 are listed in **Tables 7-1** (routine events) and **7-2** (non-routine events) respectively. Mitigating measures and residual impacts for drilling are listed in **Tables 7-3** (routine events) and **7-4** (non-routine events) respectively. Also listed are the Environmental Component, the EC Sensitivity, the Environmental Aspect, the impact, the impact significance prior to mitigation, the required mitigation, and the impact significance after mitigation.

Some of the mitigation measures require compliance with buffer zones for sensitive habitats. The methodology for establishing these buffer zones is given in **Annex 6**.

Table 7-1. Mitigation measures for routine events (seismic)

No.	EC	EC sensitivity	Environmental Aspect	Impact	SIGNIFICANCE	MITIGATION MEASURES	SIGNIFICANCE AFTER MITIGATION
				PHYSICAL AND CHEMICAL ENVIRONMENT			
1	**AIR**	**MEDIUM**	Mobilization/ demobilization and seismic operations	Reduction in air quality due to project emissions	**INSIGNIFICANT**	Regularly maintain seismic vessel motors and engines. Operate and maintain exhaust systems and engines in accordance with the manufacturer's specifications. Use preventative maintenance, leak detection and repair programs. Compliance to Annex VI MARPOL emission standards: • Diesel engine NO_x emissions should be limited to between 9.8 and 17 g/kWh, depending on maximum operating speed**.** • Substances harmful to the ozone layer (including halon and CFCs), cannot be deliberately released. New facilities can contain HCFCs until 1Jan 2020, but cannot contain other substances that harm the ozone layer.	**INSIGNIFICANT**
2	**WATER**	**HIGH**	Mobilization/ demobilization and seismic operations	Water contamination around the seismic vessel and accommodation barge due to deck drainage and bilge water	**INSIGNIFICANT**	Any bilge water from the two seismic vessels will be transferred to the accommodation barge each night. At appropriate intervals stored bilge water should be disposed of and or in accordance with MARPOL.	**INSIGNIFICANT**

No.	EC	EC sensitivity	Environmental Aspect	Impact	SIGNIFICANCE	MITIGATION MEASURES	SIGNIFICANCE AFTER MITIGATION
PHYSICAL AND CHEMICAL ENVIRONMENT							
3				Water contamination around the seismic vessel and accommodation barge from the discharge of sanitary sewage	**MINOR**	The disposal of liquid wastes will be conducted in accordance with MARPOL 73/78 (Annexes 1-4): • Sewage must be treated and disinfected (on-board treatment plant) prior to discharge. • Treated effluents shall achieve a BOD < 40 ppm, suspended solids < 50 ppm and a coliform count < 200 cells per 100 ml of effluent.	**INSIGNIFICANT**
4				Reduced water quality due to the discharge of solid wastes	**MINOR**	• Solid waste (kitchen waste) can be macerated to 25mm and then discharged to the sea (3nm at least from the coast). Untreated kitchen waste will be discharged farther than 12 nautical miles from the nearest shore. • All other solid waste must be segregated and contained for appropriate treatment and disposal according to the Waste Management Plan. • Hazardous wastes will not, under any circumstances, be discharged to the sea.	**INSIGNIFICANT**

BIOLOGICAL ENVIRONMENT							
5	**MANGROVES**	**HIGH**	Seismic survey	Impacts of sound pressure waves on mangroves	**MINOR**	It is recommended that *soft start and ramp up* procedures are implemented to minimize the risk of fishes and invertebrates inhabiting mangroves being trapped in an area of high impact near the vessel. *Soft starts* and *ramping* involves the gradual increase in the intensity of sound from the acoustic sources in order to provide affected species with sufficient time to move out of the injury zone. Respect the 200m buffer zone for the sound sources.	**INSIGNIFICANT**
6			Seismic survey	Impacts of retrieval and deployment of bottom cables/autonomous receivers on mangroves	**MODERATE**	Streamers with passive receivers should not be dragged in water less than 1m at any tidal cycle. Autonomous receivers and bottom cables must be deployed by carefully laying the equipment among the sensitive root systems to avoid abrasion. When retrieving the equipment, the cables must not be dragged across the roots. No boat traffic should be allowed in water depths less than 1m to avoid damage to root systems (even during deployment and recovery)	**INSIGNIFICANT**

7	**SEAGRASS BEDS**	**HIGH**	Seismic survey	Impacts of sound pressure waves on seagrass beds and macroalgae	**MINOR**	It is recommended that *soft start and ramp up* procedures are implemented to minimize the risk of fishes and invertebrates inhabiting seagrass being trapped in an area of high impact near the vessel. Seismic sources must not be used at water depths less than 2 meters.	
8			Seismic survey	Impacts of retrieval and deployment of bottom cables/autonomous receivers on seagrass beds and macroalgae	**MINOR**	The bottom cables and autonomous receivers must not be dragged over the bottom such that swaths of seagrass beds are uprooted. The cables must be laid directly from the deck of the shallow draft boats to prevent these from scouring several meters on each side of their length. A qualified observer must ensure, by visual confirmation, the vertical deployment and recovery techniques as these habitats are found in relatively shallow and clear water areas.	**INSIGNIFICANT**

9	**CORAL REEFS**	**HIGH**	Seismic survey	Impacts of sound pressure waves on coral reefs	**MODERATE**	It is recommended that *soft start* procedures are implemented to minimize the risk of organisms including reef fish inhabiting coral reefs being trapped in an area of high impact near the vessel. While it is thought that soft starts will encourage behavioral avoidance before the organisms can be exposed to possibly injurious levels of sound, there is no evidence in the literature concerning the effectiveness of this mitigation in respect of pelagic and neritic invertebrates inhabiting coral reefs. A buffer zone for acoustic sources must be maintained: 75m – if coral reefs are 0 to 20 m deep 50m – if coral reefs are 21 to 70m deep 0m – if coral reefs are > 70m deep	**INSIGNIFICANT**
10			Seismic survey	Impacts of retrieval and deployment of bottom cables/autonomous receivers on coral reefs	**MODERATE**	All cables and autonomous receivers must be deployed by visually assuring that they are not in contact with corals as they are put into place. When retrieving them, assure they are not dragged across coral tissues but lifted directly from the seafloor.	**INSIGNIFICANT**

11	**MARINE MAMMALS**	HIGH	Seismic survey	Impacts of sound pressure waves on marine mammals	**MODERATE**	The surveys must be planned to avoid the humpback whale season (July to December). To the extent that other mysticetes exhibit similar seasonal migration patterns, their exposure to seismic survey noise would also be avoided. It is recommended the use of soft starts to allow time for marine mammals to move away before the array reaches full power. The process should begin with the smallest source in an array and build up slowly over 20 to 40 minutes. At least 30 minutes before startup during daylight hours, visual observers should monitor a safety (exclusion) zone of a 1km radius around the source vessel. Startup of the array cannot begin until the safety zone is clear of marine mammals for at least 20 minutes. Visual monitoring of the sea surface should continue while the seismic array is operating during daylight hours, and the array should be shut down if a whale enters the 1km safety zone during visual monitoring. A whale is defined as a cetacean other than Family Delphinidae (i.e., including any baleen, sperm, or beaked whale species).	**MINOR**
12			Seismic survey	Impacts of retrieval and deployment of bottom cables/autonomous receivers on marine mammals	**INSIGNIFICANT**	No mitigation measure is applicable	**INSIGNIFICANT**

13	MARINE TURTLES	HIGH	Seismic survey	Impacts of sound pressure waves on marine turtles	**MODERATE**	It is recommended the use of Soft starts to allow time for turtles to move away before the array reaches full power. The process should begin with the smallest source in an array and build up slowly over 20 to 40 minutes. At least 30 minutes before startup during daylight hours, visual observers should monitor a safety (exclusion) zone of a 500m radius around the source vessel. Startup of the array cannot begin until the safety zone is clear of turtles for at least 20 minutes. Visual monitoring of the sea surface should continue while the seismic array is operating during daylight hours, and the array should be shut down if a sea turtle enters the 500m safety zone during visual monitoring. Maintain a 500m buffer zone from the vessel with the sound source from sandy beaches	**MINOR**
14			Seismic survey	Impacts of retrieval and deployment of bottom cables/autonomous receivers on marine turtles	**INSIGNIFICANT**	No mitigation measure is required.	**INSIGNIFICANT**
15	FISHES	HIGH	Seismic survey	Impacts of sound pressure waves on fishes	**MODERATE**	t is recommended the use of Soft starts to allow time for fish to move away before the array reaches full power. The process should begin with the smallest source in an array and build up slowly over 20 to 40 minutes.	**MINOR**

16			Seismic survey	Impacts of retrieval and deployment of bottom cables/autonomous receivers on fishes	**INSIGNIFICANT**	No mitigation measure is required.	**INSIGNIFICANT**
SOCIOECONOMIC ENVIRONMENT							
17	**POPULATION AND LOCAL ECONOMY**	HIGH	Seismic survey	Social conflicts due to the presence of foreign workers	**MINOR**	Personnel should be informed of social conduct codes based on cultural characteristics of the resident population, of local culture and customs and of the importance of respectful social relationships with the local community. Personnel should be provided with information about avoidance of sexually transmitted diseases through hygienic practices and low risk behavior.	**INSIGNIFICANT**
18			Seismic survey	Increased revenue due to the presence of the crew in Pemba	**POSITIVE**	Local goods and service providers in Pemba should be used whenever possible.	**POSITIVE**

19	**ARTISINAL FISHERIES**	VERY HIGH	Seismic survey	Temporary loss of access to fishing grounds and associated loss of catch – off-shore commercial artisanal fishers	**MINOR**	Establish a communication structure to liaise with the artisanal fishing industry. Daily notifications should be sent via SMS (where cell phone service is available) or radio stations, mobile brigades as well as the use of pamphlets and brochures to inform fishers of the planned events, as well as the location of the seismic vessel on any particular day, as well as the following day A Grievance Procedure through which valid grievances regarding the project could be raised should be implemented. Investigate the possibility of surveying the transects furthest west, thus, closest to the islands and fishing areas, at night, thereby decreasing the effect on artisanal fishers. At least one of the crew members on the chase boat should be fluent in local languages, and have knowledge of local fishing practices. A Compensation Plan will be prepared.	

20			Seismic survey	Temporary loss of access to fishing grounds and associated loss of catch – subsistence and commercial artisanal fishers operating from the shoreline	**MODERATE**	Coordination and communication with fishers – See above. Establish a Grievance Procedure – See above. Surveying at night – See above. Ensure appropriate chase boat crew members – See above. Prepare a Compensation Plan – See above.	
21			Seismic survey	Temporary decreased catch volumes in certain areas - off-shore commercial artisanal fishers	**MODERATE**	Same action as above (#20)	**MINOR**
22			Seismic survey	Temporary decreased catch volumes in certain areas - subsistence and commercial artisanal fishers operating from the shoreline	**MODERATE**	Same action as above (#20)	**MINOR**

23			Seismic survey	Effects on physical safety and health of divers due to sound source pulses	**MAJOR**	Coordination and communication with fishers – See above. Establish a grievance procedure – See above. Surveying at night – See above. Ensure appropriate chase boat crew members – See above. Compile and implement a Compensation Plan – See above. Ensure no diving in 2.4 km safety zone around the seismic vessel. An additional safety vessel should be used in conjunction with the chase vessel, in order to scout reefs and known dive sites and warn off any divers, prior to the seismic vessel entering the 2.4 km safety zone. If divers are found in the water, the seismic vessel should lay-off until they have surfaced and are safely onboard their own vessels.	**MINOR**
24			Seismic survey	Temporary loss of income and effects on food security	**MINOR**	Same action as above (#20)	**INSIGNIFICANT**
25			Seismic survey	Temporary reduction in fish volumes available for purchase and resale	**MINOR**	If all the relevant mitigation measures with regard to artisanal fishers are implemented, there should be a minimal effect on first order traders.	**INSIGNIFICANT**

26	TOURISM	HIGH	Seismic survey	Temporary loss of access to dive sites due to safety zone around the seismic vessel	**MINOR**	Establish a Provincial Stakeholder Forum, well before the advent of the actual seismic acquisition. Establish a grievance procedure through which valid grievances regarding the project could be raised. Investigate the possibility of surveying the transects closest to the islands and dive sites at night, thereby eliminating effects on divers. A media fact sheet should be prepared which can be used to assist the L&A Operators in briefing members of staff as to how to convey information relating to the seismic survey, where this is necessary.	**INSIGNIFICANT**
27			Seismic survey	Physical safety and health of divers due to seismic sound source pulses	**MAJOR**	Retaining a 2.4 km buffer – see #23 above. Additional safety vessel – see #23 above. Coordination and communication with tourism operators – See #23 above. Establish an Exploration Tourism Forum – See #23 above. Establish a grievance procedure – See #23 above. Surveying at night – See #23 above.	**MINOR**

28			Seismic survey	Discomfort of divers due to sound pulses generated by the seismic sound source	**MODERATE**	Coordination and communication with dive operators – above. Establish a Provincial Stakeholder Forum – See above. Establish a grievance procedure – See above. Survey at night – See above. Compilation of a Compensation Plan – Compile and implement a Compensation Plan. Compensate any proven losses by tourism operators due to effects of the seismic exploration.	**MINOR**
29			Seismic survey	Temporary loss / delayed access to **recreational off-**shore fishing grounds due to movements of the seismic vessel	**MINOR**	Prepare a Compensation Plan together with Grievance Procedures to address the fishing operators that may have had to significantly delay or reroute their fishing trips due to the seismic survey. Surveying at night.	**INSIGNIFICANT**
30			Seismic survey	Reduced off-shore sports fishing experience due to changes in fish behavior and movement, potentially leading to decreased catches	**MINOR**	Prepare a Compensation Plan together with Grievance Procedures to address the fishing operators that may have had to significantly delay or reroute their fishing trips due to the seismic survey. Surveying at night.	**MINOR**

31			Seismic survey	Reduced quality of sightseeing, due to mammal **movement away** from the area of exploration activities	**MINOR**	Limit the seismic survey window to the months between January and June, out of the Whale migration season. Prepare a Communications Plan to inform tourists and ecotourism operators of the drilling locations and the time that the rig will be on location,	
32			Seismic survey	Visual disturbance caused by the seismic vessel	**MINOR**	Limit distances of stoppages – any stoppages for weather or any other reason which do not require an immediate halt, should be undertaken at least at 4km from the closest island.	**MINOR**

33			Seismic survey	Potential loss of revenue to the tourism operators	**MODERATE**	Prepare a media fact sheet to assist the L&A Operators in briefing members of staff as to how to convey information relating to the seismic program, where this is necessary. Prepare a Compensation Plan along with Grievance Procedures that outlines strategies for, and means of, compensation to tourism operators that may have lost business due to the seismic survey.	**MINOR**
34			Seismic survey	Potential loss of income (in terms of wages and purchases)	**MINOR**	Same action as above (# 34)	**MINOR**
35			Seismic survey	Effects on the sale of island plots to private investors	**MINOR**	Prepare a media fact sheet to assist the L&A Operators in briefing members of staff as to how to convey information relating to the seismic program, where this is necessary. Strategic assessment – The GOM should consider strategic environmental assessment as a tool to evaluate the potential conflicts and synergies between the tourism, oil and gas, and other industries in the Quirimbas Archipelago.	**MINOR**
36			Seismic survey	Effects on the 'island paradise' image	**MODERATE**	Same action as above (# 35)	**MODERATE**

37			Seismic survey	Suspension of planned and future investment	**MODERATE**	Same action as above (# 35)	**MODERATE**

Table 7-2. Mitigation measures for non-routine events (seismic)

No.	EC	EC sensitivity	Environmental Aspect	Impact	SIGNIFICANCE	MITIGATION MEASURES	SIGNIFICANCE AFTER MITIGATION
1	AIR	MEDIUM	Seismic survey and support operations	Reduction in air quality due evaporation of VOCs from a diesel spill	**INSIGNIFICANT**	The aim should be in preventing the occurrence of a diesel spill by undertaking the correct procedures during bunkering and transferring of diesel.	**INSIGNIFICANT**
2				Reduction in air quality due to a fire/ explosion	**MINOR**	All personnel to be fully trained on the onboard health and safety procedures. Prepare and comply with the OSCP/ERP	**INSIGNIFICANT**

3	WATER	HIGH	Seismic survey and support operations	Reduced water quality due to accidental diesel spills	**MINOR**	• Conduct transfer operations during calm weather conditions • Ensure that transfer hoses are of sufficient length and strength to maneuver vessels as sea conditions require • Only conduct transfer operations during the day, if possible, and hoist the “bravo” flag. • Transfer under reduced visibility conditions (night or overcast), hoist a red light flag • Conduct transfer under favorable wind and tide conditions that would carry any spill away from sensitive habitats • Post warning signals before transfer operations begin • During transfers, maintain effective communication between the supply vessel and the seismic vessel and monitor the transfer • Use oil collector trays or drip pans under equipment • Ensure that pipes and hoses are properly connected, closed and in good condition • Monitor tank levels throughout the program • Make available absorbent pads near the area where spills may occur • In the event of a diesel spill the incident will be promptly reported through the contractor chain-of-command to AMA1.	**INSIGNIFICANT**

4	MANGROVES	HIGH	Seismic survey and support operations	Effects on coastal mangroves due to diesel spills	**MINOR**	The implementation of the proposed mitigation measures for reduced water quality due to a diesel spill will ensure the minimization of such impacts on mangroves (Action #3).	**INSIGNIFICANT**
5	SEAGRASS BEDS AND MACROALGAE	HIGH	Seismic survey and support operations	Effects on seagrass beds and macroalgae due to diesel spills	**MINOR**	The implementation of the proposed mitigation measures for reduced water quality due to a diesel spill will ensure the minimization of such impacts on seagrass beds and macroalgae (Action # 3).	**INSIGNIFICANT**
6	CORAL REEFS	HIGH	Seismic survey and support operations	Effects on coral reefs due to diesel spills	**MINOR**	The implementation of the proposed mitigation measures for reduced water quality due to a diesel spill will ensure the minimization of such impacts on coral reefs (Action # 3).	**INSIGNIFICANT**
7	MARINE MAMMALS	HIGH	Seismic survey and support operations	Effects on marine mammals due to diesel spills	**MINOR**	The implementation of the proposed mitigation measures for reduced water quality due to a diesel spill will ensure the minimization of such impacts on marine mammals (Action # 3).	**INSIGNIFICANT**
8	MARINE TURTLES	HIGH	Seismic survey and support operations	Effects on marine turtles due to diesel spills	**MINOR**	The implementation of the proposed mitigation measures for reduced water quality due to a diesel spill will ensure the minimization of such impacts on marine turtles (Action # 3).	**INSIGNIFICANT**
9	FISH	HIGH	Seismic survey and support operations	Effects on fish due to diesel spills	**MINOR**	The implementation of the proposed mitigation measures for reduced water quality due to a diesel spill will ensure the minimization of such impacts on fish (Action # 3).	**INSIGNIFICANT**

10	POPULATION	HIGH	Seismic survey and support operations	Effects on population due to diesel spills	**MINOR**	The implementation of the proposed mitigation measures for reduced air quality and reduced water quality due to a diesel spill will ensure the minimization of such impacts on population (Action # 1 and 3).	**INSIGNIFICANT**
11			Seismic survey and support operations	Effects on population due to fire/explosion	**MODERATE TO MAJOR**	The implementation of the proposed mitigation measures for reduced air quality due to fire explosions will ensure the minimization of such impacts on population (Action # 2).	**MINOR**
12	ARTISINAL FISHERIS	VERY HIGH	Seismic survey and support operations	Effects on artisanal fisheries due to diesel spill	**MINOR**	The implementation of the proposed mitigation measures for reduced water quality due to a diesel spill will ensure the minimization of such impacts on fish (Action # 3) and therefore minimize impacts on artisanal fisheries.	**INSIGNIFICANT**
13	TOURISM	HIGH	Seismic survey and support operations	Effects on tourism due to diesel spill	**MINOR**	The implementation of the proposed mitigation measures for reduced air quality and reduced water quality due to a diesel spill will ensure the minimization of such impacts on tourism (Action # 1, 2 and 3).	**INSIGNIFICANT**

Table 7-3. Mitigation measures for routine events (drilling)

No.	EC	EC sensitivity	Environmental Aspect	Impact	SIGNIFICANCE	MITIGATION MEASURES	SIGNIFICANCE AFTER MITIGATION
1	**AIR**	**MEDIUM**	Mobilization/ demobilization and drilling operations	Reduction in air quality due to use of fuel for routine operations	**MINOR**	Regularly maintain drilling rig motors and engines. Operate and maintain exhaust systems and engines in accordance with the manufacturer's specifications. Use preventative maintenance, leak detection and repair programs. Compliance to Annex VI MARPOL emission standards: • Diesel engine NO_x emissions should be limited to between 9.8 and 17 g/kWh, depending on maximum operating speed**.** • Substances harmful to the ozone layer (including halon and CFCs), cannot be deliberately released. New facilities can contain HCFCs until 1Jan 2020, but cannot contain other substances that harm the ozone layer.	**INSIGNIFICANT**
2				Reduction in air quality due to test flaring of wells[1]	**MINOR**	Maintain and effectively control well test burners for high efficiency. Consider the use of an alternative "green burner" test flare to improve the quality of flare emissions and to minimize incomplete combustion and black smoke and to prevent hydrocarbon fallout to the sea. Limit periods of hydrocarbon burning to the operationally required minimum.	**INSIGNIFICANT**

[1] Test flaring will not be carried out during drilling. However, in the event of a successful well being discovered test flaring will be carried out after drilling.

3	WATER	**MEDIUM**	Drilling operations (waste management)	Reduced water quality due to discharges of solid wastes (excluding drilling muds and cuttings)	**MODERATE**	All waste materials produced onboard the vessel will be transported back to mainland Mozambique for disposal via resources available in country or will remain onboard the vessel until suitable recycling opportunities are made available in near future anticipated ports. Disposal of solid wastes must also comply with the Waste Management Plan. Hazardous wastes will not, under any circumstances, be discharged to the sea.	**INSIGNIFICANT**
4				Reduction in water quality due to the discharge of drilling muds and cuttings	**MINOR** (shallow water[2])	<u>Discharge in shallow waters:</u> No mitigation is available.	**MINOR**
					MINOR (deep water)	<u>Discharge in deep waters:</u> Mud recovery systems must be used, whenever possible, and the rig should have an efficient solid control and mud recirculation system with the following main components: • Shale shakers to remove large-sized cuttings • De-gasser to remove entrained gas • De-sanders to remove sand-sized cuttings; • De-silters to remove silt-sized cuttings • Centrifuge to recover fine solids and weighting materials such as barite. WBM and low toxicity additives should be used whenever possible. For SBM, use the Group III NADFs – Non Aqueous Drilling Fluids (most environmentally acceptable with low to negligible aromatic content). Synthetic fluids that are low in toxicity, biodegradable and non-	**INSIGNIFICANT**

[2] Potential impacts related to drilling of the initial hole section before marine riser is in place.

						accumulative should be used. All chemicals used should conform to internationally accepted standards and submitted to MICOA and INP for approval when necessary before the drilling activities begin. The use of all drilling fluid components and other chemicals should be monitored and recorded. Ensure careful transfer of drilling muds and cuttings from the rig to the barge, proper storage of the cuttings in the barge and careful transfer of cuttings to deeper waters for discharge (at least 12 nautical miles from the coast). Once in disposal area spread the cuttings over a large surface area to reduce concentrations in the water column and minimize impacts. Cuttings to dispersed overboard via either an auger or sluice system while the vessel is underway at a constant speed. Discharge directly into the prop wash to further aid in dispersion. As with most oil and gas companies in their worldwide offshore operations, AMA1 will comply with the following requirements for discharge of drilling cuttings and muds (EPA, 2007): • Metal concentrations in the barite added to mud must not exceed: 1mg/kg for mercury and 3mg/kg for cadmium. • No discharge of drilling wastes allowed within 3 miles from shore. • Discharge rate not to exceed 1,000 bbls/hour. • Cuttings coated up with 6.9%SBMs may be Discharged Ester SBMs can have up to 9.4% SBM on cuttings	

5			Mobilization/ demobilization and drilling operations	Reduction in water quality due to deck drainage, bilge water and sewage discharge	**MODERATE**	All vessels must be certified for seaworthiness through an appropriate internationally recognized marine certification body. The rig must have adequate safety systems (alarms and automated shut-down devices), that meet regulatory and industry standards. Adequate maintenance and testing programs must be in place. The disposal of liquid wastes will be conducted in accordance with MARPOL 73/78 (Annexes 1-4): • Sewage must be treated and disinfected (on-board treatment plant) prior to discharge. • Treated effluents shall achieve a BOD < 40 ppm, suspended solids < 50 ppm and a coliform count < 200 cells per 100 ml of effluent. • Treated deck drainage will be discharged at the rig location. The concentration of oil in the water after treatment in an IMO approved oil/water separator shall not exceed 15 ppm • Oil/water separators must be regularly maintained. • Water from machinery spaces (ballast and bilge water) shall be routed to the closed drainage system, or contained and treated before discharge. • Secondary containment shall be provided for storage areas with oil and chemicals as well as equipment (deck, mud tanks and pumps) • Train crew members regarding the risks of contamination from deck water discharge and the importance of cleaning up spills on the deck as soon as they occur. • Ensure that oil separators are in place and that spills are cleaned up immediately. Equip oil and water separators with sensors and an alarm to avoid exceeding the discharge limit. • Oil derived from the oil/water separator shall be stored in tanks on board and be disposed at an accredited hazardous waste site according to the waste management plan.	**INSIGNIFICANT**

6			Drilling operations (waste management)	Reduction in water quality due to disposal of kitchen wastes	**MINOR**	As established by MARPOL 73/78 no solid waste will be discharged. • Solid waste (kitchen waste) will be macerated to 25mm and then discharged to the sea (3nm at least from the coast). Untreated kitchen waste will be discharged farther than 12 nautical miles from the nearest shore. • All other solid waste must be segregated and contained for appropriate treatment and disposal according to the Waste Management Plan.	**INSIGNIFICANT**
7			Drilling operations (waste management)	Reduction in water quality due to the disposal of produced water [3]	**MINOR**	• Comply with the MARPOL 73/78 requirements. • Ensure that 3-phase separators are in place and provide tankage to store produced water if MARPOL standards not met. • The concentration of oil in the water after treatment in an IMO approved oil/water separator shall not exceed 15 ppm.	**INSIGNIFICANT**

[3] Related to test flaring. Test flaring will not be carried out during drilling. However, in the event of a successful well being discovered test flaring will be carried out after drilling.

8	**MANGROVE**	**HIGH**	Drilling operations (waste management)	Impacts of waste disposal (including muds and cuttings) on the coastal mangroves*	**MINOR TO MODERATE***	• Regarding the $40m^3$ of cuttings, produced during the drilling of the first hole section, that may be discharged in shallow water respect the 100m buffer zone from coastal mangroves. • See mitigation Measure No. 5 for other wastes.	**INSIGNIFICANT**
9	**SEAGRASS AND CORAL COMMUNITIES**	**VERY HIGH**	Drilling operations	Effects of positioning a jack-up rig on seagrass and coral community	**MAJOR**	• Prepare an environmental survey of the seafloor prior to the mobilization of the rig. • A 100 m buffer zone will be maintained to avoid physical impact to coral reefs and seagrasses. •	**INSIGNIFICANT**
10			Drilling operations (waste management)	Effects of disposal of drilling muds and cuttings on coral reefs and seagrass beds.*	**MINOR TO MODERATE***	• Regarding the $40m^3$ of cuttings, produced during the drilling of the first hole section, that may be discharged in shallow water maintain a 100 m buffer zone to avoid impacts to coral reefs and seagrasses. • See mitigation Measure No. 5 for other wastes.	**INSIGNIFICANT**

*Potential impacts related to drilling of the initial hole section before marine riser is in place

11	**MACROBE NTHOS**		Drilling operations (waste management)	Effects on benthic macrofauna due to the discharge of drilling muds and cuttings	**MINOR***	No mitigation for the $40m^3$ of cuttings from drilling the initial hole section.	**MINOR**

12	**DEEP WATER MACROBENT HOS**	**LOW**	Drilling operations (waste management)	Effects on deep water benthic macrofauna due to discharge of drilling muds and cuttings	**MINOR**	The implementation of the proposed mitigation measures for the avoidance of water quality reduction due to the discharge of drilling muds and cuttings (Action # 4) ensures the mitigation of the impact on deep water macrobenthos.	**INSIGNIFICANT**
13	**FAUNA (FISH, MARINE MAMMALS, MARINE TURTELS)**	**HIGH**	Mobilization/ demobilization and drilling operations	Impacts due to the disposal of muds and cuttings on fauna through increased turbidity and contaminant load	**INSIGNIFICANT** (shallow water)	No mitigation is applicable for the $40m^3$ of cuttings from drilling the initial hole section.	**INSIGNIFICANT**
					MINOR (deep water)	The implementation of the proposed mitigation measures for the avoidance of water quality reduction due to the discharge of drilling muds and cuttings (Action # 4) ensures the mitigation of the impact on fauna.	**INSIGNIFICANT**
14			Mobilization/ demobilization and drilling operations	Impacts on marine fauna due to deck drainage, bilge water disposal and sewage discharge	**MODERATE**	The implementation of the proposed mitigation measures for the avoidance of water quality reduction due to the discharge of deck drainage, bilge water and sewage (Action # 5) ensures the mitigation of the impact on marine fauna.	**INSIGNIFICANT**
15			Drilling operations (waste management)	Impacts on marine fauna due to disposal of kitchen wastes	**MINOR**	The implementation of the proposed mitigation measures for the avoidance of water quality reduction due to solid food waste discharge (Action # 6) ensures the mitigation of the impact on marine fauna.	**INSIGNIFICANT**
16			Drilling operations	Impacts of noise on marine mammals, turtles and fish	**MINOR**	Periodically maintain equipment to minimize noise. Use a top drive motor on the drill string to limit drill noise	**INSIGNIFICANT**

- Potential impacts related to drilling of the initial hole section before marine riser is in place

17	**POPULATION AND LOCAL ECONOMY**	**MEDIUM**	Drilling operations and support operations	Social conflicts due to the presence of foreign workers	**MINOR TO MODERATE**	Personnel should be informed of social conduct codes based on cultural characteristics of the resident population, of local culture and costumes and of the importance of respectful social relationships with the local community. Personnel should be provided with information about avoidance of sexually transmitted diseases through hygienic practices and low risk behaviour.	**INSIGNIFICANT**
18			Drilling operations and support operations	Increased revenue due to the presence of the crew in Pemba and possibly in the islands	**POSITIVE**	Local goods and service providers in Pemba should be used whenever possible.	**POSITIVE**
19	**ARTISINAL FISHERIES**	**HIGH**	Drilling operations	Temporary loss of access to fishing grounds and associated loss of catch due to exclusion zones	**MINOR**	Prepare a Communication Plan for the drilling program. Inform artisanal fishers prior to the start of the drilling, of well locations, safety exclusion zones, and vessel locations, and of planned events through established means of communication as identified in the Plan. Once exact drill sites are determined, a site-specific addendum to the SIA and EIS should be compiled	**INSIGNIFICANT**
20			Drilling operations	Temporary catch decrease due to fish displacement and restrictions on fishing	**MINOR**	The same mitigations measures for the impact above apply for this impact.	**MINOR**
21			Drilling operations	Effects on physical safety and health of divers due to sound generated by drilling activities	**INSIGNIFICANT**	A support vessel around the rig will ensure than no diving operators or tourists are diving within 500 m of the rig to protect their health. Prepare a Communications Plan to inform divers of the drilling locations and the time that the rig will be on location, so they can relocate their diving ground and schedule the dives.	**INSIGNIFICANT**

						Once exact drill sites are determined, a site-specific addendum to the SIA and EIS should be compiled	
22			Drilling operations	Temporary loss of income and effects on food security	**MINOR**	Implementation of mitigation measures for Action #19 apply.	**MINOR**
23	**TOURISM**	**HIGH**	Drilling operations	Temporary loss of access to dive sites due to the presence of the rig and safety zone around the rig	**MINOR TO MAJOR** (depending on location of the drilling rig)	Once exact drill sites are determined, a site-specific addendum to the SIA and EIS should be compiled. A 500m safety zone must be created around the rig in which vessel movement and diving is prohibited. Respect the 100m buffer zone away from any coral reef. Provide a media fact sheet for use by L&A Operators in the vicinity of the drilling location to brief staff and inform clients regarding the temporary nature of the drilling program and the measures taken to mitigate environmental impacts. Prepare a Compensation Plan along with Grievance Procedures that outlines strategies for, and means of, compensation to diving operator that may have lost business due to the location of the rig.	**MINOR**
24			Drilling operations	Physical safety and health discomfort of divers due to sound generated by the drilling operations	**INSIGNIFICANT**	A support vessel around the rig will ensure than no diving operators or tourists are diving within 500 m to protect their health. Once exact drill sites are determined, a site-specific addendum to the SIA and EIS should be compiled. Prepare a Communications Plan to inform tourists and diving operators of the drilling locations and the time that the rig will be on location, so they can relocate their diving ground	**INSIGNIFICANT**

						and schedule the dives.	
25			Drilling operations	Temporary loss/delayed access to recreational offshore fishing grounds due to the presence of the safety zone around the rig	**MINOR**	Provide a media fact sheet for use by L&A Operators to brief staff and inform clients regarding the temporary nature of the drilling program and the measures taken to mitigate environmental impacts. Prepare a Compensation Plan together with Grievance Procedures to address the fishing operators that may have to significantly delay or reroute their fishing trips due to the presence of the rig. Once exact drill sites are determined, a site-specific addendum to the SIA and EIS should be compiled.	**INSIGNIFICANT**
26			Drilling operations	Reduced offshore sports fishing experiences due to changes in catch.	**MINOR**	Prepare a Communications Plan to inform tourists and ecotourism operators of the drilling locations and the time that the rig will be on location.	**INSIGNIFICANT**
27			Drilling operations	Reduced quality of sightseeing due to mammal movement away form the area of exploration activities	**INSIGNIFICANT**	Prepare a Communications Plan to inform tourists and ecotourism operators of the drilling locations and the time that the rig will be on location	**INSIGNIFICANT**
28			Drilling operations	Visual disturbance caused by the drilling activities	**MINOR TO MAJOR** (depending on location of the drilling rig)	Site specific addendum - Once exact drill sites are determined, a site-specific addendum to the SIA and EIS should be compiled	**MINOR TO MAJOR**
29			Drilling operations	Potential loss of revenue to tourism operators	**MINOR TO MAJOR** (depending on location of the drilling rig)	Site specific addendum - Once exact drill sites are determined, a site-specific addendum to the SIA and EIS should be compiled Preparation of a Compensation Plan	**MINOR**

30			Drilling operations	Potential loss of income (in terms of wages and purchases)	**MINOR**	Site specific addendum - Once exact drill sites are determined, a site-specific addendum to the SIA and EIS should be compiled Preparation of a Compensation Plan	**MINOR**
31			Drilling operations	Effects on the sale of island plots to private investors	**MINOR**	Site specific addendum - Once exact drill sites are determined, a site-specific addendum to the SIA and EIS should be compiled	**MINOR**
32			Drilling operations	Effects on the “island paradise” image	**MINOR**	Media fact sheet – Prepare a media fact sheet to assist the L&A Operators in briefing members of staff as to how to convey information relating to the drilling program, where this is necessary. Strategic assessment – The GOM should consider strategic environmental assessment as a tool to evaluate the potential conflicts and synergies between the tourism, oil and gas, and other industries in the Quirimbas Archipelago.	**MINOR**
33			Drilling operations	Suspension of planned future investment	**MINOR**	Same action as above (#32)	**MINOR**

34	**NAVIGATION**	**VERY LOW**	Mobilization/ demobilization and drilling operations	Interference with maritime traffic	**INSIGNIFICANT**	Apply for authorization to conduct oil exploration drilling activities at sea from the Maritime Authority (INAMAR). Inform maritime authorities prior to rig mobilization regarding detailed routes, rig locations, exclusion zones and scheduling plans through established means of communication: • National Maritime Authority (INAMAR), with details about vessel entry, duration of stay and exact area(s) and duration of exclusion. INAMAR should make a formal Notice to Mariners for international dissemination • Notice to Mariners through maritime communications networks and GMDSS / Inmarsat • Provide advance notice to the Direccao Nacional de Administracao Pesqueira, within Ministry of Fishery.	**INSIGNIFICANT**

Table 7-4. Mitigation measures for non-routine events (drilling)

No.	EC	EC sensitivity	Environmental Aspect	Impact	SIGNIFICANCE	MITIGATION MEASURES	SIGNIFICANCE AFTER MITIGATION
1	AIR	Medium	Mobilization/ demobilization and drilling operations	Reduced air quality due to hydrocarbon release	MINOR TO MODERATE	Compliance to the Emergency Response Plan and Oil Spill Contingency Plan is mandatory.	INSIGNIFICANT
2			Mobilization/ demobilization and drilling operations	Reduced air quality due to a fire/explosion	MINOR TO MAJOR	All personnel to be fully trained on the onboard Health and Safety procedures. Compliance to the Emergency Response Plan and Oil Spill Contingency Plan is mandatory. Regular maintenance and verification of the Blowout Preventor (BOP).	MINOR
3	WATER	Very High	Drilling operations and support operations	Reduced water quality due to hydrocarbon spills	MINOR TO MAJOR	<u>Planning</u> • General Oil trajectories and an Oil Spill Contingency Plan (OSCP/ERP)/Emergency Response Plan (ERP) prepared for this project are presented as Annexes to the EMP. • Prepare & submit site-specific Oil Trajectory Models and OSCP/ERP to the MICOA & the INP before drilling activities o Incorporate results of the site-specific Oil Trajectory Models in the OSCP/ERP o The Mozambique draft National Oil Spill Contingency Plan (NOSCP) should be considered • Drilling operations will <u>not</u> commence until the OSCP/ERP has been updated and addresses local environments. • Compliance to the OSCP/ERP is mandatory • The OSCP/ERP will detail how to mobilize services (Southern Africa region) for rapid response to accidental oil spills if local resources are unable to deal with spills.	MINOR

						<u>Prevention</u> Ensure that the rig and the supply vessel comply with the following: • International certification and approval by the Mozambican Authorities • Good operational conditions and serviced according to a service maintenance plan • Have OSCP/ERP and for (i) oil and chemical spills; (ii) fire and explosions, (iii) diesel or bunker fuel spills • Crews trained for emergency response relative to the cargo they transport and operations they perform • Maintain contact with the Port Authorities • Have updated information regarding the weather conditions in the area • Safety measures such as BOPs are in place • Fuel tanks or drums capped, not overfilled, marked with contents, and valves closed between connected fuel tanks • Store petroleum products & hazardous substances in adequately labeled approved containers • Store petroleum products & hazardous substances in bunded areas where spills can be contained & collected • Use oil collector trays or drip pans under equipment • Ensure that pipes and hoses are properly connected, closed and in good condition • Monitor tank levels throughout the program • Make available absorbent pads near the area where spills may occur • Conduct transfer operations during calm weather conditions • Ensure that transfer hoses are of sufficient length and strength to maneuver vessels as sea conditions require • Only conduct transfer operations during the day, if possible, and hoist the “bravo” flag. • Transfer under reduced visibility conditions	

						(night or overcast), hoist a red light flag • Conduct transfer under favorable wind and tide conditions that would carry any spill away from sensitive habitats • Post warning signals before transfer operations begin • During transfers, maintain effective communication between the supply vessel and the drilling rig and monitor the transfer • Implement drilling rig fuel transfer procedure Response • Response procedures shall be outlined in the site-specific OSCP/ERP. • Limit the spill at the source to the extent possible and contain or recover the material before it reaches the coastal or marine resources. • Clean-up actions are required if hydrocarbons reach shore. • Inform the port authorities immediately in the event of any spill or accident that could result in a spill. • Report all leaks and spills in accordance with the OSCP/ERP. Refer to the Communication Plan included as part of the EMP.	
4	**MANGROVE**	**HIGH**	Drilling operations and support operations	Effects on coastal mangroves due to hydrocarbon spills	**MINOR TO MAJOR**	The implementation of the proposed mitigation measures for reduced water quality due to hydrocarbon release will ensure the minimization of such impacts on the mangroves (Action # 3).	**MINOR**
5	**SEAGRASS AND CORAL COMMUNITIES**	**VERY HIGH**	Drilling operations and support operations	Effects on coral reefs and seagrass beds due to hydrocarbon spills	**MINOR TO MAJOR**	The implementation of the proposed mitigation measures for reduced water quality due to hydrocarbon release will ensure the minimization of such impacts on the shallow water macrobenthic communities (Action # 3).	**MINOR**

6	**FAUNA (FISH; MARINE MAMMALS, MARINE TURTELS, SEA BIRDS)**	**HIGH**	Drilling operations and support operations	Effects on marine mammals, turtles, fish and seabirds due to hydrocarbon spills	**MINOR TO MAJOR**	The implementation of the proposed mitigation measures for reduced water quality due to hydrocarbon release will ensure the minimization of such impacts on marine fauna (Action # 3). Response measures include the use of marine mammal deterrents with the buoys signaling the spill to prevent the animals from entering affected areas.	**MINOR**
7	**PROTECTED AREAS**	**VERY HIGH**	Drilling operations and support operations	Effects on protected areas due to hydrocarbon spills	**MINOR TO MAJOR**	The implementation of the proposed mitigation measures for reduced water quality due to hydrocarbon release will ensure the minimization of such impacts on the protected areas (Action # 3).	**MINOR**
8	**POPULATION**	**MEDIUM**	Drilling operations and support operations	Effects on population due to a hydrocarbon spills	**MINOR TO MAJOR**	The implementation of the proposed mitigation measures for reduced water quality due to hydrocarbon release will ensure the minimization of such impacts on population (Action # 3).	**MINOR**
9				Effects on population due fire/explosions	**MINOR TO MAJOR**	The implementation of the proposed mitigation measures for reduced air quality due to fire explosions will ensure the minimization of such impacts on population (Action # 2).	**MINOR**

10	**ARTISANAL FISHERIES**	**HIGH**	Drilling operations and support operations	Effects on artisanal fisheries due to hydrocarbon spills	**MINOR TO MAJOR**	The implementation of the proposed mitigation measures for reduced water quality due to hydrocarbon release will ensure the minimization of such impacts on artisanal fisheries (Action # 3).	**MINOR**
11	**TOURISM**	**HIGH**	Drilling operations and support operations	Effects on tourism due to a hydrocarbon release	**MINOR TO MAJOR**	The implementation of the proposed mitigation measures for reduced water quality due to hydrocarbon release will ensure the minimization of such impacts on tourism (Action # 3).	**MINOR**
12	**COASTAL INDUSTRIES**	**VERY LOW**	Drilling operations and support operations	Effects on coastal industries due to a hydrocarbon release	**MINOR TO MAJOR**	The implementation of the proposed mitigation measures for reduced water quality due to hydrocarbon release will ensure the minimization of such impacts on coastal industries (Action # 3).	**INSIGNIFICANT**

Chapter 8

CONCLUSIONS AND RECOMMENDATIONS

Chapter 8

CONCLUSIONS AND RECOMMENDATIONS

The Environmental and Socio-economic Setting

The proposed shallow water seismic survey and exploratory drilling operations will take place within the AMA1 Concession area, in water depths less than 200m for drilling and 50m for seismic. The Project area is characterized by the presence of sensitive habitats, such as coral reefs, mangroves, seagrass beds and sandy beaches (some of which are know turtle nesting beaches).

Seventeen species of marine mammals occur in the Project area including nine dolphin species and eight whale species. Two species of whales are currently listed by the IUCN as Vulnerable, (i.e., humpback whale and sperm whale). Humpback whales are migratory and occur in the coastal waters off the Cabo Delgado coast between the months of July to December.

Historically, the highly endangered dugong occurred in the littoral waters of the northern Cabo Delgado coastline but it has not been recorded in the area in recent years.

Green, hawksbill, and olive ridley turtles are known to nest on beaches on several of the islands. Reported nesting seasons are from November through July for green turtles and December through March for hawksbills. Olive ridley nesting season is not reported, but is assumed similar to that of hawksbills. All turtle species occurring the Project area are protected under Mozambican law and are listed as threatened by the IUCN Red List,

At least 78 fishing centers are located along the coastline and islands within the Project area supporting an estimated 9,713 fishers (comprising 7,530 artisanal fishers 2183 subsistence fishers). Artisanal fisheries are thus an important source of protein and income generation in the study area for the coastal communities living in Macomia, Mocímboa da Praia and Palma coastal areas.

Two of the islands (Medjumbe and Vamizi Islands) currently provide luxury accommodation and leisure activities such as diving, deep sea fishing and eco-tourism.
New lodges are in the process of being established on Macaloe, Rongui and Tecomaji Islands.

Two protected areas occur to the south and north of the Project area *viz.,:* The Quirimbas National Park (QNP) located 7.8km south of the AMA1 Concession Area the Mnazi Bay-Ruvuma Estuary Marine Park (MBREMP) in Tanzania located 3km to the north of the Concession Area.

Habitat Mapping and Environmental Screening of the Initial Seismic Program

The EIA included detailed habitat mapping of the entire Project area. High resolution QuickBird imagery covering 5,665 km^2 of near shore and island habitats was classified. Twenty habitats (both on-shore and marine) were identified and mapped.

In parallel with the habitat mapping exercise an environmental sensitivity analysis of near shore and coastal marine habitats within the Project area was conducted. The objective of the environmental sensitivity analysis was to develop an impact mitigation strategy consisting of recommendations for no-activity zones and or buffers zones for each habitat category.

An initial seismic program proposed by AMA1 was evaluated as part of this EIA. The evaluation of the initial seismic program took into account several environmental and socio-economic criteria to determine which seismic lines would not be acceptable from an environmental and socio-economic perspective. These criteria included:

1. Seismic lines occurring within, or near to, sensitive habitats identified in the sensitivity mapping analysis.
2. Seismic lines occurring near to islands with tourism complexes
3. Seismic lines occurring with, or near to, the buffer zone of the Quirimbas Nation Park.

Based on these criteria, revisions to the initial seismic configuration were made *viz*.:

1. Seismic lines passing through certain sensitive habitats and associated buffer zones as defined in the Environmental Sensitivity Analysis Report (CSA, October 2008) were excluded.
2. Seismic lines passing adjacent to islands with tourist complexes (Vamizi and Medjumbe islands) were moved or excluded
3. Seismic lines within the Concession Area 1 but also falling within the Quirimbas National Park buffer zone were excluded.

Of the initial seismic program comprising 2503 km of seismic lines, 1323 km of the lines were eliminated (i.e., a reduction of 53% of the original seismic program) resulting in a revised seismic program comprising 1180 km of seismic lines. By carrying out this initial evaluation or screening, many of the potential major impacts on sensitive habitats, protected areas and tourism activities were reduced or eliminated.

For this EIA, the environmental and socio-economic impacts were assessed for the revised seismic program covering 1180 km of seismic lines.

Impact Assessment

With regards to impact assessment for shallow water seismic surveys and drilling the following factors should be taken into consideration:

- The seismic survey is a temporary activity (not more than three months) and the presence of the seismic vessels at any one location will be very short (only a few days) before moving to a new location;
- The drilling program is an exploratory activity;
- Well locations are still undecided;
- The duration of the drilling activity is temporary (up to 3 months per well).

For the purpose of evaluation of environmental impacts, the receiving environment was divided into several discrete Environmental Components (EC): air, water, flora, shallow water and deep water macrobenthic communities, fauna, protected areas, population and local economy, artisanal fisheries, tourism, navigation and coastal industries. Each of these ECs is considered important on the basis of cultural values and/or scientific and public concern, and have been used to support the impact assessment. Potential environmental and socio-economic impacts on each of the Environmental Components associated with the seismic and drilling activities were identified for both routine and non-routine events.

Impacts associated with seismic surveys

Impact-producing factors associated with the proposed seismic survey program include sound pressure waves produced by the seismic sound source on marine fauna and the human environment (tourism and fisheries) and physical impacts on benthic habitats from the deployment and recovery of receiver ocean bottom cables and individual autonomous receivers. The main potential bio-physical and socio-economic impacts associated with the seismic survey are the following:

Routine Events

- Water contamination around the seismic vessels and accommodation barge from the discharge of liquid and solid wastes
- Impacts of underwater noise arising from the seismic sound sources on mangroves, corals, sea grass beds, marine mammals, sea turtles and fish;
- Impacts of retrieval and deployment of ocean bottom cables/autonomous receivers on mangroves, corals and sea grass beds;
- Interruption of artisanal fishing due to the safety zone around the seismic vessels, support vessels, and the deployment of receiver ocean bottom cables and individual autonomous receivers;
- Impacts on artisanal divers due to the underwater noise coming from seismic sound sources;
- Impacts on tourist activities (scuba diving), due to the underwater noise arising from seismic sound sources, or from the safety exclusion zones around the seismic vessels (affecting sports fishing);
- Interference with local shipping due to the safety zone around the seismic vessels, support vessels, and the recording cables

Non-routine Events

- Reduced water quality due to accidental diesel spills;
- Effects on mangroves, seagrass beds, corals and marine fauna due to accidental diesel spills;
- Effects on artisanal fisheries on tourism due to accidental diesel spills.

The majority of impacts associated with seismic operations are considered to be minor. Potential (unmitigated) moderate and major impacts associated with seismic surveys in shallow waters include underwater seismic sound on marine mammals, marine turtles and recreational and artisanal divers.

Impacts associated with drilling operations

No discharge preconditions for drilling

The exploratory drilling in shallow waters will be conducted by a jack-up rig The rig will be configured for no discharge of drilling mud and cuttings in shallow waters except for small amount (approximately 40 m^3) of cuttings which may be generated when drilling the initial hole section prior to setting the first structural casing and well head. There will also be no discharges of other solid and liquid wastes in shallow water except for treated deck drainage (in compliance with MARPOL). ***The drilling impact assessment reflects this pre-condition when addressing the impacts related to discharges.***

Actions to be taken in the absence of information regarding the drilling sites

The precise locations of the drilling sites are not currently known. The locations of the drilling sites can only be determined after processing and interpretation of the seismic survey data. Once the exact location of the drilling sites are known the following specialist studies must be carried out: (i) drilling and mud cuttings dispersion modelling and (ii) oil spill modelling. In addition, once exact drill sites are determined, a site-specific addendum to the EIA report should be compiled taking in to account both the biophysical and socio-economic receiving environments. The type and level of the studies will be determined on a case-by-case basis.

The main potential bio-physical and socio-economic impacts associated with exploratory drilling are the following:

Routine Events

The potential impacts from routine events associated with offshore drilling operations include:

- Localized impacts on air quality;
- Localized impacts on water quality due to the discharge of solid wastes (other than drilling muds and cuttings);
- Localized impacts on water quality due to the discharge of drilling muds and cuttings (from the drilling of the initial hole section prior to setting the first structural casing and well head some cuttings (approximately 40 m^3) may be extruded to the sea floor);
- Localized, physical impacts on habitats (such as sea grasses and coral communities) resulting from the positioning of the drilling rig on the substrate;
- Localized, behavioral and physical impacts to marine mammals and sea turtles from drilling operations and vessel traffic associated with drilling operations;
- Interruption of artisanal fisheries due to the safety zone around the drilling rig;
- Interference with the tourism activities in the area (safety zone and aesthetic impacts).

Non-routine Events

The potential non-routine events associated with offshore drilling operations are:

- Accidental leaks and spills;
- Fires and explosions;
- Collisions with other vessels;
- Blow outs

Of these potential incidents, blowouts releasing large volumes of hydrocarbons (crude oil or gas) are likely to create the most significant impacts. Such an event, while extremely unlikely to occur, could result in extensive negative biophysical and socio-economic impacts should the released hydrocarbons enter nearshore waters and coastline habitats.

The potential impacts from non-routine events associated with offshore drilling operations include:

- Reduced water quality and effects on coastal mangroves, seagrass beds, corals and marine fauna due to hydrocarbon spills. The significance of a crude oil or diesel spills will go from minor, for small[1] spills, to major for large[2] spills should the spilled material escape containment

- Effects on artisanal fisheries and tourism due to hydrocarbon spills. Again the significance of a crude oil or diesel spills will go from minor, for small spills, to major for large spills.

- Effects on population due to fire/explosions

The majority of impacts associated with the drilling are considered to be minor to moderate. Potential (unmitigated) major impacts associated with drilling include potential impacts of positioning of a drilling rig on corals and seagrass, potential impacts of a major hydrocarbon spill on components of the biological and socio-economic environments and potential visual impacts on tourism activities.

Mitigation Measures

The following mitigation measures are recommended to avoid and reduce major and moderate potential impacts:

<u>Mitigating measures associated with impacts from seismic operations</u>

Potential impacts of underwater noise on marine mammals and marine turtles:

- Scheduling – Plan surveys to avoid the humpback whale season (July to December).

- Soft start – Every time the use of the seismic array is initiated, “soft-start” procedures must be used to allow time for marine mammals and turtles to move away before the array reaches full power.

- Visual monitoring – Beginning at least 30 minutes before start-up during daylight hours, visual observers should monitor a safety (exclusion) zone of a 1 km radius around the source vessel for whales and dugongs and 500 m for marine turtles.

- Shutdown of the array – Visual monitoring of the sea surface should continue while the seismic array is operating during daylight hours, and the array should be shut down if a whale or dugong enters the 1 km safety zone or a marine turtle enters the 500 m safety zone during visual monitoring.

Human Divers

- Ensure no diving in 2.4 km safety zone around the seismic vessel.

[1] Small spill: That can be dealt locally with all spilled materials contained at this spill site.
[2] Large spill: That would escape containment and require rapid mobilization of equipment not available in the region (ie, an international oil spill response company)

- Through the Communications Plan coordinate with dive operators and artisanal fishers to ensure they are aware of survey locations and timing.

Temporary decrease in catch volumes by artisanal fishers

- Through the Communications Plan coordinate with artisanal fishers to ensure they are aware of survey locations and timing.
- Prepare Compensation Plan

Potential loss of revenue to the tourism operators

- Prepare a media fact sheet to assist the tourism operators as to how to convey information relating to the seismic program
- Prepare a Compensation Plan and Grievance Procedures that outlines strategies for compensation to tourism operators.

Mitigating measures associated with impacts from drilling operations

Effects of positioning a jack-up rig on seagrass and coral community

- Prepare an environmental survey of the seafloor prior to the mobilization of the rig.
- A 100 m buffer zone will be maintained to avoid physical impact on coral reefs, seagrasses and mangroves.

Effects of disposal of drilling muds and cuttings on coral reefs, seagrass beds and mnagroves[3]

- Maintain a 100 m buffer zone to avoid impacts to coral reefs, seagrasses and mangroves.

Potential Impacts on water quality and marine fauna and flora due to a hydrocarbon release (in the case of a large diesel or oil spill)

- Preparation of, and compliance with, the Emergency Response Plan and Oil Spill Contingency Plan.
- Regular maintenance and verification of the Blowout Preventor (BOP).

Potential visual impacts on tourism activities

- Once exact drill sites are determined, a site-specific addendum to the EIA Report should be compiled

Communication and Compensation

[3] Refers to cuttings that may be produced during the drilling of the first hole section and that may be discharged in shallow water

As indicated above, effective communication is a key measure for mitigating many of the potential adverse environmental impacts associated with seismic acquisition and drilling. Early consultation with all relevant authorities, prior to seismic vessel and rig mobilization, must be established to avoid interference with maritime traffic and other activities by providing detailed drilling locations, the seismic plan, transportation routing and scheduling information.

During seismic acquisition and drilling effective and transparent lines of communication between the proponent and the tourism industry, the artisanal fishers and the other relevant stakeholders must be maintained, To achieve this objective a Communication Plan has been prepared as part of the Environmental Management Plan. Through proper liaison, due notification of activities and careful monitoring of grievances, many of the potential impacts can be either avoided or minimized. Where impacts cannot be avoided, the affected parties should be compensated and a Compensation Plan has been prepared with a Grievance Procedure. These must be agreed to by with the relevant Government Authorities (INP, MICOA; Fisheries and Tourism sectors).

While the drilling vessel is operational, a 500m radius safety zone will be maintained around the drilling site and the Communication Plan is designed to inform the key stakeholders of the location and timing of the drilling operations and the exclusion zone.

A 1500 m safety zone will be maintained around the seismic vessels. Again the Communications Plan is designed to ensure that tourism operators, artisanal fishers and other stakeholders are aware of survey locations and timing.

Oil Spill Contingency Planning and Emergency Response Planning

Hydrocarbon spills during drilling and seismic operations include small diesel fuel releases from the rig or seismic vessels during routine operations or bunkering . For drilling operations a barge storing 3000m^3 of diesel will be anchored near Mocimboa da Praia. A catastrophic accident (such as an explosion on the barge) could potentially result in a very large diesel spill, with the 3000m^3 being spilled into the sea. However the probability of a catastrophic event of this nature is highly unlikely.

Of these potential incidents, blowouts releasing large volumes of crude oil are likely to create the most significant impacts. Such an event, while extremely unlikely to occur, could result in extensive negative impacts should the released hydrocarbons enter nearshore waters and coastline habitats.

Although a low-probability non-routine event, a hydrocarbon spill could reach shore, island or mainland, within several hours as indicated by the oil trajectory modelling.

An Oil Spill Contingency Plan - OSCP/Emergency Response Plan – (ERP) has been prepared that outlines procedures for dealing with all types of spills and emergencies including a spill that cannot be contained locally and would require the rapid mobilization of resources from outside the region (See Volume 2, Part B, Annex 2). The OSCP/ERP will be updated when the exact locations are of the drill sites are known.

Waste Management

A Waste Management Plan has been included in this EIA (see Volume 2, Part B, Annex 3). The drilling rig and seismic vessels must comply all with procedures outlined in the Plan, The EMP which forms part if this EIA (see Section) as well as with regulations detailed in the Annex V of MARPOL 73/78, which clearly defines the procedures to be applied for each category of liquid and solid waste.

Overall Environmental Management

Management of all identified impacts (implementation of the mitigating measures and monitoring their implementation) is required during all phases of the seismic and drilling programs. This EIA includes an Environmental Management Plan (EMP) – see Volume 2. part B of this EIA, that clearly defines responsibilities and obligations when implementing the mitigation measures and when monitoring their implementation.

Adherence to environmental operating procedures described in this report, in conjunction with adherence to the EMP will reduce adverse environmental impacts to a minimum for both routine and non-routine events.

With proper implementation of the mitigation measures outlined in this EIA, as detailed in the EMP, the project is feasible from biophysical and socio-economic viewpoints.

Chapter 9

LITERATURE CITED

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