Agulhas and Somali Currents Large Marine Ecosystems Project

Capacity Building and Training Component

National Training Plan for Mauritius

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EXECUTIVE SUMMARY

1. INDRODUCTION

The Agulhas and Somali Current (ASCLME) project is planned to address trans-boundary environmental issues and improve the effective management of the Agulhas and Somali Large Marine Ecosystems (LMEs) using a regional approach with the active participation of all countries which have an interest in the ocean currents system. The project is extending the assessment to include the Mascarene Plateau which lies in the path of the South Equatorial Current (SEC). There is strong evidence that the plateau extending from Mauritius to Seychelles over a range of almost 2000 km exerts a considerable influence on both Agulhas and Somali LMEs through its effects on the SEC, a primary driver of both the Agulhas and Somali current systems. The three systems are closely interlinked and should be studied together in order to obtain some deep insight understanding of the interconnection. The ocean ridge is not yet recognised as a Large Marine Ecosystem but it has all the scientific, economic and social characteristics of an LME and may represent a separate LME in its own right. The direct interest of Mauritius to participate in the project is to enhance its capacities in order to reach a level to conduct applied research in its EEZ, in particular, on the Mascarene Plateau.

However, assessment is hampered by a lack of trained scientists and specialised equipment. Consequently, capacity building and training (CB&T) in relation to the long-term LME monitoring and management process is a key output of the project.

2. OVERALL OBJECTIVES AND GENERAL PRINCIPLES OF THE ASCLME TRAINING PROGRAMME

The Capacity and Training component of the project will focus mainly on reviewing current initiatives and making an assessment in order to identify institutional, programme and human capacity building requirements with some specific actions for implementation. This will contribute towards the preparation of a Marine Ecosystems Diagnostic Analysis (MEDA) which will feed into a Trans-boundary Diagnostic Analysis (TDA) and a Strategic Action Programme (SAP) to address capacity building enhancement in the region

Attempts have been made to assess current marine–related educational capacity at University and Technical levels; identify training requirements and capacity for meeting them; review regional and international linkages with the programme and, lastly, propose appropriate start-up training projects and activities.

3. CURRENT EDUCATIONAL CAPACITY IN MAURITIUS.

The system of pre-primary, primary, secondary and tertiary is well organized and the level of education is comparatively very high. It is compulsory from pre-primary to 16 years. Education has been free through the secondary level since 1976 and through the post-secondary level since 1988. With regards to tertiary education, the University of Mauritius (UoM) and the University of

Technology of Mauritius (UTM) are the two main public universities offering courses at the tertiary level at present. The establishment of private tertiary institutions is growing. They accommodate about 25 % of the student population and operate in partnership with overseas institutions mainly from UK, France and India.

Courses related to marine sciences have been offered by the UoM since its establishment. In recent years, with the development of promising sectors such as the Seafood Hub and the proposed Land Based Oceanic Industry, it has initiated a 3-year BSc (Hons) Marine Science and Technology course. The University of Technology does not currently offer degrees related to specialization in marine sciences but provide courses which include some topics relevant to marine activities. Other training Institutions including the Mauritius Institute of Education, Mahatma Gandhi Institute, Mauritius College of the Air, Industrial and Vocational Training Board are not directly involved in providing formal training and capacities building in marine sciences but some are planning to do so in the future.

Many Institutions/organizations are involved in marine research. These include: the University of Mauritius, the Albion Fisheries Research Institute, Mauritius Oceanography Institute, Ministry of Environment and Sustainable Development and Meteorological Services.

With regards to training at technical levels, the ***Mauritius Maritime Training Academy*** initially provided pre-sea training to young school leavers. It is now being developed to become a Regional Training Centre and provide training for seafarers, port workers and other personnel employed in the shipping and related shipping sectors.

4. NATIONAL NEEDS AND CAPACITY FOR MEETING THEM

Several topics, which require special attention for enhanced education, in order to obtain a pool of well trained scientists and technicians in appropriate areas for applied research and effective operational activities using an ecosystem approach, have been identified within the framework of the ASCLME project. These include:

4.1 Oceanography

Most marine related institutions and organisations are actively involved in the coastal zone in terms of monitoring and research mostly in the fields of marine biology and chemistry. On the other hand, offshore and open sea oceanography is still in its infancy though Mauritius has a large EEZ of about 2 m sq. Km. Discussion is under way to develop a multi-sectoral Ocean Survey Project under the aegis of the MOI. A national Committee comprising members from various ocean related institutions has been set up to address the issue.

There is a need for several experts in physical, chemical, biological and geological oceanography to address various issues such as coastal erosion, degradation of coastal and marine ecosystems, loss of marine biodiversity and modeling. Understanding open sea ocean circulation and coastal physical processes need special attention.

4.2 Coastal zone management including expertise in GIS and MPA's

Several initiatives have been taken to enhance coastal zone management. However, there is currently a shortage of adequately trained people in GIS. Most of the GIS projects are implemented mainly by foreign consultants. Neither the University of Mauritius (UOM) nor the University of Technology (UTM) run GIS courses due to lack of resources. There is a pressing need for the setting up of an appropriate training program, which will foster the implementation and exploitation of GIS technology and develop a ***National Spatial Data Infrastructure,*** which will be responsible for data sharing, GIS awareness, capacity building and project implementation.

With regards to MPAs, besides the eight MPAs in Mauritius and the new South East Marine Protected Area (SEMPA) in Rodrigues, many more have been proposed to preserve coastal and marine resources and address the issue of marine biodiversity loss. However, training of more people in terms of rangers, managers and scientific staff are needed to manage them properly and more effectively.

4.3 Climate research

Records show a definite warming trend and an almost 8% decrease in the rainfall regime in the last decade when compared to the 1950s. Climate change and sea level rise is projected to continue for decades, if not centuries, even if the emission of GHGs is drastically reduced and stabilized. Adaptation to climate change and sea level is the main option for the country. However, adaptation to climate change remains a significant challenge, requiring massive investments. Research to devise response measures on adaptation to climate change needs to be pursued.

The following actions are proposed:

(i) A new vulnerability assessment for the coastal zone should be carried
(ii) The concept of "climate proofing" should be mainstreamed in marine development projects, land use planning, regulations and permitting and national development planning.
(iii)A new set back distance should be determined to take climate change and sea level rise into consideration.

4.4 Biodiversity

Mauritius has signed many conventions and agreements to preserve marine biodiversity. However, it still lacks an appropriate institutional and organisational framework as well as human resources to implement effectively these international and regional biodiversity-related conventions and treaties. Some attention should be given to enhance the empowerment of policy and decision makers through short training workshops to promote the review of legislations and the implementation of international and regional conventions and agreements.

Loss of biodiversity is a serious concern. One effective way to address the issue is to establish Marine Protected Areas (MPAs) in strategic sites to serve as development models. Mauritius is relatively far behind in the region with only an area of 71 sq. km of MPAs as compared to Seychelles (412), Comoros (400) and Madagascar (440). Many sites in Mauritius and Rodrigues have been identified as priority zones for marine biodiversity conservation. A comprehensive and coherent training programme for managers, technicians, NGOs and communities is needed to

empower them to realise their own role and importance in the process for good governance and resources management.

4.5 Environmental monitoring, including pollution and remote sensing

Many institutions are involved on environmental monitoring mostly in coastal waters leading at times to duplication. However, over the high seas, apart from some remote sensing monitoring, it is very limited. On the Nazareth and Saya de Malha areas where fishing activities are very important, monitoring is done only occasionally but not regularly enough to identify variation and long term trend. It is vital that capacity and human resources is enhanced through some training activities to conduct monitoring also in the open seas.

Environment monitoring, using remote sensing is now developing through the Africa Monitoring of the Environment for Sustainable Development (AMESD) project. A wealth of data will become available. Trained scientists would be needed to retrieve, analyze and interpret the data for operational activities.

Additional topics in the context of the ASCLME

Other topics where expertise will be needed for enhanced education and training include: Data and Information Management skills; Numerical expertise (statistics, applied mathematics); Legal expertise; Governance; Aquaculture; Coastal agriculture and forestry; Fisheries science; Marine and coastal geology and geomorphology; Microfauna and Meiofauna; Macrofauna; Environmental Education and human health; Tourism; Training of inspectors and observer and community involvement; Trans-disciplinary training for managers including ecosystem approach; Fishing technology; implementing of quality control in industry; Taxonomy and Curation; Environmental Impact Assessment Training and Economics and socioeconomics.

The national needs for each topic were identified and capacity required to address related issues were proposed. These have been elaborated in the report.

5 REGIONAL AND INTERNATIONAL LINKAGES AND SUPPORT

On account of its strategic position in the middle of the Indian Ocean, Mauritius has always been involved in the implementation of international marine programmes in the region. It has developed good relationship and created a good image to take advantage of the various capacities building schemes and training programmes established by International and Regional Organizations. Several coastal and marine projects are being implemented in the region with funding from various organization including the European Union, World Bank, UNEP and UNDP/GEF. A component on capacity building and training through the organization of various training workshops and seminars at regional for the benefit of participating countries is incorporated in most of them.

Many countries are offering support to Mauritius and Rodrigues in the implementation of coastal and marine projects. These include Japan, India, Kuwait, Norway and Republic of Greece.

MoUs have been signed for collaboration with some overseas Institutions. Many well established overseas universities mostly from United Kingdom such as Middlesex University and India have

opened local branch campus offering a range of popular subjects to obtain qualifications with honours degrees from the overseas universities. However, degree courses in marine sciences/oceanography are not currently available.

6. PROPOSED START-UP TRAINING PROJECTS AND ACTIVITIES

Intensive research and monitoring are currently being undertaken in the coastal zone. Several institutions with qualified personnel are involved in the management, governance and studies of the area. However, an ecosystems approach is yet to be adopted systematically. Trained ecosystem-based ocean governance professionals are few. On the other hand, there exists a critical need for physical oceanographic monitoring and studies. A holistic approach to capacity enhancement through training should, indeed, be extended to all categories of stakeholders including policy makers, managers, marine professionals, NGOs and communities. With the development and strengthening of the sea food hub as important socio-economic pillar, it is in the open sea and the large EEZ that human resources, equipment, finance and infrastructure for research and monitoring would be most needed.

6.1 Type of training required

A survey conducted within the framework of the ReCoMaP Regional Training Demand and Supply Assessment in 2009, identified in-service training, Geographical Information System, Satellite Imagery Analysis, Environment Engineering and Coastal Zone management as priority requirements. The preferred duration of the course was 1 to 2 weeks. The number of marine staff required was estimated to about 140 scientific and enforcement officers.

Capacity Building and Training in terms of long term monitoring and management process is required to address the needs of the country for future development in marine areas. For that purpose, a general course incorporating special topics and field works to prepare a sustainable team of scientists that addresses the increasing need of highly skilled human resources as well as short specialized courses for in service officers are proposed.

6.1.1 General course

The proposed general course is a 2 year full-time post graduate programme. The course is broadly divided into three components:

- Theoretical lectures on general oceanography/marine sciences and specialized topics using as guidance the topics identified within the framework of the ASCLME (see section 4 above)
- Ship Based Training to gain a practical level of knowledge and experience in research operations at sea.
- Small Boat Coastal Based Training on use and deployment of oceanographic instruments and coastal research.

The course includes a research project encompassing data collection, analysis and interpretation.

It is proposed that a Department of Oceanography be set up in one of the Tertiary Institutions. This will raise the status of the teaching of marine sciences and provide a mechanism to promote the

importance of the ocean in line with the aspiration of the country to become an important maritime nation in this part of the world.

6.1.2 Short Term specialized courses

Marine Protected Areas (MPAs) are one of the most effective ways of protecting marine biodiversity and serve as a vital management tool for coastal fisheries. They are key tools for mitigating the effect of overexploitation and halting marine biodiversity loss. Eight MPAs have been established in Mauritius and one in Rodrigues. But these are not sufficient compared to other countries.

At national level, there is currently no formal training for managers of MPAs. The purpose of short term courses is to establish a training programme for new serving officers and enhance the capacity of in service officers and non-state actors as well as those in managing posts.

Some training in diving will be given particular attention as well as first aid at sea.

6.2 Training methods

The general course will be organised by a University Institution in Mauritius with support from overseas experts. Arrangements have to be made to ensure practical ship-based training at an appropriate time during the course. The training of 30 students is initially planned for the first course. The short term courses will be of duration of one day to 2 weeks.

6.3 Budget Estimates

The Budget Estimates are US $ 555 450 for the 1st MSc course, US $ 27 825 for one short course and US $ 13400 for the diving course**.**

Agulhas and Somali Current Large Marine Ecosystems
- National Training Plan for Mauritius

1. INTRODUCTION

The Agulhas and Somali currents Large Marine Ecosystems (ASCLME) have a major impact on the societies and economies of the Western Indian Ocean region. They influence the climate of the region, provide numerous opportunities for employment and contribute to food security. It is therefore, vital that they managed properly to be sustainable using relevant scientific data and information and the latest technologies. However, their circulations are quite complex and there are large gaps in the understanding of their oceanographic processes, biodiversity and other fundamentals. The ASCLME project is being implemented in the South West Indian Ocean over the next 5 years in order to fill significant coastal and ocean data and information gaps in the region. The project is planning to compile a comprehensive scientific analysis of the transboundary environmental problems that affect the region. This is a starting point for the countries to set up a strategic Action Plan (SAP) in order to prepare a comprehensive programme to tackle these problems and develop a roadmap to enhance the effective and judicious exploitation of the marine resources for the socio-economic benefits of the participating countries.

The project is extending the assessment to include the Mascarene Plateau (Annex I) which lies in the path of the South Equatorial Current (SEC). There is strong evidence that the plateau extending from Mauritius to Seychelles over a range of almost 2000 km exerts a considerable influence on both LMEs through its effects on the South Equatorial Current. The SEC is a primary driver of both the Agulhas and Somali current systems. A thorough understanding of the modifications and changes brought about by the plateau is indeed fundamental for the management of both the Agulhas and Somali currents as the SEC dominates this region and in turn forces currents flows in the two LMEs. There is, indeed, growing evidence that an open-upwelling system is present in the area of the plateau.

The three systems are, thus, closely interlinked and should be studied together to obtain deep insight understanding of the interconnection. This is a prerequisite in order to develop a strategy for effective governance and sustainable development of coastal and marine resources in the region to enhance their contribution to food security and alleviate poverty. However, with regards to the plateau more data and information are still needed to demonstrate conclusively its importance in contributing to and feeding into the oceanographic circulation pattern of the system.

Mauritius, Rodrigues and Agalega due to a very narrow shelf and the islands in the region of St. Brandon are open to deep-sea oscillatory effects and are all influenced by the SEC. The current may be affected by lateral Rossby waves and by perturbations in the form of eddies on passing through the Mascarene Plateau. The effects of these on the marine environment of the islands are currently poorly understood.

Understanding the ocean circulation pattern over the Mascarene Plateau ant its environmental societal, economical and cultural importance in the region is of direct relevance to Republic of Mauritius. It has significant impacts on the variation and trend of fisheries resources which is

exploited by the country. Several fishing vessels are engaged in the shallow water banks of the plateau, namely Saya de Malha, Nazareth, and Albatross and in the Chagos archipelago. The production of frozen fish is quite significant. Table 1 shows the annual catch for the different fishing area from 2003 to 2007.

Table I
Annual Catch (t) of frozen fish by fishing area

Year	**No. of vessels**	**catch**				
		Saya de Malha	Nazareth	Chagos	Albatross	Total Catch
2003	9	2354	468	235	37	3094
2004	8	1686	855	117	21	2679
2005	7	1028	578	0	36	1642
2006	10	1645	777	136	54	2612
2007	7	1481	506	130	10	2127

It is noted that the annual catch is decreasing particularly in the Saya de Malha region.

Other fishing areas over the Mascarene Plateau are located in the St Brandon region. The catch comprises frozen fish, chilled fish, salted fish and octopus. The fishing production was 140 225 kg in 2007. On the other hand, coastal (artisanal) fishery too is undergoing severe setback. The production of fresh fish in 2007 was estimated at 640 tonnes and comprised 354 tonnes from the lagoon and 286 tonnes off-lagoon areas. This represents a decrease of 33% of the overall catch of 2006. This decrease has been growing in the last few years. It was 1 166 tons in 2003.

The ocean ridge is not yet recognised as a Large Marine Ecosystem but it has all the scientific, economic and social characteristics of an LME and may represent a separate LME in its own right. Some unknown channels (some over 10km in width and over 100 m deep) have recently been discovered around the Plateau which influence the flow of the SEC and associated nutrient and productivity relationship. Species of invertebrates that are new to the area are being discovered and it is expected that many taxa new to science would be identified from in depth analysis. The information from this assessment and data collection will most probably help to confirm the presence of a Mascarene Plateau LME so as to allow consideration to be given for initiating a comprehensive survey for this area at a later date. Ascertaining the external forcing function and linkages of the Mascarene Plateau to other entities in the system is one of the objectives of the programme. Some additional details on the plateau is given in Annex I

It is vital that Mauritius participates actively in the programme. It is in line with government policy and vision for agricultural diversification, in particular the development of a Seafood Hub for the region. Mauritius has an Exclusive Economic Zone of 1.9 million kilometre square, which has the potential to contribute immensely to the national economy. A large part of the EEZ is located within the Masscarene Plateau.

A key output of the ASCLME project is that of capacity building and training (CB&T) in relation to the long-term LME monitoring and management process. It will focus mainly on reviewing current initiatives and making an assessment in order to identify institutional, programme and human capacity building requirements for the effective and efficient governance and management of coastal and marine resources. However, assessment is hampered by a lack of trained scientists and a lack of specialised equipment. The programme particularly addresses this issue.

The strategy, develops to gather the necessary information in order to prepare the report and training plan, is given in Annex II

2. OVERALL OBJECTIVES AND GENERAL PRINCIPLES OF THE ASCLME TRAINING PROGRAMME

The overall objective of the ASCLME training programme is to identify institutional and human capacity building requirements and develop a strategy to address them through training initiatives with some specific actions for implementation to enable the country to eventually participate more actively in the ASCLME programme.

The specific objectives include:

- Review of national and regional initiatives through collection of relevant information
- Identify needs and gaps and develop strategies to address them
- Develop a training plan with training activities for some key gaps
- Prepare a work-plan and a budget estimates

In addition to these common objectives applicable to all participating countries to enhance their capacities, another aim for Mauritius to participate in the project is to reach a level to conduct applied research in its EEZ in particular on the Mascarene Plateau.

Each participating country is identifying available personnel, various levels of CB & T, counterpart's options, training requirements, sustainability of capacity building as well as trained and retained mechanism in order to prepare a Marine Ecosystems Diagnostic Analysis (MEDA).

Participating countries are identifying training needs in the following broad thematic areas *among others*:

- Strengthening of artisanal fisheries management
- Marine Conservation and Services
- Oceanographic research – theoretical and technical training
- Monitoring of the coastal and marine ecosystem
- GIS (mapping, database development and population

The outputs will be used to develop some key strategies to address gaps identified and training needs over a long term basis to improve institutional and individual capacities for LME long term assessment, monitoring and information management and other related discipline using an ecosystem approach.

These MEDAs will be synthesised, integrated and then feed into a Trans-boundary Diagnostic Analysis (TDAs) and A Strategic Action Programmes to address capacity building enhancement in the region for better governance and management of the LMEs for sustainable development.

It is recalled that following the UNEP driven preliminary TDA, the root causes identified for effective management of marine ecosystems were:

- Lack of policies and legal framework
- Inadequate knowledge
- Institutional weakness

- Lack of management strategies

A key prerequisite to address these shortcomings is an enhanced infrastructure and human resources through a well planned CB & T programme.

The present exercise is to prepare a draft Training plan to address requirements at national level to enhance capacities not only for national purposes but also to participate in the planning and implementation of regional programmes using an ecosystem-based approach . However, several regional training programmes have already taken placed. Others are being planned. The training programme is including activities not only to empower local specialists to engage in the TDA and SAP processes but also to build capacities and create an enabling environment to obtain relevant environmental status information facilitate monitoring and evaluation processes.. Links with international Centres of Excellence located in countries, such as Norway, France, USA and UK to support the effort are also envisaged.

Training on planned cruises on board research ships is being integrated in the ASCLME overall training programme. Local and regional institutes and personnel most appropriate for shipboard training and capacity building programme are being identified. Appropriate training periods, especially for data analysis, at the vessel home institute is forming part of the overall cruise package.

Several initiatives have already been taken within the framework of the programme. A major cruise was carried out as from 28 August 2008 on board the R/V Dr. Fridtjof Nansen including a survey on Mascarene Plateau to gather information about the oceanography and living marine resources. Scientists from MOI and AFRC were invited in South Africa to participate in the cruise planning process. In the region east of Madagascar, some data has been collected during the four - month voyage which deployed oceanographic equipment to gather as much information about this little known region as possible. The second and the third of four legs of the cruise conducted were of direct interest to Mauritius. Leg 2 focused on a survey around the whole island of Mauritius and leg 3 covered the Mascarene Plateau and parts of Seychelles. A wealth of data has been collected which will help to interpret remote sensing imagery and improve computational models of the region. The data will be archived at the NODC (Mauritius). Arrangements are being made with the Mauritius Museum Council to keep specimens collected during the cruise. Following the cruise, the Ministry of Agro-industry, Food Production and Security has made a request for an acoustic survey on the Mascarene plateau. This is being considered in future surveys.

A multi-parameter water quality probe will be made available to focal institutions within the framework of the project. A regional training course in the use of the probe and in experimental design and data processing took place in Mauritius in April 2010.

3. INVENTORY OF CURRENT EDUCATIONAL CAPACITY IN MAURITIUS

Mauritius traditionally has been an agricultural country. The sugar cane industry was the main pillar of the economy employing a significantly large labour force. Up to the 1970s, there were few coastal hotels and the potential of the coastal to contribute to the socio-economic development was not yet realised. The presence of cemeteries near beaches such as Cap Malheureux in the north, Rivière des Galets in the South, Flic en Flac in the west, is evidence that coastal resources were not given much socio-economic importance.

The education system in Mauritius is largely based on the British system since Mauritius was a former British colony. It can mainly be divided into pre-primary, primary, secondary and tertiary education. The pre-primary education in Mauritius that starts at the age of 3 is provided by both government-run schools and private-aided schools. In recent years, facilities for pre-primary education are offered in primary schools but it is still much a private undertaking. Primary education in Mauritius starts at the age of five. The level of education is comparatively very high. It is compulsory from pre-primary to 16 years.

With regards to tertiary education, there are 11 public and private institutions. The University of Mauritius (UoM) and the University of Technology of Mauritius (UTM) are offering courses at the tertiary level. The student population has increased steadily with the expansion of space and infrastructure. At the UoM, the present capacity is about 12000 students and the annual intake is about 4000 and the UTM about 1000. In 2009, the intake was 2846 at UoM, 496 at UTM and private about 800. Two more public universities are being planned in the near future.

The private tertiary institutions which accommodate about 25 % of the student population operate in partnership with overseas institutions mainly from UK, France and India.

A number of private institutions have joined the tertiary education sector in the past few years. These institutions accommodate about 25 % of the student population operate in partnership with overseas institutions mainly from UK, France and India. They amount to some 50 (W) and offer all types of programmes in an extensive number of disciplines such as Management, Accountancy, Medicine, Dentistry and Information Technology. They offer programmes ranging from sub-degree to postgraduate ones through a mixed-mode system, encompassing both distance learning and face-to face tutorials. The examinations are, in general, conducted by the Mauritius Examinations Syndicate (MES), apart from a few which are organised and invigilated by overseas institutions themselves in collaboration with the local partner. However, marine sciences are not currently offered. There are some opportunities for some private Institutions to include marine-related courses in their programme. For instance, the Middlesex University of UK, which has a branch in Mauritius, is internationally well known for its degree course in Integrated Coastal Zone Management.

With regards of Marine sciences, the teaching as from a young age has not been promoted in spite of the fact that this shortcoming has been highlighted for decades now. Topics on marine science are scattered in school text books and are not taught in a systematic way. It is becoming more and more difficult to introduce the subject in a formal way. The curriculum is already overburdened and

teachers are not prepared to accept the introduction of new topics. Moreover, teachers are not trained to teach the subject.

However, with the development of the tourism industry and the significant contribution of coastal and marine resources currently to the economy of the country, interest to embark on a marine related career has increased. Marine sciences and oceanography have become emerging potential areas for academic development. The number of post graduates with PhD and MSc is growing. In Mauritius the number of PhD in marine sciences at the UoM and professionals working in research institutions have increased significantly. It is vital that the enabling environment in terms of career prospects and facilities for research is improved to provide incentives to young people to embark in this area.

3.1 General capacity, funding and infrastructure

Education has been free through the secondary level since 1976 and through the post-secondary level since 1988. The government has made an effort to provide adequate funding for education, occasionally straining tight budgets and even subsidized a great part of the expenditure in the Private Confessional schools, that is, schools under the control of the Catholic Church. However, the pre-primary schools are still privately owned.

Considerable investment of resources, both human and material, has been put into the Education sector and impressive progress has been achieved in terms of free, universal, compulsory primary education, free textbooks, free secondary education and a fairly wide range of higher education courses at the University of Mauritius. However, in the last decades, many private English and French medium teaching secondary schools have been established. These schools are usually limited to students who can afford to meet the high monthly expenses. Their curriculum base is quite broad with much extra-curriculum activities for overall development in both academic and non-academic activities. However, most of the expenses of the private primary and secondary confessional schools under the control of the Catholic Church and privately owned secondary schools are predominantly subsidized by Government.

About 30 years ago, the number of secondary private schools was much higher than government run schools. However, in the last few decades, the number of public secondary schools has increased significantly through massive investment in infrastructure and logistics leading to a considerable decrease in privately owned secondary schools. The O-level examination taken after 5 years of secondary schooling and the A-level examination after 7 years of secondary schooling are carried out by the University of Cambridge. O-level and A-level examinations are also organized by the University of London mainly for private candidates. Some privately owned secondary schools take the French baccalaureate and international baccalaureate examinations.

With globalization, rapid socio-economic development and shift of emphasis on new development emerging issues, new initiatives in education approach are being taken to meet the challenges. The new Primary Curriculum Framework developed along the lines laid down in the document issued in September 2006 entitled “Towards a Quality Curriculum – Strategy for Reform”, much emphasis is placed on fostering commitment to values related to the preservation of the environment and to the concept of sustainable development. However, in the draft Education & Human Resources Strategic Plan (EHRSP) 2008-2020, some ‘‘inefficiencies’’ such as “relatively high percentage of students

failing and/or repeating the CPE and an alarming rate of young children turning out to be barely numerate and literate" are recognised. The Strategy Plan (EHRSP) has been formulated to provide "a quality education for all and developing a Human Resource base to transform Mauritius into an intelligent nation state in the vanguard of global progress and innovation through the development of a culture of achievement and excellence".

However, though some aspects related to the ocean such as coastal erosion and sea food industry are included in the study of the environment, the teaching of marine sciences is not given the importance it deserves for an island state compared to environment topics such as weather and pollution.

3.2 Evaluation of training activities, including short courses, ongoing mentorship, training of trainers, language issues, availability and selection of trainees.

A wide range of institutions offer both formal and informal education at various levels from grassroots to University levels.

3.2.1 Universities

Tertiary education institutes can be found in both private and public sectors. Those students who are engaged in a job or other important activities can avail the option of pursuing distance tertiary education. The sector is managed by the Tertiary Education Commission (TEC). It is responsible for implementing an overarching regulatory framework to achieve international quality in tertiary education. They are also some overseas institutes that offer tertiary education.

The tertiary sector is characterized by two universities, the University of Mauritius and the University of Technology and other tertiary institutions.

3.2.1.1 University of Mauritius

The University of Mauritius (UoM) formerly known as the School of Agriculture was established in 1965. It has since expanded and now comprises five Faculties, namely Agriculture, Engineering, Law and Management, Science and Social Studies & Humanities. It has also a Centre for Medical Research and Studies, a Centre for Distance Education, a Centre for Information Technology and Systems, and a Consultancy Centre. The Faculty of Science offers various degrees related to oceanography and marine sciences. It has nearly 20 years of existence and has a staff consisting of 56 academics of which 11% are involved in marine-related activities. In 2007/2008, it had an overall student population of 903. Since its creation, the Faculty has conferred more than 2500 awards, including 17 MPhil and 47 PhD. It is among the leading Faculties of the University in terms of academic staff holding a PhD degree (79%) and research output (research degrees awarded, research grants obtained and the number of publications).

Courses related to marine sciences have always been offered by University since its establishment. The Faculty of Science is equipped with a teaching as a wet laboratory. In recent years, it has been realized that lack of appropriately trained or skilled manpower has been a severe constraint for the development of promising sectors such as the Seafood Hub and the proposed Land Based Oceanic Industry. To address the issue, the University of Mauritius has initiated last year a 3-year BSc (Hons)

Marine Science and Technology course. It is run in alternate years. The first batch is now in their third year. There was a new intake in September 2009. The programme provides a basic understanding on how the ocean functions, and gives the background for use and exploitation of the marine environment and its resources.

All of the three years of the degree programme are based on a modular system. A combination of compulsory 'core' modules and a choice of 'optional/elective' modules provide a well structured degree. It offers the opportunity to allow students to undertake a research project under guidance in the final year. It includes the following modules:

- Marine Biology & Ecology
- Physical oceanography
- Meteorology and Climate Change
- Introductory Marine Chemistry & Analytical Techniques I
- Marine Pollution
- Introduction to Information Technology
- Ichthyology, Fisheries Biology & Management
- Marine Aquaculture Techniques & Business Management
- Dynamical Oceanography and remote sensing
- Marine Biogeochemistry and Analytical Techniques
- Research methods
- Marine biotechnology
- Marine Natural Product Chemistry
- Marine Resources & Law of the Sea
- Integrated Coastal Zone Management
- Project/Dissertation -
- Biochemistry, Molecular Biology & Bioinformatics
- Sustainable Development
- Coastal Engineering
- Sustainable Marine Tourism
- Public Health, Food Hygiene & Food Processing
- Environmental Management Tools

In the past, an **MSc Environmental Science with** specialisation in Environmental Management has been offered. Some modules, which are marine related include:

- Environmental Engineering
- Integrated Coastal Zone Management (Elective)
- Economics of the Environment (Elective)
- Environmental Policy & Governance (Elective)
- Environmental Modelling (Elective)

Besides the above degree courses, the Faculties of Science, Agriculture and Engineering offer other various degrees with related modules on environment/marine topics. Some courses, however, have been discontinued or are offered whenever the demand is justified.

The various degree courses are summarized in Table II with some details on core modules and elective topics.

Table II: Environment/marine related degree courses

Degree	Core Modules	Electives	Some marine related details
BSc (Hons) Marine Science and Technology	- Marine Biology & Ecology -Physical Oceanography, Meteorology & Climate Change -Marine Pollution -Marine Resources & Law of the Sea -Integrated Coastal Zone Management	-Coastal Engineering -Environmental Management Tools	- Mechanisms of ocean circulation and occurrence of tsunamis, eddies, waves, tides, turbulence, and deep water currents - effects of eutrophication, harmful algal blooms, marine biofouling, coastal water quality monitoring and assessment -remote sensing for shoreline mapping, beach profiling and monitoring
Bachelor of Laws with Honours - LLB (Hons) Yearly – LM310	Environmental Law	Corporate Governance	International Governance: Corporate governance and Globalisation
BSc (Hons) Economics with Management	Human Resource Management	Environmental & Resource Economics	Environmental Resources and Market failure. Economic measurement of Environmental Impacts. Methods of Valuation. Environmental Accounting. Issues in Sustainability. Resource Economics. Environmental Policy Analysis. Case Studies.
MSc Tourism and Sustainable Development	-Biodiversity and Ecotourism Management - Environmental Laws and Regulations	Environment and Development	framework of the Environment Impact Assessment system -International sources of environmental law; conventions - biodiversity issues,
MSc Applied Economic (Specialisation) in Environmental Economics and Policy	-Ecosystem Mgt and Resource Economics -Environmental Valuation and Policy -Quantitative Methods for Environmental Economics -Environment and Development	Dissertation	- International environmental law - Ecosystems and environmental processes - Valuation of natural resources and environmental services - Externalities and environmental policy

	Economics - Environmental governance		
BEng (Hons) Chemical and Environmental Engineering (Under Review)	-Introduction to Environmental Engineering & Renewable Energy Technologies -Environmental Management Tools	Chemistry for Environmental Engg.	-Renewable Energy –Ocean Thermal, Wave, Tidal. -Parameters of Water and Wastewater Analysis (pH, acidity, alkalinity, turbidity, , conductivity,)
BSc (Hons) Agriculture with specialisation in Aquaculture	-Freshwater and Coastal Ecology - Freshwater Aquaculture and Technology - Marine Aquaculture and Technology	Sustainable Fisheries Management	-Characteristics and dynamics marine ecosystems and wetlands -Introduction to marine aquaculture - Fish diseases and control. -New mariculture methodologies and technologies. -Fisheries habitat
BSc (Hons) Statistics with Economics	-Practical Data Handling - Analysis	Environmental and Resource Economics[2]	-Economic Measurement of Environmental Impacts -Environmental Policy Analysis. -Use of software -Methods of deriving confidence intervals.
MRes in Research Methodology	- Statistical Tools for Researchers- Remote Sensing and GIS Techniques - Image Processing Techniques - Water Quality Analysis Techniques		-Description of Data; Data Exploration and Visualisation -Linear Models - GIS as a decision making tool. Applications of GIS. -Remote Sensing
MSc Chemistry	Environmental Chemistry		- Nutrients and metals in coastal and aquatic systems -Global Environmental Change. Land Use and Climatic Change. Ecotoxicity.
MSc Sustainable Environmental Management	-Environmental Management Tools & Accounting -Environmental		water, air and noise pollution and impacts, environmental engineering technologies, wastewater treatment systems,

	Engineering		
MSc Environmental Science	- Principles of Environmental Science - Environmental Management Tools	- Integrated Coastal Zone Management -Environmental Policy & Governance	- Use & Management; Pollution Prevention & Waste Reduction -Remote Sensing & the Use of PC-based GIS Systems & Software for t, Processing & Analysis of Satellite Imagery & Marine -objectives, concepts, principles and practice of ICZM
MSc Mathematics	Statistical Inference	Advection-Diffusion Equations	Discrete and continuous parametric models and likelihood based inference
BSc (Hons) Mathematics (Minor) Optional: Environmental Science	- Mathematical Statistics - Computing Environment and Tools for Scientific Reporting	- Linear Statistical Models - Time Series Analysis - Operational Research	- Components of Time Series data. Exponential smoothing and moving averages - Estimation of mean and auto-covariance. - Forecasting
BSc (Hons) Biology (Specialisation: Environmental Protection	- Ecology I & Environmental Science - Environmental Monitoring and Evaluation - Integrated Coastal Zone Management - Environmental Hazards & Disasters	- Oceanography - Global Environmental Change	- resource use, pollution and environmental impacts - basic coastal and oceanic physical, chemical and biological processes - Ocean currents, tsunamis, eddies, waves and tides, and interaction of the ocean with the atmosphere. - marine environment, primary and secondary production - global ocean observing programs
BEng (Hons) Chemical and Environmental Engineering	- Environmental Engineering & Renewable Energy Technologies -Environmental Management Tools -Chemistry for Environmental Engg.		- Renewable Energy –Geothermal, Ocean Thermal, Wave, Tidal. - Chemistry of Nitrification/Denitrification and Phosphorus removal - Environmental Impact Assessment - Environmental Management Systems (EMS)/ Environmental Auditing.

It can be seen that much effort is being deployed by the university to offer some background training in marine sciences providing thus opportunities for further studies and professional training to meet the demand of the country in marine-based industries and activities.

However, opportunities for expansion are still limited. The teaching of marine sciences is under the responsibility of the Department of Bio-science. In order to generate interest and encourage student to embark on a marine career, it is essential that a Department of Oceanography/Marine science be established to produce more marine scientists commensurate with the future requirements of the country.

3.2.1.2 University of Technology, Mauritius

The University of Technology of Mauritius (UTM) Act was promulgated in May 2000 and became operational in September 2000. The UTM works closely with government, business and industry and operates from 3 Schools, namely, the School of Business Informatics and Software Engineering, the School of Public Sector Policy and Management, and the School of Sustainable Development and Tourism. It has the determination to become one of the leading tertiary education institutions of the region.

The School of Sustainable Development and Tourism (SSDT) caters for very specific areas of the Mauritian economy such as Tourism, Sustainable Development and Environmental Sciences. An MOU has also been signed with the Hotel School of Mauritius for UTM students to benefit from their facilities for practical sessions. In-company training, especially in hotels, is also part of the curriculum. The School aims at producing graduates to work in the sustainable economic, social and environmental sectors of Mauritius.

The University has only a couple of lecturers with some marine knowledge. It does not currently offer degrees related to specialization in marine sciences but offer degree courses which include some topics in marine sciences and relevant to marine activities as given in Table III

Table III. Some courses in Marine Sciences at the University of Technology

Diploma/Degree	Core Modules	Electives	Some marine related details
Diploma in Fisheries Enabled Services	-Introduction to Physical, Oceanography, Marine Biology and Chemistry -Marine Environment -Marine Ecotoxicology		-Introduction to physical oceanography , marine biology and chemistry -Assessment of impacts of pollutants on the aquatic environment -EIA concept
BSc (Hons) Sustainable Environmental Planning and Management	- Coastal Zone Management - Geographical Information System		- Overview of ecosystems and processes relevant to management; -Coastal pollution impacts;

Programme			-sea defense, -concepts and applications of Geographical Information Systems
MSc Sustainable Environmental Management (jointly with University of Mauritius)	-Concept of Sustainable Development (CSD)	Integrated Water Management	-development of National SD Strategies (NSDS) with particular reference to SIDS -role of environmental policy and legislation -hydrological and hydraulic systems, hydroinformatics, catchment hydrology (rainfall runoff, groundwater flow processes)

It is noted that the diploma course in fisheries enabled services has been designed for people already working in the fisheries sector and for Officers of the Fisheries Protection Service of the Ministry of Agro-Industry and Fisheries. It offers opportunities for the personnel requiring specific knowledge and skills necessary to improve their effectiveness in their work area and also to cope with the various on-going changes in the field. Fifteen officers are currently following the course.

3.2.1.3 The Mauritius Institute of Education

The MIE was founded in 1973 as a public institution, initially charged with responsibilities in the field of teachers' education, research in education and curriculum development. The role of the MIE, as a curriculum development centre, has over time (1993) been phased out such that it is at present predominantly involved in training teachers and educational research.

There are currently 5 Schools at the MIE, namely Applied Sciences, Education, Science and Mathematics, Arts and Humanities and Distance Education. The programmes have over the years slowly increased in diversity and levels. To-date, it offers training to school teachers in programme ranging from certificate, diploma and the PGCE. Presently, it also offers B.Ed as well as Masters programmes in Education, in collaboration with the University of Mauritius and the University of Brighton, UK respectively.

Figure I. Mauritius Institute of Education

It is currently not involved in training teachers in areas of marine sciences. Hence has no expertise in marine sciences. However, with the recent decision of the Ministry of Education and University of Cambridge to introduce a paper on Marine science at A level as from 2010, it will no doubt be called upon in the near future to enhance the knowledge of teachers to generate interest of students in the marine science areas.

3.*2.1.4 The Mahatma Gandhi Institute*

The MGI was established in 1970 as a joint Government of Mauritius – Government of India venture for the promotion of education and culture in general with emphasis on Indian culture and traditions. It has responsibilities, within the tertiary set-up, for running Programmes in such areas as Indian Studies, Performing Arts, Fine Arts, Chinese and Mauritian Studies.

The MGI currently has three main schools operating at the tertiary level, namely the School of Indian Studies, the School of Music and Fine Arts, and the School of Mauritian and Area Studies. Since the last few years it has been running, besides diploma and certificate level programmes, degree level programmes in Languages, Fine Arts and Performing Arts, in collaboration with the UoM. A Secondary School and the Gandhian Basic School also operate within the ambit of the MGI.

Marine science is not a priority for the institute and does not offer courses in marine sciences. It can, however, be encouraged to take an interest in some marine aspects such as marine history, marine architect values and paintings.

3.2.1.5 The Mauritius College of the Air

The MCA was established in 1971 to promote education, arts and science and culture in Mauritius through mass media. When the MCA statute was re-enacted in 1985, distance education was maintained as a major strategy to meet these objectives. Merged with the Audio-Visual Centre of the Ministry of Education and Science in 1986, the MCA has until recently been catering mainly for the primary and secondary education sector through the production of educational programmes for broadcast on radio and television. The MCA has also been producing educational materials for non-formal or continuing education, for non-broadcast use. Since the beginning of 1995, it has been involved in dispensing tertiary level programmes in collaboration with overseas institutions through the distance mode.

It has its own production unit. Its contribution to promote marine sciences from grassroots to University through primary and secondary levels has been significant. It has produced and broadcast through visual and audio means, several programmes related to marine sciences. The MCA is currently being reconfigured as the Open University of Mauritius. It will no doubt be called upon to play an important role in the teaching and promotion of marine sciences.

3.2.1.6 The Industrial and Vocational Training Board

The IVTB was set up in 1988 to promote vocational education and training with the purpose of supplying a properly trained workforce for the industrial services and domestic sectors. Most of the programmes that are being run are of a vocational nature leading to the National Trade Certification (levels 3 and 2). However, as from 1998, the IVTB has also started running selected tertiary level programmes at the levels of certificate and diploma in selected areas including Hotel Management, Automation and Information Technology.

Since 2004, the IVTB has introduced the National Trade Certificate Foundation Course for students who have completed their Prevocational Education Level 3. The aim of this course is to introduce students to Craftsmanship.

The IVTB has also introduced other courses such as IC3 for students of National Trade Certificate Level 2 and 3.

It is not currently involved in marine activities. However, it has the potential to teach marine science at technical level if its capacity is strengthened.

3.2.2 Marine-related Institutions/Organizations

Various Ministries and Institutions are actively involved in marine activities and some aspects of capacity building and training

3.2.2.1 Albion Research Fisheries Centre

The main activities of the Albion Fisheries Research Centre (AFRC) include research, development and management fisheries under the Ministry of Agro Industry, Food Production and Security (Fisheries Division).

Figure I1 Albion Research Fisheries Centre

The Centre has staff strength of some 64 officers in the scientific and technical grade. Most of them have at least a first degree in marine sciences and many have post graduate degrees in marine related subjects. Many overseas experts provide technical advice since 1996 in support of activities undertaken in aquaculture and marine conservation and in the implementation of the Ecotoxicology project. Projects/services of the Centre are implemented through the following Divisions: (i) *Fisheries Research Division, (ii) Aquaculture Division, (iii) Marine Sciences Division*

Besides fisheries activities, the centre is equipped to carry the following activities:

- Long term monitoring of coral reef ecosystem at 9 stations around the island using the CO.RE.MO software for data processing
- Continuous monitoring of lagoon ocean temperature at one site using a temperature data logger
- Regular monitoring of coastal water quality at nineteen sites for Chemical Ocean Demand, nitrate-nitrogen and phosphate with record of temperature, sea state, weather conditions, conductivity and pH.
- Analysis of trace metals from the high seas in the context of fish and fishery products to the European
- Monitoring of mercury in estuaries at eight sites and coliform bacteria at public beaches.

It is not directly involved in providing formal training and capacity building at technical and professional levels. However, the services of its staff are often solicited to give training to some training centres. On this aspect, the main thrust is the provision of services for the training of fisherman. In general much attention is given to this community. Training of fishermen has been going on since 1986, with the advent of the "Formation Itineraire de Peche. A fisheries Training and Extension Centre was set up in October 2004. It provides training to both registered and aspiring fishermen to fish off-lagoon and around Fish Aggregate Device (FAD). By the end of 2007, a total of 1203 fishermen had benefited from various training courses. In 2007, a Fisherman Investment Trust was set up, the objectives of which are to invest in fisheries and fish processing activities, fish marketing and other related activities having regards to the interest of fishermen.

In-house training courses are organised also for the benefit of the staff by overseas experts. Some courses organised include:

- Setting up a system of data collection, processing, analysis and monitoring of FAD
- Fish handling, Preservation and Marketing in Mauritius and Rodrigues for implementing guidelines and procedures including HACCP in fisheries
- Course in outboard motors conducted under the Yamaha Service Training, Japan

It is responsible for the creation and management of marine parks and reserves in accordance with the provisions of the Fisheries and Marine Resources Act and the Environmental Protection Act.

3.2.2.2 Mauritius Oceanography Institute

The Mauritius Oceanography Institute (MOI) was established in January 2000 to rationalise and co-ordinate research and development activities related to Oceanography. It undertakes scientific research in collaboration with local and international institutions to contribute to the regional and global matrix of oceanographic science.

A major responsibility of the MOI is to monitor the marine environment around Mauritius, Rodrigues and the Outer Islands, and advise the Government on appropriate policies and strategies for the intelligent management of the living and non-living resources under its jurisdiction.

Another important task of MOI is to assist the Government of Mauritius in formulating a claim to the UN Commission on the Limits of the Continental Shelf for an extension of the marine jurisdiction of the Republic of Mauritius. On-going projects and research includes: Continental Shelf Project, African Monitoring of the Environment for Sustainable Development, Modelling & mapping oceanic processes of South West Indian Ocean: a satellite-based approach, Bioprospecting Mauritius waters, Ballast Water, Bathymetric survey of the shallow lagoons of Mauritius and Rodrigues, Genetic connectivity and its implications for the design and management of marine protected areas in the East African Eco-region, Development of a pilot project for coral farming for tourism, export, education, research and conservation, Feasibility of Pearl Oyster Culture in Mauritius.

Since its establishment, MOI has completed many projects. This includes Geo-spatial Information system for Habitat Mapping of South Eastern coast of Mauritius, Inventory of the Coral Fauna of Mauritius, Coral Recruitment, Bioprospecting, Database of marine organisms of Mauritius and Evolutionary and population genetics of scleractinian corals.

New projects have been formulated. These include study of the Quaternary Geomorphology of Mauritius and Rodrigues and Molecular barcoding of Marine Organisms in the Republic of Mauritius

The Institute does not offer formal training. However, it has well qualified professionals and provides human resources to other institutes and Universities for teaching purposes. A list of the personnel is given in Annex IV. It has also taken certain initiatives to organise several national and regional training courses and training workshops/seminars.

3.2.2.3 Meteorological services

The meteorological services were first established in 1832 at the wharf, Port Louis, to meet the needs of the marine community. It is responsible to provide weather forecast and warning to the socio-economic sectors and industries and the general public and ensure safety of air and maritime navigation.

The Division of Marine Meteorology is one important Department of the Meteorological Services. It is headed by a senior official, who has a post Graduate degree in Oceanography. It is actively involved in the monitoring of physical oceanography. It maintains a wave measuring station in the south east of the country and a sea level station since 1986 in the Port area in Port Louis, Rodrigues and Agalega. Sea surface observations from ships are collected regularly from ships and archived.

A National Oceanographic Data Centre **(NODC)** was established in November 1999 within the guidelines of the Ocean Data and Information Network for Africa second phase project **(ODINAFRICA-II)** with satellite stations at the University of Mauritius, Albion Fisheries Research Centre and Mauritius Oceanography Institute. Its activities include: Preparation and maintenance of a metadata database of all national data holdings, reception, management and diffusion of oceanographic data and products, organization of training workshops/seminars for the benefit of data collectors, providers and end users. A National Committee on NODC from different relevant institutions meets regularly to review progress of ongoing activities and plan follow-up actions.

The Meteorological Services is now fully equipped to carry out training activities internally for its staff at technical level for WMO standard III and IV in weather observations and coding. The course includes also some aspects of marine meteorology with focus on ocean temperature, waves and sea level measurement. Training in Class III formerly took place in regional centres abroad. Existing facilities include the Regional Meteorological Training Centre established under a European Funding scheme. It has accommodated so far several training courses on environmental themes both at national and regional levels.

3.2.2.3 Ministry of Environment and Sustainable Development

The services provided by the Ministry of Environment and Sustainable Development include:

- Processing of PER/EIA
- Advise industrialists and public on appropriate pollution abatement measures
- Attending complaints made by the public regarding environmental pollution
- Public awareness and environmental education
- Infrastructure upgrading and enhancement of the environment
- Rehabilitation and preservation of national heritage sites
- Funding of environment projects through NEF
- Public access to environmental information
- NGO Desk

The Department of Environment (DoE) of the Ministry is responsible, inter alia, for marine-related activities. The Integrated Coastal Zone Management Division is one of the main pillars of the DoE. It has established an ICZM Committee with membership from all relevant institutions/organizations. It has undertaken some soft and hard engineering measures to address the problem of coastal erosion. Monitoring of coastal erosion is also one main activity of the DoE.

It is not directly involved in training activities. However, it has hosted on many occasions training workshops and seminars.

3.2.3 Technical Training facilities

A few institutes offer training at technical levels.

3.2.3.1 Mauritius Maritime Training Academy

A Maritime Training school - Sea Training school - was established in 1970 in Port Louis initially to provide pre-sea training to young school leavers who intend to make a career at sea. Eventually the school provided training for all categories of ratings in order to provide a pool of seamen for employment locally and in foreign shipping companies. In December 2006, the ex-Sea Training School moved to a new location at Pointe aux Sables and, in May 2007, it was renamed as the Mauritius Maritime Training Academy. It is sponsored by the Government.

The Building has a sea frontage on a 2125 sq metres of land. Its modern facilities consist of two workshops, five classrooms, one drafting room, a conference room, a library with Maritime specialised documents and audio visuals prescribed by the IMO and auditorium of 200 seating capacity equipped with sounds systems.

Figure III Mauritius Maritime Training Academy Headquarters

In its second phase, it is proposed to construct a jetty for the trainees. It is being developed to become a Regional Training Centre and will provide training in a proper environment with all necessaries amenities and equipment for seafarers, port workers and other personnel employed in the shipping and related shipping sectors.

Courses currently include:

(i) Training course for grade certificate as Efficient Deck Hand (EDH) and Able Bodied Seaman (AB).
(ii) Training for Seafarers forming part of a Navigation/Engine Room Watch as per STWC 78, as amended.
(iii) Basic safety training for Seafarers as per STCW 78, as amended.
(iv) Crowd Management, Passenger Safety and Safety Training for personnel providing direct services to passengers.
(v) Proficiency in Crisis Management and Human Behaviours Training.
(vi) Training for Skipper and Second Hand for Certificate of Competency for Local Fishing Vessels of 24 metres in length.
(vii) Training for Chief Engineer and Second Engineer for Certificate of Competency (COC) for Local Fishing Vessels of 24 metres in length.
(viii) Ad Hoc courses upon request from other Ministries and Private Sector.

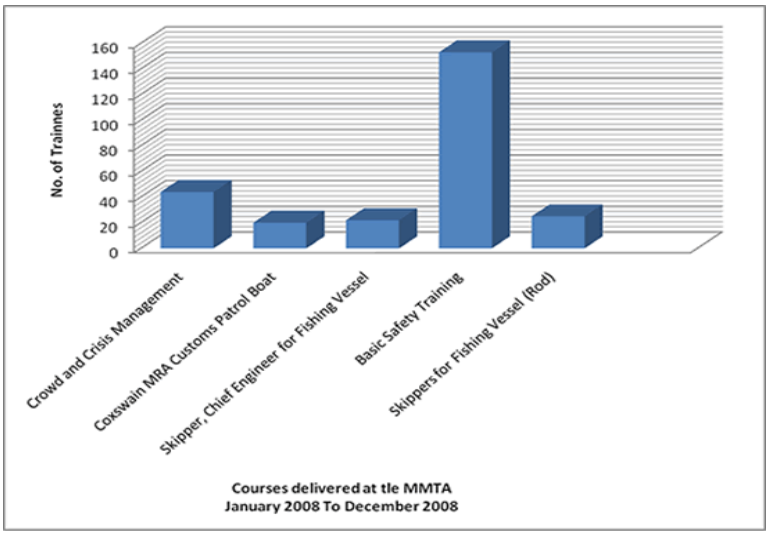

Figure IV- Courses delivered at the Mauritius Maritime Training Academy

It is expected to become a Regional Training Centre and will provide training in a proper environment with all necessaries amenities and equipment. Lecturers are professionals from the private and public sectors with extensive experience in maritime matters. Staff from the MOI, MMS and AFRC work as part time lecturers in areas within their fields of competence.

3.2.3.2 Shoals of Rodrigues

Shoals Rodrigues is a Marine Research, Training and Education organisation. The new organisation as established in September 2001 to continue the work which had been started by the Shoals of Capricorn Programme, an initiative run by the Royal Geographical Society and in the UK. The Shoals Rodrigues Centre has become a vibrant focal point for activities connected to the lagoon and the seas around Rodrigues. Shoals Rodrigues uses three complementary disciplines of Research, Training and Education to underpin our aim of raising the level of understanding about the marine environment. This is achieved through visiting international scientists, the involvement of local trainees and using educators to nurture the enthusiasm and thirst for knowledge of school children. The central ethos of their work is that sustainability and conservation can only come about through the sharing of knowledge.

With only two permanent foreign staff, the emphasis is on harnessing and developing the skills of people in Rodrigues. This training often takes place as local staff, volunteers and government personnel work alongside international staff and visiting scientists. There are also courses leading to recognised qualifications in diving, first aid and life saving. The development of these skills and the confidence to use them is vital for the sustainability of the work into the future. The local staff, government counterparts and volunteers are trained in techniques for scientific monitoring such as coral reef transects and fisheries data collection. The institution encourages visiting scientists to

develop long term scientific programmes and to visit at regular intervals to build on these skills and monitor the progress of the work. It also gives training to fisher groups to broaden their understanding of ecology and begin a working relationship for the development of our fisheries monitoring projects. These sessions also encompass skills and knowledge which are vital for working in the sea such as coastal dangers, first aid and swimming. They are already close to achieving one of our training goals: fully qualified instructors in diving, life saving and first aid amongst the local members of Shoals Rodrigues. The single storey building has three air-conditioned offices and a large open-plan laboratory and classroom area. It is equipped with audio-visual facilities, aquaria, scientific apparatus, a reference library of both books and scientific papers and computer work stations for public use.

3.2.3.3 NGOs

There are a few NGOs which are involved in technical training programmes. These include Marine Conservation Society and Marine Underwater Group. Many members are qualified marine scientists.

3.2.4 Research Institutions

Many Institutions are now involved in marine research activities. These include UoM, AFRC, MOI, MoE, and Meteorological Services.

3.2.4.1 University of Mauritius

The UoM is involved in many research activities. In view of inculcating a culture of innovation, the University is planning to enhance its research activities. In this connection, it has prepared a strategic plan for 2009 – 2015 to strengthen its role as a centre for advanced research. It has some 500 researchers and is well recognised by stakeholders and partners in industry and the education sector in Mauritius.

The University is supporting researchers to generate intellectual property that has potential commercial value and, where appropriate, to assist in successful technology transfer and commercialisation. One of the strategies is to develop a UoM Science and Technology Park and various Technology and Knowledge Transfer mechanisms. Marine Science & Technology is one of the research programme sub-clusters which represent one of major priority areas for investment by the University of Mauritius.

However, most of the research activities are in the coastal region. Some papers have been published in peer reviewed journals. But it is important that more research be done and more papers published.

There is an urgent need for open sea research. This is at present quite limited. Very few papers on research in the open seas have appeared in peer reviewed journals. Some mechanisms and innovations should be developed in this direction.

3.2.4.2 Albion Research Fisheries Centre

One of the basic objectives of the Albion Fisheries Research Centre is to carry out research and studies needed for the sustainable development and management of marine living sources including fish stocks and coral reef. These are implemented through the following three Divisions:

- Fisheries Research Division
- Aquaculture Division
- Marine Science Division

It covers a total surface area of 3,410m², which includes biological, chemical, bacteriological and marine ecological laboratories and hatcheries. In addition, a set of out-door rearing ponds of a total surface of 12,000m² is available for experimental culture work.

The main activities with regards to research and studies can be summarised as such:

- Monitoring of existing fishing activities (including fishing vessels) and fish stock assessment (artisanal, banks and tuna) in order to evolve management measures for their sustainable development.
- Surveys and charting for new or untapped resources or fishing grounds, development of appropriate fishing techniques and provision of advise on exploitation and management of these resources.
- Collaborative research/studies with regional, international organisation (e.g. the Indian Ocean Tuna Commission (IOTC) for the management of tuna stocks in the Indian Ocean, the Indian Ocean Commission (COI) in fisheries and marine ecosystem monitoring studies and other foreign institutions).
- Development and improvement of aquaculture production techniques. Seed production of marine shrimps and sea breams are being improved for stock enhancement. Red tilapia and seabream fingerlings are produced for distribution to fish farmers.
- Ecological surveys to monitor and collect base line data on coral reefs and water quality with a view to conservation of aquatic biodiversity and the marine environment.
- Management of marine protected areas. Two marine parks have been proclaimed at Balaclava and Blue Bay/Le Chaland.
- Enhancement of fish stocks and rehabilitation of ecosystems e.g. release of juveniles and mangroves propagation in the lagoon.
- Studies on potentially toxic fishes and harmful algae.

3.2.4.3 Mauritius Oceanography Institute

The MOI is a relatively new institution and was established in the year 2000. It has initiated applied research in several fields. These include:

- Continental Shelf Project to prepare the claim for the extension of continental shelf of the Republic of Mauritius
- Molecular barcoding of Marine Organisms in the Republic of Mauritius

- African Monitoring of the Environment for Sustainable Development
- Oil and Gas Exploration
- Modelling & mapping oceanic processes of South West Indian Ocean: a satellite-based approach
- Bioprospecting Mauritius waters
- Ballast Water
- Bathymetric survey of the shallow lagoons of Mauritius and Rodrigues
- Genetic connectivity and its implications for the design and management of marine protected areas in the East African Ecoregion
- Development of a pilot project for coral farming for tourism, export, education, research and conservation
- Feasibility of Pearl Oyster Culture in Mauritius
- Study of the Quaternary Geomorphology of Mauritius and Rodrigues

Many projects have been completed. These include:

- Geo-spatial Information system for Habitat Mapping of South Eastern coast of Mauritius
- Inventory of the Coral Fauna of Mauritius
- Coral Recruitment
- Bioprospecting involving the pharmacological testing of extracts for bioassays relevant to their medicinal properties and ultimately purification and isolation of the bioactive compound(s).
- Database of marine organisms of Mauritius
- Evolutionary and population genetics of scleractinian corals

It has been organising a National Ocean Forum since 2002, initially annually, but recently on a biannual basis thereby providing a platform for research Institutions to present their research findings to the General public and other research Institutions. It is an event of national importance, well covered by the media, usually attended by Ministers and high officials of the Prime Minister's Office. Prizes are offered to the best papers, presentations and posters.

The MOI is gradually developing its laboratory facilities and is now conducting many of its research in its own laboratories. It has also made some arrangements with other Institutions such as the AFRC and UoM to use their research facilities. It is also conducting some studies in collaboration with other research Institutions.

The MOI will soon have its own building. A plot of land near the sea side at Albion located in the western part of Mauritius has been identified. The building plan has been prepared. Funding has been earmarked in the 2011 budget and construction will start soon. Its new planned building will include various facilities and logistics for education and teaching purposes.

3.2.4.4 Meteorological services

The main responsibility of the Meteorological Services is to provide operational services in weather forecast and warnings for extreme weather events including flood, drought, cyclones and tsunami. It has not a well established research section. However, some research studies are conducted on an ad-hoc basis to improve current services. These include studies on coastal erosion, tides, waves and the influence of sea surface temperature on the formation and intensification of tropical cyclones in the region.

It issues regularly seasonal forecast for following tropical cyclone season for the South West Indian Ocean and winter for the Republic of Mauritius. This is based on findings from studies on the impacts of regional phenomena such as the Indian Ocean Dipole and the monsoon and global phenomena such as the El Nino and La Nina on the Western Indian Ocean.

3.2.5 Regional and international NGO'S (including industry) Programmes with TCB components

Several regional and international NGOs, with primary interest on marine science, operate in the region. Mauritius participates actively in some of them. It is one of the founder members of WIOMSA.

3.2.5.1 WIOMSA

WIOMSA is a regional professional, non-governmental, non-profit, membership organization, registered in Zanzibar, Tanzania. The organization is dedicated to promoting the educational, scientific and technological development of all aspects of marine sciences throughout the region of Western Indian Ocean with a view towards sustaining the use and conservation of its marine resources.

Capacity building is one of WIOMSA's core activities since its establishment in 1994. The overall goal of the programme is to build technical and managerial capacity and professionalism to produce experts and practitioners capable of developing, disseminating and implementing effective coastal governance practice. In addition to the on-going capacity building program in ICM and MPA, WIOMSA has organized and hosted a number of regional workshops and meetings that provided the linkage between science and management.

WIOMSA has implemented a number of region traditional and non-traditional capacity building activities mostly in Tanzania and Kenya for member countries including:

- Refresher course "governance for responsible fisheries", Zanzibar, Tanzania
- Planning workshop on river basin estuary – sea linkages in Eastern Africa, Mombasa, Kenya
- Third regional training course in marine protected areas – management in the western Indian Ocean region, Malindi, Kenya
- Mombasa port biological baseline survey, Mombasa, Kenya
- Workshop on "The experiences of the Institute of Marine Sciences of the University of

Dar Es Salaam in mariculture", Zanzibar, Tanzania
- Fishermen, fisheries and sea grasses, Zanzibar, Tanzania
- Training course in use of satellite data in oceanography, Malindi, Kenya

WIOMSA has established two research grants under the Marine Science for Management (MASMA) and the arine Research Grant (MARG) programmes, MASMA is designed to support research activities in the region as well as organisation of training courses/workshop and MARG programme seeks to enhance capacity to conduct research and increase the understanding on various aspects of marine sciences and offer opportunities for the presentation of results of the research work in different regional and international fora.

3.3 Others

A few other initiatives are or have been involved in capacity building activities.

3.3.1 The Secretariat for Eastern Africa Coastal Area Management(SEACAM)

The SEACAM established in 1997 with the purpose of improving the capacity of Eastern countries including Mauritius to effectively implement and coordinate coastal management activities in the region has developed various capacity building and information materials in the following areas:

- Capacity building of local NGOs
- Database of : (i) ICZM programmes, projects and activities; (ii) institutions and individuals
- Environmental assessment training and guidelines in tourism and coastal aquaculture
- Public sector management and
- Sustainable financing of coastal management programmes.

Though the programme has been discontinued, it remains a valuable source as the expertise in preparing training manuals still exists as does the training materials that were prepared by the programme. They are being held by the Department of Environment in Mozambique, some in limited paper form but also in electronic format and will be available if there is a need to reprint material.

3.3.2 Appui Régional à la Promotion d'une Education pour la Gestion de l"Environnement au sein des pays ACP/COI (COI/ARPEGE)

The specific objective of this pilot project (2000-2005) is to develop and validate an environmental education methodology and tool (*malette pedagogique*) adapted to the level of pilot institutions. ARPEGE is supporting the primary education systems of the IOC countries through teachers training and pedagogical materials for schools. It has targeted 60 schools and 150 teachers. However, in some countries, the project tools and methods have not fully been incorporated within the national education systems jeopardizing the sustainability of the project.

On the other hand, the legacy of the project has had an important impact in many countries. The teaching materials covered many marine topics and are being used in the primary schools of some IOC countries.

3.3.3 Participation of the Private Sector in CB & T activities.

The private sector is fully involved in the exploitation of marine resources, particular in the seafood industry and fishing activities on the Nazareth and Saya de Malha banks located at about 600 km. to the North of Mauritius on the Mascarene plateau. The potential of the seafood industry is immense and is expected to replace other industries such as sugar and the manufacturing industries in importance in creating employment and foreign earnings. At present it is mostly tuna- based.

La Ferme Marine de Mahebourg, operational since 2002, is involved in marine aquaculture with a fish farm operating in the lagoon in the south-east of Mauritius at Mahebourg. It is now exporting its aquaculture products to the EU.

3.3.3.1 Main Players from the Private sectors

Presently, tuna processing is dominated by two big operators: Princes Tuna Ltd and Thon des Mascareignes. Princes Tuna Ltd, situated just outside Port-Louis, processes about 50,000 metric tonnes of tuna yearly for the European market. It employs about 2,100 people, among whom are a few hundred foreigners.

A third enterprise, MTC Seafood Ltd, has recently started operations at Mer Rouge, near the port. This Malaysian enterprise has invested $3.3m and is engaged in fishing, processing and export of fresh and frozen fish, mainly tuna.

The logistic activities are dominated by Froid des Mascareignes and Mauritius Freeport Development Company. Another enterprise, Casamar (Mauritius) Ltd, a subsidiary of CASAMAR group, a world leader in the repair and assembly of purse seine has started its operations in the island. This company is targeting some 50 purse seine vessels operating in south-west Indian Ocean.

3.3.3.2 Private Sector in CB & T activities

The private sector is not participating directly in training activities. Most of the fishermen employed by the private sectors receive their training at the state- owned Mauritius Maritime Training Academy. Ad Hoc courses, besides the regular couses, are organized upon request from the Private Sector.

3.3.5 *Other related capacity building programmes.*

These programmes of direct interest to the country include:

- Marine and Coastal Biodiversity Conservation Programme in the SWIO to contribute to the conservation of biodiversity, marine and coastal resources within the Western Indian Ocean Marine Eco-region (WIOMER) through the establishment of a regional network of well protected and effectively managed MPAs.

- South West Indian Ocean Fisheries Project (SWIOFP) with focus on existing and potential deep-sea fisheries in the region enhancing regional capacity to manage migratory species that regularly cross national boundaries.
- Addressing Land based activities in the Western Indian Ocean (WIO-Lab project) to prepare national plans for abating land based sources of pollution as well as a regional protocol for existing environmental conventions such as the Nairobi conventions and Annexes
- Africa Monitoring of the Environment for Sustainable Development (AMESD) to exploit satellite weather images from the Second Generation Satellites to manage coastal and marine resources.

4 NATIONAL NEEDS AND CAPACITY FOR MEETING THEM

The Republic of Mauritius, comprising Mauritius, Rodrigues, St Brandon, Agalega, Tromelin and Diego Garcia, is a maritime country. Its climate, as well as the numerous socio-economic, cultural and traditional activities, is intimately and intrinsically linked to the ocean. Coastal and marine resources have immense potential to contribute to its sustainable development. Various marine policies and legislations have been promulgated as given in Annex 4. However, it should be admitted that there is still much effort to be deployed to develop innovative initiatives, policies, legal and institutional frameworks, networking, sensitisation and human resources development to take advantage of the vast coastal resources, which abound in the coastal region and the large EEZ of the Republic of Mauritius.

It is quite surprising that, though Mauritius is surrounded by water, a majority of the population does not know the basic principles of swimming. In this connection the Government of Australia is providing some funding in implementing a project on promoting some swimming activities through the teaching of the basic principle of swimming. However, development of facilities with the construction of swimming pools around the island and formal coaching is encouraging the new generation to learn the art of swimming and participate more actively in national and regional swimming competitions.

Diving, as well as snorkelling, is limited only to a few who can afford to buy the expensive equipment required for the purpose. Some attempts are being made to democratise access to the sea and facilities for diving should be extended to a great majority of the population. There are indeed opportunities for the creation of employment in this area. Many tourists visiting Mauritius are interested to learn diving and snorkelling on account of the pristine lagoon, beautiful and colourful coral reefs and offshore attractions for dolphin watching and playing. To cultivate an interest in such activities at a young age, it should be introduced in extra-curriculum school activities.

4.1 Technical Training

Technical training is quite limited in the country. A few facilities exist in a few institutions including Marine Academy and AFRC. However, these are confined to fisheries activities.

Ship models are lucrative business among tourists. Many companies are involved in this activity. Most of them have facilities for in-house training. However, formal training is desirable.

The procurement of ocean equipment is growing. This equipment is now mostly electronic-based and very sophisticated, requiring specialised technicians for maintenance and repairs. However, most institutions such as MOI, AFRC and Meteorological Services are facing difficulties for repairing them in case of breakdown due to lack of a pool of technicians in the field.

4.1.1 Needs identified

There is therefore an urgent need to provide facilities in the following areas:

- Diving and snorkelling

- Ship model building
- Ocean equipment and repairs
- Ship and boat building.

In addition, the following needs have been identified:

- Dedicated diving/snorkelling Unit in Marine Research Institutes as highlighted by the University of Mauritius with more staff to man the unit and diving and snorkelling gears

- A formal training course to obtain a diving certificate is desirable to meet the demand for trained personnel in the tourism industry

- Open diving chambers in ocean institutions in view of increasing activities in diving.

4.2 Economics and socioeconomics

Economic and socioeconomic subjects in the field of marine sciences are indeed **a** specialised subject and professional to teach it is few. Marine science professionals should have some basic knowledge on the topics to understand better in a formal way the socio-economic implications to provide advice and more effective governance for coastal and marine ecosystems.

There is currently no course in socio-economics in Mauritius. However, the University of Mauritius does offer two degree courses with some modules, which are relevant to marine and coastal marine sciences namely:

- BSc (Hons) Economics with Management and

- MSc Applied Economics

The first degree course includes a module on "Environment & Resource Economics". However, it covers environment in general and has no particular focus on coastal and marine resources. It includes Environmental Resources and Market failure, Economic measurement of Environmental Impacts, Methods of Valuation, Environmental Accounting, Issues in Sustainability, Resource Economics, Environmental Policy Analysis and Case Studies.

On the other hand, the MSc Applied Economics (Specialisation: Environmental Economics and Policy) is offered on a part-time basis. In the second year, some relevant modules with specialisation on environment economics and policy are covered, namely Environmental Valuation and Policy, Quantitative Methods for Environmental Economics and Environment and Development Economics. However, some of these modules are not offered at the University and students are expected to complete them at University of Pretoria, South Africa.

The module on Ecosystems and Environmental Processes provides students with a basic of key concepts of ecology and ecosystems functions. These should include themes such as population ecology, ecosystem ecology, ecosystems services, biodiversity and basic concepts of carrying capacity.

However, students have the choice to select Environmental Governance, which covers case studies on marine and coastal environmental management as one of the electives.

4.2.1 Needs identified

Economics and Socioeconomic with regards to marine sciences is an important but a specialised subject. There is no expertise to teach it in Mauritius. The issue should be addressed perhaps by resorting to visiting lecturers.

4.3 Numerical expertise (statistics, applied mathematics etc)

Expertise in numerical modelling, particularly in coastal and marine areas, is very limited. Some attempts have been made to develop some modelling for oil spills dispersion and movement. Modelling activities, on the other hand, are developing rapidly. Wave and current models, which have applications in various fields such as coastal engineering works and effluent discharge, should be developed for the lagoon and offshore areas. Global and regional models are available in areas such as waves and currents. Numerical expertise is needed to adapt these models to derive products of interest to the region of the country.

Undergraduate courses offered at the University of Mauritius, besides basic statistics; do have some topics on modelling. For instance, the BSc (Hons.) Statistics with Economics, have modules on generalised linear models and sampling theory, which include topic on models for binary, binomial, multinomial data. Models to develop time series analysis and forecasting whereby Dynamic Linear Models and model building using superposition, combining information, model monitoring are introduced. On the other hand, the MSc Mathematics course offers a topic on mathematical modelling in biology and health with some aspects of simple models for the spread of disease.

4.3.1 Needs identified

Modeling is a specialized domain, which needs specialized aptitude and professional to develop models for practical applications. The need for modeling is numerous. For example, in the field of coastal development, it is vital to develop a model for large scale protection structures to make an assessment of their impacts on coastal and marine resources. These models, with impressive and far-fetched outcomes, are developed in most cases by overseas experts with only a couple of week study and without any knowledge on the local environment. These are included in EIAs. However, local expertise is lacking to assess and question the outputs. These shortcomings should be addressed through short courses.

4.4 Data and Information Management skills

The National Oceanographic Data Centre **(NODC)** has been established in November 1999 at the Mauritius Meteorological Services within the guidelines of the Ocean Data and Information Network for Africa second phase project **(ODINAFRICA-II).**

It is recalled that the ODINAFRICA regional programme was established by UNESCO-IOC and the Government of Belgium, to enable member states of Africa to get access to data available in other centres, develop the skills for manipulation of data and information products and develop infrastructure for archival, analysis and dissemination of the data and products. One of the key requirements identified during the development of the project was the provision of training in marine data handling and information. The programme has contributed much to develop the infrastructure for data handling in the region. Computers have been provided to participating countries and software for data and information management developed within the framework of the programme has been made available to the countries. Several regional training workshops and seminars have been organized to enhance the capabilities of countries in marine data management. One of its main objectives is to make available to policy-makers and the marine communities, ocean data and products, in real and non-real time, for the efficient management and sustainable development of coastal and marine resources.

The Mauritius NODC is national recognized. A national committee to oversee the development of the NODC has been constituted. It comprises representatives from the following institutions:

- Albion Fisheries Research Centre of the Ministry of Agro- industries, Food Production and Security
- Central Informatics Bureau
- Central Statistical Office
- Ministry of Environment & National Development Unit
- Mauritius Oceanography Institute
- National Coast Guard
- Ministry of Housing and Lands
- University of Mauritius
- National Remote Sensing Centre
- Mauritius Meteorological Services.

The Albion Fisheries Research Centre is responsible for the Marine Information aspects of the programme. Its primary functions include the provision to marine scientists with the necessary scientific information, promotion and facilitating communication between the scientists, both intra- and inter-regionally and dissemination of information on marine scientific research activities.

4.4.1 Needs identified

The NODC has developed a website (http://www.nodc-mauritius.org/index.htm) and some information is available on it. However, much still remains to be done in order to provide a good service to marine communities. Further short courses should be organized at national and regional levels on data analysis. It should also be further equipped so that information could more easily be made available to users.

4.5 Legal expertise

Mauritius is a party to around 36 environment-related conventions, protocols and other internationally binding and non-binding instruments. These international and regional agreements

include climate change, protection of the ozone layer, biodiversity, sound management of hazardous and toxic wastes, including persistent organic pollutants, disaster management such as oil spill and chemical spills, protection of the marine environment.

The various marine related national, regional and international conventions, treaties and agreements include UNCLOS, UNCBD, MARPOL, CITES, Jakarta Mandate and Nairobi conventions and Annexes. It has many obligations to meet under them. However, it lacks expertise including legal ones to fully implement them.

It has promulgated many marine-related acts such as EPA and Marine Fisheries Acts, which need legal advice for proper enforcement. There is much lack in legal environmental expertise particularly in marine affairs to assist in implementation process.

The UoM does offer degree courses with some modules covering some legal aspects of the environment. An undergraduate LLB programme- Bachelor of Laws with Honours - LLB (Hons) Yearly- is offered and provides an excellent opportunity to gain a legal education with courses taught in both English and French. It provides an excellent education to those who wish to join other professions than practising lawyers where an extensive legal background is necessary. It covers one module on Environmental Law.

4.5.1 Needs identified

Legal expertise on coastal and marine issues is very limited. National disputes in coastal and territorial waters, particularly on pollution aspects, are increasing. Moreover, with the growing importance of transboundary issues in international waters and numerous international conventions and treaties signed by the country, it is vital that the issue of lack of legal expertise be addressed to enable the country to meet its obilgations and reap maximum benefit from regional and international negotiations.

Some short courses should be organized for lawyers on regional and international conventions and national marine policies.

4.6 Language education

The medium of instruction in schools is English. It is the official language of Mauritius and French is the second language. The teaching of some Asian languages -Hindu, Urdu, Mandarin, Chinese and Arabic- is also included in the curriculum. However, French is very popular in terms of exposure as most of the daily newspapers are in French. On TV too, the French language is mostly used. On the other hand, the majority of the population speaks the French–based Mauritian creole in their everyday life. Bhojpuri is used also mostly in villages by people of Indian-origin.

There is currently a national debate underway whether to use creole or not as the medium for teaching, particularly in primary schools. Some pilot projects, on an experimental basis, have been implemented in some primary schools in 2009. The result has been encouraging. However, its introduction on wide scale in catholic schools in 2010 has been delayed. On the other hand, the creole language has always been used as a support language to learn other languages and explain

difficult concept to facilitate understanding but a policy to institutionalize the process is yet to be adopted.

4.7 Governance

Coastal and marine observations, monitoring, policies implementation and other management issues are under the responsibilities of various organisations. These include Ministry of Environment, MOI, Ministry of Agro-industry (Fisheries), Meteorological Services. The MoE has a Policy Division which is mainly concerned with the implementation of environmental policies in Mauritius.

The Environment Protection Act (EPA) 2002 is the main piece of national legislative framework which provides among others for:-

- The protection and management of environmental assets;
- Environmental protection and sustainable development for present and future generations;
- Environmental management;
- Coordination of the inter-relations of environmental issues;
- The proper implementation of governmental policies and enforcement provisions; and
- The protection of human health and quality of life.

One part of the act is devoted to "The Coastal and Maritime Zone Management". An Integrated Coastal Zone Management Committee (ICZM), consisting of a Director of Environment, acting as Chairman and representatives of various Ministries, has been established within the framework of this act. The purpose is to develop and coordinate regional and international projects and monitor coastal water quality and coastal resources. Provision is made to empower the Minister of Environment to make regulations for the preservation and conservation of the environment of the coastal and maritime zone.

Several mechanisms have been put into place to network institutions to promote coordination. These include the ICZM committee and the bi-annual fora on marine research under the MOI, which provide opportunities for research to present their research works in the previous two years. The MOI Board, comprising members from all coastal and marine related institutions and Ministries, which meets regularly at least once a month, also provide opportunities for coordination.

The contribution of coastal and marine resources to the national economy is expected to increase, as a consequence of enhanced development of the sea food hub and land-based oceanic industry. On the other hand, marine resources in the EEZ are yet to be fully developed. Coastal and marine issues are at present incorporated in the EPA act. The Fisheries and Marine Resources Act 2007, which provides for the management, conservation and protection of fisheries and marine resources and for the protection of the marine ecosystems, focuses mainly on fisheries.

4.7.1 Needs identified

It is true that ocean management is covered in environmental and other policies. However, the coast and marine environment is a unique part of the environment and is distinct system in which a range of considerations - biophysical, economic, social and institutional - interconnects. It requires a

dedicated and integrated management approach. There should be a fundamental shift in thinking about the coast and offshore waters. There is, at present, no policy dedicated solely to coastal and marine resources. The coast and EEZ will no doubt provide immense opportunities to build the nation and transform the economy and society. Many countries, such as South Africa, have formulated policy on sustainable coastal and marine development for sustainable management of coastal and marine ecosystems and resources. It is high time that a policy be prepared to define a new approach to coastal and marine resources management.

The UoM offers a module on Environmental Governance in MSc economics. It includes topics on Applied environmental and resource economics, approaches to environmental accounting and valuation environmental dimensions of international trade and tourist, international environmental law, case studies on transport, forestry, marine and coastal environmental management. Coastal and marine governance is however thinly covered. For sound development and governance of coastal and marine resources, there is a need to develop modules, among others, on the various marine related regional and international conventions and regulations such as the Agenda 21, WSSD, NEPAD, Nairobi convention and BPoA and its related Mauritius Strategy. Much emphasis should also be laid on the benefits of Marine Protected Areas from early demonstration sites for local governance, to demonstrations of concrete fisheries benefits through the use of no-take ecological reserves to raise awareness on its importance. These could include:

- Strengthened management of parks and protected areas;
- Habitat and biodiversity conservation through threat mitigation;
- Improved environmental management by both public and private sector entities;
- Sustained livelihoods, employment diversification, and income generation;
- Reduction of negative impacts from international trade and destructive fishing practices;
- Sustainable tourism and fisheries; and
- Reduction of land-based sources of pollution and improved coastal watershed management

4.8 Fisheries science

The AFRC is responsible for all fisheries activities. They have many experts in fisheries science and most of them have received their training in overseas universities.

Very few universities in the region offer fisheries science at degree level. It is a very specialised subject and no expertise exists for the purpose. In South Africa, for instance, one module is included in the second year of a first degree of marine science. To address the issue, the organisation of some short courses on fisheries science for the benefit of all stake holders should be initiated.

The fisheries and seafood sector contribute about Rs16 billion to the national economy whilst the local fish production sector is valued at about Rs1 billion. This sector employs 12,000 persons, including those involved in fishing, canning, other processing activities, distribution and marketing. The demand for expertise in Fisheries Science is growing, particularly with the development of the Sea Food Hub and policy of the Government to promote offshore and open sea fisheries.

It is appropriate to point out that a regional fisheries project – South West Indian Ocean Fisheries Project (SWIOFP) is currently being implemented in the region. It is focusing on existing and

potential deep-water fisheries in the region. It provides the regional capacity to manage migratory species that regularly cross national boundaries. Capacity building to collect and assess fisheries information is one main activities and it is linked closely with the ASCLME project.

4.9 **Oceanography**

Most marine related institutions are actively involved in the coastal zone in terms of observations and monitoring. The MOI is conducting detailed survey of the bathymetry of the coastal zone and bathymetric maps of many regions have been completed. Lagoon currents have been mapped at a few sites by the AFRC and MOI. The DoE is collecting data on coastal erosion at several sites on a regularly basis. The Meteorological services have deployed equipment to measure sea level variation and open sea waves. However, coastal lagoon processes are still to be understood. Activities should be enhanced to conduct research on coastal ocean circulation, which is vital for effective and sustainable beach development. Apart from near-shore circulation studies, it is also important to develop a strategy to promote research in open sea circulation as the near shore and off shore circulations are inter-related.

Offshore and open sea oceanography is, indeed, still in its infancy though Mauritius has a large EEZ of about 2 m sq. Km. Research in the open sea is limited. It is true that AFRC and MOI occasionally have conducted some studies on fisheries in the Nazareth and Saya de Malha areas over the Mascarene Plateau, what is required is sustained applied research activities in order to contribute to effective and judicious exploration and exploitation of marine services for the socio-economic development of the country.

Scientists from various institutions have participated on many occasions on the invitation of friendly countries to participate in cruises on board research vessels in the region of interest to Mauritius. They have benefitted enormously in terms of capacity building and training. However, though one of the pre-condition of Government to allow foreign vessels to conduct oceanographic research in the EEZ of the Republic of Mauritius is the active participation of Mauritian scientists and sharing of all data collected, knowledge within the country is still rudimentary. Analysis of the data to understand ocean processes has been given secondary importance. Only a few studies have been done and the outcomes published for easy access to other scientists. The main reason is that after the cruises, the participating scientists have more pressing priorities within their respective institutions and all the important data and information remain in the drawer. What are really required are dedicated scientists who are involved from start to end with collection of data, archiving, analysis, discussion and publication of the result. It is noted also that some region within the EEZ has not been covered by any expedition. For instance, oceanographic surveys in the region north of Rodrigues data back from early 1950s.

The potential for research is enormous. Ocean processes around the Mascarene Plateau are yet to be understood. This is vital for sustainable fisheries activities. The deficiency has long been realised and some initiatives are being taken to address the issue.

Following a board decision of the Mauritius Oceanography Institute (MOI) on 30 April 2009, discussion was held on 7 May 2009 for the formulation of a multi-sectoral Ocean Survey Project under the aegis of the MOI. A national Committee comprising members from various ocean related

institutions has been set up. The following requirements and research, inter alia, have been identified:

- Fisheries resources
- Hydrothermal vent
- Manganese modules in the Rodrigues
- Potential for genetic resources
- Ocean and climate
- Ocean processes- biological, geological, geophysical, geochemical and physical
- Mapping of the EEZ
- Prediction of oil spill dispersion and movement

It is recognised that capacities to carry out research and studies in the open seas are still very limited. Consequently, capacity building and Training is one aspect of the endeavour which will be given much attention.

No dedicated vessel is available for open sea research. This is not foreseen in the near future. Chartering a vessel is also not financially feasible on account of the high cost involved. It will be perhaps be possible to make partnership arrangements with some friendly countries to carry out full scientific research in line with the interest and requirements of the country. Among institutions/ organisations which could provide some assistance are the Intergovernmental Oceanographic Organisation, FAO and World Bank.

In the meantime, it has been proposed that a fishing vessel is chartered and equipped with a wet lab. The National Coast Guard patrolling vessel could be used, if properly equipped, for some research surveys.

To initiate the process, the following information is being gathered:

- Surveys carried out prior to the year 2000.
- Reports from Institutions which have participated on cruises and expeditions on board foreign vessels
- Equipment for open seas surveys available within the Institutions Ministries
- Suggestions for potential projects

The idea is quite laudable and should be pursued. It should be developed step-wise and phase-wise. Initially some actions should be taken with available capacities. Requirements and needs should subsequently be identified to strengthen the programme. In the long term, a comprehensive research programme should be developed to enable the country to take a leading role in oceanographic research in the region.

Needs identified

The MOI has already identified some programme areas for research both in the coastal and open sea regions. Capacity in term of personnel and equipment needs to be strengthened to address the issues.

The procurement of a research vessel perhaps is still premature and is not foreseen in the near future. However, it is time that ocean activities and research initially be geared towards collecting data and information and carrying out analysis to understand ocean processes in the region of interest but with the aim that eventually the knowledge will reach ultimately a point when the acquisition of a research vessel will be considered desirable. It will take some time but eventually it should become a reality.

4.9.1 Physical Oceanography

Physical oceanography is the study of physical conditions and physical processes within the ocean, especially the motions and physical properties of ocean waters. Physical processes acting over a broad range of space and time scales influence the physical ocean environment and affect ocean and coastal circulation, sediment and pollution transport as well as chemical and biological parameters. It is important to understand the physical processes of the ocean and how they affect coastal and marine ecosystems in order to develop better management strategies and conservation programmes.

Mauritius is surrounded almost entirely by fringing coral reefs and a shallow lagoon of varying width. The beach types and sand/soil grain size depend on the distance of the coral reefs from the shoreline and river outflow. Wave climate is also another predominating factor. The southern and western parts are dominated by swells generated far to the south from weather systems travelling from west to east whereas the other regions are influence by waves generated by the south east trade winds. High waves from tropical cyclones during the month of November to May occasionally reach Mauritius. These waves from the open sea are transformed through refraction, shoaling and diffraction as they enter the lagoons.

Mauritius is located in the extreme southern part of the South Equatorial Current (SEC). The SEC undergoes major changes as it drifts from east to west around the islands in the region and over the Mascarene plateau. It is believed that important upwelling areas are located in the region of the Mascarene plateau. However, these physical processes are poorly understood.

9.1.1 Needs identified

A wealth of data has been collected in the lagoon by local institutions. However, with regards to the open sea, most of the data collected is in the custody of foreign countries. Some studies have been done by foreign scientists in the EEZ of the Republic of Mauritius but the involvement of local scientists in the process has been limited. Relevant data in the custody of foreign Institutions should be retrieved and a literature review conducted to prepare a compilation of all papers of interest to the region, in particular to the Mascarene plateau, published

On the other hand, coastal dynamics is poorly understood. Coastal erosion is ubiquitous around Mauritius and Rodrigues as well as the outer islands. Several reports with recommendations how to address the issue have been submitted to the authorities. However, implementation has been slow. Sand mining has been banned since October 2003 as one possible solution to contribute to address beach erosion. However, the problem still continues. Hard engineering structures such as gabions have been placed along many public beaches as short term measures to arrest erosion. Numerous reports have been published in the last few decades with some good recommendations and others

will no doubt be commissioned in the future with more or less the same recommendations termed differently. What is needed is action and implementation of recommendations which can lead to a long term solution.

Climate change and sea level rise is expected to worsen the currently bad state of coastal and marine ecosystems. Coral bleaching is already becoming more frequent. Ocean acidification will exacerbate further the coral ecosystem on which many socio-economic activities depend. Extreme ocean and weather events including more intense cyclones, higher waves and storm surges are projected to become more frequent leading to more coastal inundation and damage to coastal infrastructure. The IPCC has provided various "no regret" measures which can be adapted to the region.

It is noted that very little studies on coastal hydrodynamics have been conducted. This is pre-requisite to understand coastal lagoon processes to determine possible solutions to the problem of coastal erosion. There is definitely a lack of physical oceanographers in the country. This is most apparent when posts of physical oceanographers are advertised for recruitment. In the majority of cases, non-physical oceanographers are employed to undertake physical oceanographic activities. Training should be envisaged to produce scientists with specialization in physical oceanography.

4.9.2 Chemical Oceanography

Chemical oceanography is the study of ocean chemistry the behavior of the chemical elements within the Earth's oceans. The ocean contains many chemical compounds, elements, gases, minerals, and organic and particulate matter. Chemical oceanography is the study of one or a combination of the following: formation of seawater and seafloor sediments, relationships between chemical compounds, how chemical inputs to the ocean affect it, and how the chemistry of the ocean affects or is affected by biological, geological, and physical factors.

One important aspect of chemical oceanography is the study of pollutants. This work may lead chemical oceanographers to the Deep Ocean, coastal bays and estuaries, or inland rivers, streams, and lakes. Sources of pollutants range from the obvious (sewage, oil or fuels, ocean dumping) to sources that are harder to detect or trace (agricultural or lawn runoff containing chemical fertilizers, leaking septic systems, road runoff, or storm drain overflows). Chemical oceanographers study the impact of such pollutants by examining how they interact with seawater, marine life, and sediments. Chemicals and pollutants introduced to a marine environment may behave very differently depending on environmental conditions such as salinity, wind, rainfall, temperature, and transport methods.

Ocean acidification as a consequence global climate change has recently captured the attention of chemical oceanographers. This is expected to increase as the emission of carbon dioxide continues to increase.

Rapid technological advances, including the development of complex chemical compounds and processes used to produce and manufacture energy, food, clothing, medicine, and other products, have created a need for chemical oceanographers. In Mauritius, the disposal of waste into the sea

that results from products and by-products has contributed to the degradation of many marine and coastal ecosystems. Harmful algal blooms (HABs) around the island are becoming more common.

Several marine institutions are actively involved in chemical oceanography activities. The AFRC undertakes long term monitoring of coral reef ecosystem, monitor coastal water quality at several sites and monitor coliform bacteria in sea water at public beaches. The MOI is active in pharmaceutical research on new marine organisms.

4.9.2.1 Needs identified

Expertise in chemical oceanography will increasingly be in demand for operational and research activities. The increase emphasis to make Mauritius a sea food hub will create new opportunities in this area. Improved technologies for observing and characterizing the distribution of food web components and their associated interactions across time and space will be required. Extensive time series data from both remote sensing and in-situ systems will be necessary to compensate for the substantial spatial and temporal heterogeneity that exist in the marine environment and to improve the resolution of the paleontological patterns. Emerging molecules, chemical, optical and acoustical technologies should lead to significant improvements in remote sensing capabilities. Isolation of molecules (bioactive compounds) from marine organisms for use in pharmaceutical industry is becoming a promising field for research. New avenues for the culture of marine organism – pearls, oysters, algae and mussels- will create new job opportunities.

A first degree in Chemical Oceanography is not currently available at any tertiary Institutions. It is noted, however, that it has included several modules in marine science degree courses. However, as discoveries on new ways to use the ocean unfold, more opportunities for chemical oceanographers will become available. Emerging issues such as ocean acidification and increasingly growing pollution from land and sea based sources will enhance the need for more chemical oceanographers.

4.9.3 Biological Oceanography

Biological oceanography is a field of study that seeks to understand what controls the distribution and abundance of different types of marine life, and how living organisms influence and interact with processes in the oceans. It is also the study of all forms of life in the oceans, from microscopic plants and animals to fish and whales. In addition, it deals with all forms of oceanic processes that involve living organisms. These include processes that occur at molecular scales, such as photosynthesis, respiration, and cycling of essential nutrients, to large scale processes such as effects of ocean currents on marine productivity.

Better sustaining the biological resources in the coastal and EEZ of the Republic of Mauritius requires a better understanding of the marine food web. Though most of the marine scientists in the country are marine biologists and many studies on marine biology have been conducted, some studies have still to be done to determine the functional and structural dynamics of these biological assemblages and how they respond to environmental perturbations. A better understanding is also needed to identify the linkages between primary and secondary productivity. Also of underlying importance is the need to understand the interactions between marine data and various biogeochemical cycles, influencing any global change. These interactions can occur from the

individual organism level to the ecosystem level. Better mechanistic understanding of these interactions through observation and controlled experimentation is required to meet threats of marine ecosystems.

The UoM does not offer biological oceanography as per se. However, there are many graduates who have taken modules relating to biological oceanography. For instance, for BSc (Hons.) Biology (Minor: Forensic Science or Marine & Coastal Environmental Science)/MSc Biology. This is a new course to be offered as from August 2010. The biology graduates are trained so that they can seek employment in private seafood and marine industries.

To recruit personnel to perform activities relating to biological oceanography is not usually difficult. The AFRC, MOI, MoE and UoM are involved in many aspects of biological oceanography. Nevertheless, as indicated above, there is still plenty of scope in the field activities which will develop in the future.

4.10 Coastal Zone Management

The concept of Integrated Coastal Zone Management (ICZM) began with the coming into force of the Environment protection act of 1991. An environment Impacts Assessment Process was established under this act. A National Physical Development Plan followed in 1995.

An ICZM Division has been set up within the Ministry of the Environment as a result of a recommendation made in the National Environment Strategy (2000 – 2010). An ICZM national Committee comprising all stakeholders have been set up for judicious management of the coastal region. Its activities include:

- The National ICZM Committee of Mauritius is concentrating on Flic en Flac and Le Morne and La Gaulette (all southwest coasts) as a focus/ pilot areas for the development and implementation of an ICZM Plan.
- A project '**Developing a Strategic Plan for Integrated Coastal Zone Management' for Mauritius and Rodrigues**'is being finalised.
- A third Working Group has commenced working on a draft **National ICZM Plan for Mauritius**

In Rodrigues, the **ICZM Committee Working Groups** are active and are producing the following tangible results and outputs:

- Development of the ICZM Plan for Rodrigues
- Finalising of Terms of Reference of the ICZM Committee for approval by the Rodrigues Environmental Committee (REC) and Rodrigues Regional Assembly (RRA)
- Development of a Coastal Documentation and Data Service Centre including GIS Data Base accessible to Rodrigues ICZM Institutional Actors and other stakeholders
- Improvement of ICZM Communication modes between the ICZM Committee, the ICZM Framework and other coastal development stakeholders in Rodrigues

Two tools, which are increasingly being utilized in proper coastal management, are:

- Geographical Information System (GIS) which **analyses** and **synthesize** a broad set of data to present information in a friendly way in the form of colourful maps for easy understanding and
- MPAs to protect, in an effective way, marine biodiversity in coastal and offshore region.

4.10.1 Geographical Information System (GIS)

Many institutions are now realizing the capabilities and power of GIS technology in the field of planning, environmental management, site allocation and resource management to assist managers and decision makers in taking timely and right decision for the effective management of spatial resources.

Since 2005 several governmental departments are implementing major GIS projects. These include:

- Environmental Sensitive Area (ESA) and the Integrated Coastal Zone Management projects of the Ministry of Environment,
- The LAVIMS project of the Ministry of Housing and Lands,
- GIS project of the Central Statistic Office.

Each department is implementing their GIS on their own and sometimes results to duplication of work leading to wastage of time and money. Since 2006, 6 cartographers from the Ministry of Housing and Lands have completed a professional diploma in GIS from Salzburg University, Austria and one cartographer has done a Master course in GIS. There are several people from various departments and institution like the MOI, MSIRI, water resources Unit, Ministry of Fisheries, Meteorological services who have obtained technical assistance and training from foreign institution.

With regards to the marine sectors, the status is given Table IV

Table IV. Status of GIS in the Marine Sectors

Institution	Purpose	Equipment/software	Human resources
Ministry Agro-industry and FP & S - Marine Science Division	Marine and Coastal research,	Plotter - size E (36"X 7ft) 1 Eliminator 1 Zip drive- portable (for back-up) MapInfo ArcView	Six technicians followed a short course by the CIDA team who are developing the Marine GIS. Group reduced to three in the second follow-up short session. One of them planned for more advanced training in Canada.
Meteorological services	Weather Forecasting,	PC IDRISI	One trained person sent for training but his skills are not sufficient to set up or operate a meteorological GIS
Ministry of Environment and NDU	Management of Environment, ICZM and EIA	Sun Sparc Workstation Mirror stereoscope Scriber ERDAS/Imagine - Image processing ARC/INFO	Two members of staff followed short courses in Australia and Nairobi. Their skills are not adequate to implement a GIS project.
Mauritius Oceanography Institute	Analysis of satellites images-chlorophyll, SST and altimeter ; bathymetric mapping;	ARC info ARC View Various software procured for several projects	Training received

The International Institute for Aerospace Survey and Earth Sciences of the Netherlands recommended that for GIS technologies to be successful, minimum personnel training should comprise the following groups: (Bernhardsen 1992)

- Decision makers and planners, including officials and administrators who need a general understanding of the practical possibilities and limitations of GIS as a decision making tool
- Leading personnel in institutions, public management agencies and private companies, who need sufficient technical knowledge to coordinate the introduction of GIS
- Technicians responsible for the operation and maintenance of equipment and programs
- Research workers knowledgeable in GIS and with expertise in applications development and in GIS as an analytical tool
- Instructors responsible for training and teaching the various categories of personnel and knowledgeable in GIS technologies and their practical applications
- School pupils and University Students.

4.10.1.1 Needs identified

Application of GIS software is usually very sophisticated and requires several months of intensive training. The competence of the local scientists is not increasing at the rate of the technology transfer. To operate a GIS correctly, there is a need for competent personnel who can manage the GIS when it is implemented. Local technicians require dedicated preparation in the theoretical and practical aspects of the technology.

In spite of much effort to promote training in GIS, there is currently a shortage of adequately trained people in the country. Most of the GIS projects are implemented mainly by foreign consultants. After their departure, projects are left at a standstill and incomplete. Neither the University of Mauritius (UOM) nor the University of Technology (UTM) run GIS courses due to lack of resources.

Its application has to be seen from a national perspective. There is a pressing need for the setting up of an appropriate training program, which will foster the implementation and exploitation of GIS technology in the country. All the sectors concerned with GIS technology, private and public, have to put their efforts together for mutual benefits to develop a ***National Spatial Data Infrastructure,*** which will be responsible for data sharing, GIS awareness, capacity building and project implementation.

4.10.2 Marine Protected Areas

Marine Protected Areas (MPAs) are one of the most effective ways of protecting marine biodiversity and serve as a vital management tool for coastal fisheries. These two economic sectors benefit from MPAs, in particular. MPAs have developed rapidly in response to the worldwide degradation of the marine environment.

Manuals with guidelines are available for their proper management. They are usually managed by a range of officers: managers, wardens, rangers and others who have to deal with a multitude of different situations, issues and problems on a daily basis. These may range from purchasing a boat, managing staff, annual planning, monitoring fish populations in the MPA, building an information centre, consulting local villagers, to writing a proposal to secure funding.

MPAs range from small reserves aimed at protecting a single species to large biosphere reserves, which manage a large tract of ocean according to an integrated management plan.

In Mauritius, eight MPAs, as shown in Table V, have been proclaimed in 1999 under the Fisheries and Marine Resources Act, of which, two have been designated marine parks: Blue Bay in the south coast and Balaclava on the west coast. A long term monitoring has been proposed for these reserves.

Table V - Marine Protected Areas in Mauritius

Mauritius Marine	Date established	IUCN category	Size sq km

Protected Area			
Balaclava Marine Park	1997/2000	II	5.0
Blue Bay Marine Park	1997/2000	-	3.50
Black River Fishing Reserve	1983/2000	IV	7.80
Grand Port Fishing Reserve	(Zones A & B) 1983/2000	IV	18.30
Port Louis Fishing Reserve	1983/2000	IV	3.30
Poste Lafayette Fishing Reserve	1983/2000	IV	6.00
Poudre d'Or Fishing Reserve	1983/2000	IV	25.40
Rivulet Terre Rouge Estuary Reserve	1999 -		
Trou d'Eau Douce Fishing Reserve	1983/2000	IV	5.70

4.10.2.1 Marine Protected Area in Rodrigues

An MPA was implemented in June 2005 at Port Sud Est, Rodrigues as a pilot project following the setting up of a South East Marine Protected Area (SEMPA) Project Management Unit (PMU). Activities which have implemented include:

- An awareness campaign initiated by the PMU involving the local fishermen community villages of the localities, students and private sector with the collaboration of local NGOs.
- Committees have been set up to ensure the involvement of the different stakeholder level in the decision making process
- A South East Marine Protected Area Management Board has been set composed of representatives of the government, the Rodrigues Regional Assembly, civil society, NGOs as well as the private sector to improve coordination of the coastal zone activities and help achieve integrated marine resource management at the site through a concerted effort by all stakeholders.
- Scientific works have been carried out in field to assess the present status of the SEMPA and to establish baseline information for long term monitoring of SEMPA resources.

The SEMPA was proclaimed a MPA on 28 February 2009 in the Government Gazette. The interior parts of the MPA have been demarcated by 11 buoys. The whole demarcation is in the process of completion for effective management. Additional staff including rangers is being recruited for enforcement of law within the SEMPA. A Training program has been prepared to equip the ranges with the skills and knowhow for the job.
The project is expected to:

- Contribute to the national efforts aiming at conserving the unique marine biodiversity of the country by promoting policy and legislation, developing effective financial mechanisms,

strengthening institutional and human resource capacity for the creation of a national system of Marine Protected Areas.

- Provide long term livelihood benefits to the resident fishing community, by helping to assure the sustainability of fishing activities.
- Create opportunities for communities to diversify their livelihoods by becoming involved in eco-tourism based activities
- Provide an opportunity for environmentally sensitive development of a growing tourism industry and develop the capacity of the tourism sector to work with local communities in ecotourism based activities at the demonstration site.

However, many challenges have been identified to implement the project. These include:

- Management of the MPAs through instruments of command and control model is costly in terms of financial resources and manpower for enforcement.
- Compliance with established regulations tended to be poor because a number of stakeholders are directly dependent upon marine resources and the coastal zone and any conservation efforts will depend upon their commitment and support.

To address the challenges, co-management arrangements involving Government authorities, local communities and private enterprises are being promoted. These include the Rodrigues Regional Assembly, local fishermen, octopus fishers and tourism operators.

4.10.2.1.1 Needs identified

Some more funding has been secured from external sources to continue the SEMPA project demonstrating its effectiveness. However, new areas, perhaps starting with one in the north should be identified to extend the project to other regions. For the purpose, more trained scientists and technicians and empowerment of other stakeholders would be needed.

4.11 Marine and coastal geology and geomorphology

Mauritius is overwhelmingly of volcanic origin and has been constructed by three distinct episodes of volcanic activity, related to the activation of faults in the oceanic plate. The ancient series (10 -5 M.Y.) caused the emergence of the island, the Early volcanic series (3.5 -1.7 M.Y.) which are exposed only to the south west of the island and recent series (0.7-0.2 M.Y.). The latter episode is the most important and extensive one in terms of aerial average and has shaped the coastal plains. Most of the lava of the recent series slope very gently towards the shore, especially along the northern and eastern coasts. However, steeper slopes are observed in the recent series along the south-eastern and western slopes. This has originally shaped the coastline, the width and depth of the lagoon and the distance of coral reefs from the shoreline. Evolution of the shape of the shape of the shoreline and diversity of the beach characteristics can be attributed to various and shore term natural environmental factors. Among them are tectonic, eustatic, biologic and climate factors. Human activities-ports building, revetment and seawalls construction to protect against erosion-have modified the shoreline in the last few decades.

Two long term phenomena, the rise in sea level relative to land and the concept of an equilibrium profile, have resulted in the current characteristics of the particular section of the shoreline. Sea level has been changing over geological time with the growing and melting of ice. There have been at least four sea level fluctuations. These sea level fluctuations have left their marks on coastal landforms especially in the south and south eastern sectors of the island. The last ice age occurred about 20 000 years ago and the sea level was 120 m below its present level. Gradually with warming the sea level rose and reached its present level around 6000 years ago. The existence of a shallow shelf has given rise to a remarkably well developed coral reef. Coral reefs formation started about that period. With time the destruction of the coral reefs and abrasion of sea shells gave rise to sand deposit on the shoreline and formation of the white sandy beaches around the island. A black sand beach of terrestrial origin from weathering of basalt rocks, however, exists in the North West at the mouth of the Grand Riviére North West.

The island is now surrounded almost completely by coral reefs only at two places – in the south along almost 20 km from Souillac and 13 Km at Pointe Vacoas in the west between Albion and Pointe aux Sables with some gaps and passes opposite estuaries. Coral growth is very sensitive to oceanic conditions such as salinity and depth. In these two regions the sea is relatively deep and is thus not favourable for coral growth. Coral reefs are mainly of fringing type and its distance from the shoreline varies from place to place according to the geology of the underlying rocks. Winds, waves and cyclones have gradually shape the coast line. A barrier reef is present off Mahebourg. Numerous passes also exist around the island and they are located usually near river mouths.

A lagoon surrounds the island except in the two regions where coral reefs are absent. The width varies from place to place. It generally lies between a few tens of metres and a few hundred metres along the west, north and south with almost no lagoon in places where coral reefs are absent. In the east, it extends over more than 2 km. Its depth is less than 1 m at low spring tides and may reach more than 20 m where channels are present in the fringing and barrier reefs. The lagoon is mostly sandy filled in places with broken corals. Sea grasses are present in many places.

Depositional features on the beach and granular size of the deposits depend on many factors including its distance from the coral reefs and depth of the lagoons, river outflow characteristics at estuaries and its geographical position. It can be muddy-silty, sandy, pebble cobble or bolder beach. The most frequently observed type of beach in Mauritius is the sandy beach made of carbonate sediments originating from coral reefs and shells along the low-lying coastlines of the Recent Series lavas. Sand dunes are present on the backshore. Estuaries are conspicuous features along the shorelines. Deltas are observed in a few places mainly at GRNW, Grande Riviére Noire in the west and Baie du Cap in the south.

Many attempts have been made to divide the coasts into segments based on wave exposure and geomorphological formation, sensitivity of the coastal zone to oil spill response, Guidance for vulnerability and Adaptation Assessment (US Country Study Programme) and the nature, structure and age of underlying rocks and morphological characteristics of the beach. Ragoonaden has used the physical characteristics of the beach and shoreline, prominent headlands and estuaries, width of the lagoon and distance of reef from shoreline, land catchment area and major river outflow to divide the coast into 10 geo-morphological homogeneous units and several sub-units.

4.11.1 Needs identified

The geo-morphology of the shoreline around Mauritius is changing and will continue to change as a consequence of natural forces and human interference. Climate change and Accelerated Sea Level Rise will enhance the process. Studies need to be undertaken to understand past and present processes and make projection on future changes. The outcomes will be required to develop strategies to adapt in a proactive way to the scenario.

4.12 Aquaculture

Aquaculture, particularly marine culture, has tremendous potential for the socio-economic development of the country. Aquaculture is being encouraged to further enhance the fisheries sector. It is an important activity of the AFRC. It includes:

- Seed production of berry rouge and giant freshwater prawn for distribution to fish farmers
- Breeding of freshwater ornamental fish such as sialfin molly, platy and goldfish
- Phytoplankton and zooplankton for seed production of rosenburgii and feed rotifer
- Camaron seed production.

A fish farm at La Ferme Marine de Mahebourg, located in the south east, is operational since 2002, in the culture of red drum fish using new technology in cages. It is now exporting its aquaculture products to the EU and other countries. In 2007, the total harvested catch of red drum was 550 tons.

It is the policy of the government to encourage aquaculture particularly marine aquaculture. This is expected to play a determining role in the fisheries sector. The Fisheries and Marine Resources Act 2007 has been amended to encourage this activity and a master plan has been developed. A study to assess the potential of aquaculture development, identify potential sites and sustainable species for aquaculture has been conducted. The study revealed that an annual production of 29,000 tons to 39,000 tons of fish in the medium to long term with the possibility to create a total of 4,000 jobs is potentially possible. It is intended to develop marine aquaculture gradually. Out of the fourteen sites proposed for fish cage culture in the Mahebourg region in the Aquaculture Master Plan, only eight sites, where fish cage culture is to be undertaken, will be developed in the first instance. Out of the eight sites, two of them are operational under the Ferme Marine de Mahebourg. Potential sites have been identified in the south east region.

In view of the growing importance that marine culture will assume in the future, it is imperative that a CB & T strategy be developed to produce enough technicians and scientists to cater for the need in appropriate fields.

The UoM offers BSc (Hons) Agriculture with specialisation in Aquaculture, to equip students with a broad spectrum of scientific, technical, managerial and business skills needed to contribute to the development and enhancement of agriculture, particularly aquaculture. A module is devoted to Marine Aquaculture and Technology and an elective on Sustainable Fisheries Management. The BSc (Biology) also provide some courses in aquaculture.

4.12.1 Needs identified

Some short courses on marine culture should be organized at regular intervals with emphasis on new technology for the benefits of technicians and marine scientists. Exchange programme with countries where marine culture is well developed is to be encouraged to learn best practices for adoption in Mauritius.

4.13 Coastal agriculture and forestry

Some vegetables are produced in the coastal region. Some regions have also sugar cane plantation. With regards to coastal forestry, mangroves predominantly cover the region.

4.13.1.1 Coastal agriculture

The Republic of Mauritius consists of a group of islands with a total land area of around 2045 km^2 within an Exclusive Economic Zone of 1.9 million km^2. The mainland, Mauritius, is the largest with an area of 1865 km^2, and comprising a coastline of 322km, out of which some 42 km are declared public beaches. High quality land, particularly close to urban strips and prime coastal areas, is scarce and is sought after by a variety of competing users. Coastal vegetation covered in the past most of the coastal strips. However, large areas have been cleared for coastal development.

4.13.1.1 Need identified

Coastal agriculture covers onion and eggplants plantation mostly in the east, which produce high quality vegetables and banana plantation. Some studies have been done on the impacts of the coastal vegetation, particularly abuse use of fertilisers, on the coastal environment. Further studies need to be conducted in order to develop good agricultural practices.

4.13.2 Mangroves

Mangroves are important assets to the inshore ecology and should be protected and propagated where suitable. It acts as wind belts, shore line protection, habitat for crustacean and other wildlife including birds, as well as nurseries and breeding ground for marine life.

Mauritius lost 30% of mangrove cover in 7 years (1987-1994, from 20 km^2 to 14km^2). Through years, the extent of mangroves cover has significantly decreased through illegal cutting for firewood, construction purposes and for providing passage for boats. There are two species - *Rhizopora mucronata* and *Bruguiera gymnorhiza*. A propagation programme has been initiated in the late 1990's and is ongoing. Between 1998 and 2003 some 198,500 mangrove seedlings were planted, giving an average of about 33,000 seedlings per year (MoF, 2005). As an indication of area concerned, between 2000 and 2002, the area planted in mangrove covered 5.9 ha (MoF, 2004, 2005). The average survival rate recorded for seedlings planted between 1998 and 2002 stood at 70% (MoF, 2003). The area has now increased to more than 100 hectares.

4.13.2.1 Needs identified

There are still extensive coastal areas for the implementation of a reforestation and afforestation programme. However, some studies need to be done on salinity, soil type and water quality in order to identify potential areas for an extensive and well planned scientifically sound extension of the propagation programme. The capacity for this activity does exist. What is needed is the political will.

4.14 Climate research

The climate in the region of Mauritius is typically tropical maritime with prevailing South East trade winds. The conical shape of the country, however, gives rise to significant micro climate though it is only 60 km by 40 km. The average amount of rainfall increases gradually to almost five times from the coastal region towards the central plateau. The regional average temperature difference is about 6 deg C. It is located in the tropical cyclone belt of the South-West Indian Ocean.

4.14.1 Climate and sea level studies

Climate generally influences all socio-economic activities. In Mauritius, the close monitoring of weather, on account of its large temporal and spatial variability over the region, is one of the most important functions of the Mauritius Meteorological Services. It is worth noting that observations started very early since the18th century. More than 100 years of rainfall and temperature records are available for many stations scattered over the island. Weather observations started in the outer islands of Rodrigues, St Brandon and Agalega in the 1950s.

Many climate studies on available data have so far been done particularly on temperature and rainfall. Analyses of temperature show a definite warming trend. Average temperature at Vacoas over to the central plateau and Plaisance in the south east during the last ten years (1998-2007) compared to the decade 1951-1960 indicates a rise of 0.74 and 1.1 ˚C respectively. Most of the warming started as from the mid-seventies. Rainfall amount over the past century (1905-2007) show an almost 8% decrease in the last decade when compared to the 1950s. Heavy rainy episodes have, on the other hand, increased with more frequent flooding occurring. Moreover, the onset of summer rains which used to be the beginning of November is now occurring in late December. Since the past four summer seasons, the start of the rains was only in January of the following year.

A sea level station was established in Mauritius in August 1986 and Rodrigues in November 1986 within the framework of the Tropical Ocean and Global Atmosphere. Analysis of the recent sea level research quality data shows an accelerated sea level rise of about 3 mm/yr since 2005 as compared to about 1.8 mm/yr previously.

With regards to cyclone formation, an increasing trend in the number of intense cyclone (winds above 165 km/hr) has been noted. In the last decade, observation indicates a rapid or even explosive intensification of tropical storms.

4.14.2 Climate projection and impacts

As noted above, Mauritius is already experiencing the influence of global warming. Climate Change and Sea Level Rise is an emerging and cross-cutting issue which should be addressed urgently. It is expected to have major impacts on various socio-economic sectors and the physical environment. Model outputs on climate change projections indicate a temperature increase in the range of 0.51 to 3.77 °C and sea level rise between 18 and 59 cm by 2100. It is projected that the changes will result in:

- Continued decreasing trend in annual rainfall
- Increase in number of heavy precipitation events with increasing risk of flash flood
- More frequent heat waves in summer and milder winters
- Increase in the number of intense tropical cyclones
- More occurrences of heavy waves affecting the coastal region.

The impacts on the coastal and marine resources and ecosystems will be quite significant. These will include:

- Enhanced coastal erosion already ubiquitous around Mauritius.
- More frequent episodes of coral bleaching and mortality.
- Coral growth unable to keep up with accelerated sea level rise'
- Inland movement of mangroves leading to "coastal squeezing".
- Salt intrusion affected coastal ground water boreholes.
- Increasing events of coastal inundation from higher and more frequent wave occurrences.

4.14.3 Future climate studies and research

Climate change and sea level rise is projected to continue for decades, if not centuries, even if the emission of GHGs is drastically reduced and stabilised. However, the magnitude of change will differ from region to region and country to country. Even on a national scale, local changes and impacts will be different. Consequently, continuous monitoring to obtain a long series of data and research should be envisaged to devise response measures. Some actions have already been taken. These include:

An increase in the network of automatic weather stations from 16 stations in 2005 to 21 stations in 2009. Two new tide gauges installed – one at Blue Bay (in January 2009) and one on the outer island Agalega (in December 2008).

The IPCC Fourth Assessment report (September 2007) noted that it is now more apparent than the previous report (2001) that the most apparent response to sea level rise for coastal areas is a combination of ***adaptation*** to deal with the inevitable rise and ***mitigation*** to limit the long term rise to a manageable level. However, for small islands like Mauritius, policies on effective adaptation, that is, to take actions to adjust to changes in natural/human systems in response to climate change to moderate harm and exploit beneficial opportunities is a top priority. It has been demonstrated that adaptation costs for climate change will, indeed, be much lower that damage costs just considering property losses and human deaths.

Many actions have been taken mostly in the energy sector to reduce the emission of GHGs. Households as well as businesses to produce electricity using renewable energy technologies are being encouraged. Small Independent Power Producers with capacity below 400 KW will be allowed to feed into the national grid of the Central Electricity Board (CEB). Solar water heaters have been heavily subsidised and 1 million low energy compact fluorescent lamps have been distributed to encourage energy saving.

However, adaptation to climate change remains a significant challenge, requiring massive investments. The main constraint in the implementation of adaptation programmes is the scarcity of financial and trained human resources.

Coastal erosion is already ubiquitous around Mauritius. It will be compounded with the projected sea-level rise. It has been demonstrated, through surveys, following the often quoted Bruun rule, that coastal erosion will be 50 to 200 times the rate of sea-level rise. Moreover, with an increase of 1º C in sea temperature, coral bleaching is expected to occur more often and in case the threshold of 2º C is exceeded, mortality could ensue putting at risk the sandy beaches. The heavy swells of May 2007 and the unprecedented flooding episodes of March and September 2008 due to torrential rain are indications what could be the scenario in the years to come.

4.14.3.1 Needs identified

Many actions have been taken so far to limit the impacts. Hard engineering measures including gabions, sea walls and offshore breakers have been taken with mixed result whereas soft measures like mangrove propagation and ban on sand mining have been effective. However, this is not enough in the face of climate change and sea level rise. In the short term, the following proactive measures should be taken order to develop capacity for climate change adaptation:

(i) A new vulnerability assessment for the coastal zone should be carried

A vulnerability assessment was conducted in the mid-1990s based on IPCC common methodology developed in 1990. It was estimated that 12 km. of primary roads and 25 km. of secondary roads would be inundated and about 1000 houses affected with a 1 m sea level. This methodology has been updated, refined and considerably improved for more effective application in the light of recent findings.

Using the up-dated method, a new assessment should be made.

(ii) The concept of "climate proofing" should be mainstreamed in development projects, land use planning, regulations and permitting and national development planning.

Climate proofing is a risk-based approach. It is a process to reduce to acceptable levels, the risks due to climate variability and change including extreme events. It enables a cost-benefit analysis to be made to determine the incremental cost of projects in normal conditions and taking into consideration changes in climate parameters- wave height, wind force and rainfall- as a consequence

of climate change. It has been found more effective to mainstream climate proofing in new development projects as the incremental costs are recovered after some years. Many countries have adopted this approach.

(iii) A new set back distance should be determined to take climate change into consideration.

Presently the set back distance to be observed for coastal development is 30 m between the high water mark and construction. This should be reviewed. Some countries have adopted a setback of 100 m for any coastal development.

Local experts do exist to carry out some of the tasks. However, assistance from international experts will be required on some aspects. For medium and long term measures, a strategy should be developed involving all stakeholders to prepare a plan for actions in climate research and effective measures that should be taken to mitigate the impacts of climate change and sea level rise.

Coastal monitoring, particularly changes in shoreline retreat, is limited. Long time series of quality data is a prerequisite for the effective management coastal zone. Systematic, routine and continuous data collection is needed for the following elements for climate and sea level research:

- Sea surface temperature to one degree decimal point accuracy in the coastal zone and offshore areas.
- Coastal erosion and shoreline retreat using MSL as the reference datum
- Wave height and period in the coastal zone and open seas
- Absolute sea level
- Coastal air temperature and rainfall.

4.15 Microfauna and Meiofauna

Microfauna are the smallest animals (i.e. micro-organisms) which live on the earth surface. **Meiofauna** is the part of microfauna which inhabits algae, rock fissures, and the superficial layers of the muddy sea-bottom. More information is given in the MEDA report

Marine pollution mainly from land based sources is causing lagoon water degradation in many regions around Mauritius leading to loss of micro and meiofauna. An abnormal high number of harmful algae bloom have been noted on some beaches. At certain location, the absence of appropriate sewerage system near the seaside has contributed towards increase in lagoon nutrient causing eutrophication, leading to local population decline of some marine species, and sometimes to severe damage to coral reefs.

Destructive fishing methods such as dynamite fishing and overfishing are causing much damage to the fishing population. Marine aquaculture is another source of marine degradation to microfauna and meiofauna.

4.15.1 Need identified

Expertise in the field is scanty. There is a need for training. The University Institutions should introduce specialised modules on microfauna and meiofauna.

4.16 Macrofauna

The macrofauna diversity in the country is now well documented. Macrofauna comprises of 10 major faunal groups- polychaetes, pelecypods, isopods, ohiuroids, tanaidaceans, amphipods, gatropods, branchiopods, echiurid worms and sipunculids. Polychaetes are the most important macrobenthic group with 100% prevalence followed by peracarid crustaceans and mollusks. Among crustaceans the isopods occur more frequently than either amphipods or tanaidaceans. Agglutinating rhizopod protozoans are also encountered.

4.16.1 Invertebrates

Several species of crabs, shrimps, lobsters, molluscs, octopus and sea cucumbers are abundant in the waters of Mauritius and are of commercial value. Four species of crabs and five species of Penaeid shrimps as well as two species of deepwater shrimps have been identified and are currently being fished. Two species of lobsters are fished around Mauritius and St Brandon. Other marine invertebrates comprise polychaetes (52%), bivalves (13.7%) and isopods (12.3%). Among other groups, amphipods are important. Over 60% of the macrofauna is concentrated in the top 4 cm depth of the sediment.

4.16.2 Fish and fishery resources

Fish is an important source of animal protein for the population. It is consumed by almost all sections of the Mauritian society. Fishery resources which have been traditionally exploited are found in the lagoon and offshore areas around Mauritius, Rodrigues, St. Brandon, Chagos Arfchipelago and other outer islands. There are four main types of fisheries in Mauritius namely; (i) artisanal fishery; (ii) sports fishery; (iii) banks fishery: and (iv) tuna fisheries. Artisanal fishing is limited to the lagoon and off lagoon areas. It provides employment and livelihood to some 2200 registered fishermen and their families.

Banks fishery supplies almost all the frozen fish consume in Mauritius. The major banks are located between 400 and 800 km north of Mauritius. Twelve fishing vessels are in operation and their total catch which comprises mainly lethrinids (90%) amounts to around 3000 tonnes annually.

Tuna fishery comprises (a) coastal tuna fishery and offshore industrial tuna fishery. Tuna and tuna-like species are caught by local fishermen near the coast and mainly around FADs. The total landings from FADs and sport fishermen are estimated at around 650 tonnes annually. Species caught are bigeye tuna, skipkjack, yellowfin tuna, dorado, wahoo and sharks. Industrial tuna fishing is carried out mainly by long liners and purse-seiners.They are mostly licensed foreign fishing vessels and the catch about 10 000 tonnes yearly in the EEZ of Mauritius.

The fisheries resources are however decreasing in the region mainly due to overfishing. Many regional projects are being implemented within the framework of the Indian Ocean Commission to address the issue. Mauritius is participating in most of the projects.

4.16.3 Mammals

Marine mammals include the dolphins, whales, seals, sea lions and dugongs. Sea cows, once common in the lagoons of Mauritius are extinct, due to lack of undeveloped beaches, intense hunting pressure and predation by alien species. Seventeen marine mammal species have been recorded in Mauritian waters – mostly as they migrate to and from Antarctica to warm tropical waters for calving. Dolphins are encountered more frequently than whales, although the breeding and nursery grounds of the dolphins have not yet been located. Whale watching and dolphing watch are becoming very popular tourist attractions in Mauritius

4.16.4 Birds

Shoreline birds Information on seabirds and shoreline birds are very limited. The Rivulet Terre Rouge Bird Sanctuary located in the North East of the island, near the Port Louis Harbour is a tidal mudflat that is used as overwintering areas by migrating shorebirds. Around 1000-100 migratory birds visit this site each year representing 11 regular species and 4-5 vagrant species (Bird survey count 1997, NPCS unpublished).

4.16.4 Exotic and invasive species

Invasive species have been recognized globally as a major threat to biodiversity Species and their interactions with ecosystems are very complex. In Mauritius no marine invasive species have been recorded in the Global Invasive Species Database. However, Caulepa taxifolia which is known to occur at some sites in the lagoon of Mauritius is an invasive marine algae that form dense monoculture that prevent the establishment of native seaweeds and excludes almost all marine life and thus affecting the livelihoods of the fishermen. It is usually introduced via wastewater effluents.

Need identified

Most studies have been limited to fish resources. However, other types of macrofauna are not well covered. For instance, the distribution of benthic fauna in the EEZ of Mauritius has not been extensively studied.

4.17 Environmental Education and human health

Environmental education, at all levels from grassroots to policy makers by the Authorities to sensitise the population on the environment and its relation to sound socio economic development, is continuously being developed and strengthened. It is available at primary, secondary and tertiary levels but not as a separate subject. Materials have been developed to incorporate in other disciplines. In primary and secondary school, it is integrated in science and geography subjects. At tertiary level, specialised topics are included in some undergraduate and post graduate courses.

Informal education on the environment is promoted by the Ministry of Environment and National Development Unit through the Information and Education Division of the Department of Environment. Nearly 20 NGOs on environment education and awareness are registered with the Ministry. Talks, presentation and shows are organised regularly for the benefits of school children and senior citizens, women and youth in social centres.

Marine related environment education is also well covered in a formal and informal way. Many NGOs are involved in informal marine education. These include the Marine Conservation Society, Mauritius Underwater Group, Mauritius Scuba Diving Association, Association pour le Développement Durable and Mauritius Scuba Diving Association (MSDA). The MSDA has established a Public Beach Centre at Pérébere in the North to provide marine environmental education to primary school children. It has developed hands 0n and interactive materials such as posters, booklets and a 3-D model of the lagoon. It offers also snorkel training and initiation to SCUBA diving as well as educational glass bottom boat and snorkelling trips to children and the public to sensitise different socio-economic groups.

However, much still remains to be done in the area of formal education in marine sciences. Though complete chapters are dedicated to some environment topics such as weather, air and water, topics on marine sciences are quite fragmented and not well harmonised in formal text books. This is a major gap that has to be addressed. Some attempts have been made by the MSDA and Reef Conservation (Mauritius) to introduce basic marine science concepts in the national curriculum in collaboration with the Ministry of Education. It is developing educational materials consisting of lesson plans and hands-on practical tools to complement the Discovering the Ocean World teacher pack produced by Shoals Rodrigues.

As an insular country, the issue of enhancing the teaching of the marine environment has been raised on many occasions during national fora and debate. There is some opposition to widen the curriculum base to include the ocean as a separate topic to give it the same status as some existing natural environmental subjects. The curriculum is already overloaded and the introduction of new topics is not considered a priority. However, it is widely recognised that more consideration should be given to the teaching of marine environment as from an early age. The situation is evolving. New development is taking place, which will gradually lead to more focus being given to marine science teaching.

4.17.1 Introduction of marine science at A- level

The Ministry of Education, Culture and Human Resources has approved that the MES introduces Marine Science (Subject code 9693) as a subject at the HSC/ A- level in schools for the first examination to be planned for 2011. It is offered as an option to schools, which are willing to teach the subject if educator resources are available. The course content concentrates on the scientific study of the sea and its ecosystems as well as on human activities that depend on the sea and have an impact on it.

The introduction of this new subject is in line with the Government's policy of offering a quality education to our students and at the same time broadening the curriculum base. It is expected that, with the introduction of this subject, students will be motivated to pursue higher studies in this area and later join the tourism industry, the seafood hub and the land based Oceanographic Industry areas, which are developing rapidly.

It is also noted that possibilities are being explored for integrating some basic aspects of marine science in the 21 Century Science Syllabus, which is being presently piloted in some secondary

schools at the level of Form IV/ V. This subject is intended to students of Form IV and V who are doing non-science streams. Consideration is being given for this subject to be introduced in all Secondary Schools in Mauritius and Rodrigues with effect from 2011.

4.17.2 Needs identified for marine science teaching

In view of the policy of Government to give more importance to marine science in school in the near future, interest on the subject should be generated at an early age. At primary level, the topic should be introduced as an important part of the science and geography subjects. Guidelines and pedagogical materials should be made available for the purpose. At the early secondary level, manual on marine sciences, relevant in the context of the country, should be developed for teaching purposes. The Mauritius Institute of Education has an important role in the process to train teachers to teach properly the topic in schools. Much emphasis is laid on practical aspects and demonstration practices to better arouse interest for higher studies.

4.17.3 Marine environment and Human Health

The coastal marine environment provides a source of food, employment, recreation and residence, and is the first defence from various natural and man-made hazards and disasters. These coastal areas are impacted through land-based and sea-based with vast amounts of wastes entering on a daily basis. Maintaining these as functional and healthy ecosystems is essential for the well-being of the population. Though environmental factors, including salinity, temperature, nutrients and light, influence the survival and sometimes the proliferation of pathogens, human activities such as leaving waste on beaches, oil leaks from boats and polluting rivers also contribute to the coastal pollution.

In Mauritius, red tides and algae blooms occur occasionally due to mainly effluents rich in nitrogen and phosphates. The proliferation of jelly fish is also becoming more common. Rising sea temperatures caused by climate change may worsen the problem because many species of jellyfish are better able to survive in warmer waters. Jellyfish blooms cause many problems. The most obvious are stings to humans (sometimes deadly), and causing coastal tourism to decline. Other problems are destroying fish nets, poisoning or crushing captured fish, and consuming fish eggs and young fish.

4.17.3.1 Needs identified

The most popular recreation of the population is a day at the sea side. Hence in order to protect human health, the education of the population to keep the coastal environment healthy should be enhanced. This could be done through posters, flyers and programme on TV with emphasis on the relation between human health and marine pollution. Youth should particularly be targeted. Beach cleaning is occasionally organised for the benefit of schools to sensitise school children on the importance of protecting and preserving coastal and marine resources. This should become a regular feature and is included in school programmes.

4.18 Tourism

Mauritius has developed a tourism industry of worldwide recognition and the island is now identified as an established destination offering high levels of tourist products and services. Its high quality hotel sector is often described as the best in the world. The basis of its success has been the beauty of the island and the welcome of its people. The tourism industry is mainly coastal-based. The island is surrounded by coral reefs that provide long stretches of white coral beaches. The lagoon and beaches are the key resources that are widely publicized to attract international visitors.

Tourism Industry makes substantial contribution to foreign exchange earnings, Gross Domestic Product (GDP) growth and employment creation. While the sector showed signs of weakening in 2005, it regained dynamism, with 15% growth in arrivals in 2007 and achieving a high 7.5% growth path in 2008. As at 2008, the tourism sector was positioned as the third pillar of the Mauritian economy after the manufacturing sector and financial services. It contributed to 8.7% of GDP; created 28,764 direct jobs and generated Rs. 41,213 million ($1374 million USD) as tourism receipts.

Mauritius has performed well in developing a distinctive form of relatively high-end tourism. Growth in tourist arrivals has outpaced that of many of our competitors. Currently, the aim is to continue that growth with a visitors' target of two million tourists a year by 2015. To achieve the set target, the number of hotels and room capacity has evolved considerably over the years to cater for the ever-increasing tourist arrivals.

Since 2005, Mauritius has been awarded a series of prizes, such as: "World's Leading Island Destination" for 2009, Best Outbound Travel & Leisure Destination by the India Travel Mart, Platinum Award at INDABA 2009 for the SADC category, just to name a few.

The tourism industry is mostly coastal-based. However, coastal degradation is an issue which is causing much concern. On the other hand, Mauritius is planning to receive 2 m tourists by 2015. There is currently a serious scarcity of beach frontage sites for further hotel development and it is estimated that there are no more than some 20-30 further coastal hotel sites that can be made available. The remaining sites have constraints such as cliffs, muddy/rocky beaches and poor access. Furthermore, for a considerable proportion of these proposed sites, implementation of necessary infrastructural amenities will take some time. The challenge is therefore to release agricultural land for the development of inland Integrated Resort Schemes (IRS) and Real Estate Schemes (RES) projects.

4.18.1 Needs identified

Tourists are now environmentally conscious and usually select countries which have a clear and visible programme to preserve the environment. It is noted that many tourists would be prepared to contribute to the implementation of the programme to preserve the marine environment of their preferred destination. They should be made aware of relating activities and presentation made in

hotels by the Authorities concerned. Publicity should be made at the airport and in publications which target the tourism industry.

4.19 Training of inspectors and observers, community involvement? (MCS, including pollution etc)

Enforcement is a complex and difficult issue. The best formulated and comprehensive policies and legislation have no value if they are not implemented properly and associated laws enforced. The institutions which are responsible to enforce marine related laws and regulations are the Ministry of Fisheries and Rodrigues for fishing regulations, Ministry of Environment for marine pollution and the National Coast Guard for illegal fishing from foreign vessels and safety at sea. To ensure harmonisation and coordination among the institutions, refresher training courses on marine laws and regulations and latest technology to detect on illegal practices at sea should be organised at regular intervals to empower inspectors to become more effective to discharge their responsibilities.

In order for coastal management at some sites to be successful, it is vital that a sense of ownership is created within the country involving community in the conservation of coastal and marine resources and pollution abatement is fundamental to achieve concrete result. This bottom- top approach has been successful wherever it has been applied. For instance, in order to implement a mangrove propagation programme in a small village in the South west at Le Morne in 2009, within the framework of a EU/Decentralized Cooperation Programme of the Ministry of Finance, about 10 inhabitants were recruited to be trained and involved in the plantation. Vandalism common in other places where such type of project has been implemented was reduced to a minimum.

It is noted that the cutting of mangrove trees even by the fishing community is still common in many regions in Mauritius and Rodrigues. To obtain optimum result, regular meetings and sensitisation campaigns should be organised with the community including school children, women, senior citizens and youth to raise awareness on the preservation of the marine environment and instil a spirit of stewardship and ownership.

4.19.1 Needs identified

However, trained personnel are required to raise awareness at community level. Many NGOs are involved in the process. These include the Marine Conservation Society, Mauritius Underwater Group, Mauritius Scuba Diving Association, Association pour le Développement Durable and Mauritius Scuba Diving Association (MSDA). They should be kept abreast of new methods and new technology through short courses organised by appropriate institutions.

4.20 Trans-disciplinary training for managers including ecosystem approach

Managers are busy people and in many cases with limited technical background. However, they are key players in the process of conservation and management of ocean resources on whom the fate of a project depends. Hence, it is essential that managers have a broad and wide background on various disciplines of marine sciences. They should be kept abreast of new development and kept up to date with new and emerging technologies. This could be achieved through short courses and be provided

with incentives to attend talks and exhibitions. It is also important that projects, technical reports and workshops outcomes include executive summaries written in simple and non-scientific language with colourful maps and tables to facilitate understanding for effective decision taking.

The Ecosystem Approach is considered one of the most important principles of sustainable environment management. The Fifth Conference of the Parties to the Convention of biodiversity defined the Ecosystem Approach 'A strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way'. Essentially, it requires the taking into consideration of the effects of actions on every element of an ecosystem, based on the recognition that all elements of an ecosystem are linked.

In fisheries activities, the ecosystem-based management, as an appropriate approach, has the way forward to a sustainable fishing industry. In this context, the FAO states that one of the Basic Principles of Ecosystem Management is "The overarching principles of ecosystem-based management of fisheries, aim to ensure that, despite variability, uncertainty and likely natural changes in the ecosystem, the capacity of the aquatic ecosystems to produce food, revenues, employment and, more generally, other essential services and livelihood, is maintained indefinitely for the benefit of the present and future generations, to cater both for human as well as ecosystem well-being".

4.20.1 Need identified

The ASCLME project underscores the ecosystem-based approach for its sound implementation. However, the concept is new. It is not currently being applied due to lack of knowledge. Special training facilities are needed to promote it.

4.21 Fishing technology, implementing of quality control in industry

Fisheries development and services through the sea food hub is a priority on the economic agenda and is contributing significantly to the socio-economic development of the country. The sea food hub is geared towards **"**An efficient and attractive environment for the supply of value added processes and services related to the sourcing and marketing of sea food products**"**. The aim is to focus on the development of value added fisheries and seafood related sectors including fishing, transhipment, storage and warehousing, light processing (sorting, grading, cleaning, filleting and loinning, canning and other ancillary services.

The programme has been developed jointly in collaboration with friendly countries and overseas companies with wide experience in the seafood business. National companies mostly involve in tuna processing (canning, loinning, fresh/chilled/frozen) are participating in the initiative.

Sea food processing is becoming an important activity through the development of the fishing sector. More scientists will be needed in the future Courses in fish technology are presently not available in the country. The laboratory facilities, needed for the course, are very demanding and equipment for practical training very complex and expensive. It is offered mainly in developed countries where it prepares students to become fish culturist and/or a fishery technician and work as fish biology, fish husbandry and fishery techniques. In most cases, it includes modules on major areas. Emphasis

includes aquaculture development, biotechnology, fish/food process engineering, marine oils and nutrition, physical properties of foods, process chemical science, seafood biochemistry and toxicology.

Most of the fish products are exported to European countries. Consequently, to ensure excellent quality of the products to conform to European standards and make the industry sustainable, it is vital that the fishing technology be continuously improved and kept up to date.

4.21.1 Needs identified

It should be admitted that prospect of employment in the field of fishing technology is quite limited and it will not be cost effective to produce a mass of fish technologist. It will be most appropriate if the teaching is done at regional level in one advanced institution and students from other countries opting for the module are allowed to travel to follow the course.

4.22 Environmental monitoring, including pollution and remote sensing

Many institutions are involved on environmental monitoring. The AFRC is carrying out various activities in environmental monitoring of the lagoon. These include:

- Long term monitoring of coral reefs with stations around the island
- Monitoring of chemical parameters in coastal waters at 19 stations
- Monitoring of mercury level in estuaries within the framework of the UNEP Global Mercury Assessment programme
- Monitoring of coliform bacteria at public beaches.

Facilities at the laboratories are being upgraded to obtain accreditation for fish toxicity, marine chemistry and marine bacteriology. For the high seas, some monitoring is done to detect level of cadmium, lead and mercury in the north-west of the island in the context of export of fish and fish products.

Some monitoring is also done by the DoE of the MoE, such as beach erosion, and MOI on various parameters mostly for research. The Meteorological Services is involved in the long term measurement of sea level, sea surface temperature and waves.

Important environment study and analysis are done by the National Environmental Laboratory of the Ministry of Environment. It is well equipped and catered for various environmental monitoring activities. The main roles include:

- Studies for sitting/zoning of sensitive areas
- Coastal and wetlands management
- Contribution to solid/liquid waste management
- Contribution to protection and enforcement of environmental laws
- Provision of data to Environment Information System (EIS), for sound decision making.
- Monitoring of ambient air quality through the measurement of various air pollutants which can cause health problems especially among sensitive groups of people.

Studies conducted so far include the Physico-chemical characteristics of lagoonal water around Mauritius. Generally, water quality at fish landing stations was found to be satisfactory. However, the impact of inland activities has been noted in certain areas.

The laboratory comprises five main sections namely.

- General wet/chemistry section
- Chromatography section
- Microbiology section
- Ambient air quality monitoring
- Trace metal sections

The NEL is also equipped to **a**nalyse trace metals and pesticides residue in fish products and sea water. It is participating in **t**he "Addressing Land-Based activities in the Western Indian Ocean". (WIO-LaB) project under the Nairobi Convention, aims to address marine pollution from land based activities. It is recalled that the activities under the WIOLaB project are:

a) Establish regional assessment and monitoring programme to assess the effect of marine pollution in the WIO region

b) Assess the requirements for capacity-building and sharing of capacity and resources among laboratories participating in the WIOLaB project and eventually develop training for the staff of these laboratories.

Moreover, the NEL has the responsibility to monitor the lagoonal water and wetlands, which could be impacted by the discharge from wastewater treatment plants at four sites- Grand Baie in the north, Baie du Tombeau in the west, Montagne Jacquot and St Martin in the west for coliform and faecal streptococci are commonly found in human and animal faeces.

Need identified

For sea-based sources of pollution, the introduction of alien species from ballast waters is main concern. The MOI is implementing a project to determine the risks caused by the discharge of ballast water in Mauritius and is proposing mitigation measures accordingly. The implantation of the project should be pursued.

4.22.1 Remote sensing

Environment monitoring, using remote sensing is now developing through the Africa Monitoring of the Environment for Sustainable Development (AMESD) project. It is a follow up to the PUMA programme, which equipped 53 countries of Africa with weather satellites receivers. The AMESD is to take advantage of the large amount of data and information regularly provided by the EU new generation of weather satellites to be exploited efficiently by a number of sectors such as agriculture, hydrology, fishery, environment, land planning and management. One of the main lines of action is coastal and marine management.

The MOI is the focal point for the implementation of the project in the country. Some equipment, including an antenna and software, has been acquired to receive, on a routine basis, SST, Chlorophyll and sea topography to develop products for various marine users on an operational basis. Such products will assist in the optimum exploitation of coastal and marine resources.

A number of specialised training and institutional development activities are integrated in the programme. Many technicians and scientists have already been trained in data retrieval and processing to prepare ocean products.

Environment monitoring using particular remote sensing including satellite data is developing at a fast rate. Many institutions and facilities have been established in Africa to empower countries to keep abreast of new technologies. For instance, the Environment Information Systems (EIS)-AFRICA a non-profit organization of individuals, institutions promotes the utilization of environmental information systems (EIS) for decision making throughout the continent. Networks for the training and education have been established in Southern Africa and EIS-AFRICA is planning to build similar networks in other parts of the continent. In Eastern Africa, the Center for Geographical Information Systems and Remote Sensing at the University College for Lands and Architectural Sties (UCLAS) in Dar es Salaam has shown promise of leadership for building a network in that region. Links with EIS-AFRICA should be developed and participation in its activities envisaged to take advantage of the various training capacity and training organized by the institution. Open seas monitoring should particularly benefit from the EIS-AFRICA programme. It is noted that the EIS-AFRICA organizes on an annual basis a forum to showcase its activities and programme. It will participate in the Africa GIS Conference in Cairo in October 2011

4.22.1 Need identified

It can thus be seen that environmental monitoring of coastal waters is well covered. However, over the high seas, apart from some remote sensing monitoring, it is very limited. No continuous monitoring is done. On the Nazareth and Saya de Malha areas where fishing activities are very important, monitoring is done only occasionally but not regularly enough to identify variation and long term trend. This issue should be addressed.

4.23 Biodiversity

Mauritius is very rich in both terrestrial and marine biodiversity. However, it is terrestrial biodiversity which is most documented. There are nearly 671 species of indigenous flowering plant recorded of which 311 are endemic (Mauritius has eight endemic plant genera), and 150 are endemic to the Mascarene Archipelago. Seventy seven of these indigenous species are classified as extinct. Of the extant flowering plant species, about 35% are already classified as threatened as per IUCN criteria

With regards to fauna, 24 of the 52 native species of forest vertebrate that were known to have occurred on Mauritius and adjacent islets are now extinct, including the Dodo, a giant parrot and two species of giant tortoise. Many of the extinct species are threatened.

Causes of loss of biodiversity include:

- Logging for ebony and forest clearance for agriculture
- Gradual conversion of forest to enlarge pasture areas for deer grazing
- Invasive Alien Species (1,625 plants have been introduced – among which 20 are known as aggressive invaders
- Unsustainable use of resources. About 100 sp. of plants & animals got extinct
- Pollution from sewage and agriculture
- Pests & Diseases
- Development projects & Population Growth.

Mauritius is rich in marine biodiversity. Recently, the Mauritius Oceanography Institute published a "Database of Marine Organisms of Mauritius" in CD - ROM with the aim to provide a baseline for marine biodiversity in Mauritian Waters and a tool for researchers, developers and decision-makers. The Database is a list of marine species occurring in the Mauritian maritime territory compiled from literature and other existing databases. The classification and references of each of the reported species are provided.

It attempts to cover marine organisms reported from the entire maritime territory of the Republic of Mauritius. The highest number of species reported is coastal organisms around the island of Mauritius, followed by Chagos Archipelago and Rodrigues. Offshore Mauritian waters, however, have been poorly studied. The database includes 6363 species names, 104 images and 1003 bibliographic references.

However, it is degrading due mostly to land-based pollution, coastal erosion and climate change. Key issues associated with the coastal zone include:

- Control of shoreline development
- Management of beaches
- Waste and pollution management
- Soil and agrochemical management
- Control of lagoon usage
- EIA as a tool for mitigating adverse effects of development
- Strengthening resource stewardship
- Protection of waters around offshore islets
- Increased monitoring of ecosystem health

4.23.1 International, Regional and National Conventions, agreements and Treaties

Mauritius is taking several initiatives to preserve biodiversity. It is the first country to sign and ratify the Convention of Biological Diversity on the 10th September 1992. The Convention has three principle objectives:

- The conservation of biodiversity
- The sustainable use of the components of biodiversity
- The equitable sharing of benefits derived from genetic resources.

To meet its obligation, a National Strategy and Action Plan (NBSAP) 2006-2015, have been prepared. The National plan identifies lack of training of Mauritians and limited human capacity at all levels as one of the main gaps to address biodiversity issues.

Mauritius is committed to the Jakarta mandate on Marine and Coastal Biological Diversity, which is a process for the implementation of the CBD for the conservation of and sustainable use of marine and coastal diversity for social and economic development and poverty eradication. The five principle action areas are:

- Integrated marine and coastal management including community based coastal resource management and prevention or reduction of pollution from land based sources
- Sustainable use of fisheries and other living resources
- Establish and maintain marine protected areas for conservation
- Ensure that marine culture operation are sustainable
- Prevent the introduction of and control and eradicate harmful alien species.

Mauritius is also a party to other biodiversity related conventions and agreements such as the Cotonou agreement on cooperation on environmental protection and the sustainable utilisation and management of natural resources, the Nairobi Convention for the protection, management and Development of the Marine and Coastal Environment of the East Africa Region and the NEPAD Environmental programme.

Hence, the country has a moral as well as a legal regional and international obligation and commitment to develop strategies to preserve biodiversity. A Marine and Biodiversity Conservation programme to contribute to the conservation of biodiversity, marine and coastal resources within the Western Indian Ocean Marine Eco-region (WIOMER), is now being implemented. Initially, a regional network of well protected and effectively managed MPAs is being established.

The programme comprises four specific objectives namely:

- To identify a network of priority representative sites for biodiversity conservation and marine and coastal resources
- To support the setting up of this network through designation and strengthening of selected protected MPAs in the eco-region
- To develop a regional forum for MPAs managers in order to improve the management of capacities through of exchange of experience and best practices
- To sensitise the stakeholders and assure communication with the project ambit.

The programme is working closely with the Albion Fisheries Research Centre as project partner, which is in charge of MPAs in Mauritius.

At a WIOMER Prioritization and Strategy Workshop (Madagascar, 24-27 November 2009), three priority sites for seascape mapping namely Ile Plate, St Brandon, Sudan Bank in the EEZ and the South West Coast (from Le Morne to Tamarin) were identified for Mauritius. Rodrigues identified

Quatre Vingt Brisants and Banc d'Est sites. It is important that a strategy be developed to establish these sites as priority zones for marine biodiversity conservation.

4.23.1.1 Needs identified

A National Strategy and Action Plan (NBSAP) 2006-2015 has been prepared to review the status of biodiversity in the country, identify gaps and propose solutions to address them. It has identified lack of training of Mauritians and limited human capacity at all levels as one of the main gaps to address biodiversity issues. This applies also to marine biodiversity.

Mauritius as mentioned above is a party to various conventions and agreements. Various training programmes have been organised at national and regional levels to enhance capacities of countries to meet their obligations. However, it still lacks an appropriate institutional and organisational framework as well as human resources to implement effectively these international and regional biodiversity-related conventions and treaties. However, to develop a long term strategy, a range of human resources at various levels with proper training is required.

Training should be organised to enhance both management and technical skills. Some attention should be given to the empowerment of policy and decision makers through short training workshops to promote the review of legislations and the implementation of international and regional conventions and agreements. Some national Coastal and Marine primary Legislation is given in Annex V. Loss of biodiversity is a serious concern. One effective way to address the issue is to establish Marine Protected Areas (MPAs) in strategic sites to serve as development models for conservation, training and networking among private, public and local communities. Mauritius is relatively far behind in the region with only an area of 71 sq. km of MPAs as compared to Seychelles (412), Comoros (400) and Madagascar (440).

Facilities exist in the region. WIOMSA has developed a Manual Toolkit for the management of MPAs. Development of MPAs is a gradual process and is based on detailed baseline studies. Both well trained managers and technicians are required to establish, manage and maintain them. In many instances, technical support can be provided through NGOs assistance. Consequently, a comprehensive and coherent training programme for managers, technicians, NGOs and communities is vital to empower them to realise their own role and importance in the process for good governance and resources management.

4.24 Taxonomy and Curation

Some modules are available at the UoM on Taxonomy. Many scientists are specialised on Taxonomy. However, more training on marine taxonomy is needed

With regards to curation, the MSIRI has facilities for plants curation. However, on marine species, only the Mauritius Museum has done some curation. Some fish curation is also carried at AFRC.

It is important that some curation facilities are set up to preserve rare marine fauna and flora. New species discovered in Mauritius have type-materials deposited in museums in other countries as cataloguing/curation facilities are not available in Mauritius fauna).

4.24.1 Need identified

It is high time that some scientists be trained in curation to preserve new and rare species which are being discovered in our waters.

4.25 Pollution: land and marine based

The health of the marine and coastal environment is being jeopardized as a result of rapid population growth and associated intensification of human activities. This is leading to destruction of critical habitats such as mangrove forests, seagrass beds and coral reefs. Furthermore, pollution from domestic, industrial and agricultural sources is causing degradation of water and sediment quality, resulting in the loss and/or alteration of biological diversity, human health problems and a general reduction in fish stocks.

Some regional projects are being implemented to address the issue.

4.25.1 Addressing land-based activities in the Western Indian Ocean (WIO-Lab)

A regional programme - ***Addressing land-based activities in the Western Indian Ocean (WIO-Lab)*** - is being implemented in the region to address degradation of the marine and coastal environment due to land-based activities in the WIO. The three objectives of the GEF project are:

- Reduce stress to the ecosystem by improving water and sediment quality;
- Strengthen regional legal basis for preventing land-based sources of pollution through GPA; and
- Develop regional capacity and strengthen institutions for sustainable, less polluting development.

Various national institutions are participating in the programme including NEL and AFRC, which are responsible for environment monitoring of coastal water quality.

WIO- Lab is expected to result in a National Plan of Action for abating land based sources of pollution as well as a regional protocol for existing environmental conventions such as the Nairobi convention.

4.25.2 IOC Western Indian Ocean Islands Oil Spill Contingency Planning

Another related regional project, which has been implemented in the region, is the IOC Western Indian Ocean Islands Oil Spill Contingency Planning - 1998 to 2003 - funded under the World/GEF international waters project. It is being implemented following two feasible studies, which concluded that there was inadequate and regional capacity to deal with oil spill emergencies in the western Indian Ocean. Marine pollution from tankers is one of the serious coastal management issues identified.

The main objectives were:

- Establish legal and institutional framework to ensure compliance with marine conventions
- Develop national and regional contingency planning processes
- Build appropriate national and regional response capacity
- Establish sustainable financial and institutional agreements through regional cooperation arrangements

National capacity building was one of the five main activities. It involved:

- Training in environmental sensitivity mapping
- Training of trainers
- Expert advice on national contingency plans
- Procurement of oil spill equipment
- Risk assessment and appropriate response strategies Developing, reviewing and testing of an oil spill response manual

4.25.3 South West Indian Ocean Fisheries Project (SWIOFP).

The project is a regional fisheries project that focuses on existing and potential deep-water fisheries in the region. It has established the inshore limit of interest as the 150 m isobaths. It is concentrating on developing capacity to collect and assess information.

This is a long term project and continuing funding seems to be assured. It is linked closely with the "Agulhas and Somali Large Marine Ecosystems" project. One of the needs it is addressing includes inadequate capacity and methods of collection and communication of basic fisheries information.

4.25.4 Needs identified

Alien species from ballast water is the main source of marine based pollution. The MOI has taken the initiative to implement a project to determine the risks caused by discharge of ballast water and has proposed some mitigation measures. It is currently implementing a project on ballast water in Port Louis harbour commissioned by the Ministry of Shipping. However, capacity on the methodology for monitoring needs to be developed and short courses organized with short term attachment to a foreign Institution.

With regards to land-based pollution, the WIO-Lab project has developed some capacities in the country. The knowledge acquired should now be put into practice.

4.26 Environmental Impact Assessment Training

Formal procedures for EIAs were adopted in June 1993 following amendments of the Environmental Protection Act of 1991. A new EPA 2002 is now in force. It provides for environmental stewardship, greater transparency and public participation in the EIA mechanism as well as the streamlining of the EIA procedures.

A list of projects requiring an EIA is available. Guidelines have been established for the preparation of EIAs. The following procedures for the processing of EIAs have been established:

- EIA is open for public inspection and comments
- A copy of the EIA report is submitted to authorities concerned for views
- Joint inter-ministerial site visit for an on-site assessment of the environmental implications of the proposed development
- Carry out further studies, if required, or to submit additional information.

Most of the coastal and marine development activities require an EIA. The tourism industry, one of the key economic pillars of the country, is mainly coastal-based. Intensive coastal development in response to increasingly growing demand for tourism hotel and infrastructure has accelerated particularly in the last decade. Hence the number of EIAs has increased tremendously.

4.26.1 Needs identified

No formal training is available in EIA. It is important that some aspects of EIAs are included in some formal course at the Universities. Moreover, some short courses should be organised on a regularly basis for the benefit of stakeholders involved in the process.

5. REGIONAL AND INTERNATIONAL LINKAGES AND SUPPORT

The Republic of Mauritius has developed good relationship and created a good image to take advantage of the various capacity building schemes and training programmes established by International and Regional Organisations.

5.1 International linkages and support

On account of its strategic position in the middle of the Indian Ocean, Mauritius has always been involved in the implementation of international marine programmes in the region. It has also been active in international meetings and conferences assuming important responsibilities and positions in working groups and technical commissions including those concerned with Capacity Building and Training activities.

5.1.1 Intergovernmental Oceanographic Commission of UNESCO

Mauritius is a member of the Executive Council of the Intergovernmental Oceanographic Commission of UNESCO the nature and resources of the ocean and coastal areas.

Capacity development is an important programme of IOC through its Training, Education and Mutual Assistance addresses national priorities, empower national institutes, involve civil society and establish time-bound capacity de
The mechanisms by which it operates include training programs, workshops, UNESCO Chairs and grants. It has org

5.1.2 IOC/WMO Joint Technical Commission for Oceanography and Marine Meteorology (JCOMM)

The JCOMM has been established through the merger of Commission of Marine Meteorology of the World Meteor supporting observational, data management and capacity building programmes. One of its main programme is to pro

Mauritius participates actively in JCOMM activities. It is responsible through the Meteorological Services for pre marine weather observation and marine weather and oceanographic forecast.

5.1.3 United Nations Environment Programme (UNEP)

The UNEP has established an Environmental Education and Training (EET) programme to promote attitudes and va sustainable and socially just society. It is fundamental to the achievement of the goal of sustainable development.

Mauritius has benefited immensely recently in the series of workshops organized by UNEP to enhance the capacity

5.2 Regional linkages and support

Several coastal and marine projects are being implemented in the region with funding from various organization including the European Union, World Bank, UNEP and UNDP/GEF. A component on capacity building and training through the organisation of various training workshops and seminars at regional for the benefit of participating countries is incorporated in most of them. Mauritius is participating actively in the implementation of these projects and many scientists have benefitted from the training programmes.

5.2.1 Indian Ocean Tuna Commission Tuna Tagging project (2005-2010)

The WIO is very rich in tuna fisheries. For sustainable management of the tuna stocks, the Indian Ocean Tuna Commission (IOTC) has been established to promote cooperation among its Members with a view to ensuring, through appropriate management, the conservation and optimum utilisation of stocks and encouraging sustainable development of fisheries based on such stocks.

One the project being implemented in the region is the Tuna Tagging project (2005-2010). The project, funded by the European Union, studies the tuna stock structure and its distribution in the Western Indian Ocean. It will contribute to improve scientific and practical knowledge of the tuna and small pelagic stocks in the region.

5.2.2 South West Indian Ocean Fisheries Project (2008-2012) (SWIOP)

Mauritius is participating in the World Bank" South West Indian Ocean Fisheries Project" (SWIOFP), to provide an overall transboundary diagnostic analysis (TDA) and associated Strategic Action Plan (SAP).

The objectives of the SWIOFP are to: (i) identify and study exploitable offshore fish stocks within the Project Area, and differentiate between environmental and anthropogenic impacts on shared fisheries; (ii) develop institutional and human capacity through training and career building; (iii) develop a regional fisheries management structure and associated harmonized legislation; and (iv) mainstream biodiversity in national fisheries management policy and through national participation in regional organizations that promote sustainable exploitation of fisheries resources.

It focuses on existing and potential deep-water fisheries in the region with 150 m isobaths as the inshore limit. The following main components are in the process of implementation:

- Collection of data describing the various fish species in the 200 mile limit;
- A fish pressure survey to estimate the commercial fishing pressure in the study area;
- Establish a project management structure which includes collaboration, capacity building and shared decision making;
- Formulation of intermediate management guidelines to reduce threats to endangered fish species and to control exploitation of fish stocks to environmentally sustainable levels; and
- Adoption by the end of the project of a fisheries management strategy including appropriate institutions at a regional level for implementation of an ecosystem approach to LMEs and their fisheries resources.

5.2.3 AMESD project (Africa Monitoring of the Environment for Sustainable Development)

The AMESD project is an extension to ACP countries of the implementation of the Global Monitoring of Environment and Security (GMES) at a regional scale and on a thematic basis. The main themes covered are: forest, desertification, marine and coastal environment, prevention of natural disasters and weather forecast. IOC is coordinating the marine and coastal Environment component. The focal point for the project is the Mauritius Oceanography Institute.

Regular remote sensing data from the Meteosat Second Generation satellites are proving of valuable assistance in the mapping of coastal zones and to the creation of inventories of marine biodiversity and their subsequent monitoring. It is helping in the observation of pollution. The observations and data are also providing vital information for the production and dissemination of indicators related to marine habitats and fish stocks with particular emphasis on factors which impact their quality and productivity.

5.2.4 Regional Cooperation Management Programme of the coastal zone in the Indian Ocean (RECOMAP, 2006-2011)

This a regional project programme for the sustainable use of the coastal zones of the countries in the Indian Ocean funded by the European Union. Activities include integrated coastal zone management courses, call for proposals, education and awareness programme and support to management committees. Seven countries in the region are participating in the programme.

The overall objective of the programme is to enhance the sustainable management and conservation of natural coastal and marine resources, thereby contributing to poverty alleviation among the coastal population of the South- West Indian Ocean. Its specific objective is to strengthen the capacities of local communities and public/private bodies in order to achieve a sustainable integrated coastal zone management.

The following priority issues are covered by the programme:

- Sustainable Management of coastal marine resources
- Upland erosion control
- Coastal erosion control
- Solid waste management
- Liquid waste/waste pollution management
- Mariculture
- Coastal Eco-tourism

Many non-state actors from Mauritius and Rodrigues have received funding in the range of EUR 10 000 to 100 000 to implement various projects under the priority programme areas following a call for proposals among the participating countries.

The programme is terminating in May 2011. An extension of the programme or a similar programme in the future is not currently envisaged.

The IOC has submitted some project proposals for consideration within the framework of 10th European Development Fund (EDF) Scheme. One is on marine biodiversity and climate change.

5.2.5 Africa Coelacanth Ecosystem Programme (ACEP)

This project was launched after the discovery of a substantial population of coelacanths near Cape St Lucia off the South African coast where 18 individual were identified. This discovery in 2000 prompted the formation of ACEP as a NEPAD initiative. The programme undertakes research and training in the participating countries, the collection of biological specimens as well as other data monitoring the entire ecosystem.

5.2.6 Agulhas and Somali Current Large Marine Ecosystem (ASCLME)

The five-year Agulhas and Somali Current Large Marine Ecosystems (ASCLME) project is centred on the two Large Marine Ecosystems (LMEs) of the western Indian Ocean region. The objectives are:

- to gather new and important information about ocean currents and how they interact with and influence the climate, biodiversity and economies of the western Indian Ocean region;
- to document the environmental threats that are faced by the countries of the region in a Trans-boundary Diagnostic Analysis;
- to develop a Strategic Action Programme which sets out a strategy for the countries to collectively deal with trans-boundary threats;
- To strengthen scientific and management expertise, with a view to introducing an ecosystem approach to managing the living marine resources of the western Indian Ocean region.

Under the ODINAFRICA III of IOC of UNESCO, further assistance has been obtained to enhance the activities of the Data and Information Centres. An Inmagic DbTextworks software has been procured for cataloguing.

5.2.7 UNEP-GEF project "Addressing land-based activities in the Western Indian Ocean" (WIO-Lab)

The WIO-Lab is being implemented in the region to address the issue of marine pollution from land based sources including agricultural practices, coastal tourism, ports and harbour developments, damming of rivers, urban development and construction, mining, fisheries, manufacturing. These main sources of marine pollution are threatening the coastal and marine habitats. Three objectives developed for this GEF project include:

- Reduce stress to the ecosystem by improving water and sediment quality;
- Strengthen regional legal basis for preventing land-based sources of pollution through GPA; and
- Develop regional capacity and strengthen institutions for sustainable, less polluting development.

The project is being implemented with the participation of various organizations and institutions and being coordinated by the Ministry of Environment and Sustainable Development.

5.2.8 The Marine Research Grant (MARG) of WIOMSA

Three types of grants are awarded under the scheme:

- **MARG-I**: Awarded to individual scientists to carry out well- defined research activities in their countries/institutions. The maximum amount offered for MARG-I is US $ 6,000.

- **MARG-II**: Awarded to individual scientists for the purpose of sharing or gaining technical experience as well as data processing and manuscript write-up within the WIO region and where necessary outside the region.. The maximum offered for MARG-II is US$ 6,000.

- **MARG-III**: Travel support to individual scientists to attend scientific meetings and conferences, giving them opportunities to present their work and learn from others. The maximum offered is US$ 3,000.

Many scientists from the country have taken advantage of the granting scheme to conduct research and enhance their capacity.

5.3 Support from friendly countries

Many countries are offering support to Mauritius and Rodrigues in the implementation of coastal and marine projects. These include:

- Japan under the Overseas Fisheries Cooperation Foundation of Japan whereby various equipment had been provided to enhance the facilities at the Albion Fisheries Research Centre. Support is also provided under this scheme for the maintenance and repairs of the equipment at the AFRC and at the Fisheries Training and Extension Centre donated by Japan

- India provides on a regular basis expert advice on various aspects related to coastal and marine resources.

- Kuwait for the feasibility by the Kuwait Fund for Arabs Economic Development for the development of a long line fishery

- Norway under the Development in Fisheries in Norway for the development of a project document defining assistance needed in fisheries development

- Hellenic Republic of Greece for the setting up of a fish auction market at the Port Louis fishing Port.

As regional collaboration, an agreement was signed among the nine countries of the south West Indian Ocean region including Mauritius and the World Bank for the implementation of the Fisheries

Project which aims at identifying and assessing fisheries resources in the respective EEZ of the participating countries South West Indian Ocean countries.

Support for activities in relation to the Fish Aggregating Device (FAD) implemented by the AFRC is obtained under the International Fund for Agricultural Development- IFAD Loan 504: MU- Rural Diversification Programme.

5.4 Collaboration with overseas universities

MoUs have been signed for collaboration with some overseas Institutions. However, the collaboration should be strengthened particularly with Universities of developed countries located in the tropics and exchange of scientists encouraged.

Many well established overseas universities mostly from United Kingdom such as Middlesex University well known for its Integrated Coastal Zone Management course and India have opened local branch campus offering a range of popular subjects to obtain qualifications with honours degrees from the overseas universities. However, degree courses in marine sciences/oceanography are not currently available.

6. PROPOSED START-UP TRAINING PROJECTS AND ACTIVITIES

Ocean currents and impacts of environment changes on ocean ecosystems do not have geographical or political boundaries. Trans-boundaries issues should be addressed at regional and international levels. An insight of regional processes and circulations which can have repercussions at national level can only be obtained through regional and international cooperation. Several regional and international projects are being implemented in the region. Moreover, Mauritius has ratified numerous regional and international conventions and agreements which require specialized skills for meaningful interpretation and knowledge for effective negotiations. However, in order to participate actively in and derive maximum benefits from these programmes as well as meet its regional and international obligations, it is fundamental that the capacity at national level should be very strong.

Various regional and international marine programme- WIO-Lab, SWIOFP, WIOMER, AMESD, ASCLME- are being implemented in the region. The majority of them have a Capacity Building and Training component incorporated within their programmes to train scientists and technicians in the

participating countries to ensure more effective implementation. Capacity building is usually defined as the creation of an enabling environment with appropriate policy and legal frameworks, institutional development including community participation of women, in particular, human resources development and strengthening management systems. However, in many instances, capacity building is geared towards training, workshops and conferences. They each have organised several short courses to suit their own purposes. These include training workshops/seminars/courses of varying durations, with most of them lasting a week, on ocean monitoring, data collection and analysis, buoys, turtles, coral reefs, alien species, maritime pollution and MPA's, more often duplicating activities instead of complementing efforts.

It is often argued whether these courses have really benefitted the country. In some small countries the same scientists attend different training workshops with the result that they become "Jack of all trades but master of none" with no time and opportunities to apply the knowledge acquired in their respective countries. In any case organizing workshops is easy to implement and a good justification to dispense of available funding. There is usually limited coordination and they are regarded as stand-alone activities without any linkage to the requirements of the respective countries.

Several projects and activities are currently under way in Mauritius to develop and strengthen human and institutional capacities to enhance ocean management for the sustainable exploration and exploitation of coastal and marine resources. Several reports, guidance and projects proposals have been prepared by foreign experts and international firms for fundraising and implementation. However, in many cases, insufficient human resources and capacities have been a serious barrier for proper and effective implementation.

6.1 *Motivation for ecosystem approach*

The principle of ecosystem-based approach for the better management of sustainable management of coastal and marine resources is now widely recognized. Ecosystem-based management approach is often defined as the sustainable exploitation of natural resources by balancing the social and economic needs of human communities with the maintenance of healthy ecosystems. It is a highly integrated, scientifically based approach that encompasses all the complexities of ecosystem dynamics, human dynamics and the maintenance of diverse functioning and healthy ecosystems. However, trained ecosystem-based ocean governance professionals are few, as historically this has not been viewed as a bona fide profession.

The importance of the coastal and marine resources and their potential to contribute to socio-economic development of the Republic of Mauritius is well recognized. Consequently, several degree courses particularly at tertiary level with modules in marine science have been introduced. The number of students with basic qualification in marine sciences has increased in the last decades with the growing number of degree courses being organized at the University of Mauritius and University of Technology (sec. 3.2.1.1 and 3.2.1.2). However, ecosystem-based approach in the teaching has been given limited consideration. This is quite legitimate as the overall objective is to provide the students with a basic background on the ocean. This has been observed to be lacking

even though they have completed A level in science. At degree levels the main aim is to impart some basic knowledge in marine sciences to enable students to continue their studies in case they are interesting in embarking on marine professional careers.

Ecosystem approach is a relatively new concept. Although serious attempts are being made to address coast and marine issues in a holistic and integrated way, an ecosystems approach is yet to be adopted systematically. For that purpose, capacity building and training should be reviewed and a new approach developed.

6.1.1 General national requirements

The Republic of Mauritius consists of the mainland of Mauritius and the island of Rodrigues, St Brandon and Agalega. The main island Mauritius covers an area of 2 040 sq. km with a coastline of 177 km in length. It has a population of over 1.2 million .It is completely surrounded by coral reefs except at in the south and west. Mauritius is situated in the Western Indian Ocean which is renowned for the attractiveness of its coastal zones, high marine biodiversity and rich marine and coastal resources. The coastal habitat is abundantly diversed. It includes coastal plantations, coastal dunes, freshwater and salty water marshes and wetlands, mangroves forests, coral reefs, lagoons, sandy beaches and rocky and cliff shores. The ecosystems in turn support a wide resource base with associated economic activities. Much of this biodiversity is a result of the influence of the oceanic currents. The region is dominated by the south equatorial current which travels west across the Indian Ocean but is partially diverted northwards to feed the Agulhas and Somali currents and southwards along the eastern Madagascar coast to merge with the anticyclonic gyre to the south. The Mascarene plateau which extends from Mauritius to Seychelles over a range of almost 2000 km exerts a considerable influence on the South Equatorial Current. The Plateau has all the economical, biological and physical characteristics to be recognized as a LME. There is, indeed, growing evidence that an open-upwelling system is present in the area of the plateau

Two marine related pillars of the economy are tourism and the sea food hub. The tourism industry is mostly coast - based. The main tourist attraction is the white sandy beaches and the clean turquoise pristine lagoon surrounding the island. Fisheries activities are developing rapidly. The fisheries and seafood sector contribute about US $ 500 m to the national economy whilst the local fish production sector is valued at about US$ 30 M. The total supply of fish and fish products for direct consumption is about 18,000 tons, whereas 92,000 tons of processed fish and fish products produced mainly from imported raw materials are exported. This sector employs 12,000 persons, including those involved in fishing, canning, other processing activities, distribution and marketing. Mauritius is being transformed into a Seafood Hub. The strategy is focused on the development of value added fisheries and seafood related sectors including fishing, trans-shipment, storage and warehousing, light processing, canning and ancillary services such as ship chandling, bunkering, ship building and repair. Marine aquaculture is another sector which is developing rapidly.

The level of education is comparatively very high. Considerable investment of resources, both human and material, has been put into the Education sector and impressive progress has been achieved in terms of free, universal, compulsory primary education, free textbooks, free secondary education and a fairly wide range of higher education courses at the University of Mauritius and University of Technology and other tertiary institutions. The primary and secondary education is

well developed (section 3.1) as well as tertiary education (section3.2.1). Many research Institutions are involved in marine research (section 3.2.3) with, however, more focus on coastal ecosystems.

Chapter 4 elaborates on the national needs on the different thematic areas as identified in the context of the ASCLME programme. It has also attempted to provide the capacity needs to address them. A summary is given in Annex VI. In brief, special training is needed in oceanography, particularly in physical and chemical oceanography and on MPAs for a range of stakeholders as well as short courses on economics and socio economics;, statistics and applied mathematics; international conventions and treaties; fishing science; GIS for coastal zone management; Aquaculture; impacts of climate change and sea level rise and adaptation; microfauna, microfauna and macrofauna; ecosystem approach and curation.

6.1.2 Marine sciences education

Environmental education has assumed a new dimension since the Rio Earth Summit in 1992 and the establishment of a Ministry of Environment in early 90's. It is now well covered at all levels from pre-primary to tertiary level. However, the teaching of marine sciences does not commensurate with the aspiration of the country to become a central ocean hub in the region. Marine topics are still not covered adequately in formal primary and secondary geography and science textbooks compared to other environment subjects- air, weather, rivers- whereby whole chapters are devoted to them. A degree course- BSc (Hons) Marine Science and Technology- was only recently introduced at the University of Mauritius (section 3.2.1.1) and the second batch is currently in its first year.

However, marine science education could be at its turning point. Marine Science (Subject code 9693) will be introduced as a subject at the HSC/ A- level in schools for the first examination to be planned for 2011 (section 4.12) It is offered as an option to schools, which are willing to teach the subject. The course content concentrates on the scientific study of the sea and its ecosystems.

Some basic aspects of marine science will also be integrated in the 21 Century Science Syllabus, which is being presently piloted in some secondary schools at the level of Form IV/ V. Consideration is being given for this subject to be introduced in all Secondary Schools in Mauritius and Rodrigues with effect from 2011. These initiatives will open new avenues to encourage students to study marine sciences as from an early age.

6.1.3 Coastal Zone

The coastal zone contributes significantly to the socio-economic development of the country. The tourism industry is mostly coastal-based and artisanal fisheries in the territorial waters are one of the main activities of coastal villages. In 2008, tourism contributed 8.7% to the GDP whilst the fisheries sector contributed 1.3%. Some of the characteristics of the coastal zone include:

- The Coastline of mainland Mauritius measures 322 km and is surrounded by 150 km of protective coral reefs which cover an area of around 300 km^2
- Total lagoon area is about 243 km^2

- Two Ramsar sites (Rivulet Terre Rouge Bird Sanctuary and Blue Bay Marine Park) and 2 marine parks (Blue Bay and Balaclava), and 6 fishing reserves have been proclaimed around the island
- Live coral reef cover varies from 0.6 % to 23 % as a proportion of the whole lagoon
- Mangroves cover approximately 35,000 m^2 and other coastal cover forest covers about 652 ha and
- Coastal marine biodiversity consists of some 1656 known species, 159 species of scleractinian corals and some 340 species of fish, out of which 42 were of economic importance

Integrated Coastal Zone Management (ICZM) strategies, policies and guidelines have been finalised with contribution from all stakeholders and are awaiting formal adoption and implementation.

In view of the socio-economic importance of the coastal zone, intensive research and monitoring are currently being undertaken in the coastal zone. Several institutions are involved in the management, governance and studies of the area. These include the Albion Fisheries Research Institute of the Ministry of Agro-Industry and Food Production and Security, Mauritius Oceanography Institute of the Prime Minister's Office, the Department of Environment of the Ministry of Environment and National Development Unit, Mauritius Meteorological Services, University of Mauritius, University of Technology, Ports Authority and the Ministry of Shipping. Their activities cover:

- Coastal ecosystem research
- Coastal fisheries research
- Coastal water quality monitoring
- Marine conservation activities including Marine Protected Areas
- Coral reef ocean and land culture
- Coastal erosion monitoring
- Lagoon bathymetric survey
- Updating and enforcement of coastal legislation and regulations
- Invasive alien species studies from ballast water
- Monitoring of sea surface temperature, waves and tides and
- Biological activities of Marine Natural Substances

The Organisations/Institutions have well qualified man power to conduct the studies. Most basic equipment and laboratory facilities are available for the purpose. However, there exists a critical need for physical oceanographic monitoring and studies. Few scientific studies have been made on physical processes that affect marine ecosystems. Studies that need to be made include: transport, dispersion, transformation and fate of sediments and contaminants in the coastal zone; wave refraction and dispersion in the lagoons; beach erosion model development and hydrodynamics of the lagoon waters.

Many training workshops have been organised to empower scientists to conduct monitoring exercises in the lagoons. Equipment has been provided for the purpose within the framework of some regional projects such as the ASCLME project following the training programme organised in

March 2010 in Mauritius. However, there is a need of physical oceanographers to initiate studies such as morphological studies of the beaches, development of models for transport processes in the lagoon, shoreline changes and forecasting of the fate of pollutants within and outside the lagoon.

Ocean energy for countries like Mauritius is considered the sustainable source of energy for the future. The land ocean based industry whereby cold water pumped from about 1000 m deep to be used for the air conditioning of a computer park will soon enter its implementation phase. Technology is also fast developing to exploit wave energy and the temperature difference between the warm surface water and cold deep water (Ocean Energy Thermal Conversion) to produce electricity. The Reunion Island (France), only 100 km from Mauritius is already contemplating of exploring ocean energy. The Green Energy Revolution- Reunion Island (GERRI) project has been initiated and steered by the French Government, Regional Council, Department Council and economic actors, to make Reunion Island a demonstration ground for all sustainable development technologies of interest for the society of the future. One of the 5 priority lines is to make the island self- sufficient in energy through GERRI and the focus will be on wave and sea thermal energy as well as offshore wind turbines.

Mauritius too should develop such a vision and prepare itself for the years ahead in this area. However, ocean engineers, physical oceanographers, marine scientists and technicians will be needed to address the challenge. Capacity enhancement through training should, indeed, be extended to all categories of stakeholders including policy makers, managers, marine professionals, NGOs and communities.

6.1.4 Open sea and deep sea oceanography

The maritime EEZ of the Republic of Mauritius is very vast. It is about 1.9 million sq.km. It extends from latitude 10 deg south to 20 deg, south and longitude 55 deg E to 75 deg. E. It is a region of intensive fisheries activities, particularly in the shallow water banks of the Nazareth, Albatross, Chagos Archipelago and Saya de Malha. In 2007, seven national fishing vessels were operating in the regions. The catch was 21217 tons of fish for 27 259 fisherman-days. Fishing licences are also issued to authorise foreign fishing vessels to fish in the Exclusive Economic Zone of Mauritius, under the provisions of the Fisheries and Marine Resources Act 2007. In the bank fishery, semi-industrial fishery, slope fishery and shrimp fishery for demersal species, a quota system and a limited entry system are imposed to ensure sustainable exploitation of the resources. In December 2007, European fishing vessels started being issued licences to fish in the EEZ of Mauritius. In 2009, around 10 nationalities have been issued with fishing licences. Mauritius signed Fishing Agreements with the Seychelles in 2005 and with the Japan Tuna Fisheries Co-operative Association in 2007. In 2009, the annual revenue from such licences and fishing agreements was around $ 1.33 million.

Research and monitoring have been limited compared to the coastal zone. In spite of its importance in terms of fisheries activities, manganese nodules deposit on the deep sea bed and potential gas hydrates, only very few studies by the AFRC have been conducted on the Mascarene Plateau. The reasons are numerous. For research in deep sea oceanography, massive investment is required. Other reasons are the distance of the banks from Mauritius, limited human resources, lack of infrastructure and budgetary constraints and priorities. With the development and strengthening of the sea food

hub whereby self-sufficiency in fish products can be attained, a shift of emphasis for in depth research in the EEZ of the Republic of Mauritius and open sea fishing would be forthcoming.

Open sea research and monitoring need a lot of resources - human, equipment, finance and infrastructure. However, Mauritius is located in a very strategic position to take the lead in regional and international research and monitoring programmes. Several national and regional programmes within the framework of the European Development Fund and international marine programmes from friendly countries – France, United Kingdom, USA and Japan - and the Intergovernmental Oceanographic Commission of UNESCO have been developed and implemented in the region over decades now. Scientists from Mauritius have participated in the numerous expeditions and cruises undertaken in its EEZ to implement programmes prepared by scientists outside the region, not necessarily of direct interest to Mauritius and most of the time as observers. This is one of the conditions for foreign vessels to obtain permission to conduct studies in the EEZ of the Republic. A wealth of data has been collected and analysed to gain an insight in ocean processes and evolution of marine ecosystems. Workshops have been organized to present and discuss the findings and many scientific papers published. However, the active involvement of local scientists has been minimal in the process. In most instances, data gathered in the EEZ and over the Mascarene plateau and surroundings are not available for proper archival for future use.

The Mascarene plateau has potentially all the social, economic, scientific and environmental characteristics to be recognized as a Large Marine Ecosystem. This is one expected outcome of the ASCLME project. Mauritius and Seychelles should ensure that all efforts are deployed so that this objective is ultimately attained. The implication is immense. Many international organizations including the World Bank have the mandate to provide substantial funding to implement research and monitoring projects on LMEs. The Mascarene plateau will attract world attention as soon as it is declared an LME. Mauritius will benefit much in terms of research on fish stocks and sustainability, understanding ocean processes, the influence of the plateau on weather pattern affecting the region, in particular on cyclone formation and modification as well as on climate change.

A range of human resources from ocean managers, scientists, biological, chemical, physical oceanographers, ocean engineers, geophysicists and technicians will be needed to develop and implement a comprehensive and holistic programme for the region. Prospect to make a career in oceanography/marine sciences is currently limited in Mauritius. Marine related institutions are still small and scope for expansion restricted with limited ability for advancement. Such an endeavour will provide opportunities to create useful and productive jobs in the field of marine sciences and thus encourage the young generations to embark on a marine career with bright prospects for the future.

The ground work to enhance the capacity of the country to face the challenge should be initiated. To acquire a research vessel requires massive investment and is not foreseen in the next 10 years. Nevertheless, some open sea activities should be initiated as from now with available facilities. One or two containers could be converted into marine laboratories which could be placed on fishing or coastal vessels for short cruises over the banks. Arrangements could be made with research vessels and ship of opportunity to conduct studies according to plans and programmes designed with the active involvement of Mauritian policy makers and scientists to suit the interest of the country. The development of a Mauritius Ocean Survey project (section 3.2.3) with the involvement and

participation of all stakeholders is an initiative in the right direction. However, one of the prerequisites to ensure the long term sustainability of the strategy is adequate well qualified and well trained personnel in specific specialized areas to meet the human resource requirements.

6.2 Type of training required

The University of Mauritius started offering a 3-year BSc (Hons) Marine Science and Technology in 2007. It is run in alternate years and there was a new intake in September 2009. It covers quite a wide range of general topics and provides some basic knowledge in marine sciences (sec. 3.2.1.1). However, coastal-based and ship-based training is not available to impart skills in acquiring practical knowledge in ocean monitoring and ocean research. It is geared towards providing "an opportunity to acquire a solid foundation in Marine Science and Technology with a view to developing skills for higher studies, research and entrepreneurship in the marine sector" and prepare graduates with the possibility to "seek employment as Scientific and Environmental Officer in the public sector as well as in the private seafood and marine industry sectors". It is noted that opportunities to obtain employment in the public and marine private sectors are very limited. Most of the time the graduates join the teaching profession to teach subjects other than marine sciences or other non-marine related sectors.

The UoM and UTM also offer other BSc and MSc courses with elective modules in marine sciences (sec. 3.2.1.1 and 3.2.1.2).

In the Republic of Mauritius, the limited land resources have fully been exploited. On the other hand, the size of the EEZ is more than 1000 times the land area. The coastal and marine resources for sustainable development are immense. The EEZ is rich in living and non-living resources and abounds in energy resources. Their optimum exploitation has not yet been realized. The Sea food hub and the land-based ocean industry are expected to continue to develop. In the coastal zone, competition and conflict for the very limited land resources for coastal development will require a paradigm shift in coastal management. Moreover, the possibility offered by the University of Cambridge to "A level" students to take a paper in marine sciences will promote unprecedented interest among students and policy makers towards the ocean.

It is expected that a large number of oceanographers and marine science will be needed to cope with future demand. A proactive approach should be adopted to get prepared for the future. Well trained scientists with a clear vision should be formed to convince policy makers to invest massively in ocean studies and exploration. The training requirements should be reviewed and a new strategy and pathway developed to produce a wide range of marine scientists through training using the ecosystem-based approach.

There is no doubt that, in order to enable the Republic of Mauritius to forge ahead in the field of oceanography and take a leading role in the region, a new approach is needed. A prerequisite to realize this objective is enhanced human resources through both long term training courses and regular short term courses for scientists and technicians to keep abreast of new development and technology.

6.3 Training methodology

Following a survey conducted among four main marine institutions in Mauritius within the framework of the ReCoMaP Regional Training Demand and Supply Assessment in 2009, some common requirements were identified for in-service training. This is shown in Table VI

Table VI. Outcomes of ReCoMaP in-service survey in Marine Institutions/Organisations

Type of activities	Topics/themes
Profile of Key Skills Required:	• Enforcement of Environment Laws • Data Analysis Skills • Scientific Research Methods • Oceanographic Research • Marine Resource Management • Marine biology • Ecology • Physical oceanography • Coastal Engineering
Courses required	• Satellite Imagery Analysis • Oceanography research Method • Coastal Zone management • Oil Spilling • General ocean Management • Geographical Information System • Environment Engineering • Land and Resource planning • Risk management and assessment
Duration of course	1 to 2 weeks
Number of new staff required /yr	140 scientific and enforcement officers

The preferred duration of course for the institutions staff who could be released was 2 to 3 months. It is noted that short courses have been proposed as the assessment was made among in-service officers. Short term training workshops/seminars will indeed be needed for policy makers, managers, media and civil society besides scientists and technicians to promote and enhance the smooth implementation of national, regional and international marine projects. This should include one on TDA/SAP (including NPA) development/formulation be considered as well as one on ecosystem – based approach.

It is recalled that in order to participate actively in the ASCLME programme, Capacity Building and Training in terms of long term monitoring and management process is required. Courses currently available are not geared towards this objective. For that purpose, a general course incorporating special topics and field works is required to prepare a sustainable team of scientists to monitor and conduct research over the Mascarene plateau on a continuous basis in order to develop a short, medium and long term strategy for the sustainable management of its resources. Some details about the proposed course are provided below.

6.3.1 General course

The proposed general course is a 2 year full-time post graduate programme that addresses the increasing need of highly skilled human resources as a consequence of expected inevitable development in the near future.

Rationale for the long term course: Currently no degree courses are offered in Mauritius with focus on specialised topics. The new degree starting in August 2010- BSc Biology (option Marine and coastal environmental science) does, however, consider some of the ecosystem-based approach. The recently introduced first degree course in Marine Sciences and Technology in 2007 at the University of Mauritius provides students with only "a basic understanding of how the ocean functions". It include some practical field works in coastal waters but does not prepare graduates for open sea ship cruises and lacks the practical aspects of field works. The first batch will be graduated in 2010.

Most of the limited land resources have fully been exploited. On the other hand, the vast EEZ is yet to be explored. Mauritius eventually would have to turn its attention towards the ocean in order to sustain its socio-economic development. However, up to now, limited studies have been conducted in the region. Ocean processes are still not well understood and studies on resources stocks are very few. The Mascarene Plateau, which lies in the EEZ of , is a very productive area and it has all ecological characteristics to be recognised as an LME. This is one of the aims of the ASCLME project. Much works still remain to be done to provide strong scientific evidence and demonstrate convincingly its LME characteristics in order to be accepted as an LME by the international community.

The oceans play a unique role in sustaining life on Earth by generating half of the world's oxygen, absorbing atmospheric carbon dioxide, regulating climate and temperature, and providing the global population with food, livelihoods, energy, and transportation. Mauritius, by virtue of its strategic position in the Indian Ocean, can play a more vital role within the regional and international marine communities to contribute to the understanding of ocean processes in the Indian Ocean and their importance in ocean general circulation. This will have far reaching national repercussion. Mauritius has to prepare itself to address this challenge through enhanced man-power.

The Mauritius Oceanography Institute has taken the initiative to develop a multi-sectoral Ocean Survey with the participation of all marine related institutions. A Committee has been set up to develop a strategy on activities and actions for implementations that could be of direct interest to the Republic. Initially the charting of a vessel has been proposed.

As from next year, education in marine sciences will assume a new dimension. A paper in marine sciences at A level for the Cambridge Higher School Certificate examination will be introduced in 2011. This will open new avenues to enhance interest in ocean studies at a young age.

In the light of the above, a large number of ocean scientists will be needed to cater for the demand. A proactive attitude should be adopted. Steps should be taken as from now to produce the human resources with specialised background, skills and aptitude to participate more actively in the current ASCLME project and future ASCLME programme particularly in the region of the Mascarene

Plateau. Moreover, Mauritius is well situated to take the lead in oceanographic activities in the region. However, to this end a range of well qualified marine scientists would be needed.

***Target trainees*:** The MSc (marine sciences/oceanography) is open to first degree students with a good degree in earth sciences/marine sciences who are interested to make a career as professional marine scientists. It is open also to in-service officers and NGOs.

Approach to the course: The aim is to impart knowledge and skills to the trainees so as to form a dedicated team to conduct comprehensive monitoring exercises and research works with focus in the open sea and the Mascarene plateau as well as in the coastal region in areas which are of socio-economic and ecological importance but currently are thinly covered. It provides a thorough, stimulating and practical postgraduate education to participate actively in national, regional and international marine programmes. Graduates with these specialisations can seek employment in public marine institutions and marine related private sectors as well as Education Officers to teach marine sciences. The course is broadly divided into three components:

• Theoretical lectures on general oceanography/marine sciences and specialised topics including on national and regional marine policies, regional and international conventions and agreements, TDA/SAP, ecosystems approach, governance, socio-economic aspects and data and information management skills

• Ship Based Training to gain a practical level of knowledge in acquiring and processing of physical, chemical, biological and geological as well as hydrographic data and experience in research operations at sea.

• Small Boat Coastal Based Training on use and deployment of oceanographic instruments and coastal research.

The course includes a research project encompassing data collection, analysis and interpretation. Emphasis is also placed on personal development of students in the quest to acquire professional competence and a sense of responsibility within the community. The course material is largely based on research papers and surveys in the Western Indian Ocean and self-study.

6.3.1.1 List of modules

Based on the ecosystem- approach principles, discussion with stakeholders and some topics already covered in some university institutions, the following modules are proposed:

- ***Physical, chemical, biological and geological Oceanography***
- ***Ecosystems approach***
- ***Marine Economics and socioecomics***
- ***Statistics, applied mathematics***
- ***Data management and information management skills***
- ***Marine regulations and laws***
- ***Governance***

- ***Fisheries science***
- ***Coastal zone management***
- ***GIS and MPA's***
- ***Aquaculture***
- ***Coastal agriculture and forestry***
- ***Ocean and climate***
- ***Climate change and sea level rise and impacts***
- ***Coastal adaptation to climate change and sea level rise.***
- ***Fishing technology***
- ***Environmental monitoring, including pollution and remote sensing***
- ***Marine Biodiversity***
- ***Pollution: land and marine based***
- ***Environmental Impact Assessment***
- ***Ocean renewable sources of Energy***

Training on research cruises in the open sea and studies in inshore oceanography as we as data collection and analysis are given special attention in the conduct of the course.

6.3.1.2 Other considerations

The teaching of marine sciences/oceanography should be given special consideration at tertiary level. It is noted that no Department of Marine science/oceanography exist either at the UoM or UTM. It is therefore vital that a Department of Oceanography be set up in one of the Tertiary Institutions. This will raise the status of the teaching of marine sciences and provide a mechanism to promote the importance of the ocean in line with the aspiration of the country to become an important maritime nation in this part of the world.

A first aid course/training for people at sea will also be considered in the design of the general course.

6.3.1.3 A Regional Long-term Post Graduate Course in Marine Sciences/Oceanography.

The application of weather and climate data and information, to enhance the effectiveness and efficiency of operational services for socio-economic and sustainable development, is well recognised. Weather and climate forecast, including marine forecast, is now produced routinely for the purpose and, in some cases, has become lucrative businesses. The main reason behind this success is the collaboration and cooperation in the field of meteorology at the regional and global levels. This has taken many years to develop and is still evolving. All activities, including weather observations, exchange of data and information, analysis and preparation of forecast, are harmonized and standardised. This coordinated, harmonised and standardised programme at national, regional and global levels under the umbrella of World Meteorological Organization (WMO) is known as the World Weather Watch (WWW).

Training activities are designed to enhance and strengthen this WMO programme. In the 1970s, the WMO developed a series of long term post graduate courses in the different fields of meteorology including weather and climate forecast, agricultural, hydrological and marine meteorology at the

Regional Training Centre of the Kenya Meteorological Office for the benefit of African countries. This has proved very beneficial. Many scientists from the African continent and Indian Ocean countries received specialised training and have since contributed significantly to the socio-economic development of their respective countries.

Inspired by the Meteorological community, the oceanographic community is developing strategies to linkages and networking among scientists and countries to harmonize and standardize oceanographic activities. This is being coordinated by the Intergovernmental Oceanographic Organisation of UNESCO and is commonly known as the World Ocean Watch (WOW).

A prerequisite to its smooth development is adequate and well qualified human resources. The region should be proactive. A regional long term post graduate course should be organised for the benefit of scientists in the region. It is recalled that many developing countries offer long term courses in Marine Sciences and Oceanography and some countries in the region also provide this facility. However, a post graduate course, taking into consideration the ecosystem approach and specialised topics mentioned in this report and the development of a networking among countries in the region, is not currently available. The time is ripe and the region needs it. It should aggressively be promoted.

6.3.2 Short Term specialised courses

Mauritius has benefitted from several short term training courses/workshops within the framework of the ASCLME project. However, the country is in need of other short terms courses to empower scientists to participate more actively in coastal and open sea marine monitoring and management as well as in research and operational activities.

6.3.2.1 Marine biodiversity

One of the programme areas which need focused attention is to develop a strategy to preserve marine biodiversity in the region in general and the Republic of Mauritius in particular. The timing is most appropriate as the year 2010 has been proclaimed by the United Nations as the International year of biodiversity. Much effort is being deployed at the global level to preserve terrestrial and marine biodiversity. The WIO region should join in the effort and take some new and innovative to contribute to the effort.

The Western Indian Ocean (WIO) region is renowned for the attractiveness of its coastal zones, high marine biodiversity and rich marine and coastal resources. The area is considered a distinct biogeographical province of the Indo-West Pacific and contains some of the world's most important coastal and marine environments and resources- dry coastal forests, coastal dunes, floodplains, freshwater and saltwater marshes, mangrove forests, coral reefs, lagoons, sandy beaches and rocky shores-, and has a high level of endemism. Some steps have been taken at the regional level to address various issues related to marine biodiversity.

The Republic of Mauritius is endowed with a large EEZ of 1.9 million sq km2. Some region of the Mascarene plateau, rich in marine biodiversity and fisheries resources, lies within this area. The coastal regions around the islands are surrounded by coral reefs which abound with a wide range of

marine species. Mangroves with their rich biodiversity are located in many places. Land resources, on the other hand, are very limited and have fully been exploited. Consequently the future development of the country will depend almost entirely on the judicious and sustainable exploration and exploitation of its coastal and marine resources. Their preservation is vital and loss should be avoided.

Mauritius has signed a number of conventions including the Conservation of Biological Diversity (CBD) being the first to do so and adopted policies which support the conservation of marine biodiversity.

6.3.2.2 Marine Protected Area

It is now widely recognized that Marine Protected Areas (MPAs) are one of the most effective ways of protecting marine biodiversity and serve as a vital management tool for coastal fisheries, They are key tools for mitigating the effect of overexploitation and halting marine biodiversity loss as well as achieving the 2010 biodiversity target. Ranging in kind from strict protection to multiple-use, they provide an effective mechanism to combine long term conservation of marine resources with economic development and food security, providing opportunities for coastal communities to generating income, creating jobs, and providing for recreation and tourism. They provide a model of the value of the ecosystem approach, and are a key tool in future adaptation strategies to address climate change. Article 8 of the CBD requires Parties to establish a system of protected areas or areas where special measures need to be taken to conserve biological diversity. In 2002, the WSSD called for the *"establishment of marine protected areas consistent within international law and based on scientific information."*

Some actions have been taken to establish MPAs in Mauritius and Rodrigues (section 4.10) and there are plans to extend the programme. The agreement between Mauritius and France to jointly manage the Tromelin Island and the marine resources in its vicinity provides additional opportunities to extend the marine biodiversity conservation programme.

At the regional level too, a few initiatives have been taken. There are over 75 MPAs in the WIO. Some countries like Seychelles with its 16 MPAs are contributing in the process. However, they are not all sufficiently managed. Yet MPA managers have been trained at various workshops on specifics components and have been given the tools (i.e. Toolkit for MPA Managers in the WIO; Workbook for assessing the management effectiveness of MPAs). But unless MPAs are viewed as important both economically and socially, then the political leaders may not provide the required enabling environment for efficiently managed MPAs.

Some formal training workshops have occasionally been organised. WIOMSA, in collaboration with UNEP, is hosting a regional Group of Experts on Marine Protected Areas for the Eastern African region (GEMPA). GEMPA has been established with the aim of building a constituency for marine protected areas in the region and to provide a forum for linkages and dialogue between MPA practitioners and experts, and between government and non-government organizations.

It is recognised that capacity to manage judiciously existing MPAs and prepare an effective programme for a network of future MPAs is currently insufficient. The Marine Conservation

Division, which is responsible for management of MPAs, is one of the eight Divisions of the Albion Fisheries Research Centre. The management of MPAs is one of the 12 Technical services provided by the Division. One Principal Fisheries Protection Officer (PFPO), 2 Senior Fisheries Protection Officers (SFPO) and 7 Fisheries Protection Officer (FPO) worked at the Blue Bay Marine Park (BBMP) and 1PFPO and 2 FPOs at the Balaclava Marine Park. Surveillance over the marine parks is provided daily to control permissible activities. These include glass bottom boating, snorkelling, diving, water skiing, swimming, non-motorised boating and fishing. Mooring structures and buoys are used to demarcate the BBMP and maintenance work is carried regularly to ensure their good conditions. Visitors include the general public, officers from other Ministries and tourists.

In Rodrigues, the South East Marine Protection Park (SEMPA) was proclaimed a MPA on 28 February 2009 in the Government Gazette (Box 1). It is a good example of a collaborative approach for the effective sustainable development and management of marine resources for the environmental protection of the marine ecosystem as well as for the socio-economic benefits of the local community.

The Association pour le Développement Durable, an NGO, gave a presentation on Tsunami and precautions to take on 25 June 2010 within the framework of a Tsunami sensitization campaign in Rodrigues for the benefit some SEMPA stakeholders including the fishermen and octopus fishers.

(Photo: S.Ragoonaden) Figure IV.Tsunami awareness raising programme – Fishermen and Octopus fishers in the SEMPA region

Box 1

South East Marine Protected Area, Rodrigues

Rodrigues is a small volcanic island of the Republic of Mauritius situated about 650 km almost to the East of Mauritius. It has a large and shallow lagoon with a rich marine biodiversity. Fisheries activities are one of the main occupations of the population. However, nowadays fishers have to deploy much effort to earn a living due to the rapid depletion of its marine resources due to human and environment impacts due to overfishing and land-based pollution.

To address the issue of marine degradation and preserve marine biodiversity, the establishment of the South East Marine Protected Area (SEMPA) in the southern part of Rodrigues was initiated in 2005 with support from United Nations Development Programme and Global Environment Facility. It developed gradually and in February 2009 it was gazetted.

It can now be considered as a fully pledge marine park. It comprises 12 km of fringing reef sheltering a large shallow lagoon that is home to more than 100 species of fish, coral, turtles, mollusks, octopus and crustaceans, some unique in the region such as the coral called *Acropora Rodriguensis*. It covers an area of 43.7 km2 and is the largest MPA in the Republic of Mauritius. The active participation and involvement of the local community in the initiation, development and now in the daily management and monitoring activities has contributed much to the success of the pilot project. The adoption of the co-management principles whereby all stakeholders – Rodrigues Regional Assembly, the local community, UNDP and GEF- participate in the decision making process has helped to develop a sense of belonging and ownership.

The inner lagoon demarcation has been completed. Eleven demarcation buoys have been installed for the purpose. Two additional buoys have been placed in the conservation zone of the area called Couzoupa. The first marine rangers of the Republic of Mauritius were recruited in February 2010 from the local fishing community as well as a new batch of Community Resource Observers (CROs). Both the rangers and CROs have followed intensive training MPA operation, patrol and surveillance techniques, basic onboard motor maintenance among others to ensure smooth operation and compliance in the SEMPA. Rangers work on shift with the support of CROs.

The first phase of an ecological surveys programme was completed in February 2010 by an ecological team. During the last survey in February, a group pg CROs were trained on how to use a Global Positioning Device for tracking octopus fishing grounds. A sustainable livelihood plan is under preparation to ensure that the community can sustain a living within the SEMPA region. This will provide them with opportunities for alternative livelihood as the marine park in the region will affect the way of life of several fishers and other users of the area. It serves also as a natural classroom to conduct sensitization campaigns mainly among the younger generation to enhance awareness about the need to preserve marine resources for a better livelihood.

6.3.2.3 Short term courses for MPAs management.

Systemic and institutional capacity development, with a particular emphasis upon long- term sustainability, is fundamental to provide a strategic framework for the replication of identified best practices in other existing and planned MPAs in the Republic of Mauritius.

At national level, there is currently no formal training for managers of MPAs. On the other hand, officers involved in MPAS are usually responsible for other activities. Dedicated officers for MPAs management are required to ensure proper governance.

At regional level, more formal training workshops are organized occasionally. WIOMSA, in collaboration with UNEP, is hosting a regional Group of Experts on Marine Protected Areas for the Eastern African region (GEMPA). It has been established with the aim of building a constituency for marine protected areas in the region and to provide a forum for linkages and dialogue between MPA practitioners and experts, and between government and non-government organizations.

In order to assist countries in the WIO to manage effectively MPAs established in their respective countries, a toolkit has been developed by WIOMSA and GEMPA-EA within the framework of the IUCN/NORAD WIO Marine Biodiversity Conservation Project. This is available on the website (www.wiomsa.org/mpatoolkit.htm). It includes a hands-on guide to a diverse array of topics, ranging from Communications, Monitoring Coral Reefs, Energy Sources, Solid Waste Disposal, to Octopus and Sea Cucumber Fisheries.

The purpose of short term courses is to establish a training programme for new serving officers and enhance the capacity of in service officers as well as those in managing posts. Three generic categories of stakeholders would be targeted for training. These are:

- Local community members involved in field level interventions including locally based marine practitioners (fishermen, fishing protection unit, local communities and Forces Vives, marine NGOs and decision-makers (i.e. District Officers, and councillors),
- National (finance, environment, fisheries, forestry, ministers (marine and fisheries) , researchers, Permanent Secretaries, President (s)) and
- Regional and continental (foreign ministers, Presidents, regional entities)

6.3.2.4 Regional networking of MPAs

The issue of establishing regional networking of MPAs, to preserve and enhance coastal and marine resources at national, regional and international levels, has been discussed on many occasions in various fora. However, the main barrier has been lack of well-trained human resources. MPAs and related courses should be developed with this aim in mind.

6.3.2.5 Rationale for the course

Marine Protected Areas (MPAs) are one of the most effective ways of protecting marine biodiversity. nd serve as a vital management tool for coastal fisheries. They have developed rapidly in response to the worldwide degradation of the marine environment. Two economic sectors, in particular, benefit from MPAs namely fisheries and tourism. However, the economic and ecosystem benefits of MPAs are not well understood at the decision taking level.

It has been shown by direct observation (Christie MR, 2010) that successful marine reserves can sustain fisheries beyond their borders. The study demonstrated that many juvenile fish had travelled up to 114 miles away from their parents, some of which were sampled from protected areas. In fact, it is known that marine reserves do grow larger fish and some of them leave that specific area, which is called spillover. It has thus been that fish larvae that were spawned inside marine reserves can drift with currents and replenish fished areas long distances away.

The establishment of MPAs is, indeed, a transboundary issue and should be viewed in the context of a regional initiative. Some marine reserves, and the management issues they entail, extend across country boundaries and require transboundary resource planning and management, as well as the development of regional initiatives or programs. Some regions have already taken the initiative. Through the Middle East Regional Cooperation program, USAID is promoting cooperation between Israel and Jordan on research and management of shared resources in the Red Sea Marine Peace Park. Through the PROARCA/APM regional program in Central America, USAID is strengthening regional and transboundary management of coastal resources in the Gulf of Honduras along the Guatemala/Belize/ Honduras borders, the Miskito Coast of Honduras and Nicaragua, and the Amistad Cahuita Rio Canas area of Panama and Costa Rica.

Some weaknesses, opportunities and challenges have been identified which need to be addressed. These include:

- **Lack of political commitment and support, and political instability.**

This has led to poor understanding of the benefits, goods and services of biodiversity and its contribution to sustainable development.

- **Institutional and policy obstacles and weaknesses**

Lack of vision, attitude, perceptions, inter-sectoral and multi-stakeholder coordination as well as conflicting legislation and contradictory government policies limiting opportunities have given rise to limited marketing strategies for protected area goods and services,

- **Insufficient human and technical resources and capacity**

Inadequate and poorly qualified staffing, lack of committed and enthusiastic personnel, lack of incentives for dedicated staff, non-continuity of trained personnel and change of staff have been detrimental for effective MPAs management and expansion.

- **Lack of 'suitable' and easily applicable guidelines/tools and insufficient training in their use**

Simple, easily understandable methods and guidance at the national and local levels is not currently available in spite of various regional training organised and inadequate dissemination of such materials where they exist has worsen the situation.

- **Low awareness**

An aggressive campaign to sensitise the general public, biodiversity managers, and politicians of the importance of biodiversity conservation is yet to be organised and the requirements of the CBD have not been discussed adequately among stakeholders.

6.3.2.6 Monitoring of climate change impacts on marine ecosystems

Some initiatives to monitor climate change in certain areas and socio-economic sectors have been taken. However, monitoring of the impacts of climate change and sea level rise on marine ecosystems has been limited. The MPAs will provide ample opportunities for monitoring the impacts of climate change on marine resources.

For an effective programme to establish an expanded network in the Republic to contribute to the conservation of biodiversity there is a need for more human resources and training to enhance the capacity towards this endeavour. All these issues need to be addressed in a comprehensive way through a training programme strategy and action plan

6.3.2.7 Target trainees

A range of human resources will be involved in the training activities. These will include fishing protection officers, scientific officers, researchers, fishermen, local communities and "forces vives", district officers, administrators, policy makers, high officials of Ministries and NGOs.

Approach to the course

The programme will employ a wide variety of teaching methods, including lectures, presentations, workshops, case studies, field visits, work placement and talks by guest speakers.

Manuals on different aspects of training for MPAs personnel are available such as the "***Toolkit for MPA Managers in the WIO"; "Workbook for assessing the management effectiveness of MPAs"***. These will adapted for the different training programme. Several short courses will be organised for the different target groups using as far as possible local resources and in some cases experts in the region. Overseas experts outside the region will be resorted to in case local and regional expertise is not available.

List of proposed training

Several training courses are planned. The duration will vary between one day and two weeks depending on the targets groups. A first aid course/training for people at sea will be incorporated in the course.

Fisheries Protection Officers/MPAs Managers:
Basic oceanography

Coastal and marine conservation management and strategies
Ecosystem-based approach
Coastal and marine regulations
Enforcement laws
Diving course

Research Officers:
Oceanography
Ecosystem-based approach
Research methodology
Data collection and statistical analysis
TDA/SAP and open sea research
Report writing
Project proposal writing
Fund raising
Diving course

Fishermen:
Coastal and marine resources and conservation
Resources depletion due to overfishing
Bad and Good practices
Climate change and impacts
Data collection on coastal resources
Diving course

New recruits including Rangers:
Coastal and marine resources
Bad and good practices
Policies and legislation
Enforcement laws
Diving course

NGOs:
Oceanography
MPAs purposes
Marine resources Conservation
Climate change and resources
Diving course

Policy Makers:
Coastal and marine resources
MPAs purposes
Need for human and financial resources for conservation
Need for laws enforcement

Administrators and President of District Council:

MPAs purposes
Coastal and marine conservation strategies
Synergies among stakeholders for resources preservation and their roles

6.3.2.8 A course in diving,

Some training in diving will be given particular attention. This has been highlighted by some stakeholders. In spite of being surrounded by the sea, many people associated with marine activities do not know how to dive and have never had the opportunity to learn diving. This will be open to all organisations/institutions which are involved with marine activities: Universities students, Ministries, NGOs, civil society and individuals.

Rationale for the course.

There is an acute shortage of diving schools in Mauritius. Existing schools are very expensive and are accessible to those who can afford to procure the expensive equipment to learn diving. Most of the instructors are foreigners.

Marine institutions provide facilities for basic training of the staff in diving. However, advanced courses in diving are very few. At the university, no facilities for training in diving are available. Students in marine sciences complete their courses without acquiring any aptitude in diving.

Mauritius is surrounded by the ocean. But the number of people who can dive is very small. This facility should be extended to most Mauritians so they can appreciate and become conscious of the beauty of marine life under water in order to cultivate a deep interest in the preservation of the marine environment.

Many tourists visit Mauritius because of the clean pristine marine environment and colourful coral reefs and coral reef fishes. There is an increasing demand for diving lessons for various group ages. Some hotels do provide training facilities and many other hotels are interested to provide this service to their residents.

Objective of the course: There are few professional divers in Mauritius. The aim is to democratise access to the sea in this area and train a few people to become professional divers to make a career in diving. This will lead to the creation of opportunities to open new schools to train others.

Proposed training approach: The course will be open to in-service officers and university students. Diving equipment will be provided for the training and will be donated to successful trainees. Arrangement will be made for post follow up course until the trainees reach a good confident level to be able to train others.

6.3.2.9 Training methods

6.3.2.9.1 General course

The general course will be organised by a University Institution in Mauritius. Local expertise does exist to teach the general marine topics. However, support will be needed from overseas to teach many of the specialized subjects. Arrangements have to be made to ensure practical ship-based training at an appropriate time during the course.

The training of 30 students is initially planned for the first course. Two subsequent courses will be organised to produce after six years 90 marine scientists. Funding should be sought to sponsor most of the students. The course will be open to overseas students in the region.

For the regional post graduate course, many Institutions have facilities to host it. Otherwise, a specialised centre could be established for the purpose.

6.3.2.9.2 Short term training workshops/courses

The short term courses will be of duration of one day to 2 weeks. They will be organised for the benefits of in-service officers. Some courses will be open to non-services people who will be involved with MPAs activities. Overseas experts will be invited to cover some specialised topics. Funding will be needed to meet the expenses of overseas experts. Funding will also be needed for some logistics and infrastructure.

Most of the marine institutions have facilities where the workshops could be convened.

6.4 Work plan

Table VII Work plan for MSc course in Marine Sciences/Oceanography

Activities	1 to 6 mths	7 to 12 mths	13 to 18 mths	19 to 24 mths	25 to 30 mths	2nd course over 2 yeas	3rd course over 2 years
First MSc course	planning						
Second MSc course							
Third MSc course							
Short term Training for divers							
Short term Training for MPAs							

6.5 Budget Estimates

A budget proposal is made based on available information.

6.5.1 First MSc course

Table VIII Proposed Budget for First MSc Course

	Per Unit (US $)	**number**	**Total (US$)**
Students fees	2x3000	30	18 000
Lecturers	24 000 per year	10	240 000
Travel	3000	5	15 000
Travel allowances and accommodation for overseas experts	36000	5	210 000
Course coordinator	36000	1	36 000
University management fee	10 000	1	10 000
Incidental	5%	1	26 450
Total			**555 450**

6.5.2 Average expenses for one short course

Table IX Proposed Budget for a short Course

	Per Unit (US$)	**Number**	**Total (US$)**
Lecturers allowance	500	3	1 500
Overseas lecturers	2000	3	6 000
Travel	3000	3	9 000
Venue expenses	10 000	1	10 000
Incidental	5%	1	1 325
Total			**27 825**

6.5.3 One Diving course

Table X Proposed Budget for a Diving Course

	Per Unit (US $)	**Number**	**Total (US $)**
Equipment	1000	10	10000
Monitors	800	3	2400
Facilities(boats, transport)	1000	1	1000
Total			**13400**

National workshop

In order to develop a national training strategy, it should be clear what are the targets groups and beneficiaries that the trainings are striving to build. These could include politicians, policy makers, high officials, scientists, programme managers, technicians, NGOs, CBOs and the media. The level of capacity that various target groups requires in terms of general information, formal general and specialized courses, short-term courses, Masters/Ph.D. levels or lifelong learning should also be considered. It is also important that a national consensus on a strategy tailored to the needs of the country is reached in order to promote greater coordination and ensure buy in by all the stakeholders. The most appropriate platform for the purpose is a national workshop with well pre-defined outcomes and results. This could bring together ocean managers, both in government and non-governmental circles, private sectors including academic institutions, scientists and the general public for a common cause.

A workshop was held on …… to discuss the proposals.
……..

7. ACKNOWLEDGEMENTS

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University of Mauritius http://www.uom.ac.mu/
University of Technology http://www.**utm**.ac.mu

Appendix A

LIST OF STAKEHOLDERS

Institutions/Ministries	Persons contacted/discussed with
Ministry of Education, Culture and Human Resources	Mr R. Auckbur, Director, Post secondary and Tertiary, Ministry of Education, Culture and Human Resources
Ministry of Agro-Industry, Food Security and Production	Mrs. Rathacharan, Principal Fisheries Officer. Mrs Hurbungs, Scientific Officer, Albion Fisheries Research Institute and others. Mr.V. Soondron, Divisional Scientific Officer Mrs. Basanrai, Divisional Scientific Officer
Mauritius Oceanography Institute	Dr. Bhikajee, Director
University of Mauritius	Dr. N. Appadoo, Dr. R.Bhagooli of the Faculty of Science
University of Technology	Dr. Bholakhee
Meteorological Services	Mr. M.Beebeejaun
Ministry of Environment and NDU	
Ministry of Shipping (Marine Sea Training Academy)	

Ports Authority	
Marine Conservation Society	
Marine Underwater Group	
Ministry of Housing and Lands	Mr. Naim Ahmad Shaik Joomun, Cartographer and GIS consultant

Appendix B

Acronyms/Abbreviations

ACCLIMATE Climate Change Adaptation programme
AIMS Atlantic, Indian Ocean, Mediterranean and South China Seas
AMESD Africa Monitoring of the Environment for sustainable Development
AFRC Albion Fisheries Research Centre
ARPEGE ***Appui Régional à la Promotion d'une Education pour la Gestion de l"Environnement au sein des pays***
ASCLME Agulhas and Somali Current Large Marine Ecosystems
ASLR Accelerated Sea Level Rise
BPOA Barbados Programme of Action for Sustainable Development in SIDS
DOE Department of Environment
EDF European Development Fund
EEZ Exclusive Economic Zone
EIA Environmental Impact Assessment
EU European Union
GEF Global Environment Facility
GHG Greenhouse Gases
GIS Geographic Information System
ICZM Integrated Coastal Zone Management
IOC Indian Ocean Commission
IOD Indian Ocean Dipole
IPCC Intergovernmental Panel on Climate Change
MASMA Marine Science Program for East Africa

MCA	Mauritius College of the Air
MEDA	Marine Ecosystems Diagnostic Analysis
MGI	Mahatma Ghandi Institute
MID	Maurice Ile Durable
MIE	Mauritius Institute of Education
MMS	Mauritius Meteorological Services
MOI	Mauritius Oceanography Institute
MPAs	Marine Protected Areas
MSI	Mauritius Strategy for Further Implementation (of the BPOA)
NEF	National Environment Fund
NGO	Non-governmental Organisation
PUMA	Preparation for the Use of the Meteosat Second Generation satellite in Africa
RECOMAP	Regional Cooperation Management Programme of the coastal zone in the Western Indian Ocean
SAP	Strategic Action Programme
SIDS	Small Island Developing States
SLR	Sea Level Rise
SLRF	Sea Level Rise Foundation
SST	Sea Surface Temperature
SWIOP	South West Indian Ocean Fisheries Project
TDA	Trans-boundary Diagnostic Analysis
UoM	University of Mauritius
UTM	University of Technology of Mauritius
UN	United Nations
UNCCD	United Nations Convention on Combating Desertification
UNDESA	United Nations Department of Economic and Social Affairs
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UTM	University of Technology of Mauritius
WIO	Western Indian Ocean
WIO-Lab	Addressing land-based activities in the Western Indian Ocean
WIOLAB	Western Indian Ocean Land-Based pollution
WIOMSA	Western Indian Ocean Marine Science Association

Annex I

The Mascarene Plateau: a Potential Large Marine Ecosystem

1. Introduction

It has been claimed that the Mascarene Plateau is the only prominent ocean submarine physical feature, which can be observed from a spacecraft by an astronaut. This is not surprising, as the plateau is unique on many counts. It is the only continental shelf in the world, which is detached from a mainland and this remoteness has kept it away from land-based sources of pollution. It has marked influence on the ecosystem, biodiversity and fishery resources in the vicinity and on the physical, and biological and chemical environment of the region.

Though much economic activities have taken place in the region for decades now in terms of fisheries exploitation, much is still unknown about it as very few literatures is available. It is certainly one of the few shallow water areas worldwide with vast opportunities for scuba diving, where, nevertheless, no in-depth research has been conducted. However, much interest has been shown recently by the international community to study the oceanography of the plateau. In particular, the Royal Geographical Society within the framework its marine environment programme has selected it as a research priority following review of various global project proposals submitted by the marine science community. This developed subsequently into a three-year programme (1998-2002) known as the Shoals of Capricorn project.

2. Physical Characteristics

This physical structure has been described as a plateau on the basis of extensive studies conducted during the International Indian Ocean Expedition in the 1960's. It was argued (Fisher et al) that "despite gaps in continuity, the feature is properly called a plateau rather than a ridge for it has characteristically wide and level summit due to extensive growth of calcareous reef organisms and precipitous flank down to depth nearly 2000". It has a broad base and extends from Mauritius (20° S) to Seychelles (5° S) in the form of an arc almost 2600m long. The northern extreme including the Seychelles Islands is composed of granite whereas the southern part is mainly basalt origin.

The geology, topography and bathymetry of the plateau are of great scientific and navigational interest. It is an aseismic plateau and is the result of intensive volcanic activity It is believed that it started to form some 50 million to 40 million years ago along the Chagos - Laccadive ridge and then detached and progressively displaced towards the south-west along a north east -south west fracture zone by the relative movements of the Carlsberg and mid-Indian Ocean ridges. It represents a "micro-continent" and is a separate entity from Africa, Madagascar and India.

Its submarine relief is a varied one. Extensive shoals and banks characterise it. More than 115,000 km^2 lie largely between 33 m and 90 m depth with a shallow rim at 8 to 20 m depth. The largest (estimated 40000 km^2 of fishable area) is the Seta de Malta where the seabed is predominantly Seagram and calcareous rubble. It has rich reef communities dominated mainly by finely branching Acropora species, which occur in large groups in some places and cover more than 50% of the reef areas. Studies have shown the presence of a healthy reef ecosystem potentially covering 100s of square kilometres on the southern part of the bank. The next largest banks are the Nazareth bank (7625 - 26000 km^2) and the St Brandon Bank (1,208 km 2 fishable area). The St Brandon Archipelago consists of nearly 55 small, low coralline islands not exceeding 6 m in altitude and sand cays covering several thousand km^2 although the total area of the reef does not exceed 190 km^2. The Soudan Bank lies between St Brandon and Mauritius.

Mauritius (1876 km^2) is the oldest of the Mascarene Islands. It is composed of three major basaltic lava flows, ranging in age from 7-8 million years to 200,000 years. Its coastline is over 200 km in length and comprises sandy, rocky and cliffed coasts and is surrounded by fringing reef enclosing 243 km^2 of lagoon. The granitic Seychelles Island lies in the extreme north of the plateau. The islands rise from the Seychelles Banks, a shoal area of 3,000 km^2 with water depth less than 60 m.

3. Meteorology

During the winter months (May - October), the southeast trade winds from the sub-tropical anticyclones in south hemisphere blow almost constantly over most of the plateau. In summer, the southern part remains most of the time under the influence of the trade winds, albeit with less force, whereas in the northern part, a change of wind regime occurs, with winds from the western sector which originates from the Asian sub continent and Arabian sea.

The Inter-tropical Convergence Zone, which on average lies on latitude 10^0S during the summer months gives rise occasionally to heavy rainfall causing significant changes in the salinity. Most of the plateau lies within the belt of tropical cyclones of the Southwest Indian Ocean. Almost every year on several occasions, cyclonic winds up to 200-km h-1 and phenomenal seas cause much

damage to the coral reef system within the plateau. Some low-lying coralline islands constantly undergo marked change in their geomorphology as a consequence.

4. Oceanography

Most of the plateau is influenced almost all the year round by the South-Equatorial Current (SEC). During the Southern Hemisphere summer months, the SEC is concentrated between 10 and 15° S with westward flowing north-equatorial current well developed to the north. The SEC is a 100-200 m thick layer of relatively low salinity, which originates in the heavy convective rainfall of the Eastern Indian Ocean. It has an estimated transport of 50x10 6 m^3 s^{-1} and current speed of up to 0.5 ms^{-1}. In its westward passage over the Mascarene Plateau and through deep channels, the SEC undergoes major changes. On the west of the plateau, it divides itself into two branches, one flowing to the north Madagascar and the other branch flows southwards along the east coast of Madagascar. In winter, the SW monsoon winds cause surface water north of the equator to change direction. The north equatorial current reverses to form the eastward flowing SW monsoon current. The SEC is then displaced northwards as far as 6° S.

The Sea-Surface Temperature (SST) varies from 28°C to 30° C along the plateau in summer, whereas in winter, it lies between 28° C and 23° C. Occasionally, abnormal high SST do occur in the region with widespread coral bleaching. A well-documented episode, particularly in the northern part is the 1998-bleaching event, believed to be associated with the 1997-1998 El Nino. The impact was unprecedented with some reefs exhibiting 95% coral mortality. In the southern part, the impact was less dramatic with less than 30% coral bleaching occurring, for instance, in the region of Mauritius.

5. Economic Values of the Mascarene Plateau

The most significant economic activity is the exploitation of the fisheries resources of the shallow banks, which extend from St Brandon to Saya de Malha and is an important source of protein for the Mauritian population. Fishing is still carried out using traditional methods. It is largely undertaken by mother ships carrying small dories. Handling by fishermen from the dories is still considered as the best method for fish capture. The catch is brought to the mother ship where, after gutting, it is frozen and preserved in cold rooms. Large nets and basket traps are also used in the St. Brandon area. The most important species in the region is the Lethrinus Mahsena commonly known as "Berri" fish with peaks occurring during the periods of December to January and May to June and contribute to 90% of the total catch.

The landing from Mauritian vessels from the banks fishery annually is shown in Table I

Table 1 - Catch in tons of Banks Fishery

Year	Nazareth	Saya de Malha	Albatros	Chagos
2003	468	2354	37	235
2004	855	1686	21	117
2005	578	1028	36	0
2006	777	1645	54	136

2007	506	1481	10	130

The northern part of the plateau is also rich in fisheries resources and is being exploited by Seychelles.

The Soudan Bank, which is located at 120 nautical miles from Mauritius, is also being exploited by commercial fishing boats. The most common species is the lethrinus rubrioperculatus.

Though the fisheries resources are mainly harvested by Mauritius and Seychelles in their EEZ, licenses have been issued to foreign vessels to operate in the region. These are mainly distant-water fishing fleet from Japan, Korea and Europe, which exploit the fishing resources without due attention to sustainability. The proportion of unreported catches is largely unknown. Some foreign fishing vessels also operate in the region without licenses.

The overall geology of the plateau, when seen in the context of dismemberment of continental Gondwanaland during the Jurassic time appears to be favourable at least theoretically for hydrocarbon resources. However, a survey carried out in mid 1970s by Texaco in the region of St Brandon however did not reveal any oil/gas fields of economic importance. Nevertheless, a detailed study in this direction may prove beneficial even from an academic point of view.

6. Scientific Interest of the Mascarene Plateau

The Mascarene Plateau is scientifically of unique interest. Extensive areas of shallow waters completely detached from land boundaries like the Mascarene plateau do not exist elsewhere. Its influence on ocean processes is definitely different from that of ordinary continental shelf where the system is constrained by land boundaries and the dynamics and ecosystem are strongly influenced by river inputs. It is strongly believed that Mascarene Plateau plays a key role in driving the ocean systems of the Western Indian Ocean with far-reaching ramifications on global ocean circulation patterns, fish stock and climate. It could be an important potential source of mixing, given its location, the surrounding steep topography and the relatively large tides in the region to provide the necessary downward heat flux to drive the thermohaline circulation.

From physical oceanographic theory, the plateau should have a strong influence on water movement, which can lead to areas of high and low plankton productivity. It has been found that, besides islands and land promontories, changes in underwater topography do cause turbulence in the flow of near surface currents creating large eddy currents resulting in an upwelling of deep water. In the case of the Mascarene plateau, it is well known that it acts as a barrier to the water flow towards the west forcing the water mass to rise as it approaches the plateau. It is believed that very complex circulation develops in its vicinity of the plateau as the water flow is channelled through with the formation of gyres and circulation cells of small diameters. Up to now, no detailed investigation has been conducted to identify the small-scale structure of the current pattern. How the South-Equatorial current behaves as it crosses over and through the channels plateau is also an issue of great scientific interest for investigation.

In addition to the physical structure mass effects, the wind pattern in the region could also contribute to the intensification of the large-scale divergence off the western region of the plateau.

Very strong winds from the southern sector particularly during the winter months of June to August occur quite often, when very strong anticyclones influence the region. This should give rise to Ekman transport on the western side of the plateau leading to divergence and convergence on the eastern side Seasonal upwelling should constitute an interesting feature worth investigating to study the combined effect of physical and dynamic elements.

It is also strongly believed that the plateau does have some influence on the changes in intensity of weather systems particularly tropical cyclone during their passage over this mostly submerged structure. A tropical formation derives its energy from the heat storage of the water mixed-layer depth, which during the peak cyclone season is around 80 m in the cyclonic belt of the Southwest Indian Ocean. A slow moving tropical cyclone, on passing across or along the plateau because of its shallowness, will, therefore, be deprived significantly of its sources of energy for the maintenance of its intensity. This has been observed in some cyclones but more investigation is required to verify this hypothesis.

However, a few studies are already providing an insight of the richness, both biologically and scientifically, of the region.

6.1 Past Studies

A first study (Ragoonaden et al, 1987) of the effect of the plateau on flow patterns and consequent redistribution of some physico-chemical parameters did reveal some interesting result. Oceanographic data collected by RS Discovery on both sides of the plateau with a lag time of only 9 days were used to study the ridge effect. A general rise in the depth of the isotherms was observed in the upper 100-m layer in the western side of the edge with a drop in temperature by more than 2°C at certain depths. Presence of **domes** and depressions in the thermal structure in the west as compared to the smooth flow pattern in the eastern side of the ridge was noted. Distribution of salinity with a well-defined salinity maximum zone cantered around 150 m in the eastern side and 2 **pockets** of high salinity cells around 150 m in the western side were also observed. With regards to phosphate distribution, it was shown that the phosphate level increased from about 0.15 μgl^{-1} in the east to more than 0.3 μgl^{-1} in the west. It was also noted that the phosphate isopleths was down at some depth in the east whereas in the western side it was almost near the surface indicating a rich zone on the West Side of the plateau.

To identify seasonal variability on either sides of the plateau, observations along two additional sections on either side were also analysed. It was found that the water is generally colder in the west as compared to that in the east especially in winter. The meandering nature of isotherms in the west was some indication of the presence of some eddies in the region. It was found those phosphate values, at surface and near surface, increased during winter with formation of a surface maximum zone (>0.3 μgl^{-1}) around the region of Agalega in the north during winter. Phosphate distribution also increased equatorwards from south to north.

A subsequent study focussed mainly on biological aspects (Devassy and Goes - 1991) showed the distribution of chlorophyll 'a' varied from 0.05 to 0.15 mg/m^3 and increased northward from Mauritius. High values of chlorophyll 'a' ranging from 0.06 to 0.09 mg/m^3 occurred on the Mascarene Plateau that increased in a westward direction. Much higher concentrations (0.10 - 0.15 mg/m^3) of chlorophyll 'a' were observed southwest of Agalega. It **was** also found that the most dominant species of phytoplankton were diatoms with, however, a mixed population of diatoms on Saya de Malha Bank.

Winter cooling, wind-driven upwelling and vertical diffusion were the most important mechanism believed to be bringing up nutrients up to the emphatic zone. In the case of Agalega, current-driven upwelling rather than wind-driven upwelling was suspected to the most important physical mechanism.

A recent study (Badal, 2002) using remotely sensed ocean colour data from Sea WIFS to investigate primary production in the region of Mascarene Plateau over a three-year period from January 1998 to December 2000 confirmed the findings of the two previous studies. Annual averages of chlorophyll 'a' and sea-surface temperature data were used for the purpose. A strong seasonal variation with annual periodicity was observed with peaks between May and September with the western region being more productive.

Eddies formation on the western side of the plateau was also observed during the winter months. It is believed that, besides the mechanical Ekman effect of the plateau, interval waves, observed east of Madagascar, could too be responsible for enhanced primary production as a consequence of refraction from the Plateau. These types of waves are known to have particularly high amplitude in areas of submarine ridges, banks and continental slope and enhanced by the high amplitude of semi-diurnal tidal wave, which is typical of the region.

Additional information about the productivity of the plateau was obtained within the framework of the Shoals of Capricorn's 3-year programme (1998-2001). Using a continuous Plankton Recorder towed by the HMS Beagle from south-east of Seychelles to the northern end of Saya de Malha (17-19 February 1999) over a distance of 443 NM at 10 metres depth, 59 phytoplankton taxa and 97 zooplankton taxa were identified in the samples. It was found that the phytoplankton consisted of 20 diatom and 39 dinoflagellae taxa.

Another study to look at the gradient of biodiversity between the north and south of the Mascarene Plateau was conducted by the SRV Zuza. This cruise focussed on the study of zooplankton in the area in terms of size and species-distributed biomass and its temporal and spatial variability in terms of physical and environmental processes that produce it. Results from the Zuza cruise showed surprisingly high levels of zooplankton biomass and provide another scientific evidence of the importance of the region. The data showed that the region is more productive than formerly thought. The influence of the Mascarene Ridge and the SEC impinging upon it is believed to be responsible for the explanation far higher than expected values. If the data gathered on Zuza are typical of the region as a whole, it is possible that an area of sub-tropical south-western Indian Ocean exhibits levels of biological productivity comparable to, or possibly in excess of upwelling areas of the world's ocean.

7. Large Marine Ecosystems (LMEs) in the western Indian Ocean

Sixty-four LMEs have received recognition globally within the scientific community. These are regions of ocean space encompassing coastal areas from river basins and estuaries to the seaward boundaries of continental shelves and outer margins of the major current systems. They are relatively large regions of the order of 200,000 km^2 or greater, characterised by distinct (1) bathymetry, (2) hydrography, (3) productivity and (4) trophically dependent populations. All the recognised LMEs, except the Insular Pacific - Hawaiian LME, which are located in the Hawaii Islands region, are extension of the mainland countries or continental shelves of continents. These continental shelves have been divided into distinct regions for a more ecosystem-based approach for management purposes.

In the Western Indian Ocean, the Agulhas current and Somali coastal current have been identified as the two LMEs in the region. The Somali LME develops during the southwest monsoon to become one of the most intense coastal upwelling in the world, bringing rich nutrients to the surface of the tropical surface waters. The Agulhas current, which flows along the coast of south-eastern Africa also, represents a region of dynamic nutrient cycling and associated fisheries potential.

The Mascarene Plateau ecosystem is, in many respects, directly connected to the Agulhas and Somali LME. The southwest monsoon, which gives rise to the formation of the Somali current, originates in the region of the Mascarene Plateau as the southeast trade winds. Any study of the Somali LME will be incomplete if the ocean processes over the Mascarenes Plateau are not taken into consideration. The Agulhas current too is indirectly connected to the Mascarene plateau circulation. The Mozambique current, which feeds the Agulhas LME, originates from the south equatorial current, which is modulated by the Mascarene Plateau. This water flow, on reaching the East Coast of Madagascar, divides itself into two currents. The northern part drifts to the northern part of Madagascar and becomes the Mozambique current. The second branch flows pole wards along the eastern side of Madagascar to feed the anticyclone gyre in the south. Consequently the Somali and Agulhas LME and the Mascarene Plateau are inter-connected and should be studied together.

7.1The Mascarene Plateau as Large Marine Ecosystems

During the Fourth Session of the IOC Regional Cooperative Investigation in the North and Central Western Indian Ocean (IOCINCWO) (Nairobi, May 1997), a recommendation to initiate the process so that the Mascarene Plateau could be recognised as an LME was approved. To justify the recommendation, the following factors were taken into account:

- It is of economic importance;
- It is scientifically of interest

The issue of considering the Mascarene Plateau as an LME was also discussed at the Fifth Session of IOCINCWIO (Nairobi, September 2002). In particular, it was decided that a scientific assessment to justify the classification should be developed and proposal, to this end, should be prepared for submission to the IOC Working Group on LMEs

The conference of the Indian Ocean Global Ocean Observing System (Mauritius, November 2002) too recognised the Mascarene Plateau as an entity for focussed attention and intensive research. In particular, deep sea moored buoys, in the region of the Mascarene Plateau monitoring various meteorological and surface and sub-surface oceanographic parameters are being proposed within the framework of the WMO/IOC Western Indian Ocean Marine Applications Project (WIOMAP). This will enable the collection of valuable metocean data, which can prove critical in the understanding of the western component of the "Indian Ocean dipole", the centre of which lies in the region of the Mascarene Plateau.

8. Concluding Remarks

It is firmly believed that the Mascarene Plateau plays a key role in driving the oceanic systems of the Western Indian Ocean with far reaching effects on global ocean circulation pattern. With the recent renewed interest in the Mascarene Plateau some oceanographic research cruises have been conducted in the region.

Valuable data have been collected. These have been shown that the plateau indeed is a rich and important oceanographic area, and the Western Indian Ocean is not an ocean desert as previously thought. However, still much of the area remains unknown and many scientific geologic questions unanswered. Ocean processes mechanism is still unclear and large portion of the area is yet to be chartered.

In view of the inherent economic and scientific implication of the plateau and its influence on a regional and global scale, it will, no doubt, continue to attract international attention as a natural laboratory for scientific investigation. Every effort should be deployed so that eventually it is recognized as Large Marine Ecosystem as recommended by the Regional Committee of IOC of UNESCO (IOCINCWIO). In this way, it will become entitled to receive international assistance in the assessment and management of its vast living and non-living resources as well as the protection of its biodiversity.

In order to adopt an integrated approach to bridge the wide gaps in knowledge about the plateau, it is suggested that a regional workshop sponsored, among others, by the IOC of UNESCO be convened with the participation of countries in and outside the region to discuss future actions and develop a project proposal. Mauritius is prepared to take the lead to this end.

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Annex II

Capacity Building and Training Component

Strategy to prepare the report

The Agulhas and Somali Currents Large Marine Ecosystems (ASLME) project is part of a multi-project and multi-programme to institutionalise cooperative and adaptive management of these LMEs. A key output of the programme is that of Capacity Building and Training (CB & T) in relation to the long term LME monitoring and management process. It is focussing mainly on reviewing national and regional training and capacity building initiatives, identifying key gaps and producing a draft comprehensive work plan to address institutional and human capacity building requirements through training initiatives. The following tasks are expected from the CB & T Specialist within the framework of the project:

- Collect of all relevant information on various themes and topics according to a pre- agreed harmonized list following in-depth discussion with all stakeholders at regional level
- Identify key elements for incorporation into a Marine Ecosystem Diagnostic Analyses (MEDA) in line with a format provided
- Develop a Draft Training Plan
- Identify key gaps and develop proposals for key training activities including work plans and budgets to address the most urgent and priority needs.
- Attend key meetings and present key findings

The work was expected to commence on 30 October 2009 and terminate on 31 March 2010. The contract was signed and forwarded on 14 January 2010 by e-mail immediately after its reception

from the ASCLME office. Though discussion was held with the CB & T coordinator and preliminary work started prior to the reception of the contract, initiatives accelerated after signing it.

Information to plan and prepare the draft report is being obtained through various channels:

- Literature review – through websites, flyers, brochures, institutions reports such as annual reports, occasional reports prepared by Ministries/related institutions and published reports on websites, interviews and personal discussion whenever the opportunity arises.
- A questionnaire prepared for the purpose (see Appendix to this Annex)
- Field visits for discussion and assisting in filling the questionnaire

In depth formal discussion on several occasions was held with the CB & T Coordinator to update the zero draft report. It is planned to send this report to all stakeholders for feedback. A first draft would be prepared incorporating all comments and suggestions received. A national review seminar is planned in order to prepare a second draft. An updated second draft would be forwarded to all stakeholders for further feedback. A daft final report would be prepared integrating all comments from the stakeholders for submission to ASCLME office. A final report would be prepared following comments and suggestions from the office.

Progress so far is satisfactory. A few institutions have responded to the questionnaire. Attempts will be made in the next phase to obtain feedback through personal visits and interviews on staff and equipment status, on gaps and needs to enhance human resources and institutional capacity.

Annex I11

SUMMARY OF NATIONAL NEEDS AND CAPACITY FOR MEETING THEM

	Themes (Chapter 4)	**Needs/gaps identified**	**How to address them**
4.1	Technical Training	• Diving and snorkelling • Ship model building • Ocean equipment and repairs • Ship and boat building. • Open diving chambers in ocean institutions in view of	Organise short courses and procure equipment

		increasing activities in diving.	
4.2	Economics and Socio economics	Very specialised subject and Expertise to teach it.	Initially visiting lecturers
4.3	Numerical expertise (statistics, Appplied mathematics ete.)	Local expertise to develop numerical models to assist in large scale protection works.	Short dedicated courses.
4.4	Data and information Management skills	A good service to marine communities in terms of data and information and products for application.	Short courses at national and regional levels on data analysis.
4.5	Legal Expertise	Legal expertise to assist in negotiation on the numerous international conventions and treaties .	Training and short dedicated courses on the numerous international conventions and treaties. Introduce modules on international conventions and treaties in law degrees
4.6	Language Education	None	None
4.7	Governance	A fundamental shift in thinking about the coast and offshore waters and a dedicated and integrated management approach.	A policy on sustainable coastal and marine development for sustainable management of coastal and marine ecosystems and resources is formulated A new approach to coastal and marine resources management promoted particularly with emphasis on the management of Marine Protected Areas.
4.8	Fisheries science	Expertise for the teaching of fisheries science.	Some short courses on fisheries science should be initiated with assistance from overseas lecturers.
4.9	Oceanography	Capacity in term of personnel and equipment to	More specialised training and equipment. Initially containers with equipment on national vessels

4.9.1	Physical Oceanography	implement programme areas identified by MOI for research both in the coastal and open sea regions. Collection of data and information and carrying out analysis to understand ocean processes in the region. Data in the open sea on and studies particularly of the Mascarene plateau. Act on the several recommendations from various reports commissioned in the past.	Acquisition of a research vessel eventually for open sea monitoring Relevant data in the custody of foreign Institutions retrieved and a literature review for compilation of all relevant papers. Review all recommendations and develop strategies and appropriate actions prior to other studies. Relevant data collected and models developed
4.9.2	Chemical Oceanography.	Studies on coastal hydrodynamics. Lack of physical oceanographers.	Training with specialization in physical Oceanography Training with specialization in chemical oceanography.
4.9.3	Biological Oceanography	More chemical oceanographers to cater for more opportunities as marine development continues with more pollution. New specialised courses for new field of activities	New specialised courses for new field of activities. .
4.10	Coastal zone management	Competent personnel who can manage the	Short GIS courses

	Geographical Information System (GIS)	GIS when it is implemented. A shortage of adequately trained people in GIS in the country.	Short GIS courses.
	Marine Protected Areas	New MPAs More trained scientists, rangers and technicians for management of new PMAs identify. Empowerment of other stakeholders.	Identify new areas for MPAs Organise short training courses. Involve stakeholders e.g. fishermen in management processes
4.11	Marine coastal geology and geomorphology	Studies on past and present processes and projection on future changes.	Strategies developed to adapt in a proactive way to the scenario.
4.12	Aquaculture	More trained expertise. New Technology	Short courses on marine culture with emphasis on new technology for the benefits of technicians and marine scientists. Exchange programme with countries where marine culture is well developed.
4.13 4.13.1 4.13.2	Coastal agriculture and forestry Coastal agriculture Mangroves	Further studies on the impacts of the coastal vegetation, particularly abuse use of fertilisers, on the coastal environment in order to develop good agricultural practices. Some studies on	Conduct studies for base line data Survey to identify potential areas for mangrove propagation

		salinity, soil type and water quality. to identify potential areas for an extensive and well planned scientifically sound extension of the propagation programme.	
4.14	Climate research	(i) A new vulnerability assessment for the coastal zone (ii) The concept of "climate proofing" mainstreamed in development projects, land use planning, regulations and permitting and national development planning. (iv) A new set back distance to take climate change into considerat ion.	Systematic, routine and continuous data collection on: • Sea surface temperature in the coastal zone and offshore areas. • Coastal erosion and shoreline retreat • Wave height and period in the coastal zone and open seas • Absolute sea level • Coastal air temperature and rainfall.
4.15	Microfauna and Meiofauna	Specialist on microfauna and meiofauna	Specialised modules on microfauna and meiofauna in Tertiary Institutions.
4.16	Macrofauna	Information on other types of macrofauna, apart from fish.	Studies on other types of macrofauna
4.17	Environmental	More emphasis in	Guidelines and pedagogical materials made

	Education and human health . Marine environment and Human Health	marine science at primary level. A more healthy coastal environment healthy for human health	available and manual on marine sciences for secondary schools for teaching purposes. The Mauritius Institute of Education to contribute in the process Posters, flyers and programme on TV with emphasis on the relation between human health and marine pollution. Regular beach cleaning by schools as a regular feature.
4.18	Tourism	Tourists to be made aware of the eco-friendly marine activities	Presentation in hotels and publicity at the airport and in publications which target the tourism industry.
4.19	Training of inspectors and observers, community involvement? (MCS, including pollution etc)	Keep abreast NGOs of new methods and new technology	Short courses organised by appropriate institutions.
4.20	Trans-disciplinary training for managers including ecosystem approach	Promotion of concept of Eco-system	Special training facilities and new approach in management.
4.21	Fishing Technology.	Quality control in industry Fish technologists.	Training and New regulation Teaching of fishing technology at regional level in one advanced institution.
4.22	Environmental monitoring, including pollution and remote sensing	More studies on ballast water	Implementation of the MOI project on ballast water be pursued. Enhance capacity to conduct studies

	Remote sensing	Environmental monitoring over the high seas particularly on the Nazareth and Saya de Malha areas	
4.23 4.23.1	Biodiversity International, Regional and National Conventions, agreements and Treaties	More human capacity to address biodiversity issues Appropriate institutional and organisational framework as well as human resources to implement effectively international and regional biodiversity-related conventions and treaties. More MPAs to be at par with other countries in the region	Proper training for more human resources at various levels. Empowerment of policy and decision makers through short training workshops Comprehensive and coherent training programme for managers, technicians, NGOs and communities for good governance and resources management.
4.24	Taxonomy and Curation	Limited expertise	Some scientists trained in curation to preserve new and rare species
4.25	Pollution: land and marine based Addressing land-based activities in the Western	Capacity on the methodology for	Short courses organized with short term

	Indian Ocean (WIO-Lab)	monitoring of marine pollution developed and	attachment to a foreign Institution.
4.26	Environmental Impact Assessment Training .	Formal training is available in EIA.	Some aspects of EIAs included in some formal course at the Universities. Some short courses organised on a regularly basis for stakeholders involved in the process.