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National Marine Ecosystem Diagnostic Analysis (MEDA)

Agulhas and Somali Current Large Marine Ecosystems (ASCLME) Project

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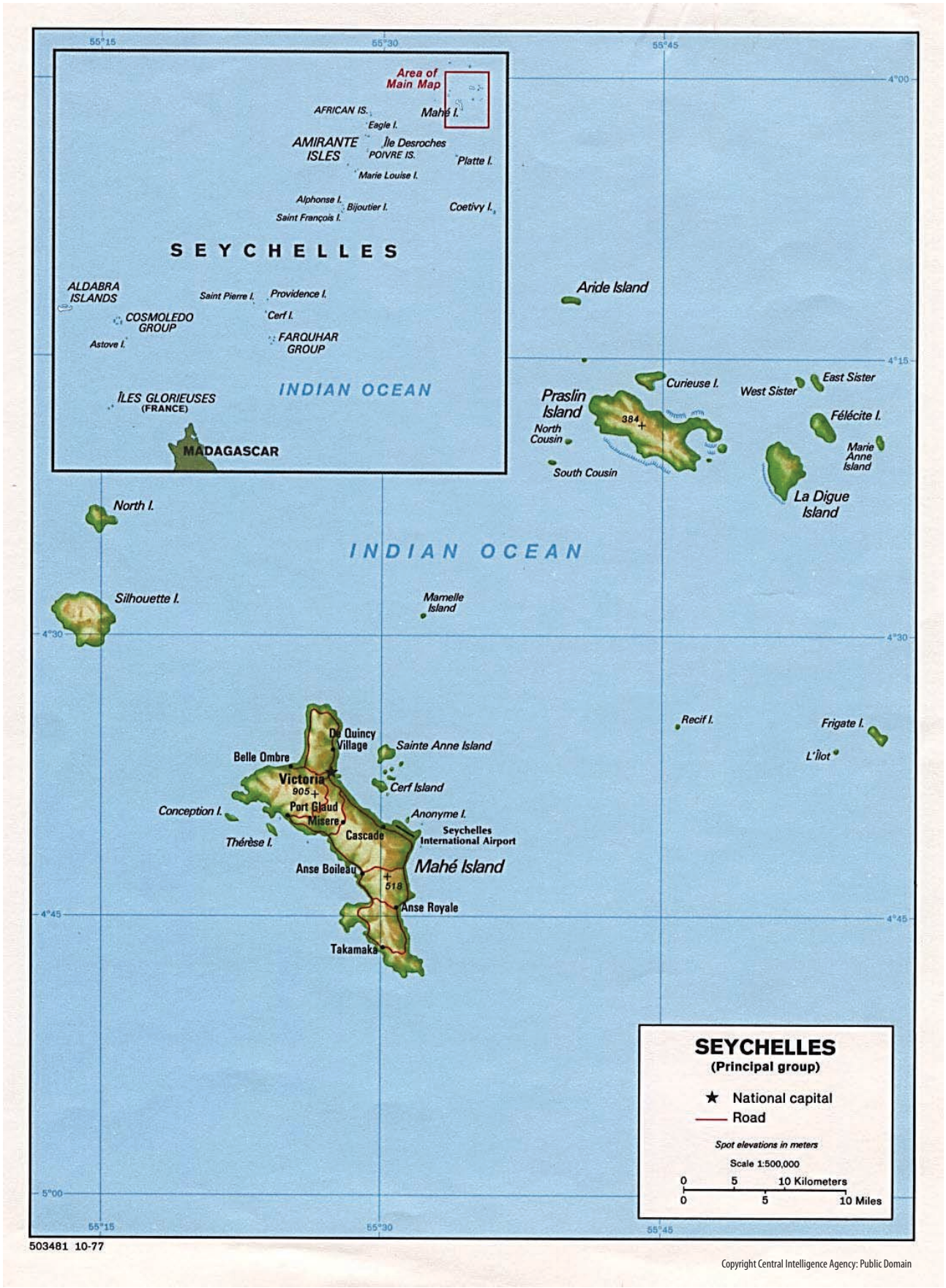
Seychelles



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ACRONYMS

ASCLME:	Agulhas and Somali Current Large Marine Ecosystems
CPUE:	Catch per Unit Effort
DoE:	Department of Environment
EEZ:	Exclusive Economic Zone
EIA:	Environmental Impact Assessment
ENSO:	El Nino Southern Oscillation
GCM:	Global Circulation Model
HABs:	Harmful Algal Blooms
ICZM:	Integrated Coastal Zone Management
IDC:	Island Development Company
IOD:	Indian Ocean Dipole
IOTC:	Indian Ocean Tuna Commission
IPCC:	Inter-Governmental Panel on Climate Change
IUCN:	World Conservation Union
MCSS:	Marine Conservation Society of Seychelles
MEDA:	Marine Ecosystem Diagnostic Analysis
MPA:	Marine Protected Areas
MSY:	Maximum Sustainable Yield
NODC:	National Oceanographic Data Centre
NGO:	Non-Governmental Organization
ODINAFRICA:	Ocean Data Information Network for Africa
POPs:	Persistent Organic Pollutants
PSMSL:	Permanent Station for Monitoring Sea Level
TDA:	Transboundary Diagnostic Analysis
TOGA:	Tropical Oceans Global Atmosphere
STB:	Seychelles Tourism Board
SETIO:	South East Tropical Indian Ocean
SEYPEC:	Seychelles Petroleum Company
SFA:	Seychelles Fishing Authority
SNPA:	Seychelles National Park Authority
SOTN:	Seychelles Ocean Temperature Network
SST:	Sea Surface Temperature
SWIOFP:	South Western Indian Ocean Fisheries Project
SWOT:	Strengths, Weaknesses, Opportunities and Threats
UHSLC:	University of Hawaii Sea Level Centre
UNFCCC:	United Nations Framework Convention on Climate Change
WIO:	Western Indian Ocean
WIO-LaB:	UNEP-GEF Project Addressing Land-Based Sources and Activities
WTIO:	West Tropical Indian Ocean

EXECUTIVE SUMMARY

The Marine Ecosystem Diagnostic Analysis (MEDA) for Seychelles presents an analysis of the status of the coastal and marine resources. It identifies the status of the biophysical and human environment including challenges in the management of the coastal and marine environment. The Seychelles archipelago is made up of 115 islands which are located between latitudes 4–11°S and 45–56°E. In addition to open ocean waters, which constitute the bulk of the Exclusive Economic Zone (EEZ), Seychelles is also characterized by a series of continental shelves with a total surface area of almost 50,000 km^2. The main critical ecosystems are coral reef, seagrass beds and mangrove forests. Coral reefs cover approximately 1,690 km^2 of which only 40 km^2 are found within the inner islands. Eight species of seagrasses and a total of eight species of mangroves are found in Seychelles.

Seychelles is vulnerable to climate change. According to climate change scenarios, marked changes in the seasonal rainfall pattern are expected. Extreme climatic events are occurring more frequently due to global warming leading to relatively higher average rainfall during an intense El Nino and abnormally low rainfall during an intense La Nina. The most serious threat of global warming has been coral mortality resulting from bleaching which in the warming event of 1997/1998 which caused 90% mortality in the inner islands. There has been a notable increase in the mean sea level, with some instances of sea level anomaly exceeding +10cm, with an annual sea level anomaly of +0.146 cm per year.

The principal freshwater sources are found on Mahé, Praslin and La Digue where several river catchments interconnect with numerous rivers and streams. Most of the rivers are ephemeral with few perennial ones. The low retention capacity of the soil coupled with the steep topography entails very high and rapid flows during rainy season and very low flows during dry season. Rainfall recharge is however extremely abundant at average annual above 2,362mm/yr. Out of this only 2% infiltrates into the groundwater aquifers and eventually seeps into rivers and streams. There are in total 38 catchment areas on Mahé covering a total of 56 km^2. Praslin has 11 catchment areas covering a surface area of 8.6 Km^2 and La Digue has 8 smaller catchments totalling 1.2 km^2.

The coastal waters of Seychelles are generally low in nutrients, with the exception of areas which receive significant inflow from food and processing factories, such as Port Victoria. Thus productivity is low and variable. However, in general, the southeast monsoon period is relatively more productive than the northeast monsoon period. There are 129 species/groups of mero-planktons and halo-planktons and 78 genus/species of copepods of which 45 are calanoids, 5 are cyclopods, 5 are harpaticoids, 22 are poicillomastoids and 1 is a monstrilloid.

The Seychelles economy is dependent on tourism and fisheries. The fishery sector has three main components, namely the artisanal fishery, semi-industrial fishery and industrial fisheries. In 2008, the total catch from the artisanal fishery was 4,777 tonnes. The major species groups targeted are Carangidae, Lutjanidae, Lethrinidae and Serranidae. The industrial component of the Seychelles fishing sector is made up of the foreign owned purse seiners and industrial distant waters longliners with license to operate in the Seychelles EEZ. The industrial fishers target mainly tuna and tuna like species. The semi-industrial fishery comprises of the monofilament longline fishery and major species targeted are swordfish (*Xiphias gladius*) averaging 60%, yellowfin tuna (*Thunnus albacares*) 20% and big eye tuna (*Thunnus obesus*) 20%. The estimated catch by the semi-industrial fleet is around 233 tonnes of which 98 tonnes were swordfish, followed by 59 tonnes of big eye tuna and 44 tonnes of yellowfin tuna. The small-scale fisheries, which includes the artisanal, contributes between 1% and 2% to GDP annually, while the fisheries sector as a whole contributes 7.7% of the GDP. About 17% of the total population is employed in the fishery sector, 30% of which are active in the small-scale sector. 10% of the population is directly dependent on the small-scale fishery sector. The tourism sector contributed 25.6% to GDP in 2010 and directly employed 25% of the labour force and generated large foreign exchange. There is a high dependency on tourism as a means of generating employment, foreign exchange and economic activity. This reliance on tourism has also spread across other sectors, with resources in agriculture and forestry largely being seen as a means to generate activity in tourism, while further growth in ports and coastal transport now directly hinges on increased activity from cruise and leisure vessels.

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CONTRIBUTING INSTITUTIONS

This document was compiled by Michelle Etienne, based on the data and information provided by a group of national consultants. Seychelles National Parks Authority provided the overall framework for the compilation of the report. The national consultants who contributed in drafting various sections of the report are: Mr. Vincent Amelie (Climate), Mrs. Helena Francourt (Birds), Mr. Calvin Gerry (Oceanography), Mr. Vincent Lucas (Fish and Fish resources), Mr. Justin Prosper (Coastal and Continental shelf), Mr. Rodney Quatre (Coast and distinctive features, marine mammals and reptiles) and Mr. Nimhan Senaratne (Freshwater resources and drainage).

1. COUNTRY OVERVIEW

The Republic of Seychelles is a remote, small Island state consisting of an archipelago of granitic and coralline islands scattered across the 1.374 million Km^2 Seychelles EEZ in the Western Indian Ocean. Although it is often quoted that the number of islands in Seychelles is 116, the constitution of the Republic of Seychelles lists 155 islands. These islands lie between 4 and 11° South and 46 to 56° East. The total land area of all the islands is 455 km^2. Hence, almost 99.97% of the Seychelles is ocean (Payet, 2006). As per the constitution of Seychelles, there are 42 granitic islands that rise from the Seychelles Bank. This bank (31, 000Km^2 & 44-65m deep) forms the Northern arc of the Mascarene Ridge (Bijoux *et al.,* 2008a). The granitic islands are characterised by lush, but steep and rugged hills, the highest of which is Morne Seychellois Mountain (on Mahé Island) which rises to 914m above sea level (Payet, 2006). The granitic islands were formed from the break-up of Gondwanaland approximately 130 million years ago by tectonic activity. They are made of pre- Cambrian rock approximately 650 million years old (Braithwaite, 1984). A total of 113 coralline islands consisting of sand cays, coral islands and raised coral atolls, are scattered across the inner island group and several other banks in the South and South West of the archipelago (table 1). Although these coral islands are typically low lying, some sand dunes are as high as 32m A.S.L (Shah, 1998). The coral islands were formed during the last reef formation period some 125 million years ago (Braithwaite, 1984).

Climate

The climate is humid tropical and dominated by alternating monsoons. The monsoons are generated by changes in the air pressure over the Indian sub-continent (Payet, 2006). They consist of the relatively calm Northwest monsoon (Mid Nov-Mid March) and South East Trade winds (end of May to Oct) which average 6 m/s (UNEP, 2004). The periods in between are referred to as inter monsoon periods and are often characterised by variable winds. The temperature in Seychelles remains high throughout the year (mean 26.9°C) as does the humidity (mean 80 %). Sea surface temperature in Seychelles ranges from 26 to 31°C whilst salinity ranges fom 34.5 to 35.5 ‰ (Payet, 2006). Rainfall is an average of 193mm per month the maximum of which occurs in January or February in the Northwest monsoon (UNEP, 2004). The sea salinity also tends to be lower during this time of year. The Seychelles lies outside the cyclone belt.

The main island, Mahé

Mahé is the largest island of the archipelago and consists of approximately one third of the land area of Seychelles (Bijoux *et al.,* 2008a). Over 80% of the Seychelles' population live on Mahé (Table 2). This main island is 60 percent urbanised (World Bank 2011). The country's capital, Victoria and the main fishing port are located on its central east coast. Port Victoria is a major hub for the Western Indian Ocean tuna fishery. In 2003 it handled 88% of the total amount of tuna caught by purse seiners in the Western Indian Ocean (SFA, 2003). It is estimated that approximately 40% of the population is found on the East Coast of Mahé, a coastal belt about 7km long and 1 Km wide (Shah, 1998).

Demographics

Before the first settlement in 1770, there were no indigenous people present on the islands. Hence the Seychelles population is of a mixed European, Asian and African heritage. The population is 88,311 (NBSb, 2010), the smallest population of any African state. At present, 60.7% of the population is between 15 and 65 years of age (NBSa, 2010). According to a census in 2010, 94.2 % of the labour force of Seychelles (50, 923 persons) is employed (NBSb, 2010). It is estimated that 90 to 100% of the population is concentrated on the coastal zone (Shah, 1998). The coastal population of Seychelles (found within 100m of the coastline) is expected to increase from 161 persons/Km^2 in 1995 to 203 persons/km^2 by 2015 (Payet, 2002). The languages used are English, French and Seychellois Creole. Over 80% of Seychellois are Christian, the majority of which are Roman Catholic.

Flora and fauna

Like many small islands, the ecosystems are fragile. Seychelles saw a loss of biodiversity following first settlement in 1770. These included extinction of giant tortoises from the granitic islands, the saltwater crocodile and Seychelles Black terrapin. Nevertheless, the Seychelles archipelago is now widely known for its array of wildlife including the coco-de-mer which is found only on two islands in Seychelles (Praslin and Curieuse) and the Seychelles black parrot which is also the country's national bird. Seychelles is reputed for success stories in flora

and fauna protection and is a world leader in sustainable tourism.

Marine life around both the coralline and granitic islands is rich in abundance and diversity. A total of 17 freshwater fish have been recorded (UNEP, 2004) and the Seychelles also hosts some of the largest seabird colonies in the world. The Seychelles has the highest diversity of marine fish and reef associated species in the region (UNEP, 2004). 1159 Marine fish species have been recorded, 749 of which are reef associated (UNEP, 2004). One of these species, the Seychelles clownfish (*Amphiprion fuscocaudatus*) is endemic to the Seychelles (Bijoux *et al*., 2003). A ban of the use of spear guns and dynamite for fishing has been in force since the 1960s. The species of fish found on the Seychelles Bank is less well known and information is often limited to catch data. Seychelles boasts 1690 Km^2 of coral reef cover (Spalding *et al.,* 2001), which is more than its total land area. The majority of these coral reefs are found in the outer islands and lack description and exploration (Bijoux *et al.,* 2008b). The Seychelles has an estimated 174 species of coral in 55 genera (McClanahan *et al.,* 2000). Although mass coral bleaching in 1998 killed over 80% of coral cover, many reefs have shown promising signs of recovery, especially the granitic reefs (Payet *et al.,* 2005).

Protected Areas

To date, over 45% of the total land area is protected. The country has over 25 Protected Areas (PAs), 14 of which are Marine PAs and 2 of which are World Heritage Sites. The PAs are designated primarily under three Acts; the National Parks and Nature Conservancy Act (CAP 141), the Fisheries Act (CAP 82) and the Protected Area Act (CAP 185). The MPAs are managed by various institutions ranging from the government to Non-Governmental Organisations, (NGOs). The Marine National Parks (MNPs) are managed by the Seychelles National Parks Authority (SNPA). The SNPA is a public enterprise of Seychelles. All three Special Reserves are managed by individual NGOs of some form. The Shell Reserves are managed by the Seychelles Fishing Authority (SFA) and the Protected Area is managed by the government.

Ecosystem health

Land-based pollution (sedimentation & nutrients) is one of the largest threats to the marine ecosystems within 5 Km around the 4 main, inhabited islands of the Seychelles owing to the fact that most of the population lives on the narrow coastal strip (Payet, 2006). The other islands remain relatively uninhabited and the only potential anthropogenic threat is that of overfishing and accidental oil spills from tankers. Another growing concern is that of coastal erosion which is more common in the inner islands where it has been aggravated by anthropogenic effects (Bijoux *et al*., 2008a).

Environmental law framework

The main legal framework for environmental protection in Seychelles is the Environmental Protection Act of 1994, the National Parks and Nature Conservancy Act of 1969, the Wild Animals and Birds Protection Act of 1991 and the Seychelles Fisheries Act of 1991.

Government and socio-economic indicators

The government of Seychelles can be described as a socialist multi-party republic. The President, James A. Michel was re-elected in 2011 and is the head of state and head of the government. The President presides over and appoints the cabinet. There is also a Seychelles National Assembly (Seychelles parliament) which consists of 34 members. The president and members of parliament serve five year terms.

The country boasts a generous welfare system and public provision of education and healthcare. These systems combined have lead to good social indicators in the Seychelles. The life expectancy is high at 73 years, infant mortality low at 12/1000 and Seychelles has universal primary enrolment (Ivaschenko, 2007). In Seychelles less than 1% of the population does not have access to potable water (UNEP, 2004).

Economy

The economy is primarily dependent on upmarket tourism and fisheries. The Seychelles is categorised as a country with middle income characteristics with a Gross Domestic product (GDP) of USD 833 million in 2008 (World Bank, 2011). It has one of the highest per capita incomes among the Middle Income Countries – approximately USD 10, 290 in 2008 (World Bank, 2011). The monetary unit is the Seychelles rupee.

The economy of Seychelles is predominantly service based. The tourism industry generates 25.6% of GDP, provides 70% of foreign currency earnings and employs approximately 30% of the labour force (NBSc, 2010). Seychelles targets a low volume but high value tourist market. In 2009, 77% of the visitors were from Europe, primarily, France, Italy and the UK (NBSa, 2010). Any decline in tourism is rapidly reflected in a drop in GDP, declines in foreign exchange receipts and hence budgetary difficulties (Shareef & McAleer, 2008). Hence, the Seychelles' economy is also extremely vulnerable to external shocks.

The industrial tuna fishing industry is an increasingly significant factor in the economy (Shareef & McAleer, 2008). The tuna fishery in the Seychelles began in 1982 and today it has exceeded the artisanal fishery (Payet, 2006). The industrial fishing sector accounts for 8.4% of GDP (NBSc, 2010). Port Victoria is now one of the most important trans-shipment and canning Ports in the Indian Ocean. 90% of Seychelles' exports are canned tuna. Other exports include frozen fish, fish meal, shark fins, medicaments and medical appliances, cinnamon bark and re-export of petroleum products (NBSa, 2010). On the other hand, Seychelles imports more than 90% of total primary and secondary production inputs (Shah, 1998). For this reason, a trade deficit is common

The aquaculture industry is expected to become increasingly important in the coming years with new projects being implemented by the Seychelles Fishing Agency.

2. BIOPHYSICAL ENVIRONMENT

Description of the coast and distinctive features

The Seychelles archipelago is made up of 155 islands which lie between latitude 4–11°S and 45–56°E. The islands are classified into two distinct groups: the inner granitic islands and the outer coralline islands. There are 41 granitic islands located in the northern part of the archipelago which rise from the Seychelles Bank, forming the northern arc of the Mascarene Ridge. The inner granitic islands are characterized by relatively steep slopes and limited flat land on the coastal plains where most urban developments are found. The coastline of the granitic islands of the Seychelles can be classified into two basic types: 1) granitic coastlines where waves break directly onto granite rocks and steeply sloping inselbergs and, 2) coralline coastlines backed by coastal plains and fronted by fringing coral reefs (Stoddart 1984). The 74 coralline islands are located to the South and South East of the archipelago. Most of these are a few metres above sea level. Between the reef crest and shoreline, sheltered lagoons with fine sandy beaches are found. Though the bio-physical composition of the Seychelles islands differ considerably, the habitat types are similar.

Coral reefs in the Seychelles cover a surface area of approximately 1,690 km^2 (Spalding *et al.* 2002) of which only 40 km^2 are found within the inner islands (Jennings *et al.* 1996b). The reefs around the inner islands are usually relatively narrow as compared to those found in the outer islands. The reefs can be classified into 2 main types: (i) granitic reefs, which consist of corals growing over large granite boulders, and (ii) carbonate reefs which are further divided into fringing reefs, atolls and platform reefs (Stoddart 1984). A number of studies have been carried out on coral reefs of Seychelles, both for the inner islands (Braithwaite 1971, Rosen 1971, Jennings *et al.* 1995, 1996a, b, Turner *et al.* 2000, Engelhardt 2004, Payet *et al.* 2005, Graham *et al.* 2006, 2007) and for the outer islands (Spalding and Jarvis 2002, Sheppard and Obura 2005).

According to Spalding *et al.* (2001), eight species of seagrasses are found in Seychelles. These are *Cymodocea rotundata, Cymodocea serrulata, Enhalus acocroides, Halodule uninervis, Halophila ovalis, Syringodium isoetifolium Thalassia hemprichii* and *Thalassodendron ciliatum.* Six of the eight species are found around Mahé (Aleem 1984, Kalugina-Gutnik *et al.* 1992). It is however important to note that limited studies have been carried out on various species of seagrass. Most of the previous studies focused on distribution, abundance and community structure of seagrass beds. The most comprehensive study pertaining to seagrass composition around Mahé was carried out by Holland (2000) during the Shoals of Capricorn programme.

Soft bottom habitats are the most extensive habitat type found around the coast of Seychelles. Studies have been carried out to map the distribution of soft bottom habitats around the inner islands and also around the Amirantes islands. Soft-bottom habitats of the outer islands are extensive in lagoons. These provide feeding grounds for sea birds including migrant birds. The soft bottom and rubble habitats of the banks are habitats for most of the demersal fish caught in Seychelles. Rocky shores are another type of habitat found along the coast of the Seychelles. They make up the longest and narrowest inter-tidal marine habitat in the inner islands. Rocky shores of carbonate origin are also found in the outer islands around raised atolls such as at Aldabra, Cosmoledo and St. Pierre Island.

Mangrove forest and coastal wetlands are found within the inner granitic and outer islands. They occupy a total surface area of 29 km^2 and there are a total of eight species, namely *Rhizophora mucronata, Bruiguiera gymnorhiza, Ceriops tagal, Sonneratia alba, Lumnitzera racemosa, Avecenia marina*, *Xylocarpus granatum* and *Xylocarpus mulocuensis.* At Port Launay in Mahé, all eight species of mangroves are found in an area that has been designated a RAMSAR site.

i) Issues

- Various biodiversity hotspots are found throughout the Seychelles. Some hotspots are located in remote places with very little anthropogenic interference, such as those found in outer islands. Other biodiversity hotspots are threatened by various anthropogenic pressures as a result of their close proximity to human populations. Various development pressures along the coast, especially tourism, are posing threats to the diverse marine habitats located along the coasts.

ii) Gaps

- The extent, distribution and status of seagrass habitats in Seychelles is still poorly known. There is a need to carry out specific studies to fill this gap.

General description of the climate

The climate of Seychelles is generally warm, humid tropical type. There is no distinct dry season and even in July, the driest and coolest month, the average rainfall still exceeds 70mm. The topography of the island plays a significant role in influencing the spatial distribution of rainfall. The main seasons can be divided as follows:

South East Monsoon: This occurs from May to October and is relatively dry and cool. Wind blowing over the Seychelles is dominated by the strong and persistent *'South-East Trade Winds'* which attain maximum speeds in the month of July and August. Precipitation during this period is normally light and rather shot-lived.

Pre-North West Monsoon: This period occurs in November and is mainly characterised by the shift in wind regime from South East to North West which is associated with the onset of the proper rainy season. This period is usually relatively warm with very light winds.

North West Monsoon: This occurs from December to March. This is the principal rainy season and it gets extremely wet in December and January. With the sun in the Southern Hemisphere, this period is also fairly warm. Winds are predominantly from the west to northwest but are generally light. This is also the Cyclone Season over the Southwest Indian Ocean region.

Pre-South East Monsoon: This occurs in April. This is the calmest and warmest period of the year as the intensity of winds reduces significantly before reversing to the Southeast.

During the Northwest Monsoon, rainfall tends to concentrate more around the highlands towards the north of Mahé. The Southeast Monsoon brings the reverse phenomena, though the western side of Mahé receives more rainfall. This is most apparent during the Southeast Monsoon.

Evaporation measurement is recorded by the Seychelles Meteorological Service. Data for the period 1972 - 2001 shows that the mean evaporation is 5.2 mm. The maximum evaporation of 6.1mm occurs in September and the lowest evaporation of 4.3mm occurs in December and January.

i) Issues and Gaps

- Only one main weather station located at the Seychelles International Airport monitors the main climatic parameters. The rest of the stations observe only rainfall and are mainly located on Mahé and on the inner and outer islands. Furthermore, many of the stations located in outer and inner islands have operated for only short periods and their data is therefore limited. In order to have a good representation of Seychelles' climate, there is a need to increase climate observation network in the country both in terms of stations and number of parameters measured. There is also the problem of limited metadata infrastructure, which is required to track climate events and to improve data analysis.

Impacts of Climate Change over Seychelles.

There is evidence that climate is changing due to an increase in greenhouse gases emissions into the atmosphere which are causing global warming. Seychelles is already feeling the effect of global warming, which is a threat to the stability of its pristine environment - a resource upon which the nation's livelihood rests. The effect of climate change is being manifested through rising temperatures (Figures 1 and 2).

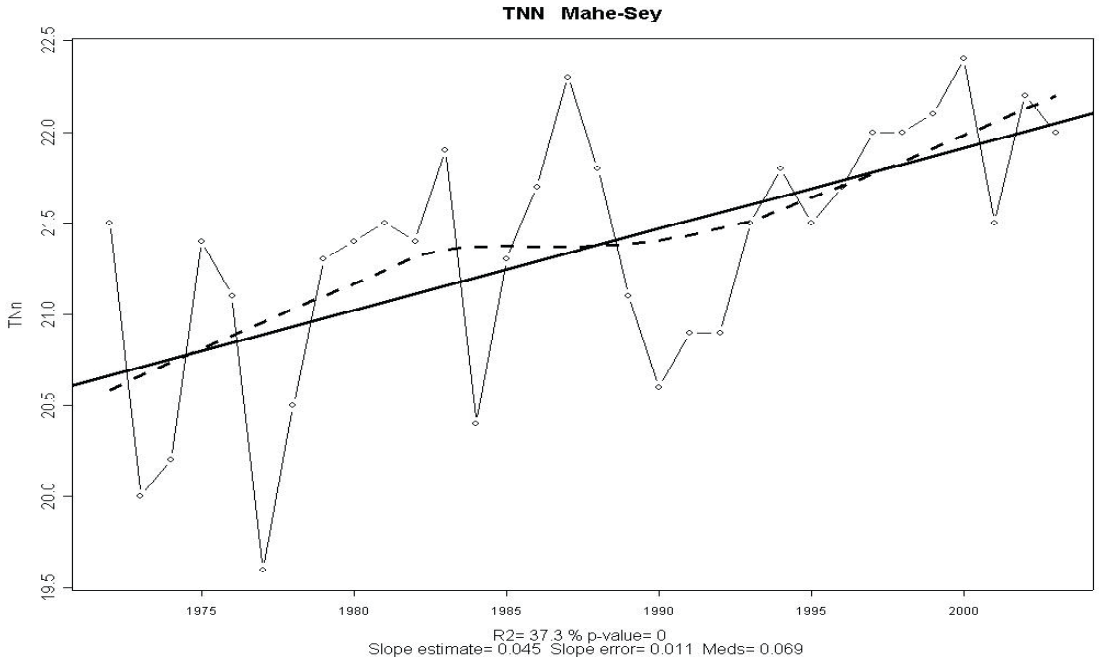

Figure 1: Monthly Daily Maximum Temperature in Mahe, Seychelles.

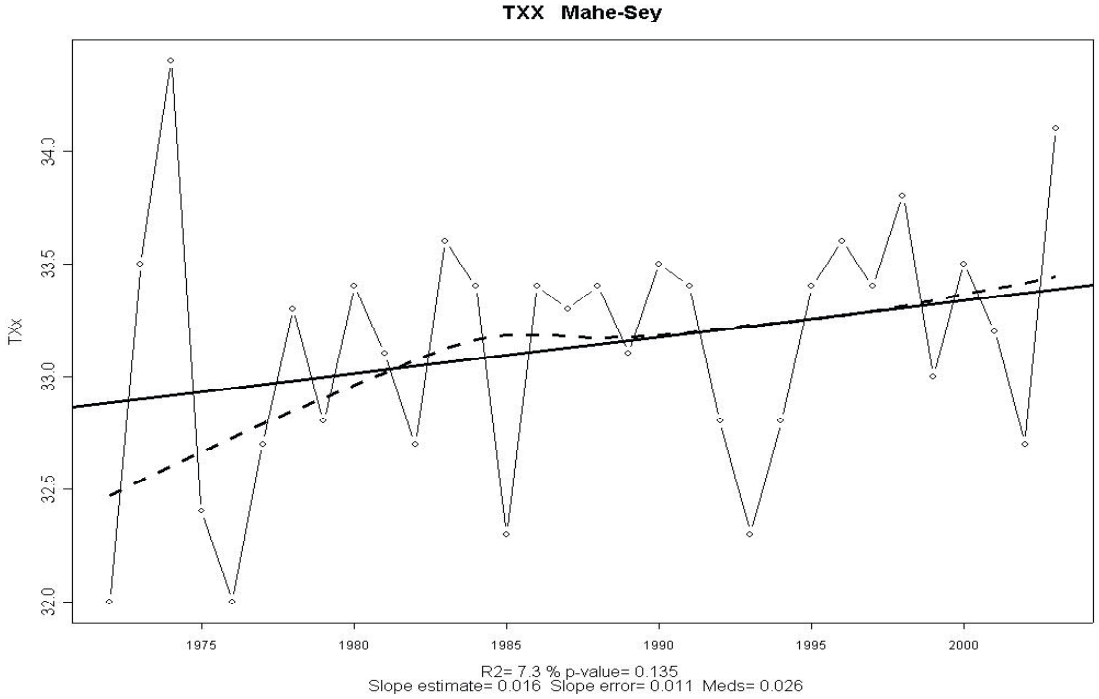

Figure 2: Monthly Daily Minimum Temperature in Mahe, Seychelles.

The climate change projections for Seychelles show that marked changes in the seasonal rainfall pattern are expected (Figures 3 and 4). The dry season is expected to be much drier and warmer, causing more serious droughts than in past years. Also, the rainy season is predicted to be much wetter than in the past with high potential for flooding on lowlying areas and landslides on hill sides.

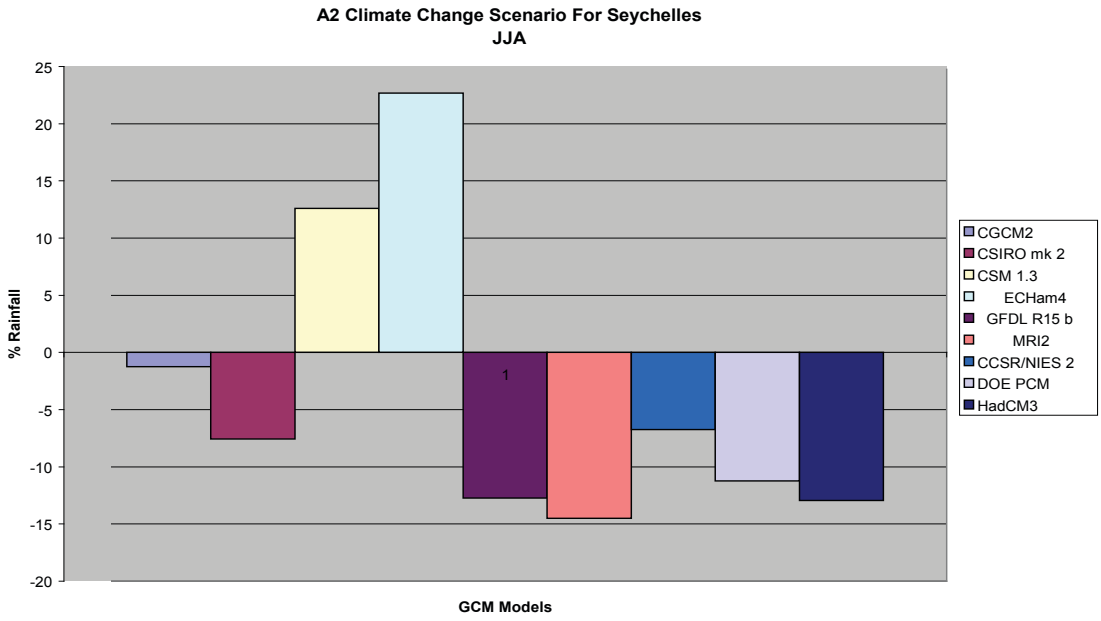

Figure 3: Long term predicted rainfall in Seychelles.

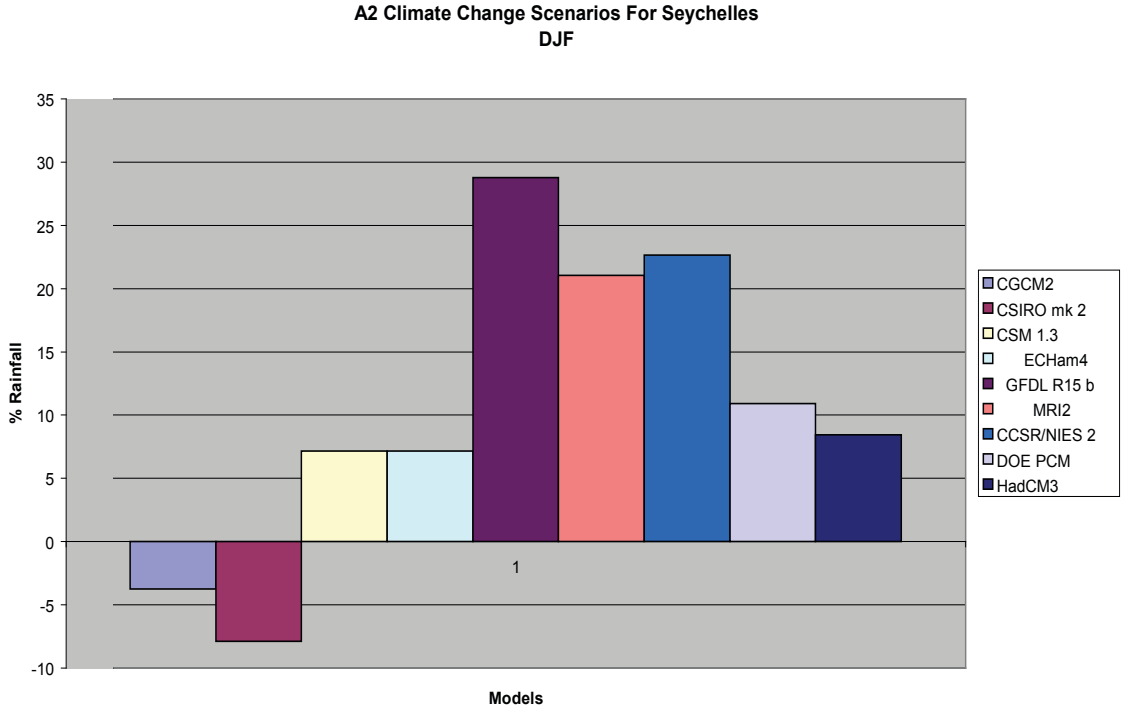

Figure 4: Long term predicted rainfall in Seychelles.

With regard to temperature, model results predict a temperature increase of between 0.63 and 3.67˚C by 2100. It is worth noting that the threats posed by global warming in the Seychelles are numerous. The most notable impacts are presented below:

Extreme weather events: Models show that extreme climatic events will occur more frequently due to global warming leading to relatively higher average rainfall over the Seychelles during an intense El Nino and abnormally low rainfall during an intense La Nina. This has potential to lead to major losses (Figure 5). The La Nina phenomenon of 1998-1999 resulted in a severe drought which caused acute shortage of freshwater resulting in some establishments to close down. The 1997 El-Nino caused a 40% loss of revenue from the fisheries sector (Robinson *et al*. 2010).

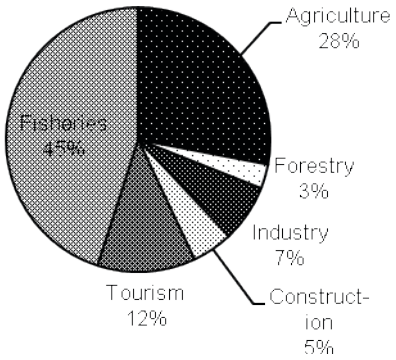

Figure 5: Estimated distribution of losses (%) as a result of the 1997-1999 ENSO event in the Seychelles.

Sea level rise: Sea-level rise will particularly affect tourism and fisheries sectors, which are the pillars of the Seychelles economy. Coastal erosion will adversely affect coastal infrastructure and biodiversity. Several low-lying coral islands and sand cays would disappear. The coastal flooding would be enhanced due to severe storms and abnormal high tides, resulting in erosion of shoreline and beaches that are critical for the tourist industry.

Natural habitat and biodiversity: Most habitats will be severely modified by the changing climate, with some being more vulnerable than others. An increase in sea-level will flood mangrove areas and reduce their extent on the granitic islands located behind the sand dunes and often below the sea-level level. An increase in sea water temperature will have various impacts on the coral reefs. The destruction of coral reefs would effectively destroy vital habitats for a wide variety of marine organisms, with dire socio-economic consequences. Seychelles is an important destination for migratory birds and it is expected that climate change would severely affect their migrating patterns.

Fisheries: Coastal systems are expected to vary widely in their responses to global warming and sea level rise. Global warming will influence ocean-atmosphere interactions, altering ocean currents, and hence changing the delivery of nutrients in different layers of the water column. This would result in changes in reproductive patterns of organisms including their migration routes and ecosystem relationships. Sea level rise would also result in saltwater intrusion in rivers, marshes, groundwater aquifers and wetlands and in the process, adversely affect critical habitats of certain species of fish. It would also impede the ability of coastal shellfish to relocate.

Long term predicted climate changes

Model results shows that the dry season will become drier and the wet season will become much wetter. Since rainfall depends on a number of closely interrelated variables, it could either rise or fall. However, most models predict an increase in rainy during wet season. As for the surface temperature, maximum and minimum are expected to increase for all seasons (Chang-Seng 2007).

Marine and coastal geology and geomorphology

The Seychelles islands have a complex geological history. In the late Cretaceous period, the north-eastern movement of a Malagasy-India block from Africa as a result of the Gondwanaland break up led to the creation of the Mozambique Channel (Stoddart 1984). The Seychelles-Mascarene Plateau may have moved with India about 65 million years ago but there was limited evidence, until extensive offshore fieldwork and geochronology were undertaken in early 1960s (Baker 1963, Stoddart 1984). It was later established that Seychelles developed through a 3-phase rift tectonism. This rift formation is somehow linked to the Reunion hotspot, which brought about Reunion Island and the Deccan Traps of India (Library of Country Congress Studies 2009). The extension of the Seychelles Bank starts from Cargados Carajos at the southern end of the Nazareth Bank, through to Saya de Malha Bank (Figure 6) and into the Mahé- Praslin Bank (Baker 1963).

The Seychelles archipelago comprises of over 41 islands of granitic origin which are believed to be the oldest rocks from the Precambrian, and over 70 coral islands which are either coral rocks or calcareous sand cays (Baker 1963). There are three types of granites- grey, red and pink granite which are quarried and used in

civil engineering and construction projects (Baker 1963, Jemielita *et al.* 1995). All three granites have similar mineralogical properties and include microperthite, quartz, oligoclase, minor amphibole and some occasional biotite. The granites are found on both the seafloor, as big boulders which provide suitable substrata for coral and other marine organisms' settlement and also above sea level. Most of the coral islands and sand cays are built on patchy reefs, and some, notably Aldabra and Cosmoledo atolls and Assumption Island are made of partly fossilized reefs which have emerged from the seafloor. Most sand cays and reef-rock islands of the Seychelles had extensive guano deposits, some has leached into the underlying sands to create phosphatic sandstone on the cays while on others is mined and exported as fertilizers (Baker 1963).

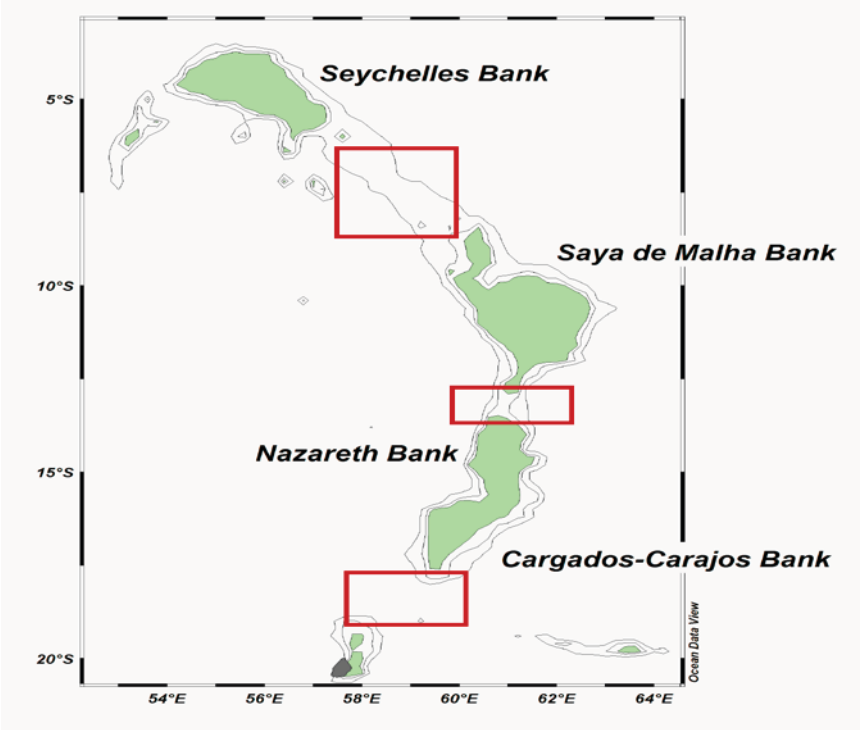

Figure 6: Location of the various banks along the Mascarene Plateau, with the red rectangles illustrating the deep channels separating the different banks (Strømme *et al.* 2008)

The surface layers of the granites on the granitic islands are exposed to weather elements and erode to form dark red laterites. This is clearly noticeable on the north-east coast of the highest peak on Mahé, Trois Frères. Most low-lying coastal areas of the main islands are well drained plateaus with calcareous sediments originating from bioclastic carbonates. Soils of the sand cays are dominated by Shioya Series soils and calcium carbonate sediments with a higher organic content shown by the darker surface horizon (Stoddart 1984). Seychelles' islands possess about 60km^2 of suitable agricultural land of which only 10% is being used for arable farming. Soil types are of very low fertility due to a large red clay content, so their agricultural productivity is very low (Government of Seychelles 2000).

i) Issues

- **Coastal erosion**
  The total length of the Seychelles coastline is 491 km (The World Fact Book 2008), which generally comprises a narrow coastal plateau surrounding mountainous inland areas. As the country develops, the major constraint has been the limited flat land. As a consequence of this, since 1973, major reclamation works have been undertaken off Victoria and the East coast of Mahé to provide more land for settlement and urban development (Bijoux *et. al.* 2008a). Coral rubble is used as fill during reclamation and this process of extraction causes erosion on one side and accretion on the other. It also damages the benthic habitat and alters the coastal and nearshore hydrodynamics (Pulfrich *et al.* 2006).
- Coastal erosion is a problem caused mostly by the change in wave patterns during the monsoons. Other triggering activities include inappropriate infrastructural development along the coast. Synergistic interactions of spring tide and storm surges further exacerbate coastal erosion problem. The prevalence of

coastal erosion is expected to follow the current trends and further escalate as a consequence of natural and anthropogenic changes. Mitigation measures to reduce coastal erosion include sea walls and breakwaters built in low lying areas to deflect and reduce wave action. However, hard coastal defence barriers provide only a certain degree of protection. Other mitigation measures include the rehabilitation of coastal vegetation in cleared beachfronts. The Department of Environment has also initiated beach profiling and monitoring programme in 2004 (Bijoux *et al.* 2008a). This monitoring programme involves the collaboration of various hotel owners, local authorities and NGOs dealing with coastal issues.

- **Mineral exploration**
  The first detailed oil exploration took place in 1969 but no significant oil reserves were found. However, following the successive well and geophysical studies carried out in 1973, a block faulted sequence overlaying a flat-lying sequence similar to rift-drift succession was located (Seychelles Investment Bureau 2009). By 1994, 23 150km of seismic profile and 27 900km of aeromagnetic lines were covered. Another active oil exploration activity took place in 1995, but with no discovery of commercially important petroleum products. However, tar balls from subsurface seeps have been observed in some of beaches around Mahé and Coetivy Island (WIO-LAB 2008). The government of Seychelles is keen on encouraging foreign oil companies to invest in hydrocarbon exploration surveys through the Petroleum Mining Act of 1976. Permission to participate in such activity must be sought prior to commencement (Seychelles Investment Bureau 2009). Minerals found in Seychelles are not strongly mineralized and have low mineralization potential, though there may be significant mineral deposits.

ii) Gaps

- The access to key data and information on coastal and marine natural resources is problematic. In addition, there are no specific data centres to archive important data sets. There are also no hydrodynamic models of the coastal zones of Seychelles.

Freshwater resources and drainage

The principal freshwater sources are found on Mahé, Praslin and La Digue where several river catchments interconnect with numerous rivers and streams. Many of the rivers are ephemeral with very few perennial ones. The islands generally have steep, swift flowing streams riddled by boulders. The low retention capacity of the soil coupled with the steep topography entails very low flow volumes during the drought season (April to August and early September). Input to the hydrological cycle via rainfall, though extremely abundant at an average 2,362mm/yr (over the last 37 years), only makes up for 2% of water seeping into groundwater aquifers and sustaining seepage into rivers and streams.

There are 38 catchment areas on Mahé Island (Figure 7) covering a total surface area of 56 km2, another 11 on Praslin (Figure 8) with an area of 8.6 km2 and 8 smaller catchments totalling 1.2 km2 on La Digue. The major catchments on the main island of Mahé are the Mare Cochons with a total area of 5.42 km2 and dry weather flow rate of 25.9 L/s. The other exploited catchments within this island are those of Le Niol, Grand St Louis, Rochon, Mamelles, Cascade and Baie Lazare. In Praslin, the major catchment is Nouvelle Decouverte which has a surface area of 1.6 km2, with a dry weather flow rate of 2.1 L/s. Other water sources that are exploited on this island include Salazie, Anse Kerlan and Fond Boffay catchments. For the island of La Digue, the biggest catchment is Maurice Payet which covers a surface area of 0.33 km2.

The abstraction of river water is complicated by factors such as short flow lengths, presence of boulders and limited surface exposure. On Mahé, there are 2 major direct river abstraction points (Rochon and La Gogue) and 11 minor ones. Abstraction type varies from domestic, agricultural and supply to treatment works. Praslin has 4 direct river abstractions, while the island of La Digue has 2 abstraction works. However, La Digue also has borehole water abstraction works with the major one located at Lalee Quersley.

Drainage networks can largely be categorized into two types, the roadside drains and agricultural canals, and the storm water canals in Victoria. The road side drains mainly caters for surface runoff from roadways and overlying steep embankments, while the storm water canals drain the five main rivers that flow past central Victoria (Public Utilities Corporation 2009).

i) Issues

- As the population grows, increasing need for housing is a major issue. The impermeable roofs of houses convey additional water into the natural drains, which in turn discharges into the artificial drains and into the main drainage systems of the lower area. There is a need to cater for increases in the volume of water flowing into the lower drains. Another effect of the upper region developments is the disturbances of soil materials, which are eventually carried by moving water and deposited into the lower areas. As a result, excessive silting of the lower reaches of rivers occurs, which restricts the capacity of the main drains leading to flooding during heavy rainfall. This issue is expected to become more critical as rainfall amounts increases due to global warming.

Physical Oceanography

Seychelles has limited capacity for oceanographic research and there is a lack of information on oceanographic features and processes on shallow banks and the nearshore environment. One critical factor in the understanding and development of oceanographic science is the availability and access to quality data. Several initiatives have been set up to address this issue, including the development of the National Oceanographic Data Centre (NODC). The NODC provides a service in accessing ocean and coastal data for the sustainable development of the country and is responsible for archiving and making available quality data and products to various users. The Seychelles Fishing Authority (SFA) is the NODC for Seychelles under the ODINAFRICA Project. This project has enabled SFA to develop the necessary capacity for achieving the NODC objectives. Furthermore, SFA has access to the different products and tools such as atlases, maps and databases that are made available for users in Seychelles.

Currents

Seychelles is impacted by the Indian Ocean Gyre as shown in Figure 7. Seychelles is mostly influenced by the eastward flowing Equatorial Counter Current and the two westward flowing currents, which are the North Equatorial Current and South Equatorial Current during the Northwest trade wind. During the Southeast monsoon, the Equatorial Counter Current and North Equatorial Current disappear and major currents that drive the circulation within Seychelles region are the South Equatorial Current and the Somali Current.

There has however been limited study on coastal currents in Seychelles waters. Most studies have been done on a project basis and usually, the studies of ocean currents have only constituted a small component within given projects. Studies have however been conducted around Mahé with the aim of providing basic information on speed, direction and distribution of the coastal currents. In the north west of Mahé (Beau Vallon) the current speed during the South East Trades vary from 0.05 to 0.1 m/s. During the North West monsoon, current speeds vary from 0.1 to 0.2 m/s (Figure 8).

A hydrodynamic model has been developed to determine the variability of the coastal current system around the main inner islands. The model outputs were considered robust and have the potential to be used as baseline data for studies of ocean circulation in the area. However, there is a need for more reliable *in situ* measurement of sea level and ocean currents to validate the model.

The lack of information on the near-shore hydrodynamic processes is a matter of concern due to the importance of the coastal zone to Seychelles' socio-economic development and due to the country's reliance on small-scale fisheries and coastal tourism. There is a need for hydrodynamic modelling to assist in better management of the coastal areas through mechanisms such as Integrated Coastal Zone Management (ICZM). Change in coastal hydrodynamic processes can result in coastal erosion and sediment displacement, with implications for sustainability of mitigation and adaptive measures. Hydrodynamic models will also be important for safety at sea and maritime risk management, including enabling of more effective search and rescue operations and management of oil spills.

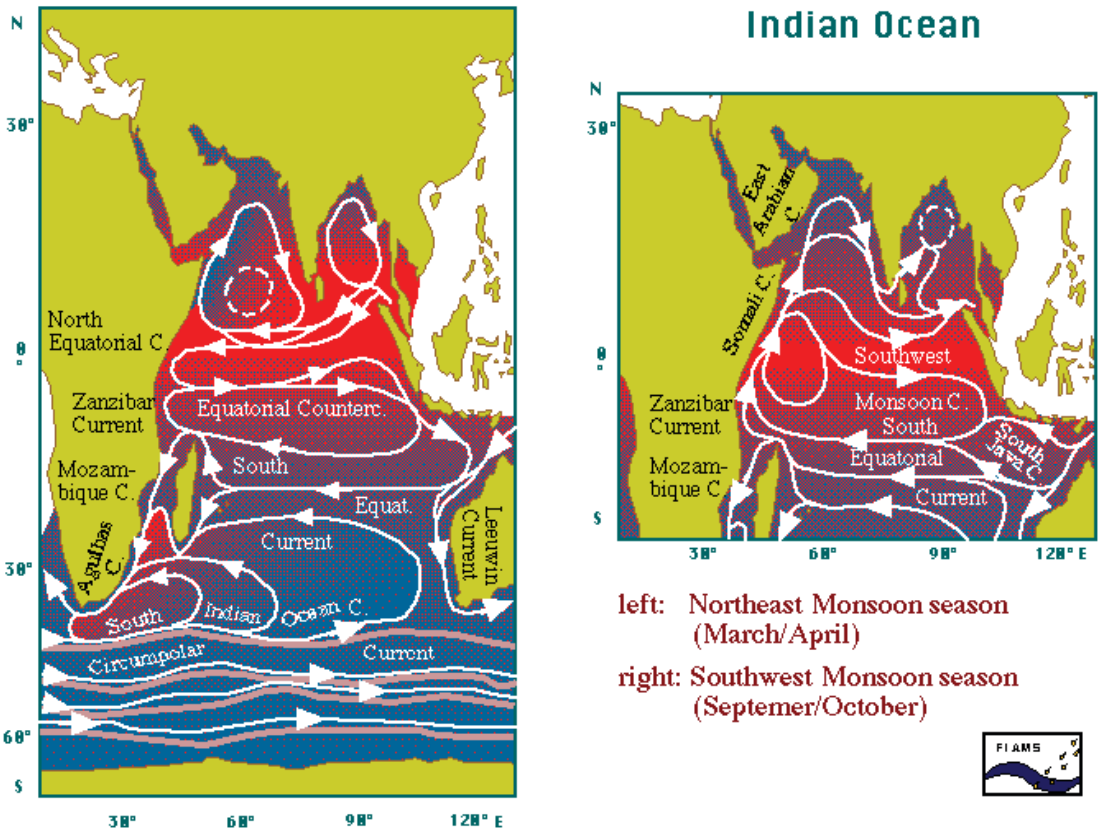

Figure 7: The major surface currents for the Indian Ocean (FIAMS)

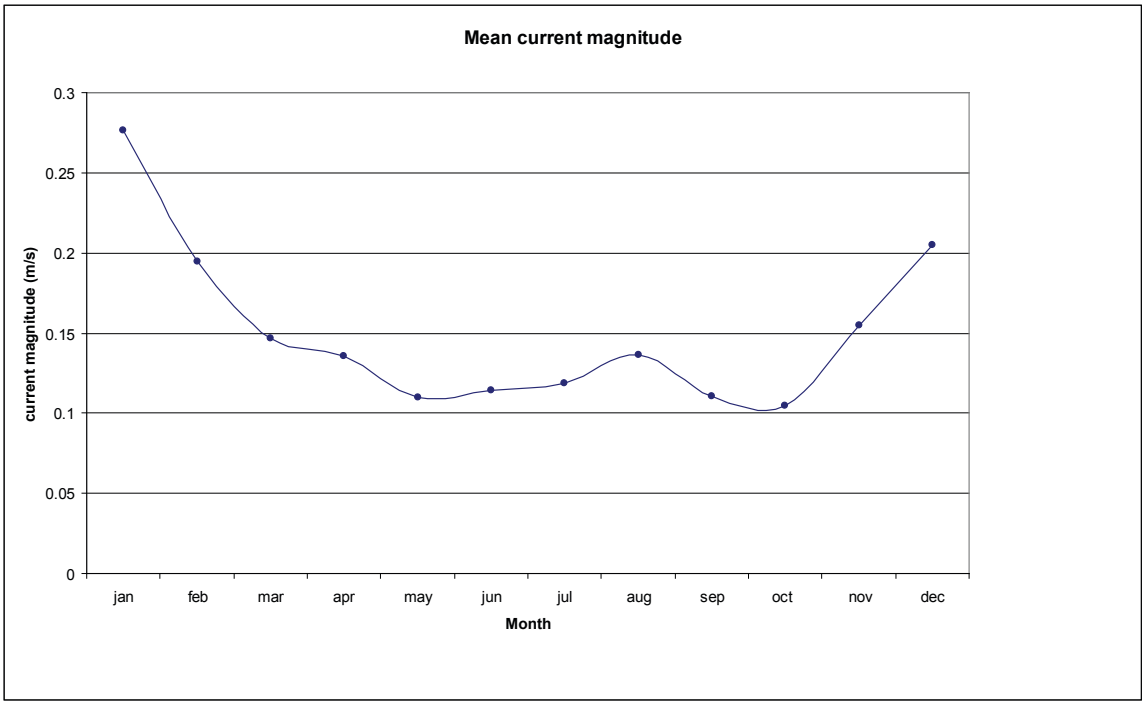

Figure 8: Mean monthly current magnitude at Mahé derived from altimetry (Source: NOAA)

Tidal regime and waves

The first tide gauge installed in Port Victoria, Seychelles provided time-series data in 1962. Electronic versions of the data are however only available from 1977 until 1982. A new tide gauge was installed at Seychelles Coast Guards jetty in 1987 and data are available in a computer compatible form from 1986 to 1992. In 1991, the University of Hawaii Sea Level Centre (UHSLC) under the Tropical Oceans Global Atmosphere (TOGA) Sea Level Science project, installed an automatic tide gauge at the Seychelles International Airport at Pointe Larue, replacing the tide gauge installed at the Coast Guard base. This tide gauge is still operational and has provided continuous data since 1993. Near real time data from this gauge can also be accessed online (Tables 1 and 2).

In May 2009, the Department of Risk and Disaster Management installed a tide gauge on Denis Island but the data are not yet available online. Both operational tide gauges are managed by the Seychelles National Meteorological Services. Tide gauges have also previously existed on Aldabra Atoll (1975-1977) and Praslin Island (1986-1989). The location of the data from Aldabra is not known, whereas those from Praslin are in analogue and digital format stored at the University of Hawaii and Bidston University.

Using the Port Victoria data collected in the early 1960s, the tidal prediction is undertaken annually by the Institute of Oceanographic Sciences. The distribution of tide tables is however the responsibility of Seychelles Maritime Safety Administration (SMSA).

Measured sea level data is required for the determination of sea level variation within the archipelago. Most of the coralline islands are low-lying and are vulnerable to sea level change. Additional sea level measurements within the EEZ will assist in mitigating adverse effects resulting from sea level rise.

Table 1: Seychelles sea level variation based on a series of tide level, charted against a fixed Admiral Chart Datum (ACD).

Tide	Height (m) above chart Datum
Highest Astronomical tide (HAT)	2.10
Mean high water spring (MHWS)	1.63
Mean high water (MHW)	1.45
Mean high water neap (MHWN)	1.27
Mean Level	1.10
Mean Low water neap (MLWN)	0.81
Mean Low water (MLW)	0.63
Mean Low water Spring (MLWS)	0.45
Lowest astronomical tide (LAT)	0.20

(Source: Hydrographic survey – Seychelles Navy)

Table 2: Information available from tidal stations located within Seychelles

Tidal Station Name	Location data	Operational Date
Aldabra	Unknown	1975 - 1977
Hodoul	University of Hawaii	1962 - 1964 1975 - 1976 1978 - 1979
Port Victoria-A Port Victoria-B	University of Hawaii & Seychelles Coast Guards	1977 - 1982 1986 - 1992
Praslin	University of Hawaii	1987 - 1989
Pointe La Rue	University of Hawaii & Seychelles Meteorological Station	11th January1993 to date
Denis Island	Seychelles Meteorological Station	May 2009 to-date

Waves

The Seychelles Meteorological Services (SMS) is responsible for monitoring of sea waves. Daily marine meteorological forecasts issued by SMS include forecasts on significant wave heights. During the Northwest monsoon, offshore waves generally approach the coast from the N-NE direction and remain relatively moderate in height, with only 9.5% of the waves being more than 2m high. During the South East Trade winds, waves are relatively higher and approach the coast from the S-SE direction. Significant wave height data for the inner islands show that that wave height peaks at 2.4m in the May to October period during South East monsoon. However, from November to April during the North West monsoon, wave heights are relatively low being of the order of 1.1m (Figure 9).

In combination with currents, wave action significantly influences the coastline, leading to inundation of the coastal plain and erosion of the beaches. It is therefore important to monitor waves in order to enable effective preparedness and mitigation of extreme wave events associated with storm surges and swells.

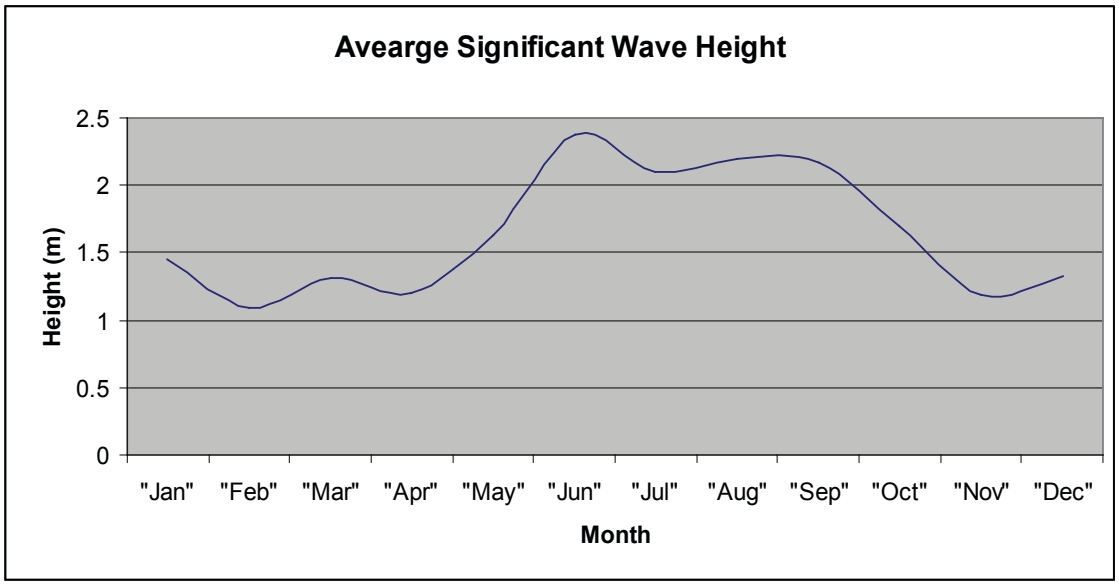

Figure 9: Significant average wave height derived from altimetry data for the inner island area (source of data).

Sea Level Change

Pointe Larue Station on Mahé is the only permanent station for monitoring sea level in Seychelles. Since its inauguration in 1993, it has provided quality data (Table 3). Available data shows that there has been a notable increase in the gradient of the mean sea level, with some instances of sea level anomaly exceeding +10cm. Furthermore, the data show an annual sea level anomaly of +0.146 cm per year, which reflects the trend computed by the PMEL in August 2005 (Figures 10 and 11). The local sea level trends are consistent with global average sea level rise at an average rate of +1.8 mm (1.3 to 2.3 mm) per year over the 1961 to 2003 period. The rate was however faster over the 1993 to 2003 period at about +3.1 mm (2.4 to 3.8 mm) per year. It is not clear if the faster sea level rise is linked to decadal variability or to changes in the long-term trends. Sea level variability in the last few years has also been influenced by extreme equatorial and mid-latitude generated storm surges and swells, as is the case with cyclones (Chang-Seng 2007)

Table 3: Information on PSMSL in the Western Indian Ocean (August 2005)

Country	Start	End	Trend (mm/yr)	Standard Error (mm/yr)	Lat			Long		
MAPUTO	1961	2000	1.24	0.51	25	58	S	32	34	E
MOCAMBIQUE ISLAND	1963	1966	14.36	7.05	15	2	S	40	44	E
NOSY-BE	1959	1972	-3.54	2.84	13	24	S	48	17	E
PT. LA RUE	1994	2003	1.05	2.11	4	40	S	55	32	E
PORT LOUIS	1942	1965	2.98	0.94	20	9	S	57	30	E
PORT LOUIS II	1987	2003	-0.94	1.9	20	9	S	57	30	E
RODRIGUES IS	1991	2003	3.95	2.5	19	40	S	63	25	E
POINTE DES GALETS	1979	1985	-1.58	4.59	20	56	S	55	18	E
DIEGO GARCIA-C	1989	2000	2.26	3.63	7	17	S	72	24	E
GAN II	1992	2003	5.76	1.71	0	41	S	73	9	E
MALE-B, HULULE	1993	2003	2.03	1.36	4	11	N	73	32	E
ZANZIBAR	1985	2003	-3.75	1.11	6	9	S	39	11	E
MOMBASA	1989	1999	3.69	2.85	4	4	S	39	39	E

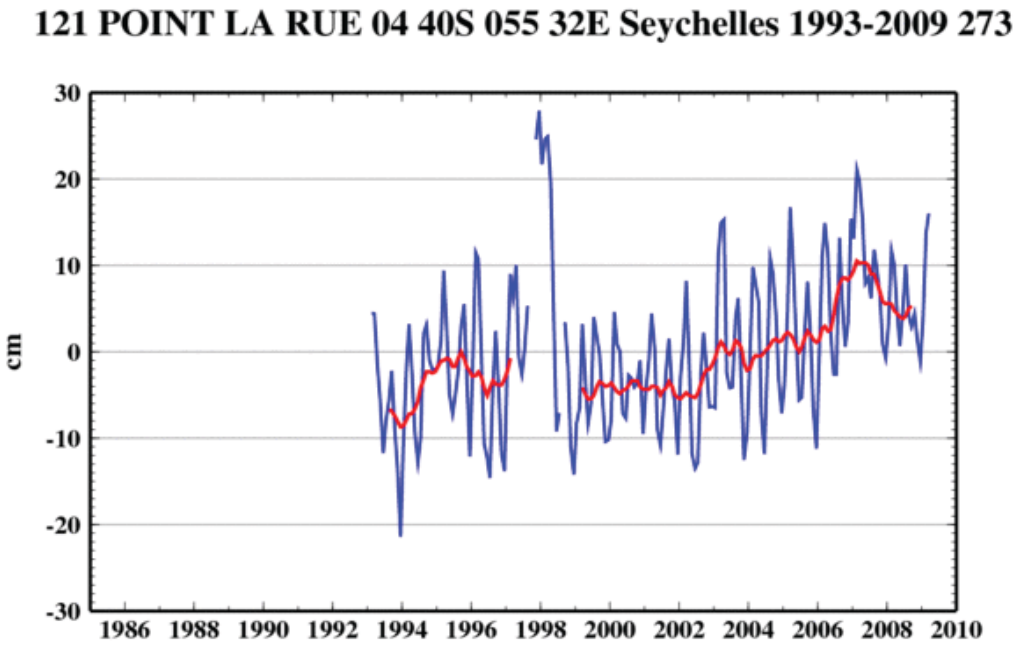

Figure 10: Time-series of Pte Larue monthly sea level anomaly. Red curve is smooth sea level (source: University of Hawaii)

There is a potential for disturbances of the natural and human environments as a result of sea level rise. These include destruction of coastal infrastructure, inundation, and erosion of the shoreline and beaches. Therefore, there is a need for monitoring sea level and conducting robust analyses in order to determine sea level variation trends. Monitoring will also assist in the development of sea level products such as coastal hydrodynamic models and tide tables. Information generated through analysis should be disseminated to users in order enable incorporation in coastal management processes.

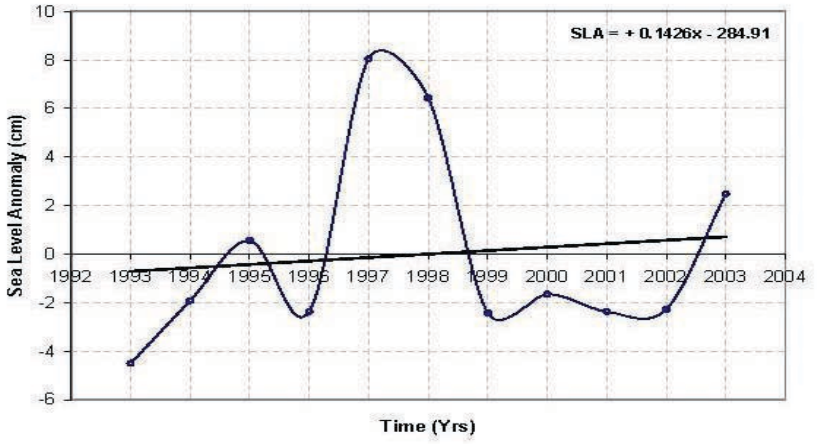

Figure 11: Time Series (1993-2003) of Pte Larue month sea level anomaly (Source: Chang-Seng, 2007)

Ocean Temperature

The sea surface temperature (SST) in Seychelles waters is characterised by two maxima and minima (Figures 12 and 13) which are linked to the transition period associated with the monsoon and Indian Ocean Equatorial currents. The primary maxima occur in April, one of the Inter-Tropical monsoon phases, when SSTs can reach 30.7°C. The Primary minima occur in July-August, when the Southeast monsoon is at its peak and the sun is in the northern hemisphere. In July-August period, SSTs may be as low as 24.0°C. From November to February, secondary maxima occur and this is followed by secondary minima. The SST difference between secondary maxima and minima has a range of about 1°C. Overall, Seychelles has a mean sea surface temperature of 27.96°C with a standard deviation of 1.5°C.

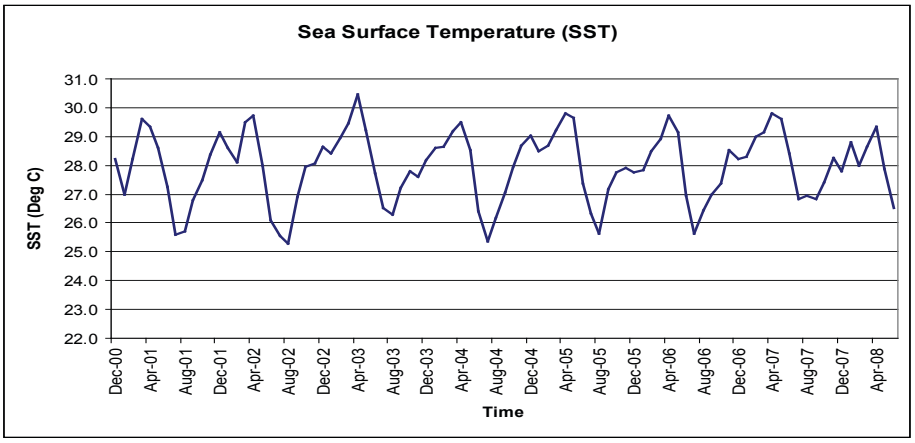

Figure 12: Time-series of sea surface temperature in Seychelles

Monitoring of ocean temperature is essential for predicting patterns of coral bleaching, which has caused significant degradation of coral reefs in Seychelles (Graham *et al.* 2005). Ocean temperature is also a variable which can provide indication of upwelling areas, where nutrients are brought to the euphotic zone within the water column. Upwelling has a significant influence on marine resources (Tarbit 1980) but the distribution and strength of these features are poorly known for Seychelles. Likewise, in-situ studies of the thermocline are lacking for Seychelles and remotely sensed data have been used to understand the behaviour and status of pelagic fish. Monitoring of ocean temperature is also critical in long term climate change studies.

To strengthen knowledge on climate variability and change dynamics and influences on marine ecosystems, Seychelles established a Seychelles Ocean Temperature Network (SOTN) as part of the Enabling Activities for the Seychelles Second National Communication to the United Nations Framework Convention on Climate Change (UNFCCC). The aim of the network is to promote collaboration in ocean temperature monitoring and access to data based on the use of *in situ* temperature loggers deployed across the Seychelles archipelago. There is website access to data, which are available from remote sensing as well as from *in situ* measurements.

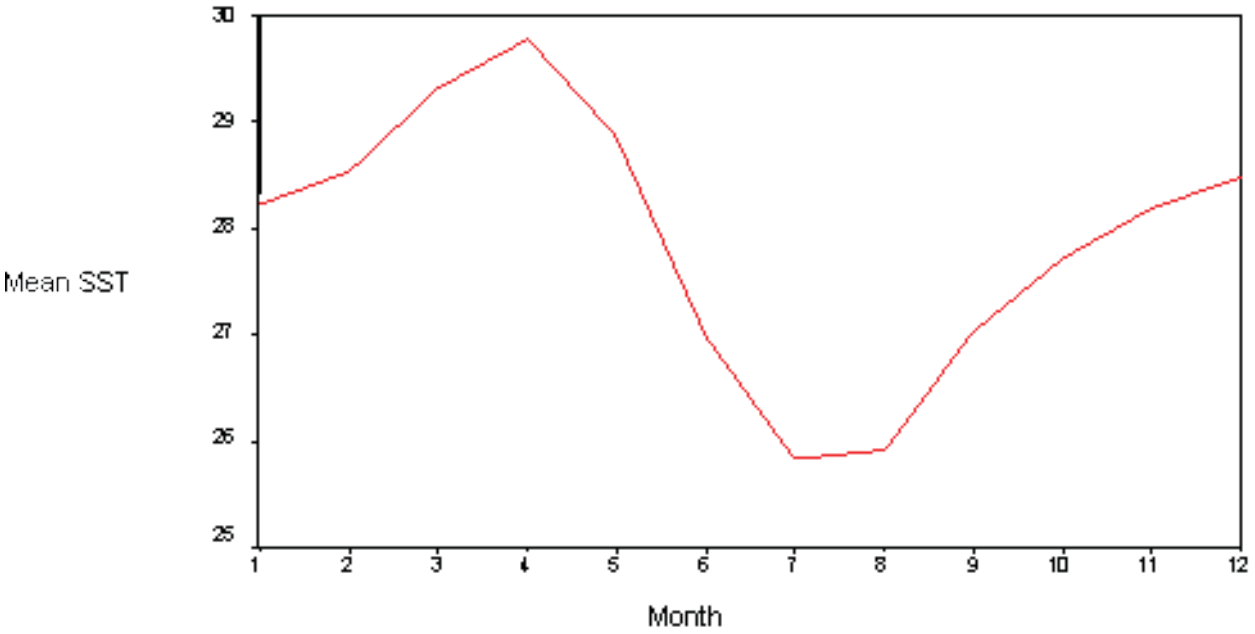

Figure 13: The mean monthly sea surface temperature (SST)

Salinity patterns

Salinity patterns and variability are poorly known in Seychelles. Conductivity, density and temperature (CDT) have been undertaken in Seychelles waters by various research programmes. In 1992, salinity measurements were taken at Beau Vallon, Port Victoria and along the East Coast. The average salinity for Beau Vallon and East Coast was 32.72 PSU, whereas for Port Victoria it was 33.14 PSU. There are a few historical salinity profiles taken in Seychelles waters. These are available in the world ocean database (URL). This data show a mean surface salinity of 35.13 PSU with a standard deviation of 0.7079.

Ocean-atmosphere interactions

Seychelles falls within the equatorial region which is indirectly affected by cyclones and the Inter Tropical Convergence Zone (Walsh 1993) and spiral rain bands associated with tropical cyclones passing south of the Seychelles islands. However, from local studies conducted by Chang-Seng (2007), it was highlighted that Seychelles has cyclonic impacts through intense rain that is equivalent to rain rates in the inner core of cyclones. The swells generated due to the cyclones create risks to maritime users and coastal populations. Therefore, predictions that cyclones in the WIO are getting stronger and more frequent are a concern to Seychelles. Another issue of concern is the potential for cyclone prone areas to widen. It is believed that with climate change, anomalous warming will probably extend into lower latitudes and conditions would become more favourable for low latitude cyclonic development. There is evidence that the risk area for tropical depressions in Seychelles is widening. Historical tropical cyclone trajectory data (Figure 14) has shown that the outer islands have been previously affected by various tropical cyclones. According to the IPCC Fourth Assessment Report, however, there is no firm evidence of changes in cyclone activity and number in other ocean basins due to lack of quality data prior to routine satellite observations.

Seychelles is also influenced by the Indian Ocean zonal dipole (IOD) - a "basin-scale pattern of surface and subsurface temperature that causes the inter-annual climate anomalies in the Indian Ocean rim" (Saji *et al.* 1999, Webster *et al.* 1999, Meyers *et al.* 2007). It is an indicator of the east-west temperature gradient across the tropical Indian Ocean and the difference between the West Tropical Indian Ocean and the South East Tropical Indian Ocean sea surface anomaly.

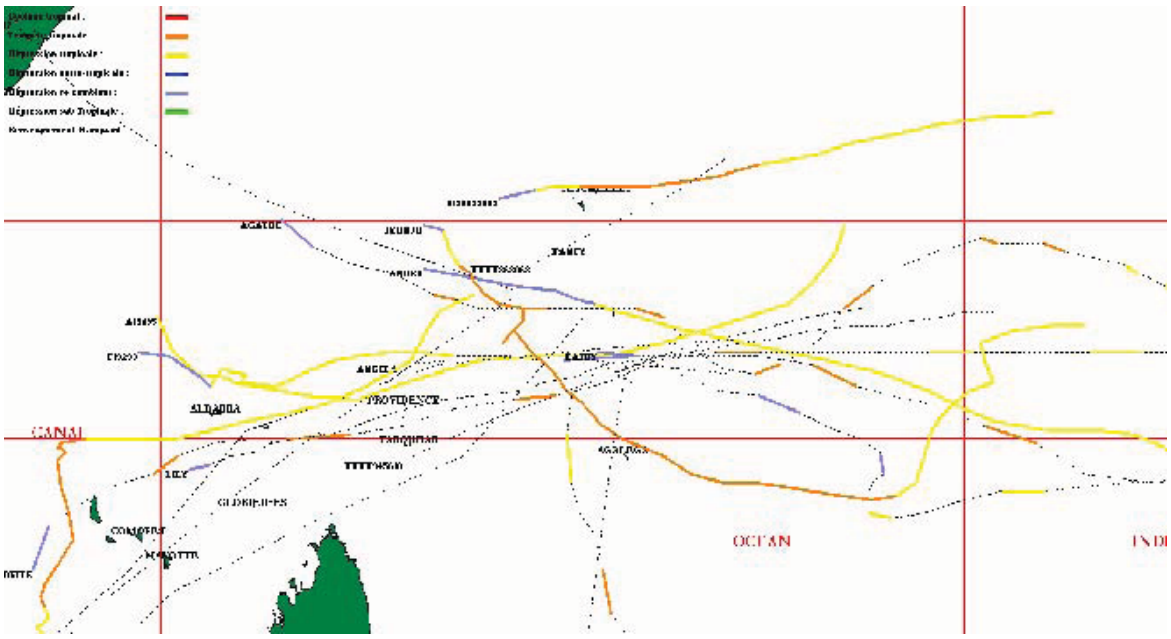

Figure 14: Historical tropical cyclone tracks in the Seychelles EEZ from 1847 to 2003 (Chang-Seng 2005)

Chemical and Biological Oceanography

Nutrients

The coastal waters of Seychelles have been found to be generally low in nutrients, with the exception of areas which receive significant inflow from food and processing factories, such as Port Victoria. In the rainy season, areas where there are significant river inflows influence the microbial quality and community structure in the coastal waters. Department of Environment (DoE) has a nutrient monitoring programme. However, there is a significant gap with regard to understanding of the effects of rapid coastal and upland development on nutrient loading, including implications for water quality and coastal habitats (Littler *et al.* 1991, Grandcourt 1995).

I) Issues

- High nutrient inputs in areas such as Port Victoria has led to eutrophication and formation of algal blooms in certain periods of the year when hydrodynamic and climatic conditions are favourable. This has effects on the marine life. However, in the absence of a monitoring programme, the risks associated with harmful algal blooms are yet to be fully established.

Persistent organic/ inorganic pollutant

The main sources of Persistent Organic Pollutants (POPs) in the marine environment are agricultural activities. However, the use of POPs such as DDT and Aldrin has been banned in Seychelles. DTT was historically used as a pesticide. Although Seychelles previous stockpiles have been disposed of, there is a possibility of leaching from landfill sites. The analysis of coastal sediments for chlorinated pesticides such as Aldrin, Lindane, Dieldrin, pp'- DDT and the breakdown products of DDT (pp'-DDD and pp'-DDE), has shown that the concentrations of these chemicals are very low in Seychelles. Most of the previously used pesticides have mostly broken down through the years (Radegonde 2008). Moreover, agricultural activities in Seychelles are mainly small scale with the result that pollution from pesticides and fertilizers are minimal. In addition, concentrations of heavy metals are quite low, with the exception of chromium, copper, lead and zinc in Port Victoria (Radegonde 2008).

i) Issues

- Port Victoria has been affected by pollution from industrial activities including effluents from the tuna canning factory and the loading, unloading and transhipment of goods. There are three main rivers flowing into Port Victoria, which alter the water quality and sediment in this area. Furthermore, the Saint Anne Marine National Park is an important area for the tourism industry. Its proximity to the Port Victoria means that the park can potentially be affected by the pollutants from the port area.

ii) Gaps

- Limited studies have been performed to examine the presence of POPs in coastal waters and their subsequent effects through bio-accumulation in the food chain. There is also limited information on leaching of POPs from landfills. Also, diffuse and point sources of oil spillage are not known. There is a need for a comprehensive monitoring of POPs, nutrients and oil spills in Seychelles.

Primary production

The oceanic waters surrounding Seychelles are characterized by low and variable rates of production. Primary productivity varies with changes in the monsoon season. In general, the Southeast monsoon period is relatively more productive than the northeast monsoon period (Cuching 1973 cited in UNEP Seas and Reports and Studies No.13). In Seychelles, there have been relatively few studies focusing on primary production. Most data are captured through satellite images and model outputs. These data have been used to examine the effects of primary production on the breeding of several bird species in Seychelles (Monticelli *et al.* 2007, Jaquemet *et al.* 2007).

The harmful effects of anomalous primary production have been felt in Seychelles. The largest phytoplankton bloom recorded in Seychelles occurred in August 2003. It caused extensive macrobenthos and fish deaths (Bijoux *et al.* 2003). Phytoplankton blooms have also been reported to cause major concentrations of tuna in the Western Indian Ocean, for example in February 2005 where very high catches were obtained from a bloom area (Fonteneau *et al.* 2008). To obtain a better understanding of these events, it is important to conduct research on primary production processes in the coastal zone. Such studies can be carried out at a regional scale since they are transboundary and many of the resources that can potentially be at risk are also transboundary, for example tuna stocks. A number of genera are known to occur in Seychelles waters. The most noticeable of them is *Ceratium* that are often caught in zooplankton nets due to their long appendages. Other species caught are often overlooked as a result of their small sizes and uninteresting shapes (Bijoux *et al.* 2003).

i) Issues

- With the increasing concerns about climate change, there is a need for studies aimed at examining shifts in phytoplankton distribution and assemblages. Such shifts can lead to changes in ocean's primary productivity which might have subsequent effects on the distribution of pelagic fishes, potentially affecting the fishing industry. In the inshore areas, the occurrence of harmful algal blooms (HABs) leads to oxygen depletion in the water column, resulting in extensive deaths of fish and macrobenthos. Such events can have short term adverse effects on the marine organisms and subsequent effects on coastal fisheries and livelihoods.

ii) Gaps

- In general, there is a lack of knowledge on phytoplankton assemblages in Seychelles. There is a need to train local scientists in the fields of phytoplankton taxonomy and research. In addition, there is lack of *in situ* measurements on primary productivity in Seychelles waters. Such measurements need to be carried out in order to provide data at a much finer scale and validate data obtained from satellite images and models.

Secondary production

In Seychelles, there are 129 species/groups of mero-planktons and halo-planktons. There are also 78 genus/species of copepods of which 45 are calanoids, 5 are cyclopods, 5 are harpaticoids, 22 are poicillomastoids and 1 is a monstrilloid (Bijoux *et al.* 2003). However, only few studies have been conducted on secondary production. A DETR-Darwin Initiative project, which started in October 2000, provided knowledge on zooplankton species and assemblages in the coastal waters of Seychelles and established a long-term coastal zooplankton sampling programme. This programme is currently on hold due to a limited number of trained personnel. However, there are data for at least three years.

In 2001, the research vessel 'RV Zuza' carried out a biological and hydrographical survey of the Mascarene Plateau and Basin between Seychelles and Mauritius as part of the Shoals of Capricorn programme. The survey found similarities in zooplankton assemblages between the offshore and inshore areas close to Mahe (Bijoux *et al.* 2003, Gallienne *et al.* 2004). The major finding of this cruise was on the role of the ridge in enhancing secondary production. More recently, in October to November 2008, as part of the ASCLME programme, the research vessel "RV Dr Fridjof Nansen" conducted an extensive multi-disciplinary cruise encompassing the

whole of the Mascarene Plateau and the adjacent basin, including the Mahé Plateau. The results of the survey shed light on the oceanic and deep water zooplankton assemblages and distribution. In addition, it provided data on the micro-zooplankton community structure.

i) Issues

- With the increasing concern on climate change and its effects on small island states, there is a need for studies that examines the possibility of shifts in the distribution and assemblages of zooplankton. It is believed changes in marine communities will first appear in the zooplankton with respect to species range and population. Hence, there is a need for closely monitoring species diversity in the zooplankton as it may have repercussion on fisheries and marine habitats.

ii) Gaps

- There is a lack of data on oceanic and deepwater zooplankton in the Seychelles. In addition, there is a need for modelling secondary production. In order to facilitate modelling, there is a need to build the capacity of the local scientists.

Coastal zone and continental shelf

Description and extent of coastal and marine habitats

The coastal environment of Seychelles encompasses a series of habitats and biogeochemical processes that influence the dynamics and functionality of the ecosystem. These habitats include coral reefs, mangrove forests, seagrass beds, rocky shore, and intertidal areas as well as coastal plains. These ecosystems are interconnected to form a complex coastal-marine ecosystem. They provide nesting and foraging grounds for numerous micro- and macro-organisms (nesting grounds for micro-organisms), assist in nutrient and hydrological cycles, larval and sediment transports and important protein sources for the coastal communities.

i) Issues

- **Coral bleaching**
  The most serious threat to the Seychelles reef system is coral mortality resulting from bleaching (Sheppard 2003). The mortality resulting from bleaching in the wake of the warming event of 1997/1998 was particularly severe in Seychelles. Live coral cover was reduced by 90% in the inner islands (Sheppard 2003, Turner *et al.* 2000). This warming also significantly affected reefs in the outer islands although to a lesser extent (Spencer *et al.* 2000, Bijoux *et al.* 2008a). Prior to the El Niño event, most corals around Seychelles were in a healthy state (Salm *et al.* 1998). The recovery of corals in Seychelles has been slow in comparison to other regions (Ahamada 2004). In Seychelles, some areas have been faring better than others with the inner islands doing much better than the outer islands (Bijoux *et al.* 2008a).
- **Destructive fishing methods**
  Most fishing methods that are destructive to benthic habitats are illegal in Seychelles. This has been the case since the introduction of the Fisheries Act (1986) which incorporated regulations banning destructive gears. It is illegal to be in possession of and use explosives such as dynamites. Bottom-trawling was also prohibited due to environmental concerns. Pelagic trawling is a very unselective fishing mode with a 5% by-catch which includes charismatic species such as dolphins, turtles and sharks. Other destructive fishing methods such as spear guns and pelagic drift nets are also prohibited. Illegal, unreported and unregulated (IUU) fishing activities are known to occur in the EEZ. In the past, some fishing vessels have been confiscated and fined for illegal activities. However, the resources required for monitoring and surveillance are high for a developing state with a small economy like Seychelles (Seychelles Fishing Authority 2009).
- **Seagrass clearing**
  Seagrass clearing is an activity which is neither encouraged nor practiced extensively in the Seychelles. However, exceptions have been made for the removal of small patches of seagrass to create bathing areas close to a few tourist hotels. However, permission has to be obtained from the Department of Environment and the areas to be cleared have to be verified before approval.
- **Beach Cleaning**
  With regards to beach cleaning, the Landscape and Waste Management Agency is the main body responsible for this task on the main inhabited islands (Mahé, Praslin, La Digue and Cerf Island) of

Seychelles. Depending on the size, the beaches in the vicinity of the tourist hotels and owners' property are cleaned regularly. As for the other Seychelles islands, the Island Development Company (IDC) workers are responsible for the upkeep of the islands. Debris from the sea also causes pollution on the outer islands' beaches (Department of Environment 2009).

- **Urban expansion**
  The expanding population is putting pressure on the coastal environment. There are only two areas which could be considered 'urban' in Seychelles, both of which are located on the main island of Mahé. The first being the capital Victoria and the second being a proposed town of Anse Royale. Victoria, which has long been the country's main and only town, has expanded inland. Due to the islands' geomorphology and protection plan (mountainous parts normally falling into National Parks), housing expansion is taking place along the coast or on low-lying hillsides. Urban development and expansion could cause additional stress on the coastal areas if not monitored and controlled (Ministry of National Development 2009).
- **Macrofauna**
  Except for shells and other invertebrates, information for macrofauna in the Seychelles is available and for some species such as turtles and whale sharks, a significant amount of work has been done. Information on shells however is quite limited and even the curio trade is not well studied. It has to be mentioned that most of the curios that are being sold by the traders in Seychelles are imported from South East Asia. With regards to sea cucumbers, the Seychelles Fishing Authority has carried out several surveys on the existing stock in some areas of the Seychelles. Other invertebrates such as urchins as not exploited in the Seychelles.
- **Invertebrates**
  There is quite a significant amount of published information on invertebrates (Garth 1984, Bruce 1984, Clark 1984, Land and Stel 1994, Hartog 1994, Hoeksema 1994, Hoeksema and Borel-Best 1994, Mackie *et al*. 2001, Bijoux *et al*. 2003). Sea cucumbers have become heavily exploited in Seychelles (Table 4) as the fishery has developed over the last decade. According to Aumeeruddy *et al.* (1999), by 1999 there were signs of depletion of the sea cucumber population. The survey carried out in 2004 found that two species were over-exploited and another three species were fully exploited (Aumeeruddy *et al.* 2005). Currently there are only 25 licensed boats that are allowed to fish for sea cucumbers and there is a three month closure (July to September) on the fishery. More than two dozen species of holothurians are exploited in the Seychelles and all products are exported to South-East Asian countries. So far, over harvesting appears to be the major threat to sea cucumbers. There has however been significant habitat destruction along the East coast of Mahé due to major reclamation works.

i) Gaps

- There is limited information on invertebrates in the Seychelles. There is therefore a need to conduct studies in this area.

Table 4: The numbers and species of invertebrates exploited in Seychelles (source: SFA, 2006)

Year	Black Teat	Sandfish	White Teat	Prickly Red	Pentard	Others	Total
2002	6,926	903	41,212	6,561	9,912	46,027	111,541
2003	8,543	33	26,374	15,779	48,504	69,482	168,717
2004	9,417	622	41,221	12,254	59,488	52,181	175,183
2006	11,602	100	45,928	17,194	83,822	98,055	256,701
2006[1]	10,050	1,852	38,148	16,189	160,190	103,844	330,273

[1] The 2006 figures are still provisional as not all catch and effort forms have been submitted to the SFA.

Fish and Fish Resources

The vast majority of fishes found in Seychelles are wide ranging species that extend across the Indian Ocean to the western or mid Pacific Ocean (Smith and Smith 1969). In addition to open ocean pelagic waters, which constitute the bulk of the EEZ, Seychelles is characterized by a series of continental shelves with a total surface area of almost 50,000 km^2 (Sweenarain and Cayré 1988). Therefore, there are a wide range of marine habitats for fishes, including shallow water fringing reefs, granitic reefs, banks, plateaux, shelves and drop-offs, atolls, lagoons, seamounts, abyssal and pelagic habitats (Jennings *et al*. 1999). The Seychelles waters are therefore relatively rich in fishing resources (Sweenarain and Cayré 1988). A total of 1196 marine species belonging to 140 families have been recorded in the Seychelles. However, a relatively low percentage of these species are targeted by any sort of fishery.

Currently, the Seychelles fishery sector has three main components, namely the artisanal fishery, the semi-industrial fishery and the industrial fisheries. The industrial fishery consists of the foreign owned purse seiners and industrial long liners, whilst the artisanal fishery consists of a subset of 15 different types of fisheries.

Up until the beginning of the 1980s, Seychelles fisheries were exclusively artisanal, located on the Mahé Plateau (within 10 miles of Mahé) or close to the outer islands, and dominated by the hand line fishery (Bach 1992). During this period, the average annual landings totalled about 4,000 tonnes (Mees *et al.* 1998) in which snappers, groupers, emperors and jacks were the dominant species. Over time high levels of exploitation within the inshore fishing grounds region raised concerns over the status of resources.

The artisanal fishery is operated solely by Seychellois fishers. The fishery is comprised of different boat types, which employ a number of different fishing gears. The fishing grounds are dispersed widely across the EEZ. Smaller boats with limited storage capacity operate in the shallow inshore fishing grounds. In contrast, larger boats such as whalers and schooners fish in the offshore banks and on the drop-off of the Mahé Plateau. Some even venture further offshore to the Amirantes groups.

In 2008, the total catch from the artisanal fishery was 4,777 tonnes. In general, the major species groups targeted are the Carangidae, Lutjanidae, Lethrinidae and Serranidae. Table 5 shows the percentage composition of the total catch for the different species group from 2000 to 2008. In 2008, *Carangoides* spp. comprised 25.7% of the catch, followed by *Lutjanus* spp. with 22% and *Aprion virescens* 15.8%. The major species comprising the artisanal catch are *Carangoides gymnostethus, Carangoides fulvoguttatus, Lutjanus sebae* and *Aprion virescens*

Table 5: Percentage (%) species/species-group composition of artisanal catch for the period 2000-2008

Species Group	Percentage (%) of total annual catch								
English/Scientific Names	2000	2001	2002	2003	2004	2005	2006	2007	2008
Trevally (*Carangoides* spp.)	37.1	30.1	41.7	33.6	28.2	24.8	19.7	18.7	25.7
Red snapper (*Lutjanus* spp.)	8.7	13.9	10.0	11.6	17.0	22.3	26.7	29.6	22.0
Jobfish (*Aprion virescens*)	11.6	16.4	12.5	15.8	12.5	11.2	15.5	15.7	15.8
Emperors (*Lethrinus* spp.)	8.9	11.2	6.9	6.1	6.2	5.1	4.4	4.6	7.1
Groupers (*Epinephelus* spp.)	3.2	2.5	1.5	2.4	2.3	2.1	3.2	3.8	3.2
Rabbitfish (*Siganus* spp.)	3.7	2.1	4.2	6.6	7.6	5.4	7.3	5.1	4.0
Mackerel (*Rastrelliger* sp.)	9.9	6.2	7.1	5.8	11.0	15.4	6.6	9.2	7.9
Other Pelagics	8.1	8.9	8.8	10.8	7.4	7.5	8.6	7.7	8.0
Other Trap Fish	4.5	3.6	3.7	3.5	3.7	2.6	3.3	2.4	3.4
Others	4.3	5.1	3.6	3.8	4.2	3.5	4.9	3.1	2.8
Total annual catch (MT)	4748.4	4285.0	4889.1	3835.7	4174.0	4433.3	3845.0	4181.4	4777.1

The semi-industrial fishery is comprised of the monofilament longline fishery operated solely by Seychellois fishers. The fleet consists of 8 longliner vessels which vary in size from 13 to 23m. They operate around the Mahé plateaux concentrating their efforts in the North Eastern section of the Seychelles EEZ. The fishery targets large pelagic fish, mainly swordfish and tuna. Table 6 illustrates the catches of different species of fish caught by the fishery from 2004 to 2008. Over the period, the major species targeted were swordfish (*Xiphias gladius*) averaging 60%, yellowfin tuna (*Thunnus albacares*) 20% and big eye tuna (*Thunnus obesus*) 20%. Other species caught includes, sailfish, marlin, several different species of sharks and other pelagic species. In 2008, the estimated catch by the semi-industrial fleet was around 233Mt of which 98 tonnes were swordfish, followed by 59 tonnes of big eye tuna and 44 tonnes of yellowfin tuna.

Table 6: Catches by species (2004-2008) of semi Industrial fishery, 2004- 2008

Year	Swordfish	Yellowfin	Big eye	Sailfish	Marlin	Sharks	Others	Total Catch (Mt)
2004	71	7	7	3	0	1	0	90
2005	168	50	56	8	2	5	2	290
2006	115	43	52	4	2	2	1	219
2007	111	70	55	5	2	3	3	248
2008	98	44	59	22	3	7	1	233

The industrial component of the Seychelles fishing sector is made up of the foreign owned purse seiners and industrial distant waters longliners operating under license agreement to operate inside of the Seychelles EEZ. These usually target tuna and tuna like species. Some longliners also target swordfish. The main fishing nations involved in purse-seining are from European Community (France, Spain) which take over 70 percent of the annual licenses. Seychelles registered purse seiners (French and Spanish origin) started operating in 1997. Currently there are 10 Seychelles registered purse seiners all of Spanish origin. In 2008, a total of 49 purse seiners were active. The total catch reported by this fleet in Western Indian Ocean for that year was 278,956 tonnes comprising of 137,330 tonnes of skipjack (*Katsuwonus pelamis*), 112,734 tonnes yellowfin tuna (*Thunnus albacares*) and 26,951 tonnes of big eye tuna (*Thunnus obesus*) (Table 7).

Table 7: Tuna catches reported in 2008 by the main purse seine fleet fishing in the WIO

	Species				
	Skipjack	Yellowfin	Bigeye	Others	Total
Spain	64,266	44,544	12,247	465	**121,522**
France	29,811	37,663	6,696	962	**75,131**
Seychelles	30,036	20,681	5,369	296	**56,382**
Others*	13,217	9,835	2,640	229	**25,921**
Total	**137,330**	**112,724**	**26,951**	**1,952**	**278,956**

** Others include Mayotte, Thailand and Italy*

Industrial longline fishing is dominated by vessels from Asiatic nations (Japan, Taiwan). The reporting of their activities is restricted to within the Seychelles EEZ unless the vessel is registered in the Seychelles. Currently there are 25 Seychelles registered vessels most of them of Taiwanese origin. Eighty-two longline vessels were active during 2008 and the total reported catch was 10,477 tonnes of which 6,027 tonnes were bigeye tuna, 1,622 tonnes yellowfin tuna and 2,819 tonnes were other pelagic species (Table 8).

Table 8: Catch by species reported by the longline fleet from 2004 to 2008.

Year	Yellowfin	Bigeye	Swordfish	Albacore	Others	Total
2004	9,451	11,695	1,910	245	1,621	24,432
2005	13,706	12,391	1,734	299	1,770	29,301
2006	6,562	8,614	1,231	162	1,850	18,096
2007	3,697	7,341	944	475	2,686	14,192
2008	1,622	6,027	794	785	2,819	10,477

i) Issues

- **Overfishing**
  The artisanal fishery is an open access fishery. Lack of management poses a threat on the sustainability of demersal fisheries. *Lutjanus sebae* is the most important commercially exploited demersal species in the Seychelles. It is caught mainly offshore on the Seychelles Bank by hook and line, although catches are also made with traditional heart-shaped bamboo traps set in coastal waters. The average annual landings of 282.9 tonnes during the period 1987–2003 approximated the MSY of 380 tonnes (Lablache and Carrara 1988). However, there has recently been a dramatic increase in annual landings to an average of 692.8 tonnes between 2004 and 2006, associated with increased targeting by the artisanal fishery. Recent assessments of the emperor red snapper (*Lutjanus sebae*) stocks showed that the stock is overexploited. Moreover, the MSY of 380 tonnes is likely to have been overestimated. Recent artisanal catches is around four times higher than the new maximum sustainable yield (MSY) estimated at 208 tonnes (Grandcourt *et al.* 2008). The Emperor red snapper, which is considered a delicacy by both locals and tourists, is targeted by fishers since it fetches a relatively higher price than other species on both the local and international market. It is clear that urgent management action needs to be introduced for *Lutjanus sebae* fishery. Recent attempts to introduce management measures for the fishery have failed mainly as a result of disapproval of the stock assessment results by fishers.
- Similarly, in recent years there has been a major threat of overfishing of sharks. In 2007, a National Plan of Action (NPOA) for the conservation and management of sharks was produced. Historical, anecdotal and fisheries-independent information suggest that inshore populations sharks have continued to be severely depleted (SFA 2007). Moreover, stocks of inshore sharks have been described as being depleted in recent fisheries reports (FAO Fisheries and Aquaculture report No. 899, 2009). As part of the implementation of the NPOA several stakeholders meeting has been organized. Several research programmes are about to get underway with the aim of improving fishers knowledge and participation in the collection of catch

data. Furthermore, the research will improve our knowledge on the ecology, biology and spatial dynamics of sharks.

- The *Siganus sutor* stocks have also been overfished (Fisheries and Aquaculture report No. 899, 2009). Relatively recent assessments of the stock showed that current fishing mortality greatly exceeded the optimal or limit reference values of fishing mortality. Research is ongoing to get a better understanding of the spatial dynamics of *Siganus sutor* at spawning aggregations and in marine protected areas, so as to improve the management of this resource. Management of this species will also be addressed as part of a wider co-management project for the trap fishery under the GEF-UNDP Mainstreaming Biodiversity programme, which was finally approved by GEF in 2007 and began implementation in 2008.
- On the industrial side, there is major concern on the status of stocks of yellowfin and big eye tuna. Recent stock assessment conducted by the IOTC working party on Tropical Tuna in 2009, incorporating recently obtained data from the Regional Tuna Tagging Programme revealed that over recent years, the stock of yellowfin tuna has been over-exploited with catches averaging 343,000 tonnes in the 1992-2002 period. It was recommended that catches should not exceed the MSY (250,000 and 300,000 tonnes) estimated by the current assessment. The results of the stock assessments conducted for big eye tuna in 2009 were broadly similar to previous work. The 2008 exploitation levels for this stock (107,000 tonnes) were within the range of estimated MSY levels (100,000 -115,000 tonnes, however catches in the past (1997-1999) have significantly exceeded MSY. The Working Party on Tropical Tuna recommended that catches of bigeye tuna should not exceed MSY levels and that effort should be maintained at or below that of 2006 (IOTC-2009)
- **Conflict between fishers and tourism activity**
  Inshore fishing activities often conflict with tourism activities, in particular, dive operators and glass bottom boat excursionists. One such example is the conflict between inshore shark fishers and dive operators. Both parties rely on sharks for their livelihood. Dive operators often have special sites where they take clients to observe shark in its natural environment. However, with increasing fishing pressure, it has become increasingly difficult and rare to observe sharks in their natural environment. As part of the Seychelles NPOA on sharks, stakeholder meetings were organized and areas designated for fishing and diving were delineated. However, this remains an over the table agreement between the two parties which has not been formalized in any law or management plan.
- **Effects of Aquaculture**
  The aquaculture sector is not well developed in the Seychelles. Currently (2009) only one small scale aquaculture farm - the Ocean Farm Ltd, is in operation. It produces black pearls from black lip oyster (*Pinctada margeritifera*) and giant clams (*Tridacna maxima*) for the aquarium trade. The Coëtivy Prawn Farm for tiger prawns (*Penaeus monodon*), stopped its operation in 2008. However, as demand for marine living resources increases and natural stocks diminish, the Seychelles Government has found it necessary to promote the development of the mariculture industry in the Seychelles. The other reason is to diversify into new sectors and generate value addition service opportunities.
- In early 2009, a scoping exercise to access the potential for mariculture development was conducted and one of the recommendations was the need for the Seychelles to develop a Master PLAN to drive such initiative. Seychelles is opting for caged mariculture because of the scarcity of land for land-based aquaculture. The Master plan will guide existing and potential aquaculture/mariculture operations by identifying specific species, suitable sites and technologies which can then be used to set up aquaculture/mariculture operations.
- **Habitat Destruction**
  Coral bleaching events due to climate change leads to changes in habitat complexity and has had major effects on coral reef fish diversity in Seychelles. Studies by researchers from the University of Newcastle-upon-Tyne, Australia and the Seychelles have shown that the coral bleaching event in 1998 altered reef ecosystem. They reported local extinctions, substantial reductions in species richness, reduced taxonomic distinctness and loss of species within key functional group of reef fish (Graham *et al*. 2007). The main families of fish that have been heavily impacted are the monaenthids, chaetodontids and pomacentrids. Species which they observed possible local extinction were *Labrichthys unilineatus*, *Chaetodon lineolatus*, *Plectroglyphidodon johnstonianus*, and *Thalassoma hardwicke*. In contrast species which they observed a reduction in abundance to critically low levels were *Oxymonacanthus longirostris*, *Chaetodon trifascialis*, *Chaetodon melannotus*, *Chaetodon meyeri*, *Plectroglyphidodon dickii*, and *Chromis ternatensis* (Graham *et al*. 2007). It is important to note that loss of habitat complexity due to bleaching will only have minor

implications for Seychelles' artisanal fisheries as a whole. This is because the vast majority of demersal fish are bank species and the shallow line and trap fisheries for reef fish proper are relatively minor (Graham *et al*. 2007).

- Dredging and reclamation in the marine environment has been and still is a controversial issue. A large part of Victoria as is known today is built on reclaimed land. There has been extensive reclamation works since the early 1980s on the east coast of Mahé to create flat land which is a necessity due to the small terrestrial area of the main island of Mahé coupled with its steep mountainous terrain which makes building on higher ground difficult. At present there are still small amount of land reclamation that are taking place mainly by individuals and far away from coral reef ecosystem.

ii) Gaps

- Small pelagic species migrate seasonally in Seychelles waters. However, little is known on their potential as fisheries resources. There is also lack of information on deep water resources such as deep water snappers as well as deep water crustaceans (crabs, shrimps etc). Research surveys need to be undertaken to identify species composition, distribution patterns, abundance and fisheries potential for those resources as well as other small pelagic resources. The vastness of the Seychelles EEZ presents enormous opportunities for research initiatives into new and under-utilized resources that could be of potential commercial and economic importance for the country.

Mammals

Two orders of mammals occur in Seychelles, the Sirenia and Cetacea (Table 9). The only Sirenian species is the dugong (*Dugong dugon*), with only few individuals having been recorded in the atoll of Aldabra. Data on marine mammals in Seychelles is relatively limited with the earliest information recorded during the whale fishery era which started in 1823 (Best 1983). Even if the area of the Indian Ocean where the Seychelles islands are scattered has been declared as a whale sanctuary, there have been very few studies that specifically target marine mammals.

The most important areas for cetaceans in the Seychelles include the area North and South of the Mahé Plateau, the Amirantes and the area around the Aldabra atoll. There have been no specific studies to investigate whether these areas are important breeding, foraging or resting grounds. The Marine Conservation Society of Seychelles (MCSS) is the only NGO that works with marine mammals in the Seychelles. According to the MCSS website (www.mcss.sc), 41 species of cetaceans have been observed in Seychelles waters. A volunteer Observers network was set up in 2002 by the Ministry of Environment in collaboration with MCSS, the Zoological Society of Paris and the Paris Museum with the aim of gathering more information on marine mammals. Unfortunately, this network has not yet provided much information. Another main source of information relating to marine mammals over the years has been from purse seiners fishing in the Seychelles waters in the 1980s.

i) Issues

- Fishing: Although all marine mammals are protected under the law and therefore harvesting is not a major threat. There are however several incidents of poaching of dolphins every year, although the number of occurrences is decreasing.
- **Sound Pollution**: Although marine pollution is also not a major threat for marine mammals in the Seychelles, oil exploration causes some amount of sound pollution which can pose great danger to the cetaceans.
- **Habitat destruction**: Most habitat destruction in the Seychelles has occurred on the inhabited Inner Islands of the Seychelles archipelago and has mostly affected the immediate coastal marine environment. These include reclamation, sedimentation from runoff and alteration of the coastline. These however have minimal effect on the cetaceans.

ii) Gaps

- There are many existing gaps relating to marine mammals in the Seychelles and there is a need for research to better understand these species. Gaps are particularly evident with regard to information on the migration patterns, behavioural ecology, breeding, foraging and resting grounds.

Table 9: Known species of cetaceans found in the Seychelles (Wendling *et al.* 2003).

Scientific names	Vernacular names
Dolphins	
Stenella longirostris	Spinner dolphin
Stenella attenuata	Spotted dolphin
Stenella coeruleoalba	Striped dolphin
Tursiops truncatus	Bottlenose dolphin
Lagenodelphis hosei	Fraser's dolphin
Steno bredanensis	Rough toothed dolphin
Grampus griseus	Risso's dolphin
Toothed Whales	
Globicephala sp.	Pilot whale
Peponocephala electra	Melon-headed whale
Orcinus orca	Killer whale
Feresa attenuata	Pygmy killer whale
Pseudorca crassidens	false killer whale
Ziphiidae	Beaked whales
Mesoplodon grayi	Gray's beaked whale
Mesoplodon pacificus	
Mesoplodon densirostris	Dense beaked whale
Ziphius cavirostris	Goose beaked whale
Baleen Whales	
Kogia simus	Dwarf sperm whale
Physeter macrocephalus	Sperm whale
Megaptera novaeangliae	Humpback whale
Eubalaena glacialis	Right whale
Balaenoptera physalus	Fin whale
Balaenoptera borealis	Sei whale
Balaenoptera acurostrata	Minke whale
Balaenoptera edeni	Bryde's whale
Balaenoptera musculus	Blue wale

Reptiles

Sea turtles

There are four species of sea turtles found in Seychelles waters. However, only the green turtle (*Chelonia mydas*) and hawksbill turtle (*Erethmochelys imbticata*) nest in the country. The nesting grounds for hawksbill turtle are mainly in the granitic islands, whereas Green turtles nest mainly in the outer islands. The other two species of sea turtles that are found in Seychelles waters are leatherback turtle (*Dermochelys coriacea*) and the loggerhead turtle (*Caretta caretta*). The Seychelles hosts 1 of the 5 most significant populations of hawksbill turtle, which is listed as critically endangered (Mortimer 1985). According to the SEYMEMP Report (2003), over the past 20 years there has been a 50% decline in the number of female nesting hawksbills. Fortunately, some of the most important nesting sites have protected status either as special reserves or as marine national parks for green turtles, the numbers of nesting females appears to have increased significantly during the past 35 years. Mortimer (1985) reported that nesting activity on Aldabra during the period 1981- 1985 was approximately double the figures that were by reported by Frazier in the period 1976/1984 (Gibson 1979). Initial results produced for the most recent study indicate that there has been an increase in nesting activity of Green turtles since the early 1980s and that the average numbers of egg clutches produced during the period 1995 - 2002 are approximately 2 to 3 times the number produced during 1981-1984. This shows that, the Aldabra Green turtle population has increased in size as a result of been given protective status.

i) Issues

- All marine turtles are protected under the law and many important nesting grounds have legal protection

status. However, there are still incidents of turtle poaching, especially of greens in the outer islands and the Hawksbill around the inner islands. There have also been instances where marine debris has been swallowed by turtles or entangled the animals. There is also concern that coral reef degradation and seagrass loss could affect the feeding of hawkbill and greens, respectively. Coastal development constitutes a significant threat, especially tourism related development, where nesting habitats are either being destroyed or there are increasing activities on previously undisturbed beaches. Also, the nesting turtles are disorientated by lights of hotels. Sea level rise also poses a threat to the nesting habitats. Although turtle bycatch rates may be low, it still occurs in many fisheries. There are also issues with entanglements in Fish Agregation Devices (FADs).

ii) Gaps

- There is a need for data and information on the behavioural ecology of the marine turtles at the various stages of their life cycle. There is also a need for better understanding of migration patterns. There is also a need to determine the population status and threats in areas other than Aldabra and the inner islands and to evaluate the extent of turtle poaching.

Birds (seabirds and coastal birds)

Seychelles' high ornithological profile is partly due to the vast amount of breading seabirds that occur within its EEZ (Bijoux *et al.* 2003). Despite the fact that the archipelago is not situated along any important migratory routes, some colonies of *Fregata* spp. regularly consist of more than 1 million birds and hence, are amongst the largest colonies in the world (Bijoux *et al.* 2003). Hence, seabird conservation is of great importance in maintaining both national and international bird biodiversity.

To date, 18 species of seabirds are known to breed in the Seychelles (Burger and Lawrence 2003). The most comprehensive document on seabirds of the Seychelles is the Important Bird Areas (IBAs) of the Seychelles inventory by Rocamora and Skerrett (2001). This report encompasses the seabirds and water birds of Seychelles. Historically it had been recorded that 20 species of seabirds bred in the Seychelles islands (Bijoux *et al.* 2003). However, seabird population sizes have reduced significantly since 1968, with the advent of human settlement in the Seychelles (Bijoux *et al.* 2003). Two species have become locally extinct, namely *Pelicanus rufescens,* commonly referred to as the pink-backed pelican (Bijoux *et al.* 2003), and *Papasula abbotti*, Abbot's booby. A population of the latter once bred on Assumption Island but were driven to local extinction at the beginning of the 20th century largely due to destruction of their habitat by phosphate mining (Rocamora and Skerett 2001, Bijoux *et al.* 2003). The species which continue to breed in Seychelles are listed in Table 10. Within the Seychelles, the inner granitic and outer coralline islands can be considered as two distinct bio-geographical regions.

Inner Granitics:

In this biogeographical region, Aride, Cousin, Cousine and Bird Island host seabird colonies of regional and global importance (Rocamora and Skerrett 2001). Seabirds found in large numbers on these four islands include *Puffinus pacificus* (wedge-tailed shearwater), *Puffinus Iherminieri* (Audubon's shearwater), *Anous tenuirostris* (lesser noddy), *Anous stolidus* (brown noddy), *Gygis alba* (white tern*), Phaeton lepturus* (white-tailed tropicbird), *Sterna fuscata* (sooty tern), *Sterna anaethetus* (bridled terns and *Sterna dougallii* (Roseate terns). The presence of the Yellow bittern, *Ixobrychus sinensis*, on Mahé, Praslin, La Digue and Curieuse is of particular interest as the Seychelles in the only location within the Western Indian Ocean and African regions where this Asian species occurs (Bijoux *et al.* 2003). Two other species of waterbirds that have been described in the granitics include *Bubulcus ibis sechellarum* (cattle egret) and *Butorides striatus degens* (green-backed heron) (Bijoux *et al*. 2003).

Outer coralline islands:

Seabird colonies of regional and global importance can be found on the outer islands (Table 10). Aldabra atoll stands out amongst the outer islands for having unique bird life and large colonies of nesting seabirds, particularly the greater and lesser frigate birds and red-footed boobies (Skerrett 1995). Aldabra is also unique as it is the only location in Seychelles and non-continental area in the world where the Caspian tern *Hydroprogne caspia* breeds (Skerrett 1995). Two of the world's three species of tropic birds, the red and the white-tailed tropic bird, breed on Aldabra (Skerrett 1995). The atoll is also a haven for a multitude of migrant birds. Within the

waterbirds category, *Egretta dimorpha* (dimorphic egret) can be found on Aldabra in possibly several thousand pairs (Bijoux *et al.* 2003). This species is restricted to the Western Indian Ocean. The Near-Globally Threatened *Ardeola idea* (Madagascar pond heron) which is found in Madagascar is also found on Aldabra in small numbers of approximately 20-50 pairs (Bijoux *et al*. 2003). A small population of 25-50 Greater flamingos, *Phoenicopterus ruber roseus* can also be found on Aldabra (Bijoux *et al.* 2003). Important heron colonies of *Ardea cinerea* (grey heron) are found at Providence. The subspecies *Butorides striatus crawfordii* is endemic to the outer islands.

i) Issues

- Prior to human settlement on the islands, it is likely that breeding populations were limited by habitat availability rather than food (Bijoux *et al.* 2003). However, within the past hundred years, several factors have been considered to play a role in the declines in the population of seabirds in the Seychelles. These threats include human exploitation for food, habitat destruction/loss from land use changes such as coconut plantations, guano harvesting, and the introduction of alien predators such as cats and rats (Feare 1978, Bijoux *et al.* 2003). The main issues are detailed below:
- **Human disturbances:** A good example of a seabird affected by human disturbances is the red-footed booby (*Sula sula*). Massive and continual declines in the global population have been observed (Burger and Lawrence 2003). Although the sooty tern *O. fuscatus* is the most abundant seabird that breeds in Seychelles, its eggs are also commercially exploited. The effects of this harvesting in Seychelles and management options have been investigated and are part of ongoing research in Seychelles (Feare and Doherty 2004). Despite enforcement efforts to control the amount of eggs harvested, poaching still remains an issue, especially on the outer islands (Feare *et al.* 1997, Rocamora and Skerrett 2001). Lack of monitoring, control and surveillance is largely due to logistical and economic constraints.
- The issue of poaching also applies to the population of roseate terns (*Sterna dougalii*) in Seychelles which also appears to be in decline (Burger and Lawrence 2003). This has been attributed to competition with the more abundant Lesser Noddies for food and egg poaching at the African Banks. Studies have also shown that not only disturbances from poachers but uncontrolled mass tourism can also affect breeding success of seabirds (Rocamora and Skerrett 2001). Fortunately this is not an issue in Seychelles as of yet, as eco-tourism is promoted at length.
- **Habitat loss:** Habitat loss is a threat, especially in the inner granitic islands due to the ever growing human population coupled with the tourism industry. This includes land clearing and drainage of wetlands for developments such as housing. This can be exacerbated by the additional threat from global warming and sea level rise which can particularly affect the outer low-lying coralline island and the African banks where breeding colonies occur, as well as Bird and Denis Island (Rocamora and Skerrett 2001).
- **Introductions and alien invasive species:** Another threat to bird populations in the Seychelles is that of introduced plants and animals. Some introduced animals such as *Rattus* spp., *Felis catus, Tyto alba* and *Acridotheres tristis*, have caused severe reductions in breeding populations through the predation of eggs, chicks and adult birds (Rocamora and Skerrett 2001). For example, the barn owl, *Tyoto alba* particularly favours seabird colony islands and feeds on terns (Neville 2009). Some seabird species such as *Gygis alba* are restricted to mostly rat free islands such as Cousin, Cousine and Aride (Burger and Lawrence 2003). Introductions of other birds can also cause a problem through competition for food and other resources (Rocamora and Skerrett 2001). The introduction of invasive plants can also have a secondary, indirect effect through habitat modification. For example, populations of *Sterna fuscata* have suffered declines due to the replacement of indigenous vegetation on the islands where they breed with cultivations such as coconuts *Cocos nucifera* (Feare *et al.* 1997).
- **Fisheries and fishing methods:** The threat caused by the expansion of the commercial fishery within the Seychelles' EEZ is important. This threat is yet to be quantified. However, the hypothesis is that industrial fishing will reduce the abundance of predatory fish which in turn will affect the food supply to seabird species (Rocamora and Skerrett 2001). A good example is the wedge-tailed shearwater, *Puffinus pacificus* which feeds on schools of fish brought to the surface by predatory fish such as tuna (Burger and Lawrence 2003).
- **Effects of fisheries:** Procellariiformes species are most vulnerable to being caught in by-catch in longline fisheries (IOTC 2009a). These include albatrosses and petrels. Mitigation measures used within the IOTC to reduce seabird by-catch include night setting with minimum deck lighting, bird-scaring lines (tori lines) and weighted branch lines (IOTC 2009b). However, it is important to note that within the Seychelles' EEZ, commercial fishing vessels are prohibited from fishing within the vicinity of multiple IBAs as these

are already protected areas, e.g. Aldabra. In addition, the universal method of using a tori line is used to deter feeding seabirds from longliners (Vincent Lucas *pers comm*).

- **Lack of knowledge:** The status of knowledge of seabirds for the granitic inner islands is generally quite sound. However, for the outer islands the quality of data is lower and in many cases out of date (Bijoux *et al*. 2003). This is largely due to their remoteness and difficulty of access.

Conservation infrastructure:

The Ministry of Home Affairs, Environment and Transport (MHAET) is the government agency responsible for all environmental matters and conservation of fauna and flora in the Seychelles. The main laws covering the protection of nature in the Seychelles include:

- The Wild Animals and Birds Protection Act (1961) which defines the basic regulations for protection. Laws covering the exploitation of species includes; (i) the wild Birds Protection Regulations (1966) and (ii) Wild Birds Protection (Nature Reserve) regulations (1966).
- The National Parks and Nature conservancy Act (1969).
- The Animals Disease and Imports Act (1981) which regulates the importation of exotic species.
- The Environment Protection Act (1994).

There are three main categories of protected areas relevant to seabird conservation in the Seychelles. These are:

- **Special Reserves:** This category provides the highest level of protection to wildlife and its habitat as it bans all forms of human activities except nature conservation and restricted ecotourism (Rocamora and Skerrett 2001). There are four special reserves in Seychelles. Three are in the inner granitics; Aride Island, Cousin Island (declared in 1975) and La Veuve Reserve on La Digue (declared in 1991). Aldabra atoll which was declared a Special Reserve in 1981 is found in the outer island group.
- **Marine and Terrestrial National Parks:** The main aim of the 6 Marine National Parks is to protect marine life, but they also protect seabirds and shorebirds. Fishing is banned in these parks and other human activities are controlled. The Morne Seychellois and Praslin Terrestrial Park are the largest protected areas of land in the inner granitic islands and can serve as a sanctuary to some birds.
- **Nature Reserves:** There are seven additional Nature Reserves, two (2) in the Amirantes and five (5) in the granitics that were declared under The Wild Birds and Protection Regulations (1966) for the protection of breeding seabirds. Unfortunately enforcement in these sites is lacking and they are subject to poaching and disturbance.

Other Protected Areas: The African Banks was designated as an area of restricted access in 1987. This site is an important breeding area for some seabirds such as *Anous stolidus* and *Sterna dougalii.* Other *areas that are* privately owned but unprotected by law, such as Cousine and Frégate, are carrying out rehabilitation projects and can offer protection to breeding seabirds (Rocamora and Skerrett 2001).

ii) Gaps

- Although the knowledge of seabirds in the Seychelles is quite enormous, some data is now out of date, especially data for the remote outer islands. The following specific gaps have been identified:
- There is a limited understanding on the breeding biology of Aubudon's shearwater (Burger and Lawrence 2003).
- There is a limited understanding on the size of remaining population of boobies (*Sula* sp.) especially the masked and brown booby which have suffered massive decreases in the recent years (Burger and Lawrence 2003). Colonies ranging between tens of thousands of these two species have ceased to exist on a number of outer islands and some inner islands.
- Limited research and monitoring of S*terna caspia, Sterna bergii* and *Sterna sumatrana* in the Seychelles (Burger and Lawrence 2003).
- Populations of White Tern (*Gygis alba*) need to be determined especially on the coralline islands (Burger and Lawrence 2003).
- *Pisonia grandis* is also predicted to have a severe impact on seabirds in the Seychelles. The effects of his native plant on seabirds on Cousin and Aride were surveyed in April-June 2009 (SSG 2009). In April-June 2010, a new survey was conducted on Cousin. The survey confirmed that *Pisonia* have a significant impact

on white tern, white-tailed tropicbird and Audubon's sheawater on Cousin (Derand *Pers Comm*). However, it remains to be determined whether the densities of *Pisonia* in the Seychelles are above natural levels.
- Data on seabird by-catch in Seychelles EEZ is very limited. There is a need for data on the effects of longline fisheries on seabirds in Seychelles' EEZ (IOTC 2009a).
- An assessment of impact of purse-seine fishing on tropical seabirds is required.
- Indirect impacts of commercial fisheries on tropical seabirds which forage in association with tuna (IOTC 2009b).

It is important to note that this list is not exhaustive as no quantitative meta-analysis was carried out and therefore should only be used as a guideline for possible further research that can be carried out in Seychelles.

Table 10: Summary of the breeding seabirds in Seychelles Islands.

Common Name	Species Name	Colony size	References
Wedge-tailed Shearwater	Puffinus pacificus	31, 000 pairs	Burger & Lawrence, 2003
		11,107 pairs (95% CI: 7,548-14,665) in Nov. 2002	Bristol, 2002
		19, 500 pairs	Burger & Lawrence, 2003
		15, 000 pairs	
White Tailed Tropicbird	Phaethon lepturus		Burger & Lawrence, 2003
		763 pairs (95% CI: 461-1,005) in Feb. 2010	Derand, 2010
Audubon's Shearwater	Puffinus lherminieri	57,000 pairs	Rocamora & Skerrett, 2001
		1,418 pairs (95% CI: 764-2,071) in Feb. 2010	Derand, 2010
		several hundred pairs	Rocamora & Skerrett, 2001
		600 pairs	
		50-100 pairs	
Red-footed Booby	Sula sula	15, 000 pairs	Rocamora & Skerrett, 2001; Burger & Lawrence, 2003
		6, 000-7,000 pairs	
		50-70 pairs	
Red-tailed Tropicbird	Phaethon rubricauda	1,900 pairs	Burger & Lawrence, 2003
		few hundred pairs	
		5-7 pairs	
Masked Booby	Sula dactylatra	5, 000-6,000 pairs	Burger & Lawrence, 2003
		3, 000-5,000 pairs	
		a few possible	
Brown Booby	Sula leucogaster	60 pairs	Burger & Lawrence, 2003
		4 pairs in 1976, none in1999	
		undetermined	
Greater Frigatebird	Fregata minor	4, 000 pairs	Burger & Lawrence, 2003
		16-20 pairs (1,000 in 1970s)	
Lesser Frigatebird	Fregata ariel	6, 000 pairs	Burger & Lawrence, 2003
		Extinct	
Sooty Tern	Onychoprion fuscatus		Feare et al., 1997
Bridled Tern	Sterna anaethetus	3,300 pairs	Burger & Lawrence, 2003
		404 pairs (95% CI: 195-612) in Feb. 2007	Allen, 2007a
		100-200 pairs	Burger & Lawrence, 2003
Caspian Tern	Sterna caspia		Burger & Lawrence, 2003
Greater Crested (Swift) Tern	Sterna bergii		
Black-naped Tern	Sterna sumatrana		
Roseate Tern	Sterna dougalii	1200 pairs	Ramos et al., 2002, Monticelli et al., 2008
		82 pairs (1997)	
		100-200 pairs	

Common Name	Species Name	Colony size	References
White (Fairy) Tern	Gygis alba		Burger & Lawrence, 2003
		2,083 pairs (95% CI: 1,541-2,625) in Feb. 2010	Derand, 2010
Lesser Noddy	Anous tenuirostris		Burger & Lawrence, 2003
		66,272 pairs (95% CI: 54,398-78,145) in July 2009	Derand, 2009
Brown (Common) Noddy	Anous stolidus	10,000 pairs	Burger & Lawrence, 2003
		8, 200 pairs	
		1,861 pairs, 95% CI: 1,005 – 2,717 in July 2007	Allen, 2007b
		2, 000-6,000 pairs	Burger & Lawrence, 2003
		1,000-3,000 pairs	
		Thousands	
		800-1,200 pairs	
		1,000 pairs	

3. COASTAL LIVELIHOODS

A comprehensive coastal livelihoods assessment has been carried out. Chapter summaries are presented below, and the full Coastal Livelihoods Assessment may be found in Annex X for further information.

Small-Scale Fisheries

The small-scale fisheries, which includes the artisanal, contributes between 1% and 2% to GDP annually, while the fisheries sector, as a whole, contributed 7.7% in 2008, an increase of 1.3% from 2004. Seychelles has very limited land-based opportunities for agriculture, tourism etc. Thus, the fishery is a vital source of income, employment, food security and foreign exchange in the country. This reliance on the sector is most evident in the fact that 17% of the total population is employed in the fisheries sector, 30% of which are active in the small-scale sector, while 10% of the population is directly dependent on the small-scale sector.

The role of the small-scale fisheries sector as one of the main coastal livelihoods faces numerous challenges. For example, high operating and investment costs have made it difficult for the sector to meet quality standards set by the European Union which has both blocked the sector's access to the European market and also made its products less competitive in the global market. Lack of development in value-added products, poor marketing, as well as limited number of processing companies, also continue to constrain growth in the sector. The government has however, recognized the importance of infrastructure development and finance to the sector, particularly as a means of remaining competitive. For example, the Youth Enterprise Scheme not only provided fuel vouchers to registered fishers, but it also distributed loans to purchase new equipment. Likewise, the Investment Promotion Act has provided numerous tax breaks and concessions to local companies in the semi-industrial sub-sector, while infrastructure upgrades, such as reef clearing and improved port facilities, continue to be implemented by the state.

As a whole, there are several strengths and opportunities (Table 11) through which the small-scale fishery can grow. The country's close proximity and easy access to the migratory path of tuna in the Western Indian Ocean, and its stable investment environment highlight the great strengths prevalent in the sector. Because of these strengths, there is also an opportunity in the sector to begin grading products, expand processing facilities, develop more efficient marketing strategies and further exploit resources offshore. Nevertheless, over-reliance on government subsidies as well as the threat of over-exploitation in high-value species are risks that need to be mitigated in the future.

Tourism

Tourism contributed 25.6% to GDP in 2010, an increase of 2.2% from 2007, directly employing 25% of the labour force and generating an estimated SR 2437 million in foreign exchange in 2008. Despite reaching its peak in 1996, revenue increased from SR 938 million to SR 2,437 million between 2004 and 2008. Bed occupancy increased from 44% to 57% between 2005 and 2008. The European market accounts for an overwhelming 76% of total visitors, with France, Germany, Italy and the UK being the most predominant.

Numerous challenges have been highlighted in the sector (Table 12), despite the expected increases in activity. For example, environmental constraints, such as climate change, conflicts over land use between agriculture and tourism, as well as water shortages, have all been identified as problems surrounding tourism. The carrying capacity of communities to handle increases in activity, as well as the capacity of government to monitor development in the sector, has also been highlighted as threat in the sector. Likewise, foreign investors and developers often tend to design projects around sensitive areas to gain an advantage over competitors, which inevitably has a great environmental impact. Communities and local operators also remain limited in their understanding of, and engagement with, sustainable tourism, which means many of the aforementioned environmental problems continue to be perpetuated.

While the environmental impacts of the sector have been brought to question, the opportunity to develop a sustainability label for the sector is clearly available. The private sector is also firmly entrenched in tourist activity with clear links to the Seychelles Tourism Board, which should facilitate the implementation of nature-based tourism. The Department of Environment is also well respected, and working in conjunction with increasing public awareness around the importance of the environment should accentuate the implementation

of its sustainability mandate. In all cases, the overwhelming importance of tourism for economic activity and employment in the country, both directly and indirectly, makes evident the importance of sustainable tourism, particularly as a means of preserving the entire Seychelles economy.

Mariculture

Few mariculture activities are currently operational in Seychelles. Only prawn, giant clam and pearl oysters are produced in small-scale commercial operations. Prawn and clam production has also been decreasing in recent years, with clam production falling from 1,960 tonnes in 1996 to 585 tonnes in 2006 due to weak demand. Prawn production fell from 1175 tonnes in 2004 to 704 tonnes in 2006. Farming of clam and pearl oysters are not labor intensive practices, thus little local employment has been generated, and while the prawn farm on Coetivy Island employed 350 people, only 18% were Seychellois.

Little policy, planning or comprehensive assessment of opportunities has been established for the sector to date. Bio-technical mariculture capacity is still developing in the country which makes any recommendations for sectoral development relatively premature. The government has however, commissioned a development plan for the sector with funding from the African Development Bank, which should provide further comprehensive analysis into bio-technical and economic prospects inherent in the sector. The Seychelles Fishing Authority also has numerous international links, particularly in research, which should certainly benefit the planning process moving forward.

While there are currently few activities associated with mariculture in the islands, there are numerous strengths and opportunities apparent that could potentially be utilized for moving forward (Table 13). For example, high-quality seawater, strong investment incentives, as well as recognition from the private-sector of mariculture's potential in the country, could all facilitate development in the sector. There is also great potential for farming of sea cucumber and crustaceans, both holding export potential, while fin-fish cage culture is likely to receive approval in the government's sector development plan. Expansion of pearl culture has also been highlighted as an opportunity. Thus, while awareness with regards to the vulnerability of wild caught fish stocks needs to be generally raised, the mariculture development plan should provide an objective basis upon which to take the mariculture sector forward.

Agriculture and Forestry

There are few land-based opportunities in Seychelles, thus, agriculture and forestry naturally contributes far less economically than the more dominant tourism and fisheries sectors. Subsistence agriculture and forestry does however, contribute 6% to GDP and agriculture alone employed nearly 6% of the labor force in 1995. Traditional exports of cinnamon and copra have also recently been revived, as the government continues to provide incentives to the sector to increase productivity. Food security does, however, remain an issue due to a heavy reliance on staple imports, despite the country becoming relatively self-sufficient in eggs, poultry and pork in the late 1990's.

Many of the problems in agriculture are of natural original, as difficult mountainous terrain and low soil fertility severely constrain productivity in the sector. There is also a lack of data and resources available to make any concrete assessment of the forestry sector, which obviously affects the policy and planning process.

Perhaps the greatest strength of the sector, as a whole, is its ability to accentuate tourism and support tourist activity with a strong natural resource base (Table 14). Tourism also has the potential to support the development of community capacity, particularly in terms of improving natural resource management at the local level. At least 45% of the country's land is also protected, which highlights the fact that there is clearly awareness amongst decision makers of the importance of the country's resources for future generations. Nevertheless, climate change and the possibility of La Nina activity does have potential to severely hamper the agriculture and forestry sector, which would inevitably have a significant impact on tourism and the overall economy.

Energy

The downstream oil sector is a vital component of the Seychelles economy, with fuel and liquefied petroleum gas accounting for over 25% of total imports in the country. The Seychelles Petroleum Company (SEYPEC) is responsible for both upstream and downstream activities, including the importation and distribution of refined oil and liquid petroleum gas as well as the procurement, storage and marketing of petroleum products. The company also has international activities, including marine bunkering, aviation refuelling, bulk storage and transhipment and transportation of petroleum products by tankers. SEYPEC has also merged with the Seychelles National Oil Company (SNOC), which has allowed the company to both increase its number of tankers, as well as secure its logistics of supply.

Some constraints have been identified in the sector, many of which are indirectly related to energy activities. For example, the country continues to face a serious human resources shortage due to out migration, while public participation in environmental assessment processes remains quite weak. Despite a relatively strong economy in comparison to other African states, GDP growth per capita also remains sluggish, which could facilitate the trends in out migration. Weak Environmental Impact Assessment (EIA) capacity, as well as low EIA compliance rates, have also been identified as weaknesses. Also, the spatial separation of the country's islands has been documented as a challenge for governance. The potential side-effects of offshore oil exploration, particularly on marine ecosystems has also been highlighted as a threat in the future.

A number of strengths and opportunities have however, been highlighted in the report (Table 15). For example, a strong commitment from government to develop upstream activities is certainly a positive for the sector, which should be fruitful when accentuated by the country's investment facilitator and the transparency of government. The country's implementation of the ICZM program, along with its willingness to protect the environment, are also strong points that should ensure that proper measures are taken to protect coastal resources when developing the energy sector. This commitment to protecting the environment is also important considering the country's dependence on tourism, which is directly dependent on the country's natural environment. Thus, while activities are limited in the sector at present, the commitment of SEYPEC to further develop upstream activities and pursue offshore exploration should not only be beneficial in terms of creating employment and mitigating the human resource shortage in the future, but it could also be very positive for the overall economy of Seychelles.

Ports and Coastal Transport

Seychelles has only one port in Port Victoria which is relatively limited in throughput. The port is however, the central point of economic activity in the country, being vital for the fishery and the country's bulk imports, particularly fuel, which is the most significant sector of general cargo. The fishery is also a large component of port activity, as it generates demand for processing and trans-shipment facilities, as well as fuel, supplies and associated commodities. Cruise ships and leisure vessels have also been documented as important contributors to activity. The port is managed by the Seychelles Port Authority (SPA). However, the government has shown willingness to facilitate greater private sector activity in recent years.

The most prevalent constraints in ports and coastal transport are largely external to the sector. For example, the country's proximity to Somalia and increased levels of piracy activity, has negatively affected cruise vessel activity, with the number of cruise calls falling from 62 to 38 between 2004 and 2007. A more significant cost to the country are the increased freight charges due to higher insurance as a result of piracy. Likewise, reduced spending by tourists, as well as the country's low GDP have both been identified as significant challenges in the sector. Fishing activity, tourism and imports of goods and services all remain prevalent, which means commercial activity in Port Victoria should remain relatively strong.

A clear positive in the sector is identified in the plans to modify and diversify port operations to keep pace with demand and stay competitive in the region. There are also plans to expand operations to meet shipping requirements and handle increasing volumes from cruise and leisure vessels, while a recently commissioned report has identified the potential for private-capital to modernize container-handling operations. The fishery has, however, largely matured with little increases in activity expected in the future. Thus, the government has identified the need to maximize current operations and maintain processing facilities, particularly as a means to stay competitive with ports in Mauritius and Comoros. Nevertheless, while accommodating the fishery

remains a predominant issue, there is clearly a need to increase tourist activity in Port Victoria, particularly as other sectors begin to decline (Table 16).

Coastal Mining

Mining activity in Seychelles is very limited, with production concentrated in construction materials such as clay, coral, sand and stone. Coastal sand and coral mining was widely practiced until the 1990s. However, both activities were widely reduced due to coastal erosion, as well as the passing of the Removal of Sand and Gravel Act and the Environment Protection Act. Experimental granite quarrying was also attempted in the 1980s, however, environmental opposition led to the termination of the activity.

Due to the exceptionally low volume in mining activity, few plans or policies, other than the Removal of Sand and Gravel Act, have been designed around the sector. Informal sand and coral mining does, however, produce extensive erosion, as well as the loss of reef habitat and natural breakwaters, which inevitably affects adjacent ecosystems. Given the importance of the country's natural landscape for tourism, the Removal of Sand and Gravel Act and the Environment Protection Act were clearly proactive policies to implement. The implementation of Integrated Coastal Zone Management (ICZM) should serve to accentuate these aforementioned policies, as should the UNESCO sand monitoring project, which trains students and youth to assess beaches and gather data for community management.

Overall, with no onshore potential for mineral production and special regulations for sand mining already in place, mining will clearly not play an important role in the lives of Seychellois in the future. Although sand and coral mining does take place, it is heavily regulated, thus, environment damage around the country's beaches are minimal (Table 17).

Conclusions

There is a high dependency on tourism as a means of generating employment, foreign exchange and economic activity in Seychelles. This reliance on tourism has also spread across sectors, with resources in agriculture and forestry largely being seen as a means to generate activity in tourism, while further growth in ports and coastal transport now directly hinges on increased activity from cruise and leisure vessels. For the most part, there does not appear to be any sign that this reliance on tourism will subside. Thus, coastal communities are clearly vulnerable to fluctuations in tourist activity, which could become problematic in the future.

Outside of tourism, economic activity also appears highly concentrated in the fishery. The small-scale fishery does, however, face a number of obstacles. High investment costs, low returns, piracy risk and limited value-added development are obstacles in the sector, which has had a negative impact on the ability of producers to compete internationally. A reduction in the small-scale fishery would also be detrimental to Port Victoria, which is heavily reliant on the spill-overs of demand generated by small-scale activity. The sector has also recently seen an influx of government subsidies and support, which, while helpful in incentivizing production in the present, could however lead to overcapacity in the future.

Despite this dependence on mainly two sectors, there are clearly strengths and opportunities apparent in Seychelles that could be utilized to diversify the economy and subsequently strengthen livelihoods in the coastal zone. For example, the potential for sea cucumber and fin-fish farming highlight the opportunities available in mariculture. However, the high operational and labour costs of mariculture in Seychelles can only be overcome by focusing on high value mariculture products for export. The small-scale capture fisheries will still be critical for coastal livelihoods and food security. Likewise, exports of cinnamon and copra have also recently been revived in agriculture and forestry, which does highlight the potential for growth in those land-based practices. In relevance to the economy as a whole, the government has also recognized the necessity of increasing private-sector activity in the future, which, along with a stable and strong investment climate, should promote growth in foreign investment.

Seychelles' comparative advantage is, however, clearly found in its natural environment. For example, the country's proximity to the migratory path of tuna in the Western Indian Ocean, along with its rich source of other pelagic and demersal fish, both highlight the great strengths in the small-scale fishery. The country's extraordinary bio-diversity and conserved habitats have also been identified as key factors in facilitating activity

in the tourism sector. This is, however, why issues of sustainability should not be undervalued, particularly in relation to the country's economy in the long run. Most, if not all, economic activity clearly depends on the country's coastal resources; thus, all measures to sustainably manage the use of these resources should be taken by both government and the private sector.

As a whole, despite the government's strong and good environmental track record, the realities of climate change, as well as the country's natural dependence on imports, both inevitably present great challenges moving forward. Nevertheless, the opportunities outlined in each of the sectors do make evident the prevalent prospects for sustainable socio-economic development.

4. POLICY AND GOVERNANCE

A comprehensive report was prepared on Policy and Governance, which is Annex V to this MEDA. A summary is presented below.

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

There is a lack of monitoring and enforcement of the domestic fisheries regulations. In this respect there is a need for the local laws to be harmonized and for the local enforcement agencies – SFA, NPA, Coast Guard, the Police and the AG's Office to work in closer cooperation. For this to happen there is a need to build capacity. The Fisheries Act of 1986 is being revised and this provides an opportunity for inclusion of other pressing emerging issues. The issue of fishing License application and issuance is one that demonstrates lack of harmonization and coordination between the Licensing Authority (LA) and Seychelles Fishing Authority (SFA). Capacity building is needed in all areas of fisheries governance.

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

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

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

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

Oil exploitation can potentially create a disturbance to local ecosystems, both for the physical (biocoenosis) and the biotic aspects (biotype). Mastering these effects requires not only monitoring, but also human and financial resources to do so.

Currently there exists no coherent network or "system" of MPAs but rather a collection of Marine Protected Areas which address diverse objectives; and have no unifying strategy. However, a diversity of management bodies is in principle good as it allows for focused management initiatives taking into account the local communities and stakeholders.

The mandate of the two main Agencies responsible to manage the MPAs, i.e. the SNPA and the SFA is quite

distinct and offers a limited leeway for harmonization;

Revision and updating of the legislation concerning protected areas should be done in a holistic and comprehensive manner taking into account all aspects of the legislation on Biodiversity and taking into account the IUCN categories and guidelines (Domingue *et al*. 1999).

The current infrastructure at the commercial port in Victoria is inadequate, not only is the quay too small and gives rise to congestion but modern loading and unloading facilities are lacking compared to regional ports like Port Louis in Mauritius.

There is the need to improve the planning, coordination and monitoring capacities of SNPA and DOE to enable them to fully benefit from the available external support and the national opportunities for increased mobilization of NGO and private sectors for conservation and sustainable utilization of forest resources.

5. PLANNING AND MANAGEMENT

National disaster management plans (Oil spills, Tsunamis, other)

Hazards like tsunamis, cyclones and floods that occur in regions of low vulnerability are not usually considered as disasters. For this reason, National disaster plans are concerned with the area of the three main islands of the Seychelles; Mahé, Praslin and La Digue including Silhouette, because they hold most of the nation's population. A natural disaster is the effects of natural hazards that brings upon damage and destruction to the surrounding environment, and leads to various losses such as financial, environmental and/or human losses. The Seychelles Tsunami, Cyclone and Flood Emergency Response Plan is the national emergency plan to respond to the various impacts of tsunami and storm surges in Seychelles which was designed under the aegis of UNDP and the Government of Seychelles as an early warning and disaster management system in November 2007. The documents are termed as TERP (The Seychelles Tsunami Emergency Response Plan), TCRP (The Seychelles Tropical Cyclone Emergency Response Plan) and TFRP (The Seychelles Flood Response Plan). These plans describe the disaster management organizations responsible for response preparedness of the population during any tsunami, cyclone or flooding events. The three plans all share similar aspects and generally follow the same trends which will be discussed throughout the rest of this section.

The TERP/TCRP/TCRP were designed to be easy and simple, and their main aims are; to establish an institutional mechanism; to describe the flow of events during an emergency; to provide emergency procedures for the response to tsunami events; and to define and delineate the roles and responsibilities of all the bodies taking part in the evacuation process. The parties involved in this section are the Department of Risks and Disaster Management (DRDM), Meteorological stations, the National Disaster Committee and the National Emergency Operation Centre. In the latter group, the DRDM is responsible for reviewing the Tsunami/cyclone Response Plan and also other National Disaster Response Plan such as oil spills. DRDM also plays a key role in directing the response operations at the national level from the National Emergency Operations Centre (NEOC) located at the Central Police Headquarters in Victoria, Seychelles. Telecommunication centers are very important aspects in National Disaster plans as it is through them that the different bodies communicate to execute the plans. For example, the NEOC, DRDM, Metrological station and the Fire Brigade should each always have at least one telecommunication centre active at all times.

The initial warning is initiated first from the Meteorological station where the warning level is also calculated (that is; low, medium or high depending on the wave/surge characteristics or rainfall level or wind levels in the case for cyclones) and is dispersed as soon as possible to the other parties. In response, the appropriate parties (i.e. DRDM) then sends the information to both SBC radio and television broadcasts to notify the public and explain the overall scenario as well as how the evacuation will be held and by who if any was to take place and also dictate shelter sites.

Emergency Public Information Officers from each district or the Disaster Risk Reduction Platforms then execute relevant evacuation plans ordered by DRDM depending on the surge characteristics or current damage levels or threat. Other governmental assistance then follows such as the Police force, the Coast Guard, the army and the fire brigade department to aid the movement procedures as to be as effective as possible. After the wave(s) or cyclones have died, the fire brigade and the coast guard services perform a search and rescue where required, and DRDM then assesses the damages on the different infrastructures. The Ministry of Health also assists in the different medical attention needed to anyone and also aids in the environmental aid issues such as sewage outpour. Furthermore, the Seychelles Land Transport Agency (SLTA) also clears blocked roads and also other damages on roads where necessary.

National Disaster Committee

The NDC (National Disaster Committee) by protocol should always hold a meeting (Pre-impact meeting) after being notified by DRDM to assess the scenarios and confirming any plan of action during the disaster period. This is done mainly because the scenario may be different to what was ideally planned. The issues which are to be discussed in the Pre meeting include:

- Shutting down several activities (Working places, schools, businesses, public utilities, services etc…)
- Close surveillance of different Public Utilities and other services(e.g.: Electricity, Water, Telephones,

Fuel)
- Decisions concerning evacuation of vulnerable areas/islands.
- Activation of Rest Centres/Shelters and other gathering centres.
- Activation and operations of the National EOC and District Platforms
- Appointment of the National EOC's Director of Operations, Director of Telecommunications and Emergency Public Information Officer.
- Ensuring that the EOC members go to the EOC and stay there for the coordination of the emergency.
- Security related decisions (e.g.: Declaration of the State of Emergency and Curfew or not. Passes for vehicles and for individuals)
- Preparing and taping (video, audio) messages to be broadcasted immediately with the decisions made by the NDC and recommendations to the general population (President to the Nation)
- General warning to the population (TV, radio, Police cars and personnels, loud hailers, church bells, blowing car horns, etc.)
- Ensure that press releases are continuously produced in the EOC and sent to the media (TV, radio, press) every hour or as determined by the NDC/EOC.

Table 11. Emergency Response Functions, Responsibilities and the respective parties.

Emergency Response Function	Primary Responsibility	Secondary responsibility/ support from
Warning	Met Office	
Notification	DRDM	All responders.
Emergency Public Information	SBC	DRDM, Met Office, District Platforms.
Coordination (EOC)	NDC/DRDM	MDC, District Platforms, IDC, SIF, STB, Police. Private Sector.
Telecommunications.	Telecommunications Sub-Committee from NDC	Police, DRDM, District Platforms, Airtel, Cable and Wireless.
Transportation.	District Platforms	Agencies with transportation: SMB, Red Cross, Seychelles Helicopters.
Evacuation.	Police	District Platforms.
Shelter Management	District Platforms	MDC. Ministry of Education.
Security.	Police	SPDF.
Damage and Needs Assessment	NDC/DRDM	District Platforms, all sectors involved.
Disaster Relief	District Platforms/Red Cross	Police, SPDF, Ministry of Community Development, DRDM.
Search and Rescue (Land and Maritime)	Fire Service (Land). Coast Guard (Maritime).	District Platforms.
Medical Attention	MOH.	Accidents and Emergencies Department, Clinics, Red Cross.
Environmental Health	Environmental Health Unit	MOH, DPs.
Rehabilitation of Public Utilities.	PUC (water and electricity)	District Platforms (DPs).
Post-event Clean-up	LTD	DPs, SWAC, STAR, EES.

Cyclones and tsunamis on uninhabited outer islands are initially picked up from the Seychelles Meteorological services or international stations depending on the scale of the waves or radius of the cyclones or origin of the

wave. The Meteorological station then confirms to DRDM which further takes the initiative to assess and deal with the damages, and if there will be some inhabitants which will somehow be affected, the SBC is notified for awareness purposes as well as for evacuation wherever the disaster is taking place; the disaster relief and rescue parties help the people in need.

There is definitely a great need for the contingency plans especially after experiencing the effects of the Tsunami of 2004 which caused many damages to the Seychelles islands including its inhabitants. The main damages include; strong coastal wave surge and strong backwash which ultimately caused coastal flooding and erosion and furthermore affected the terrestrial vegetation with the sea water. Coral heads suffered primarily mechanical damage (breakage of branches and overturning), mechanical damage to substrate (soft carbonate sediment suffered damage and basically led to mass movement which ended up moving other rock bodies), damage to seagrass beds, damage to Curieuse Marine Park (extensive damage to mangrove protection wall better known as the causeway), coastal flooding to the three main islands which led to traffic congestions especially in Victoria, damages to sea wall around Mahé island, damages to boats and fishing traps which affected the fishermen, sewage outpour from the gutters, saltwater input on farming areas, flooding homes, coastal erosion, damages to the ports and harbors and deaths (3). In addition to the Contingency plan, the Seychelles Government has also put in place a "Development of a shoreline vulnerability model and planning capacity" in order to illustrate the main areas of higher vulnerability to wave actions such as tsunami (Abdulla et al., 2005; Obura & Abdulla, 2005).

Environmental sensitivity mapping

The oil spill contingency plans are made up of basically guidelines and maps which are easy to understand and anyone can follow the steps for the clean-up teams. On these maps, essential information for the oil spill responders are provided which show where the various coastal resources are, and by indicating environmentally sensitive areas as well (e.g. the locations of estuaries, mangroves, fish farms or bird colonies). The main uses of sensitivity mapping programs range from planning practical site-specific bay/shore protection and clean up to strategic planning for larger less accessible areas. The main plan also provides information and guidelines on different map types and there legends. Furthermore, these maps, shows the resources of great importance in a 360° direction from the event that the oil slicks can possibly travel. As a result, this alerts the responsible parties/authorities to prepare for the potential environmental issues that can arise and the plan shall provide the practical information for spill response and shore clean-up (e.g. dispersants or booming points). The main information to be included about prioritizing protection and clean-up options needs to be decided through important parties in the country such as fisheries departments, tourist boards and other conservation groups.

The basic requirements

- Maps must contain an instant and simple message without having specialized knowledge to understand hence react faster.
- They should contain enough information to be just of value, but without confusion.
- They should use suitable universal symbols
- The maps should have suitable scale
- They should clearly mark scale, direction, legend/key, date of production and title.
- They should include a location map to show the relationship between any sub-area and the area as a whole.

The director of the GIS Centre in Seychelles, Mr. Francis Coeur De Lion, created sensitivity maps of the main islands which basically illustrate the main sensitive coastal regions which are sensitive to erosion and other hazardous events such as cyclones, tsunamis and oil spills. It should be noted that any protection priorities, which have been agreed by the relevant organizations after the old plan have been created there should have time intervals whereby the plans should be checked and see if it is worthy of any change in terms of adding any new sensitive sites accompanying by new guidelines during spill events. Some issues that GIS personnel are currently working on to prevent lag in response to an event (e.g. oil spill), for example a single map is ideal, but more than one map is also good as it shows a diversity of resources. In cases where putting everything onto one map, it can become very confusing and can delay personnel during an event, therefore to avoid the danger of this is to have a large number of maps (one for each resource). In addition, the maps in the contingency plan should convey a clear and simple message to the spill responders to react as quickly as possible instead of

relying on experts to interpret them. A distinction should be easily made between sensitive resource data, spill response and clean-up information from the maps.

The different layers that are included on maps and are important to oil spill contingency plans

Shoreline types
A basic principle in this case is that sensitivity to oil increases with increasing shore length or embayment area from wave action, as well as penetration of oil into the substratum, natural oil retention times on the shore, and biological productivity of shore organisms. As a result, one should take into account the uses of the shore by wildlife and people. For example, a rocky shore supports a seabird colony and sandy shore accommodates for tourists.

Subtidal habitats
Subtidal habitats are sensitive to oil spills. These include coral reefs, seagrass beds and kelp beds. Hotspots where sensitive species live are also mapped and illustrated.

Wildlife and protected areas
The maps from the oil spill contingency plan shows the areas of greatest sensitivity for wildlife species such as the marine reserve/ parks. This is because it is in those protected areas where feeding and breeding habitat of important species of conservation concern, is protected (e.g. green turtles). Therefore, the contingency plan makes sure that locations which are important in maintaining the threatened or endangered species should be highlighted, because in case of any oil spill events, the risk of depleting their populations is greatest in these areas.

Fish, fishing activities, shellfish and aquaculture
Both commercial and subsistence fishing is taken into consideration as in the Seychelles, fish forms part of the staple diet. The following features are aspects in the fisheries industry that should be identified and placed onto the sensitivity maps of the existing spill contingency plan:

Nearshore shallow water fishing areas (e.g. crabs, lobsters)
Shellfish beds
Fish and crustacean nursery areas
Beaches mainly used for hauling in nets
Permanent or semi-permanent fish trap platforms/bays
Aquaculture facilities (e.g. fish, molluscs)

Socio-economic features
Boat facilities and recreational resources where socio-economic events take place such as the yacht clubs, harbours, and marinas (e.g. Eden Island) and other industrial facilities such as water intake points for power stations and desalination plants, should also be accounted for. Furthermore, sites of cultural, historical or scenic significance (e.g. Atolls, sunken ships etc) should all be mapped and placed into the sensitive areas for they hold touristic attractions hence should also be protected during spills.

Oil spill response features and procedures
Based on the spill type and composition, and also the region where the spill has occurred in relation to the sensitive areas, proper dispersant types should be used so as not to further disturb the affected area. For instance, there are regions where booms should be deployed, and another option is to deflect the spill into a small embayment or onto a beach of low sensitivity. In other words, it should be agreed between relevant organizations before launching on a spill affected area whether to use dispersants or not.

Spatial development plans / integrated development planning in coastal zone / Coastal management plans

Most of the coasts of Seychelles islands are flat, on both coralline and granitic islands. The coasts on the main granitic islands are flat narrow strips of land forming the base/foot of the granite rugged peaks and highlands. These coasts are very important to the Seychelles for they are of great importance in the tourism industry, and is where most of the hotels are located. They serve great visual and leisure attraction for the tourists and also for the local fishermen as well. Furthermore, since most of the coastal areas are flat unlike the far inland areas, most of the housing and developments take place within this narrow belt of coastal land. Ultimately, the coastal areas have become over-developed so people have sprawl upwards into the higher reaches, especially on the islands of Mahé and Praslin. The increased population locally and worldwide has brought increased pressure on coastal resources, through higher influx of tourists and increased level of pollution. As a result, this has led to social and economic instability of the country, and ultimately over the past decade, public awareness about the need for environment protection has increased significantly.

At present, there is no actual Coastal management plan in the Seychelles, so most of the responsibilities regarding coastal issues are passed through a board/committee (e.g. NDC) where decisions are taken and assessments are made (e.g. EIAs) and most of the actions and responsibilities are then laid in the hands of the Coastal management section which is in the Ministry of Environment and Energy of the Seychelles. The director of the GIS Centre in Seychelles, Mr. Francis Coeur De Lion, created sensitivity maps of the main islands which basically illustrate the main sensitive coastal regions prone to erosion and other hazardous events such as cyclones, tsunamis and oil spills.

Local involvements such as wildlife clubs and NGOs are normally affiliated with educational institutes in order to broaden knowledge with regards to the coastal environment. Their main purpose is to integrate greater coastal environmental awareness among the various stakeholder groups and the general public, whereby this could then further increase public participation in coastal environmental matters. The main activities includes "Clean up the world campaigns" along coasts, advising the public on more responsible practices relating to the various harmful discharges from domestic activities, inappropriate solid waste dumping sites and generally more responsible use of coastal resources by the coastal communities. Furthermore, the Government has been more active in implementing better waste management standards. In addition, the "Solid Waste and Cleaning Agency" (SWAC), originating from the Environment Protection Act (1994) ensures proper disposal of domestic solid wastes both along the coasts and in the more inland areas.

Marine protected areas

MPAs (Marine Protected Areas) or "Marine parks" in Seychelles are regions in which human activities have been restricted in order to conserve the natural environment including habitats and ecosystems of special concern. MPAs help to protect the marine ecosystem from long-term human impacts, and also maintain the marine biodiversity of areas, as well as the current food chains and webs. The main purpose of MPAs is to provide refuge/shelter for many species in their native habitats including their related ecological processes to recover from the pressures imposed from non protected regions of the ocean. Within these MPAs, there are limited recreational activities; mostly non-motorised watersports such as snorkeling are encouraged rather than jet skis and power boats. Fishing and collection of shells are strictly prohibited.

In Seychelles there are at least five different types of MPAs:

- Marine National Park (National Parks and Nature Conservancy Act 1969 (Cap 141)) Marine Protected Areas in the Republic of Seychelles
- Shell (Mollusc) Reserve (Fisheries Act (Cap 82))
- Special Reserve (National Parks and Nature Conservancy Act 1969(Cap 141))
- Protected Areas (Protected Areas Act (Cap 185)
- Strict Natural Reserve (National Parks and Nature Conservancy Act (Cap 141))

Table 12. Marine Protected Areas within the main island group in the Republic of Seychelles

Name	Designating Regulation	Date Designated	Land Area (ha)	Sea Area (ha)	Total Area (ha)
Ste. Anne Marine National Park	National Park (Ste. Anne Marine)(Designation) Order. Cap. 141, Sub. Leg. pg. 1-2	19/03/1973	388.71	669.04	1,384.75
Baie Ternay Marine National Park	National Park (Baie Ternay Marine) (Designation) Order. Cap. 141, Sub. Leg. pg 5-6	11/06/1979	0.99	86.28	87.27
Curieuse Marine National Park	National Park (Curieuse Marine) (Designation) Order. Cap. 141, Sub. Leg. pg. 6-7	11/06/1979	286	1,370	1,656
Port Launay Marine National Park	National Park (Port Launay Marine) (Designation) Order. Cap. 141, Sub. Leg. pg. 7	11/06/1979	3.59	154.26	157.85
Silhouette Marine National Park	National Park (Silhouette Marine) (Designation) Order. Cap. 141, Sub. Leg. pg 9.	26/10/1987	?	?	?
Ile Coco, Ile La Fouche, Ilot Platte National Park	S.I. 20 of 1997 (National Parks and Nature Conservancy (Ile Coco, Ile La Fouche, Ilot Platte) Order 1997	19/02/1997	5.05	165.48	170.53
Total			**684.34**	**2.772.06**	**3.456.40**

The Seychelles has seventeen MPAs altogether (UNEP-WCMC, 2008), which are managed by six different organizations based on the legislation under which the protected area was designated. The Seychelles National Parks Authority (SNPA) is responsible for six, the Seychelles Fishing Authority is responsible for the four shell reserves, Nature Seychelles and the Royal Society for Nature Conservation (RSNC) both manage one (Cousin island), the Seychelles Islands Foundation (SIF) manages the World Heritage Site of Aldabra atoll (Special reserve and the rest are managed by the IDC (Island Development Company) (UNEP-WCMC, 2008).

Guidelines for successful MPA management plan

- Stakeholders should actively participate at all level of planning before an area is designated as an MPA.
- Clear goals and objectives should be set out in the management plan of protected areas in every aspect possible.
- Local community involvement should be encouraged in the management of a designated area.
- An integrated management approach is encouraged since most marine protected areas cannot function in isolation.
- Reduce conflicts between different groups of resource users within an MPA by introduction of activity zones.
- Education of the general public on the purposes of creating MPAs is highly beneficial.

The coastal management plans for the different MPAs do vary based on the purpose of protection and under which act they are categorized as well as the current time allocation each plan is given. Some main management common objectives of general MPA management plans include: to improve the environmental protection and conservation measures, to develop policies on important issues hence expanding the scope of existing management plans, to expand financial support bases and make them more secure, to enhance the scientific research programmes involved, to improve the quality of the available monitoring programme, to prepare for an increased level of nature conservation tourism, to ensure that environmentally friendly technology is used maximally and create an appropriate balance between conservation and exploitation by the nation (Domingue *et al.* ***YEAR***, UNEP-WCMC, 2008).

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