SUSTAINABLE MANAGEMEMENT OF THE BAY OF BENGAL LARGE MARINE ECOSYSTEM (BOBLME) GCP/RAS/179/WBG

The Maldives: National Report

by

Dr. Mohamed Ali
FAO/BOBLME National Consultant

STATUS AND DEVELOPMENTAL POTENTIAL OF THE COASTAL AND MARINE RESOURCES OF THE MALDIVES AND THEIR THREATS

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Executive Summary

Maldives is a nation of small reef islands located in the Indian Ocean, stretched over an area of 90,000 square kilometers. Of its 1200 islands, 202 are inhabited.

Fisheries and tourism is the dominant contributor to the economy, both are intrinsically reef-related.

Severe environmental threats and problems to the marine and coastal environments exist due to the absence of a comprehensive status of environmental parameters for the region. In addition to the risk of oil pollution due to increasing number of oil tankers, increasing industrial discharges from the countries to the north of the Maldives into the Indian Ocean or the Bay of Bengal area boosts the level of contamination of the marine environment around the Maldives. Discharge of heavy metals such as mercury, cadmium, lead, and arsenic, in either waste water or in runoff is noted in the Indian Ocean

Presence of organochlorine residues such as DDT in sediments, water column and marine organisms are reported in the Bay of Bengal region

Concentrations of population around the Bay of Bengal region has resulted in voluminous discharge of sewage, garbage and other domestic effluents.

The marine and coastal resources of the Maldives can be classified into extractive and non-extractive uses. These include bait, reef and aquarium fisheries, sea cucumber, lobster, grouper, giant clam, black coral, and turtle exploitation

The status of the stocks of baitfish is not very clear. Catch rate of live bait species have increased greatly in recent years. Since the tuna is caught by pole and line, the bait fishery is pivotal for the tuna fishery.

The increase in demand for reef fish especially from the tourism industry and overseas markets raises the level of exploitation of particular reef fish varieties.

The export of the aquarium fish from the Maldives is on the rise, Currently, about 100 species of fish are exported in the aquarium export fishery, with 20 species comprising over 75% of the trade. Some of the species exported are very rare in the Maldives and are very vulnerable to overexploitation.

The grouper fishery became a specially targeted fishery due to the increase in demand for groupers from the local tourism sector and international markets. Indications that the grouper fishery may be under stress. Some species of groupers may be threatened because they are specifically targeted.

Nine species of sea cucumbers are exported from the Maldives. The most popular species of sea cucumbers have been overexploited.

The lobster fishery is mainly targeted for the tourist industry. The continuing growth of tourist arrivals is likely to increase the demand for lobsters. However, due to the nature of exploitation and the control regulation, this resource may not be commercially exploited in a sustainable manner.

Cuttlefish numbers caught are negligible as no organized fishing is practiced so far. Given the demand, there appears to be good possibility for the expansion of a culturing of the cuttlefish resource.

Black coral was presumably abundant on Maldivian reefs. However, over the last two decades large quantities were removed, but is now protected.

Seaweed culture has been tried in the Maldives. However, very little success has been made so far. Given the extensive reef flats which can provide suitable habitats for extensive cultivation, the potential for its culture appears very promising.

Red coral has been harvested from reef flats for centuries. The markets for red corals are on the rise. In the absence of organised harvesting, it is difficult to estimate the number of people or areas engaged in exploiting red coral.

The giant clam fishery was a very short-lived one, which lasted about a year from 1990. *Tridacna maxima* and *T. squamosa* are two species harvested for their meat. The exploitation of the giant clam was very destructive to the reefs and hence the government intervened and banned the fishery in 1991.

The tuna fishery is the major fishery and takes place all year round throughout the country. This fishery utilizes three techniques; 1) Pole and line fishery, 2) Hand-line fishery, and 3) Long-line fishery.

Pole and line fishery represent 90% (2002) of the total fish catch. Large yellowfin ranks second in importance, in terms of fish export from Maldives.

Shark fishing has been carried out for centuries in the Maldives. Three groups of shark fishery practiced in the Maldives are: 1) Reef shark fishery; 2) Deep water Gulper shark fishery; and 3) Oceanic shark fishery. Amongst the these, the reef shark fishery is more valuable than the other two groups as this fishery generates revenue for both fisheries and tourism.

Shark fishery has continued to be exploited mainly for export purposes. This fishery is quite attractive on the basis of return for effort. However, the aesthetic value of sharks is increasing.

The exploitation of turtles for local trade and consumption date back hundreds of years. Turtles were further exploited to produce curios for the tourists. A ten-year moratorium on catching turtles is in force since 1995.

Fisheries used to be the dominant sector of the economy until 1985, when tourism industry overtook fisheries in terms of its contribution to GDP. Marine resources such as tuna, frigate tuna and finfish were exploited in a sustainable manner, both for local consumption and export. In the absence of credible information pertaining to the yellowfin stock assessment, maximum sustainable yield (MSY) estimates has not been attempted to set targets for total allowable catch (TAC).

The traditional tuna industry using pole and line method has contributed to the sustainability of this resource in the Maldives. With the increase in effort, particularly through recent improvements in fishing gear and methods, it appears that the catch levels may have now reached or be close to the MSY.

Of the coastal resources, the bait fishery is the most extensive and also the most sustainable, forming an integral part of the pole and line tuna fishery. The future and sustainability of further expansion and development of the traditional pole and line tuna fishery depends very much on the availability and viability of the bait fishery.

Of the reef fishery, grouper is the most significant. This fishery has remained somewhat sustainable. The estimated MSY levels for the grouper fishery indicate that there is very little potential for further expansion of this fishery as practiced now.

The sea cucumber fishery has been an important coastal resource in the Maldives. Although very successful initially, with the level of exploitation exceeding the replacement rates, the populations dwindled to the extent of adversely affecting the fishery. Extensive research into sea cucumber cultivation has shown enormous potential. Considering the status of the environment, it appears that sea cucumber cultivation on massive scales is possible in the Maldives.

Other coastal resources such as cowrie, red coral, lobster, and cuttlefish appear to play a nominal role and their resources can be sustainably exploited at this scale. However, resources that can be cultured such as giant clam, some species of aquarium fish, and including turtles appear to have some potential for developing further.

The potential for sustainable utilization of many of these resources depends upon the widespread use of scientific knowledge and appropriate technology, for improving the stocks, harvesting adding value for post-harvesting purpose.

Reefs as premium resource for tourism growth and development is evident in the Maldives. All effort is required to protect and preserve the reef system in its pristine state to continue benefit for posterity.

Threats to the coastal and marine environments and consequently on resources contained within them arise from both natural as well as human-induced causes, working at local as well as regional or global scales.

Local level threats include those that are fisheries-related, Loss of coastal habitats, Poaching, Domestic and agricultural disposal.

Changes in the tuna fishery are impacting the baitfishery. Bait fishing using lights and occasional use of household chemicals such as bleach and chlorine are causing damage to the coral reefs, and collection of certain species can be particularly destructive to the reefs while during netting for the bait.

Anchor damage to the reef and intensive collection at certain points or concentration of boats on a reef over a period of days or even weeks amplify reef damage. Bait and grouper fisheries are affected by waste water from sea cucumber fishery.

Since the majority of the reef fish species taken are carnivores their removal from the reef system may adversely affect the functioning of the reef system.

Extensive sea cucumber fishery has caused depletion of target species, leading to a collapse of the fishery since 1997. Fishers often complain of the effects on bait fishery associated with the preparation of the sea cucumber.

Loss of coastal habitats, particularly seagrass beds mangroves and coral reefs occur in the Maldives. These losses are associated with dredging of harbours, reclamation, mining of coral and sand for construction.

The significance of mangroves areas to the coastal and marine fishery is to yet be studied in the Maldives. Yet, the loss of habitats such as coral reefs, seagrass beds and mangroves will either have direct or indirect impacts on the potential of the marine and coastal resources.

Poaching is another local threat affecting the coastal and marine resources. Indications are that poaching is a serious issue.

Domestic and agricultural disposal which includes solid waste and particularly in the increase of non-degradables and hazardous wastes such as dry cell batteries or hospital wastes pose serious threats to the aesthetics and health of people on many islands.

At a regional or global level threats include oil pollution, heavy metals and pesticides, which can occur in the wider Indian Ocean/Bay of Bengal areas. Others are oil pollution, invasive alien species and flotsams that can threaten the marine and coastal resources of the Maldives.

Other global threats include increased ultraviolet radiation and global climate change, as a result of ozone layer depletion and global warming respectively.

The causes of these threats are both natural and human-induced. Often human-induced threats tend to make the ecological systems or sub-systems more prone to natural perturbations. The natural causes include global warming and increased sea surface temperature, which are manifested in sea

level rise and coral bleaching, increased storminess, and other natural disturbances.

Human-induced or anthropogenic threats include development such as harbour development land and reclamation, population expansion, domestic, industrial and agricultural discharges. Lack of alternatives at a local level also pose threats to the limited available resources, such as coral and sand, and other reef resources.

The competition and resource depletion elsewhere in the world is diverting attention to relatively resourceful such as the Indian Ocean/Bay of Bengal area particularly for marine resources.

Threats that have transboundary effects and those of special concern to the Maldives include: global climate and other environmental changes and their consequences, increasing threats of persistent organic and heavy metal pollutants to the marine and coastal resources, accidental or deliberate oil spill along the tanker route in the region, continuous discharge and runoffs of pesticides and other harmful agricultural chemicals, risk of alien invasive species that may enter the territorial waters, poaching and other destructive fishing methods in the EEZ, and straddling and migratory fish stock management.

Using a multi-criteria analysis, 14 threats identified in the context of coastal and marine were evaluated against seven criteria of most direct concern.

Oil pollution risk was likely to cause the severest of the impacts, affecting six of the seven criteria, while increased storminess affects five criteria used in the exercise. Other threats with equal scores include; loss of habitats from developmental activities, domestic and sewage disposal in the coastal system, anchor damage during bait fishing. Coral bleaching and increased sea surface temperature, related with global climate change are also serious threats. Most of the 14 criteria affect the biodiversity status, thus the reef fishery and the bait fishery which are directly related with the reef systems.

The effects of both natural and human-induced impacts on reefs have implications on the resource-base of the country with short and longer term environmental, economic and social vulnerability.

Threats identified are being addressed at both local as well as national levels. Local level actions include resort-operations and island/atoll operations. National level actions include planning for sustainable development, designation of protected areas, and development of regulatory and legal mechanisms.

1.0 INTRODUCTION

This report is intended to provide the status of the living coastal and marine resources of the Maldives and the threats they face, as input for the preparation of the larger ecosystem-approach project aimed at addressing the health and management issues of these resources in the Bay of Bengal area.

Based on this report and together with the issues identified by the countries in the region, a broad project will be formulated to provide a comprehensive framework for and identify the specific actions required to address the priority national and transboundary issues.

This project will also identify potential national and regional investment, technical assistance and capacity-building interventions to improve the management of the living marine resources, with an initial focus on fisheries and the health of the Bay of Bengal area.

1.1 The geography and geomorphology

Maldives is a nation of small reef islands located in the Indian Ocean, stretched over an area of 90,000 square kilometers, 900 kilometers south west of Sri Lanka, stretching along 73° East longitude from about 8° North to 1° South. The archipelago consists of 26 natural atolls with about 1200 islands. Of these, 202 islands are inhabited, with a population of 270,000 (2000 census). The total land area is less than 1%. The islands are relatively small in size, with an average area of 25 hectares. The largest island is just over five km^2.

Being a linear string of atolls set in the Indian Ocean, strong latitudinal gradients in some environmental and morphological characteristics are evident. This is shown in Figure 2.

Features that increase from north to south are; lagoon depths, continuity of atoll rim reef, and the amount of rainfall, while the features that increase from south to north are; number of faros, number of patch reefs inside the atoll, effects of storms, seasonal reversal, number of reefs with a single island.

These climatic and morphological variations are expected to be manifested in some form in the distribution and utilization of the coastal resources, like the duration and methods, and impacts of threats and consequences.

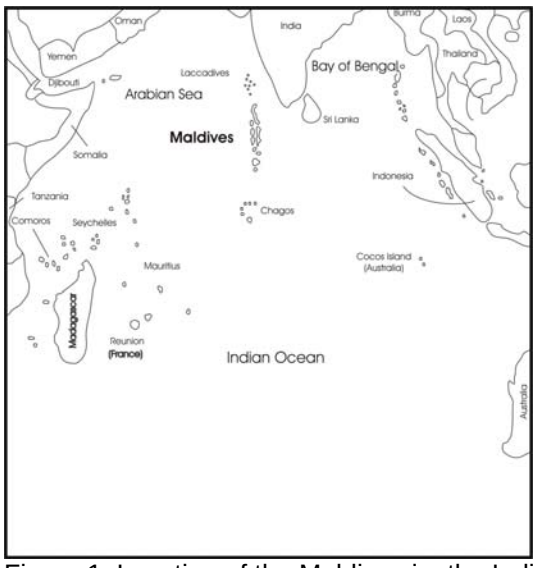

Figure 1. Location of the Maldives in the Indian Ocean

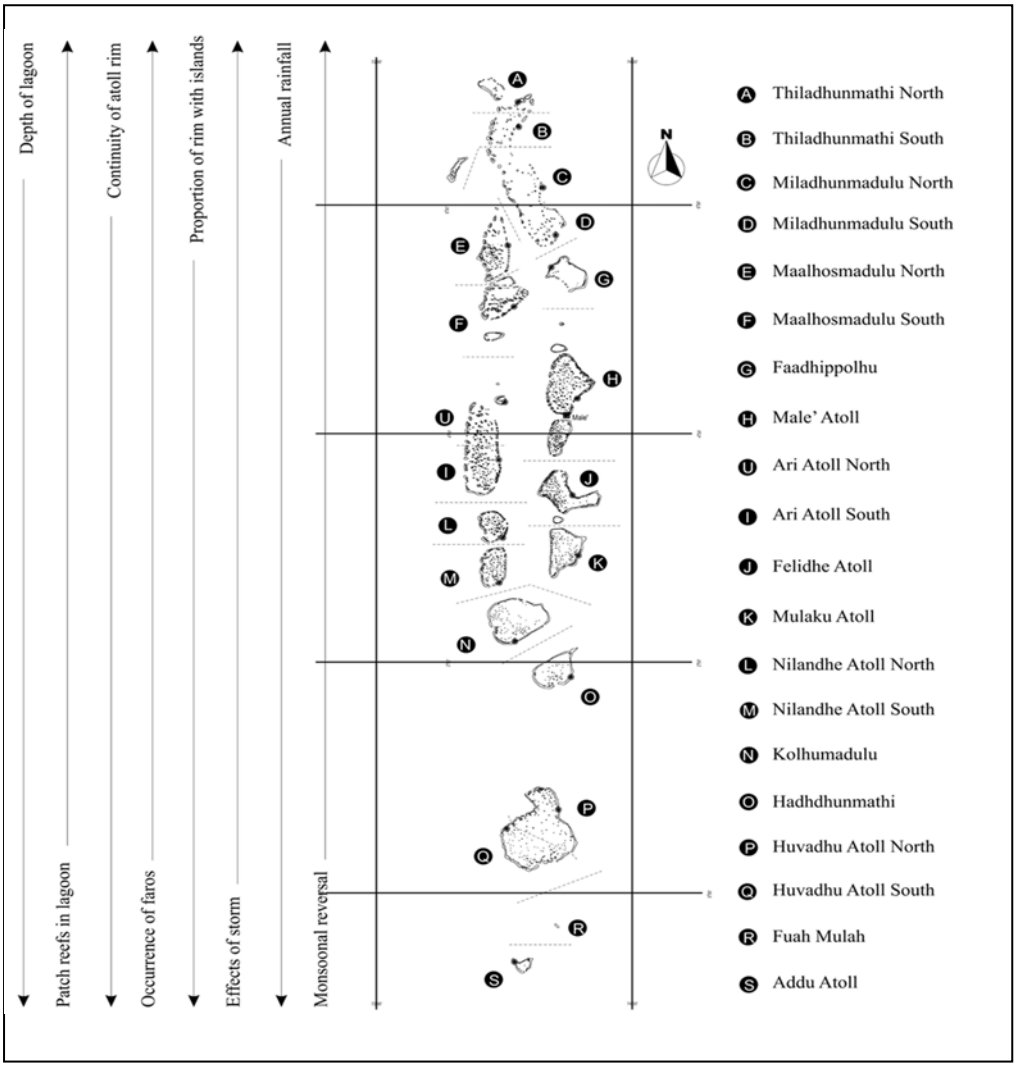

Figure 2. Latitudinal variations in morphological and climatic trends through the Maldives (source: Woodroffe 1993).

1.1.1 Climate

Two distinct seasons affect the Maldives, the westerly (*Hulhagu*) between May and November, and the easterly (*Iruvai*) from December to March. The westerly season generally has the strongest winds and stormy weather. It occurs and the easterly season occurs (Figure 3).

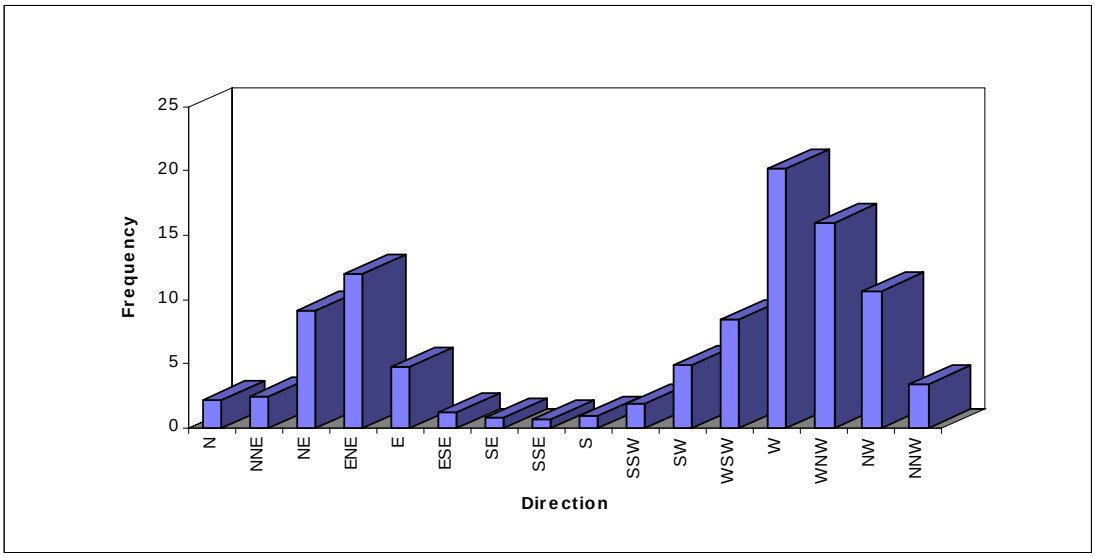

Figure 3. Recorded wind direction and frequency for Male'.

The seasonal reversal in winds, and hence the currents and wave direction affects many aspects of resource utilization. These dynamics cause morphodynamic changes on many islands.

1.1.2 Waves, tides and currents

In the Maldives there is a semi-diurnal mixed tide, with a maximum range of 1.2m. The meteorological tides show a normal distribution with no significant seiche activity, and inside the atoll wave climate is often governed by locally generated waves of five seconds or less; and significant wave heights outside the atoll for wind-waves are about 1.6m to 2.0m for swells.

The highest waves occur between June to August (Harangozo 1992), when wave heights are commonly over 2m high (and reach a maximum H_s of 4.2m). By comparison wave heights are generally less than 2m during November to May period. The maximum deep water wave height in the record was calculated H_{10}=5.33m.

These seasonal variations in wave climate were confirmed by Young (1999) who also notes that in the Indian Ocean equatorial region immediately south of the Maldives, there is a strong background southerly swell (H_s 2 to 3m) generated by winds in the Southern Ocean between Australia and South Africa. Maximum wave heights are reached between May and August in the southern Maldives. In addition, analysis of recent tide gauge data from Hulhule' indicate a fluctuation of about ±10 cm in MSL between 1991 and 2000.

In the absence of storms, wind is the most important process-driving factor affecting throughout the archipelago.

1.1.3 Islands

The islands are made of bioclastic sediments derived almost entirely from the reef. Currents and waves aided by unusual weather events help in the formation and development of the islands in the Maldives. Much of the geomorphologic characteristics of the islands such as island shape, size orientation proportion of reef an island occupies, topography, elevation, sediment calibre and type can be explained by type of reef platform and the level of exposure (Ali 2000). The reefs are therefore an integral part of the islands that provide the stability and protection to the islands.

The islands of the Maldives occur on reef platforms associated with 26 atolls. Atolls are taken to mean emergent reefs or islands forming distinct entities surrounded by relatively deeper waters that separate one atoll from another.

Since the islands are made up of calcareous sediments and the islands being relatively young (Ali 2000), the soil is very porous and poorly developed. Hence agricultural development is very limited.

1.2 The economy

The economic growth of the Maldives is notable. The GDP increased from 5.4 in 1993 to 10.4% by 1997 and has declined to 3.5% in 2001, but increased to 6% in 2002. Fisheries and tourism being the dominant, followed by construction and transport and communication are the main players in the economy.

1.2.1 Fisheries

The relative importance of the fisheries sector has declined from 6.7% in 1997 to about 6% in GDP share by 2002. The fisheries sector's contribution to GDP declined from about 30% in the 1970s to less than 10% in 1997-2000.

1.2.2 Tourism

Tourism, in recent years, has been the most dynamic sector of the economy. Tourism commenced in 1972 with two resorts, and by 2002 there were 87 resorts with a bed capacity of over 16,000. Tourism share in the GDP amounts to over 32%, and 26% of government revenue. The number of tourists visiting the Maldives rose from 1,096 in 1972 to 59,079 in 1984 and increased to 155,758 in 1989, and to 461,000 in 2001, and exceeding 500,000 in 2003. Tourism is exclusively nature-based and specifically reef-related. Diving, snorkelling, sunbathing and swimming are the attractants, all attributed to the reef system for most part.

1.2.3 Agriculture

Agriculture is not well developed in the Maldives as the land area is very small, the soil is poor and the supplies of freshwater are limited. Census data of 2000 indicate that only about 3% of the total workforce was employed in agriculture. Agriculture constituted only about 3% of GDP in 2001.

1.3 Administrative setting and definitions

Administratively, the country is divided into 20 atolls. An appointed Atoll Chief, is responsible for administering the day to day affairs of the islands in the atoll, and liaise with the central government regularly. All inhabited islands report to the atoll capital daily.

The administrative atoll consists of select number of islands that either is part of a large geographical atoll, or a collection of islands from two or more geographical atolls. The reference to ***atoll***, unless otherwise specified, refers to the administrative atoll. The ***island*** refers to in most cases the vegetated area and the entire reef area, or the ***house reef*** on which an island is set. Boundaries for islands that share house reef are set arbitrarily.

There is no established traditional ownership or custodianship of either islands or coastal/marine areas. The laws and regulations allow free access to all throughout the country. Hence the issue of user conflict has been minimal in terms of resource use.

This report considers the coastal and marine resources separately, as the contents and the approaches to their utilization are distinct. '**Coastal'** refers to areas extending from the high water mark on the island to the outer edge of the reef. In other words, 'coastal' refers to the area confined within the outer edges of the reef within an atoll. **'Marine'** is used for the area extending outwards from the outer reef edge to the extent of the EEZ.

As for the other terms used in the report, ***Reef flat*** refers to the area of the reef extending from the low water mark to the edge of the reef on either sides of an island. ***Lagoon*** is the deeper area on a reef flat, while atoll lagoon is the 'sea' within an atoll, that varies from about 30m to 80m in the south. A ***faro*** is a type of reef platform with a distinct relatively deeper lagoon within it, while a ***patch reef*** is one without such a lagoon.

2.0 STATUS AND DEVELOPMENTAL POTENTIAL OF COASTAL AND MARINE REOURCES

The maritime area of the Maldives is relatively extensive with an exclusive economic zone of 1.2 million km^2. Being the only resources available, the Maldives have depended on the coastal and marine resources from time immemorial. The largest and most important component is the pole-and-line tuna fishery, which has continued for centuries. There is a heavy reliance on the tuna which makes the fisheries very vulnerable to external economic and environmental shocks such as world market fluctuations, effects of globalisation, or even environmental perturbations such as coral bleaching.

Exploitation of the marine and coastal resources in the Maldives has been almost exclusively, that of extracting from the wild. This practice has continued for centuries. However, indications are that some of these resources are either threatened or have been exploited to its fullest. (See

relevant sections). Apart from the extractive values of these resources, the non-extractive uses and values of many of these resources are being increasingly realized today.

2.1 State of marine and coastal environments

The “bay effect’ of the Bay of Bengal area exerts unusual influences on the ocean dynamics. The effects of which may be the persistence of pollutants in the area.

The ‘flushing’ of the area is very limited unlike that of the open oceans such as the Atlantic or Pacific. Being subjected to heavy maritime traffic and burdened for most part by discharges and run-offs increasingly addition of nutrients and other pollutants to the Bay of Bengal area continues.

Available literature suggests that there is no comprehensive and coordinated monitoring of the background and changing status of environmental parameters such as pollution and other significant environmental aspects. This section deals with some environmental aspects that have significant bearing upon the state of the marine and coastal environments.

2.1.1 Oil pollution

Although consistent data is not available, it appears that oil residues are present around the waters of the Maldives. This is due to the increase in size and number of oil tankers carrying oil from the Middle East to the Far East. According to studies by Sen Gupta and Kureishy (1981), very high occasions (480) of sighting oil slicks in the northern Indian Ocean occur. They also report a mean concentration of 35-29μg/kg of petroleum residues in the northern Indian Ocean from depths of 0 to 20m.

2.1.2 Industrial pollution

Large industries are absent in the Maldives. However, available literature suggests that the growth of population in the Indian subcontinent has steadily increased, and as a result, industrial discharges into and around the Bay of Bengal area has also increased. As a result the level of contamination of the marine environment around the Maldives is likely to increase as well.

Discharge of heavy metals such as mercury, cadmium, lead, arsenic, in either waste water or in runoff is noted in the Indian Ocean, similarly the contamination of fish and other marine organisms such as lobsters, oysters and shrimps from the Indian Ocean is also noted (UNEP 1982, Sen Gupta et al. 1990). According to UNEP (1982) the Bay of Bengal is more polluted by mercury than the Arabian Sea.

Since the Bay of Bengal area is bordered by countries with substantial agricultural activities, the cumulative effects of pesticide consumption in the region can be considerable. Sen Gupta et al. (1990) indicated that over 70,000 tonnes of pesticide were used and about 25% of these may end up in the sea. Presence of organochlorine residues such as DDT in sediments,

water column and marine organisms are reported in the Bay of Bengal region (Sen Gupta et al. 1990).

2.1.3 Domestic and agricultural waste

On a regional scale concentrations of population around the Bay of Bengal region will undoubtedly result in voluminous discharge of sewage, garbage and other domestic effluents. Pumping out of untreated sewage to sea causes eutrophication which reduces the amount of dissolved oxygen, and the increase in phosphate-phosphorous concentration is noted with concern (Sen Gupta et al. 1990). Presence of bacteria and viruses also adds to the stresses and the risks to the marine environment. Quantifiable figures are currently not available on the status of marine and coastal environments. However, it is expected that the new approach taken by the GEF project for the Bay of Bengal area will address these issues specifically.

2.2 Coastal and marine resources

The marine and coastal resources of the Maldives can be classified into extractive and non-extractive uses. Until the advent of tourism in 1972, only extractive uses of these resources have been made of. These include, tuna fishery, and shark fishery, the two marine resource-based fishery. Several coastal resources are utilised in the Maldives, some of which remains significant from the past, while others have either being regulated, controlled or banned. These include: bait, reef and aquarium fisheries, sea cucumber, lobster, grouper, giant clam, black coral, and turtle exploitation. In addition, coral had been mined for various purposes for centuries. These and other resources and their status and potential are accounted below.

2.2.1 Living coastal resources

Bait Fishery

Small live fishes of at least 40 different species are used as bait in the pole and line tuna fishery. Since the tuna is caught by pole and line, the success of tuna fishing depends largely on the availability of live bait. Fishers have to secure an adequate amount of small live baitfish before they head towards the tuna fishing grounds. The bait fishery is hence pivotal for the tuna fishery.

Although the status of the stocks of baitfish is not very clear, the livebait fishery is considered to be sustainable. However, the total catch and catch rate of live bait species have increased greatly in recent years as a result of an increase in tuna fishing effort.

A recent introduction is the bait collection using lights. This practice was allowed in the southernmost atoll, as fishing effort increased in the atoll, and the availability of bait is generally low here. Few other islands have also tried this method, but is not encouraged by government policy. The common live bait species used and their utilization are summarized in Table 2.

Table 2.Common live bait species used and their utilization

Local Name	*Species*	*English Name*
Rehi	*Spratelloides gracilis*	Silver Sprat
Hondeli	*Spratelloides delicatulus*	Blue Sprat
Miyaren	*Encrasicholina heteroloba*	Shorthead Anchovy
Thaavalha	Various species	Silversides/Hardyheads
Boadhi	Various species	Cardinalfishes
Muguraan	Various species	Fusiliers
Nilamehi	*Chromis viridis*	Blue Damselfish
Bureki	*Lepidozygous tapeinosoma*	Fusilier Damselfish

Anderson (1994) The Maldivian Tuna Livebait Fishery - Status and Trends

There are considerable fluctuations in the availability of different varieties of baitfish from year to year (Anderson and Saleem, 1995), season to season and regionally ((Anderson and Saleem, 1994), For instance, Cardinalfish abundance and utilization was unusually high in 1993-94. Livebait species diversity is greater and composition of bait south of the Kudahuvadhoo Channel (at about 02°40'N) is reported to be very different from that in the north and centre of the Maldives. In this regard, three main patterns of variations in livebait abundance and utilization in the Maldives are evident:

1. Blue Damselfishes, Silversides, and to a large extent Fusiliers are common on the east coast during the Northeast Monsoon season (December to April), and on the west coast during the Southwest Monsoon.

2. Silver Sprats and Blue Sprats are common on the east coast during the Southwest Monsoon season, and on the west coast during the Northeast Monsoon.

3. Anchovies are common during the intermonsoon periods.

Traditionally livebait fishing was carried out using a hand made cotton lift net, later replaced by nylon nets. The new nets were lighter and could be made much larger, hence are more efficient and durable.

These nets are deployed over the side of the vessel using four long poles attached to the net. An attractant is used to get the livebait over the net.

With the introduction of diving masks, their use spread rapidly throughout the country. The use of masks eliminated some problems encountered earlier, such as locating bait schools. Fishers are able to deploy nets without the use of poles. further still, the use of SCUBA diving equipment has also been reported but their use is limited. This gear is useful for catching deep swimming varieties such as cardinalfishes.

These developments while they may reduce the physical damage to reefs, extracting of larger quantities of bait has implications on the stocks and availability of baitfish.

Relatively small quantities of some bait species, notably *Spratelloides gracilis* and adult Fusiliers, are used for human consumption in the Maldives. A few bait species, notably *Chromis viridis* (Adam, 1995) but also some other Damselfishes and Cardinalfishes, are taken by aquarium fish collectors for export, however, the quantities involved are very small. Given the importance of the baitfishery, and the potential damage that might be done if an export market were developed for any of the livebait species, the export of any bait used for pole and line fishing has been banned since 1985.

Reef Fishery

Until recently, reef fishing was not regarded as a serious economic activity in the Maldives. On most islands reef fish were caught and consumed only when tuna fishing was very poor. Many people still loathe the strong smell of reef fish. However, over recent years, fishing for reef fish has become increasingly important because of the high demand from the tourism industry and with increasing awareness, especially considering that reef fish being healthier. This fishery has also further expanded due to the development of new export markets for reef fish products. Table 3 shows the amount of reef fish exported between 1996-2002.

Table 3. Amount of reef fish exported between 1996-2002.

Reef fish (MT)	1997	1998	1999	2000	2001	2002
Dried reef fish	-	1.58	0.95	-	-	-
Frozen reef fish	20	-	-	-	10.8	-
Fresh & chilled reef fish	98.14	6.83	189.63	311.09	267.16	249.5
Salted dried reef fish	-	-	-	74.03	79.08	37.14
Live reef fish	-	-	-	-	10.8	-

The increase in demand for reef fish especially from the tourism industry and overseas markets raises the level of exploitation of particular reef fish varieties. In June 1995, the Government of Maldives banned export of a number of reef fish varieties that are ecologically important for the functioning of the reef system. These include eels, pufferfish and parrotfishes. Napoleon wrasse was considered specially in danger of being over exploited hence it was declared protected species in 2000.

Aquarium Fishery

The aquarium fishery began in the early 1990s. Its major markets include Europe, Far East, and USA. In 2002, 175,878 fish were exported and produced revenue of about US$ 0.5 million. The aquarium export fishery started in 1979 exporting mainly to Sri Lanka at the time, but today markets are available in Europe, USA and the Far East. About 100 species of fish are now exported, with 20 species comprising over 75% of the trade. Some of the species exported are very rare in the Maldives and are very vulnerable to overexploitation. Table 4a shows the 20 commonest species of aquarium fish exported, and Table 4b shows the quantities exported for 1997-2002.

Table 4. (a) Commonest 20 species of aquarium fish exported in 1994.
(b) Export of live aquarium fish (000s)

(a)

Species	*Local Name*
Acanthurus leucosternon	Powder Blue
Gobiodon citrinus	Poison or Yellow Goby
Pseudanthias evansi	Purple Wreckfish
Zebrasoma veliferum	Sailfin
Anthias sp.	Anthias
Dascyllus aruanus	Three-stripe Damsel
Rhinecanthus aculeatus	Picasso
Oxymonacanthus longirostris	Longnose
Chromis viridis	Green Damsel
Chaetodon falcula	Saddleback
Pomacentrus pavo	Jade Damselfish
Pseudanthias dispar	Longfin Wreckfish
Amphiprion nigripes	Maldives Clown
Pygoplites diacanthus	Royal
Nemanthias carberryi	Anthias
Chaetodon xanthocephalus	Yellowhead or Goldring
Clown Fish	Clown Fish
Macropharyngodon bipartitus	Rare Wrasse
Labroides bicolor	Yellow Diesel, Cleaner
Novaculichthys taeniourus	Dragon Wrasse

Source: Adam (1994)

(b)

1997	262.64
1998	182.9
1999	167.5
2000	148
2001	176.5
2002	175.9

Grouper Fishery

The grouper fishery became a specially targeted fishery and developed as a commercial fishery in 1993, when the demand for groupers, both live and processed, increased drastically. This was as a result of attaining a new market for groupers in certain Far East countries. Groupers are mostly exported live, fresh/chilled or salted or as frozen whole. In 2002, the combined net revenue received from this fishery was over US$ 2.4 million. There are indications that the grouper fishery may be under stress. Conservation measures are formulated to protect the stocks for the grouper fishery.

As many as 40 species of groupers occur in the Maldives and of which only a few species are utilised. Groupers are caught by handline, but the techniques have improved or refined due to the increase in demand. It is difficult to asses the number of fishers engaged in grouper fishery as it is also practice by regular tuna fishers in the tuna off-season or when the tuna fishing is poor. The demand from the tourist sector is also increasing the demand for reef fish including groupers.

Based on the total reef fish and grouper catch some effort was made to assess the MSY of reef fish including grouper. Using similar methods as employed by Anderson at al. (1992) to calculate maximum sustainable yield of

reef fish, Shakeel (1994) made assessment of groupers for three major habitats as shown in Table 5.

Table 5. Estimate of groupers for three major habitats

Habitat composition	MSY (t/yr)	Percentage of grouper in the survey catch
Atoll basins	810 ± 370	15.80
Shallow reef areas	960 ± 320	4.15
Deep reef slopes	60 ± 15	17.91
Total MSY	1800 ± 700	7.95

The grouper fishery has intensified particularly since 1995 following the crash in world market for tuna. While the export figures for groupers may not indicate that the grouper fishery is approaching its MSY levels, some species of groupers may be threatened because they are specifically targeted. Grouper fishery while it appears a viable, caution is required to sustainably utilize the resources from the natural habitats.

Sea Cucumber Fishery

The export markets of sea cucumbers are in the Far East and Asia. Nine species of sea cucumber are exported from the Maldives. The most valuable species of the sea cucumber is *Thelonata ananas.* This species was rapidly overfished and other medium value species were subsequently overexploited. Sea cucumber is exported mostly dried, while a small quantity is exported either frozen, dried, salted or in brine. Table 6 shows the export quantities of sea cucumber between 1997-2002.

Table 6. Export quantities of sea cucumber between 1997-2002.

Sea Cucumber	1997	1998	1999	2000	2001	2002
Dried	318.03	85.01	53.84	201.51	223.22	190.29
Salted/dried/frozen/brine	-	-	-	3.74	2.63	0.51

Export value of sea cucumber picked up in 1995 after dropping to its lowest level in 1994. However, this increase did not indicate any stock recovery but was due to high international demand. In 1998, the total value received from the export of sea cucumber again dropped to almost the same level as 1994 (US$ 0.3 million). This was a 47 percent drop compared to the export value received in 1997. As a conservation measure, use of SCUBA diving gear for the harvesting of sea cucumber is banned in the Maldives.

Lobster and cuttlefish fishery

The lobster fishery is mainly targeted for the tourist industry. At least five species of lobsters are exploited in the Maldives. Lobsters are collected mainly at night by hand, using lights. However, harvesting of small lobsters with carapace lengths less than 25cm and berried lobsters are banned. The continuing growth of tourist arrivals is likely to increase the demand for lobsters. However, due to the nature of exploitation and the control regulation, this resource may not be commercially exploited in a sustainable manner. The figures for 2002 indicate that 66,592 lobsters were caught, more than 50% of

which caught from one atoll (Shaviyani) in the north.

Similarly, cuttlefish is becoming popular particularly targeted at the tourism industry. The numbers caught are negligible as no organized fishing is practiced so far.

Giant clam
The giant clam fishery was a very short-lived one, which lasted about a year from 1990. *tridacna maxima* and *tridacna squamosa* are two species harvested for their meat. The methods used in the exploitation of the giant clam was very destructive to the reefs, hence the government intervened and banned the fishery in 1991.

Seaweeds
Based on the collection of seaweeds made so far (Hackett 1977), 163 species of red algae, 83 green algae, 21 blue-green algae and 18 brown algae including one new species of Dictyurus were found in the Maldives. The most abundant species belong to the genera *Chondria*, *Laurencia, Hypnea, Polysiphonia, Lithophyllum, Tydemania, Acrochaetium, Padina*, and *Ceramium*. Seaweed culture has been tried in the Maldives. Despite the favourable environment and with several attempts to commercially culture it, very little successful has been made so far. Given the extensive reef flats which can provide suitable habitats for extensive cultivation, the potential for its culture appears very promising.

Red and Black coral and cowrie
Red coral (*Tubipora musica*) has been harvested from reef flats for centuries. It has also been used as decoration for buildings, but it is mostly targeted for export markets. The initial market was in Sri Lanka but now markets exist in South East Asia and the Europe. In the absence of organised harvesting, it is difficult to estimate the number of people or areas engaged in exploiting red coral. The amount of red coral exported (in kilograms) is indicated in Table 7 below.

Table 7. Amount of red coral exported (in kilograms)

1997	23.67
1998	8.42
1999	12.85
2000	14.27
2001	28.82
2002	36.66

Black coral was presumably abundant on Maldivian reefs. However, over the last two decades large quantities were removed, to make jewellery and other souvenirs for tourists. Indications are that a certain type of bait fish is associated with black coral, hence depletion of black coral may impact the baitfishery. Export of black coral was banned in 1990. Cowrie trade had flourished very successfully in the Maldives dating back to centuries. Since

cowrie was used as money, it became a highly sought after item. Maldivian money cowrie was reported to have reached the Roman Empire by about the first century AD. During the 16th century, the Portuguese were interested in colonizing the Maldives partly for the valuable cowrie resources. With the granting of permission, the Portuguese established a factory in Male' in 1518 to conduct the trade (Maniku, 1998). Special methods for sustainable collection and management of the cowrie were utilized. Limited export of cowries still takes place.

2.2.2 Living marine resources

Tuna Fishery

The tuna fishery is the major fishery and takes place all year round throughout the country. This fishery utilizes three techniques; 1) Pole and line fishery, 2) Hand-line fishery, and 3) Long-line fishery.

The pole and line fishery is exclusively used for skipjack and small yellowfin tuna where as hand-line fishery targets its operation for large yellowfin tuna and long line is used to catch yellowfin and big eye tuna in deeper water.

Pole and line fishery represent 90% (2002) of the total fish catch. The fish are caught from schools of tuna in open waters, around Fish Aggregating Devices (FADs), or those associated with drifting flotsam and sometimes along the outer reef edge. The annual harvest of skipjack and yellowfin in the Maldives in 2002 was 140,607 metric tons. Except for a reduction in the total landing in 2000, an average of 6% increase in catch was recorded between 1996 -2002.

Large yellowfin ranks second in importance, in terms of fish export from Maldives. Yellowfin catches in the Maldives are seasonal and their proportion in the total catch varies throughout the atoll chain. The estimated yellowfin production in the Maldives ranged from around 12,000 to 25,285 metric tons per year for the period 1996 -2002.

Shark Fishery

Shark fishing has been carried out for centuries in the Maldives. Three groups of shark fishery practiced in the Maldives are: 1) Reef shark fishery; 2) Deep water Gulper shark fishery; and 3) Oceanic shark fishery. Amongst the three groups, the reef shark fishery is more valuable than the other two groups as this fishery generates revenue for both fisheries and tourism. Although there is no clear evidence of over fishing of reef sharks, a number of complaints about the reduction of shark numbers from some dive sites have been reported by divers in recent years. Anderson and Ahmed (1993) concluded that the reef shark fishery is moderately fished and if continued, the stock would be adversely affected. Recognizing the economic importance of shark watching in the country, the Government of Maldives has introduced regulations aimed at promoting shark and ray conservation. This culminated in the ban on all types of shark fishing within the main tourism zone.

Sharks are mainly fished for the export of their fins and meat, as there is little or no market for shark products locally. The main products of sharks are salt dried shark meat and dried fins. Shark meat is exported to Sri Lanka and dried fins to the Chinese markets in Singapore and Hong Kong. Some species of jaws are also sold to tourists. The only product used by the locals is the shark liver, which is utilized to extract oil used for sea faring vessels. Although shark fishing is a well-established and traditional fishery, fishing for reef sharks only started in the early 1980s when export markets for shark fins developed (Anderson and Ahmed, 1993).

Turtle
The exploitation of turtles for local trade and consumption date back hundreds of years. Turtle eggs have been used as gifts to the royalty and others particularly in the capital. Some turtles, mainly *Chelonia mydas,* were killed for extracting oil for preserving wooden boats.

Until about 1950's religious taboo has barred the slaughtering of turtles for meat, but since then killing of sea turtles began for meat and a local trade item. Turtles were further exploited with the development of the tourist industry in 1972, which has prompted a lucrative trade in turtle products such as stuffed turtles, shells, jewellery and ornamentals.

An export market for tortoise shells also developed, but did not last long. Signs of overexploitation were evident. In late 1980 the export of whole turtle shells was banned, and a second regulation banned the catching, sale or display for sale of small shells (less than 60cm for *Eretmochelys,* and 75cm for other species i.e., *Chelonia mydas;* Didi, 1983). These reduced direct exportation by tourists.

The significance of the turtles to the tourism industry resulted in the introduction of many vital steps. A ten year moratorium on the capture of turtles was introduced in 1995. Reported sightings of turtles by fishermen, locals from islands and responses from resorts indicate that the turtle population has increased and significant attitude changes have occurred towards turtles in the Maldives. However, egg collection has not yet being banned.

2.3 Developmental potential of coastal and marine resources

2.3.1 Extractive resources

Living Marine resources
Fisheries used to be the dominant sector of the economy until 1985, when tourism industry overtook fisheries in terms of its contribution to GDP. The contribution of fisheries to GDP declined from 10.7 percent in 1990 to 6.0 percent in 2000.

Marine resources such as tuna, frigate tuna and finfish were exploited in a sustainable manner, both for local consumption and export. Fishers would sail out early in the morning and return by sunset, with the catch. Hence, the

distance, catch and effort were very limited. The vessels, catch methods and utilization have changed over time.

The most important component of the tuna catch is skipjack (*Katsuwonus pelamis*), which contributes some 75% of the total tuna catch. Yellowfin tuna (*Thunnus albacares*) is the second most important species, contributing some 13% to the total tuna catch. Other tuna species taken include kawakawa (*Euthynnus affinis*), frigate tuna (*Auxis thazard*) and bigeye tuna (*Thunnus obesus*). Figure 5 shows the adjusted pole and line catch per unit effort for skipjack tuna and yellowfin tuna. Total tuna catches have increased dramatically in recent years, to nearly 150,000mt in 2002, largely due to increase in effort. Figure 6 indicates this increase in effort especially commencing with mechanization and later with the introduction of fish aggregating devices (FADs).

Vessel type influences the extent of exploitation of these resources. Wooden sail vessels called *Masdhoni* (10-15m) is the largest vessel used for offshore fishing, followed by *vadhudhoni* (5-6m), used almost entirely for trolling. *Bokkuraa* (2-3m), a small row vessel was used for finfish catch in the nearshore areas. The average distance tuna fishers travel is therefore confined within twelve km from the shore, the trolling fishers to about 5-6 km and the bokkuraas to 2-3 km. The size distribution of the fishing vessels show that the majority vessels are between 15-20m in length (Figure 7).

Mechanization of the fishing vessels since 1974 increased the distance fishers were able to travel. Later both *vadhudhoni* and even *bokkuraa* were also mechanised. As a result, the catch and the utilization of the marine resources increased significantly. However, the trolling fishery appear to have collapsed (Adam et al 2002) due to the socio-economic and developments and modernizing of the industry.

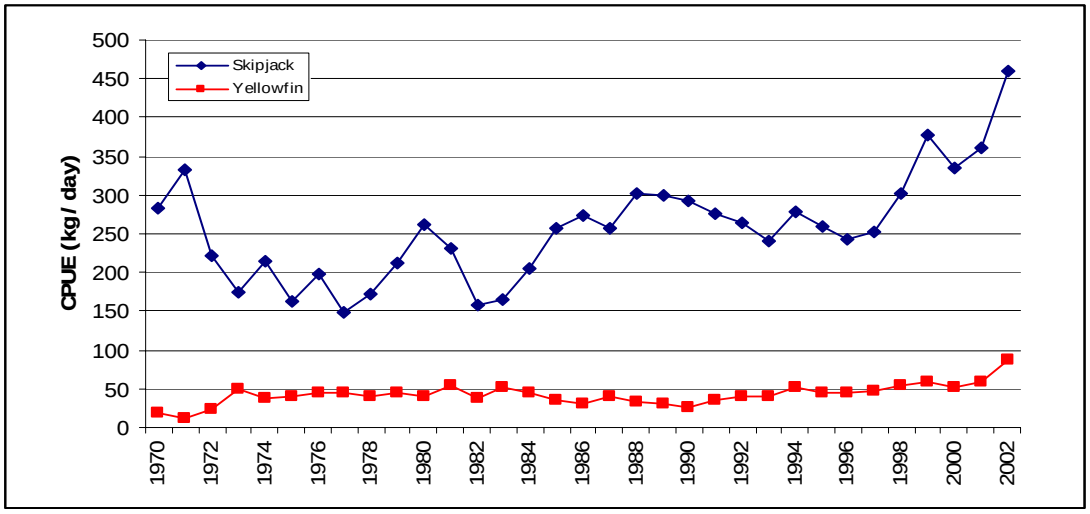

Figure 5. Adjusted pole-and-line CPUE for skipjack (diamond) and yellowfin (squares)1970-2002. Source: MOFMAR, Statistics and Database Management Services.

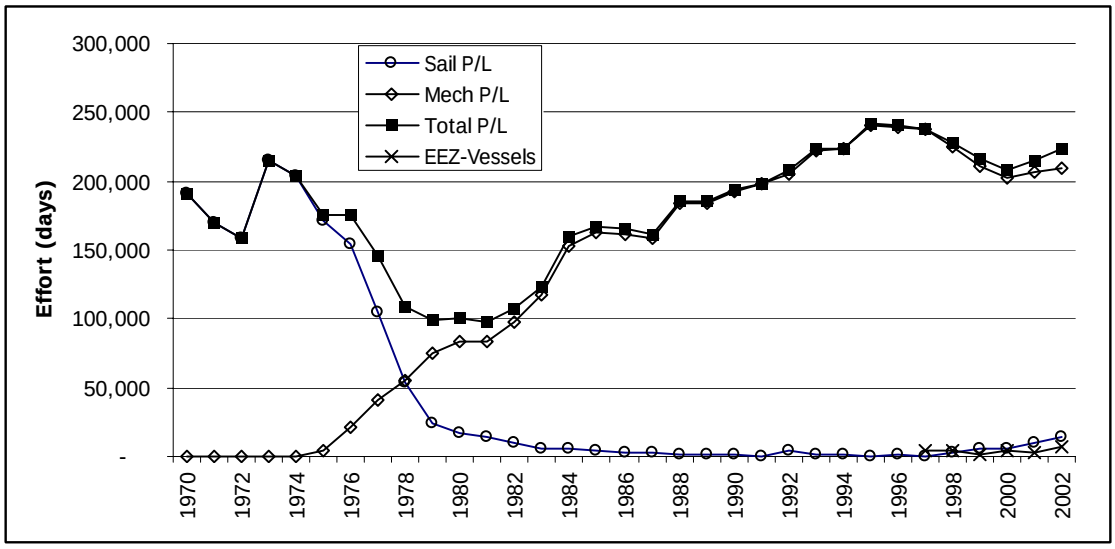

Figure 6. Annual fishing effort of the Maldivian pole and line fleet (1970-2002). Also shown is the number of longline days for the EEZ vessels (1997-2002).
Source: MOFAMR / Statistics and Database Management Section.

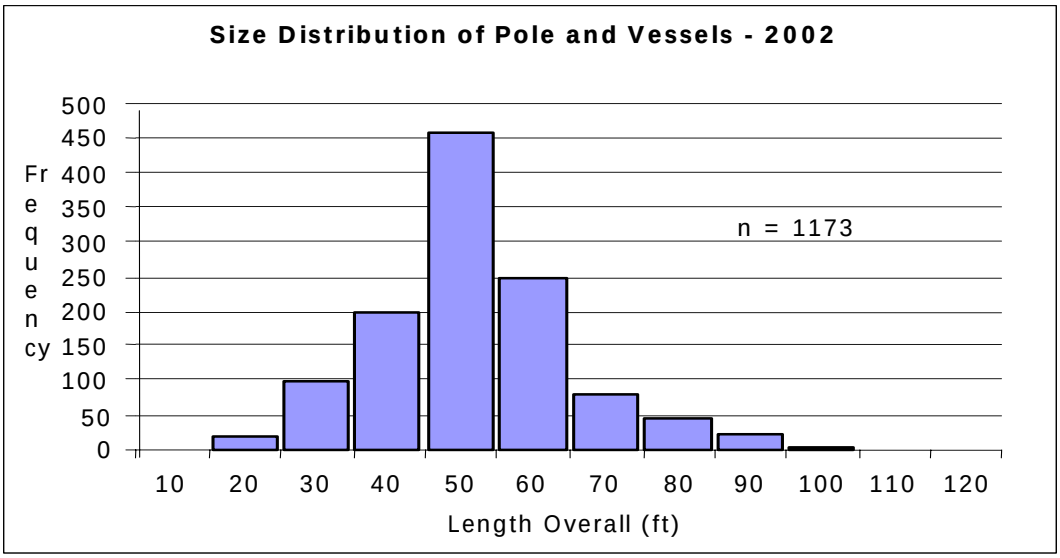

Figure 7. Length distribution of fishing vessels, 2002
Source: MOFAMR

A further development in the tuna industry was the introduction of the fish aggregating device (FAD) in 1991. FADs have revolutionised the fishing effort and the approach. FADs have reduced the amount of time fishers spent locating schools of fish. Fishers can therefore set off late and return early with the catch. FADs have therefore improved the potential catch and increased the potential to save fuel and time. Reduction in the amount of time between fish catch and delivery tends to improve the quality of the fish as well. A combination of mechanization, FADs and increase in the size of fishing boats is believed to have improved the catch per unit effort. The demand for FADs from the atolls indicate the success of the device and the potential for future development of the tuna fishery in the country.

A further development relating to the improvement in the quality of fish is the easy availability of ice. Several attempts have been made by the government to provide ice to fishers since the early 1980s. With the opening of the fishing zones, private investors are encouraged to provide and facilitate easy access for fishers to ice. With these new developments, fishing boats were redesigned with the provision for storing ice and also to haul in larger quantities of fish. Notable market and product changes have also influenced the developmental potential of the marine and coastal resources in the Maldives.

Traditionally the Maldives have exported smoked and dried tuna almost exclusively to Sri Lanka until 1971. With a market crash for 'maldive fish' in 1971 and a change in the Sri Lankan government policy caused a turning point in the direction and dimension of the marine and coastal resources industry of the Maldives. Product diversification and value addition increased, with the introduction of other ancillary fisheries-related goods and services.

With the collapse of the demand for 'maldive fish' in Sri Lanka, two Japanese long lining companies (Hoko Maldives and Marubeni Corporation) both with long distant fleets took the opportunity to set up operations in the Maldives. With this development, frozen fish export was initiated in the Maldives in 1972. A tuna cannery was set up by the Hoko Maldives in 1975. This is the only canning factory that operates in the country currently.

Following the opening of the EEZ to foreign investors, from 1990 fishing rights were granted to foreign operators, and joint venture undertakings were taken to operate long line fishery in the EEZ for the deep ocean yellow and bluefin tunas.

With the realization of the potential in long line fishery, local and foreign investments increased. More durable and larger often fiberglass boats of 30-35m length are built with accommodation and proper cooking facilities, as long line requires fishers to be at sea longer than the traditional tuna fishery.

In the absence of credible information pertaining to the yellowfin stock assessment, maximum sustainable yield (MSY) estimates has not been attempted to set targets for total allowable catch (TAC). However, the government is conscious about the sustainability of this fishery, and is cautious about its expansion. Hence, limitations are imposed on the number of foreign licensees to be engaged in this fishery.

The export of fish and fish products has increased substantially since 1972 and notably between 1990 and 1999 export of fish and fish products increased from 76,373 to 123,298 MT. Despite a sharp decline by 19% in 1997, the exports on average have increased by about six percent per annum. In 2001, more than 50% of the total export earnings of the country came from fisheries. It is interesting to note that the biggest market for fish products particularly the dried 'Maldive fish' is Sri Lanka. The value exported amounts to $13 million.

Other major markets for fish products are Hong Kong, Singapore, Thailand and Taiwan but these are very specific markets for reef fish products such as dried sea cucumber, grouper and shark fins.

Most of the frozen skipjack tuna is exported to Thailand and the market for the canned tuna is generally UK, and Japan is emerging as a potential market for fresh chilled yellowfin tuna, and 'katsubushi'. Other potential markets are Canada, Malaysia and Netherlands.

Following a Presidential Directive in 2000, the buying of fish from local fishers and exporting of tuna were opened to private investors. Three zones are designated for this purpose and two already have been awarded to local investors. Indications from this development is the creation of value addition. Frozen fish and loins, fishmeal, special market-specific products such as loins for shashimi, katsubushi (special dried, extremely hard tuna pieces) were introduced, in addition to proposing fish burgers (both for local and export markets). Additional canning facilities have been proposed under this development. The potential for further development of the marine resources of the Maldives has thus increased with the value addition.

The persistence of traditional tuna industry using pole and line method can be regarded as contributing to the sustainability of the tuna resource in the Maldives. With the increase in effort, particularly through recent improvements in fishing gear and methods, it is important to be vigilant about future catch levels in relation to the maximum sustainable yield (MSY) of this important resource.

Living coastal resources

Of the coastal resources, the bait fishery is the most extensive and also the most sustainable, as bait collection has prevailed for centuries, forming an integral part of the pole and line tuna fishery. Bait is sometimes used for human consumption, especially when the tuna catch is low or minimal. Cooked or uncooked and dried bait especially sprats appear to have a good domestic market potential. According to available data, over 10,000 MT of bait is collected annually. With no reliable stock assessment, it is not possible to evaluate the potential of this fishery. The utilisation of the bait increases with the expansion and development of the tuna fishery, and this can be as rapid as a 100% increase in live bait collection over seven years (Anderson, 1993). The future and sustainability of further expansion and development of the traditional pole and line tuna fishery depends largely on the availability and viability of the bait fishery.

The potential of bait fishery is limited in the two southernmost atolls, Addu and Fuahmulaku. Being smaller and in the absence of patch reefs, habitats for bait fish is very limited in these atolls. An experimental bait fish aggregating device (BFAD) was tried in Addu Atoll, and preliminary results indicate limited success in that they have the potential to attract and increase bait fishery. Although tuna fishery is not very extensive in Fuahmulaku, it is gaining significance in Addu Atoll. Hence the need to increase bait fishery in Addu Atoll is crucial.

Shark fishery, which can be considered as a marine resource has continued to be exploited mainly for export purposes. This less labour intensive fishery, fetches high prices for products such as shark fins and salted fish. Traditional markets for shark products still exist. Shark fishery is therefore quite attractive on the basis of return for effort. However, the aesthetic value of sharks is increasing, particularly in association with tourism development. Fishers are also increasingly realising the significance of sharks associated with the tuna and thus want to ban catching them (deliberations of the National Workshop on the BOBP/LME).

With the growth of tourism and increasing popularity of diving, sharks are a major asset for the tourism industry. Estimates made in 1992 indicate that shark-watching was valued at about US$ 2.3 million with an average value of a live grey reef shark at US$ 3,300 (Anderson and Ahmed 1993). With increasing awareness on the non extractive benefits of shark for the tourism industry, the potential of shark fishery appear to be limited.

A similar development is evident with the ray fishery. Fourteen species of rays occur in the Maldives, and an initial market for rays and ray skin was evident. However, considering the significance of rays for the tourism market, the government banned the export of rays in 1995, and export of ray skin in 1996. On the basis of 'willingness to pay', a nominal value of US$ 7.8 million was attributed to the manta rays alone (Waheed, 1998).

Of the reef fishery, grouper is the most significant exporter. Since its mass exploitation from 1995, this fishery has remained somewhat sustainable. Grouper fishery has persisted for many reasons, including guarantee of income and as an alternative source of income when the tuna fishery or the weather is unfavourable. Fishing can also be carried out in all types of fishing boats: rowing boats (*bokkura*), sailing or mechanised trolling boats (*vadudhonis*), and mechanised pole-and-line fishing boats (*masdhonis*). The fishery initially concentrated in central atolls- Alifu, Vaavu and Meemu, but has now spread across the country.

The estimated MSY levels for the grouper fishery indicate that there is very little potential for further expansion of this fishery as practiced now. The Ministry of Fisheries, Agriculture and Marine Resources is presently formulating conservation strategies for the grouper fishery. In addition, the Marine Research Centre of the Ministry of Fisheries, Agriculture and Marine Resources has attempted to culture the grouper. Given the biology and the growth and development of the grouper, the potential for grouper culture appears to be limited. Zoning and partial closure during the year some suggestions to sustainably manage the grouper fishery in the Maldives (deliberations of the National Workshop on BOB/LME).

The sea cucumber fishery has been an important coastal resource in the Maldives, since 1985, and has been very successful initially. With the level of exploitation exceeding the replacement rates, the populations dwindled to the extent of adversely affecting the fishery. Extensive research into sea cucumber cultivation has shown enormous potential (Shakeel pers.com).

Private sector investments are necessary to make this resource a viable and sustainable item. Considering the status of the environment, it appears that sea cucumber cultivation on massive scales is possible in the Maldives.

Other coastal resources such as cowrie, red coral, lobster, and cuttlefish appear to play a nominal role and their resources can be sustainably exploited at the current scale of exploitation. However, resources that can be cultured such as giant clam, some species of aquarium fish, and including turtles appear to have some potential for developing further.

2.3.2 Non extractive potentials.

Reefs as premium resource for tourism growth and development is evident in the Maldives. Despite tourism being targeted to the higher income levels, it has grown and indicates that it will continue to grow. The prime reason is the pristine environment, and the white sandy beaches, the azure blue lagoons and the attractions in the reef systems. The willingness to pay and the extractive value of sharks and rays are indicated in this section. In addition, dolphins, turtles and whales are added value to this premium resource. Since dolphin and whale watching is increasingly becoming popular globally, enormous potential exists for further development of non extractive potentials and benefits of these resources.

2.4 Potential and prospectives of coastal and marine resources

The developmental potential of the marine resources, especially pelagic tuna, demersal yellowfin and bluefin tuna lies with the ability of the local fishing industry to produce new products or increase value addition, market expansion and adapt to new market developments, and increasing the ability to fully utilize the resources within the EEZ. In the face of increasing competition between tourism and fisheries attracting and retaining the required workforce for the fishery industry is a significant challenge, and a critical factor in further development of the marine resources of the Maldives.

The potential for sustainable utilization of many of these resources depends upon the widespread use of scientific knowledge and appropriate technology, for improving the stocks, harvesting adding value for post-harvesting purpose. A further, potential development in these resources lies with the possible expansion of non-traditional uses of these resources, such as for educational, scientific for medicinal and pharmaceutical purposes. In addition the present and future environmental state of Maldives will also affect the developmental potential of these resources.

3.0 THREATS TO THE COASTAL AND MARINE ENVIRONMENTS AND THEIR RESOURCES

Threats to the coastal and marine environments and consequently on resources contained within them arise from both natural as well as human-induced causes, working at local as well as regional or global scales. Often the two causes work in synergy to complicate or magnify the impacts of any single or series of incidents or events.

3.1 Local level threats

3.1.1 Fisheries-related threats

In the Maldives exploitation of the marine and coastal resources have been very manual. Except possible impacts on targetted species or populations, there appears to be little or no impact on the environment.

Most fish in Maldives are caught using lines, and thus by-catch that is wasted is almost non-existent. Although mechanization of fishing vessels and other applications on fishing vessels have revolutionized, the fishing methods remained traditional in the Maldives. Therefore, the fishing methods generally practiced in Maldives can be characterized as non-destructive (UNEP, 2002).

Baitfishery

Baitfishery being the most significant for the traditional pole and line tuna industry is changing by size and technique. While bait fishing has not negatively impacted the reefs, several changes are evident that can and will have impacts on the baitfishery.

Traditionally the bait was collected during the day. Bait fishing using lights while not encouraged, is also practiced as well. The environmental implications of this change are not known and needs to be studied. Destructive fishing methods such as use of cyanides, fishing with herbicides or pesticides are not practiced in Maldives. However, not widely practiced, but isolated cases of use of household chemicals such as bleach and chlorine have been recently reported.

Indications are also that baitfishing itself can cause damage to the coral reefs, as the collection of certain species, such as cardinalfishes and damselfishes, that are closely associated with the corals can be particularly destructive to the reefs while during netting for the bait. Most susceptible to damage is the branching corals, where bait shelters. In the case of essentially pelagic varieties such as Fusiliers, Sprats and Anchovies the net is generally kept off the bottom, and so reef damage is minimal.

Anchoring is a more serious cause of reef damage associated with baitfishing. With increases in baitfishery effort, anchor damage, intensive collection at certain points or concentration of boats on one reef over a period of days or even weeks amplify reef damage.

Bait and grouper fisheries are affected by waste water from sea cucumber fishery. Fishermen report that cooked water of sea cucumber has an unfavorable effect on the fish that lives in the vicinity of the discharge. The effects of which may cause a reduction in the fish population in the area and can therefore impact the baitfish, groupers, and other reef organisms.

Reef fishery
Of the reef fishery, the sea cucumber fishery is most unsustainable and damaging. Apart from exploiting targeted species or large quantities, with implications for stocks, the methods and techniques are fairly environment friendly. However, the great majority of the reef fish species taken are carnivores, and their removal from the reef system may adversely affect the functioning of the reef system. It appears that reef fishing harms baitfishing as reef fishes tend to keep the baitfish in tight, stationary schools.

Sea cucumber fishery has considerable environmental impacts. Most fishers move continuously from atoll to atoll harvesting from the wild, often causing depletion of target species for long periods. From section 2.2 it is evident that the level of exploitation has far exceeded the MSY, leading to a collapse of the fishery since 1997. Fishers often complain of the effects on bait fishery associated with the preparation of the sea cucumber.

3.1.2 Loss of coastal habitats
Loss of coastal habitats, particularly seagrass beds and mangroves, in addition to coral reefs occur in the Maldives. Since these habitats are essential for the continued provision of the living resources, their losses and causes need to be highlighted. These habitats themselves lend as resources especially with diversifying tourism attractions. Many of these habitats are under threat particularly in association with population pressure, infrastructural development, and solid waste disposal.

Seagrasses
Since seagrass beds colonize sandy areas that are relatively stable, and often in the lee of islands. Extensive reef flats favour these conditions and development of seagrass is also dependent upon the size and shape of the island. They are not extensively developed in the Maldives. However, they have either developed or extended with increase of nutrients particularly associated with densely populated islands.

Seagrass beds on tourist resorts are considered aesthetically unpleasant. Extensive efforts or resources are often diverted to check and control the development of sea grass beds on many resorts. Dredging techniques and more manual methods such as regular removal, covering beds with non-transparent materials or use of domestic chemicals have been tried to achieve this.

On some inhabited islands where extensive sea grass beds cover the lagoon area, accessibility is often limited or difficult. With the increase in transport and the demand for consumer goods, throughout the Maldives, and due to the need to provide accessibility for primary services (eg. health services, trading,

etc.), dredging of harbours on many islands have removed or adversely affected seagrass beds throughout the Maldives. Demand for land particularly on congested islands has also resulted in loss of seagrass beds to reclamation for housing and infra structural development.

Ecologically seagrasses are important for the coastal resources as these habitats are nutrient providers for the reef system; they act as breeding and nursery grounds for many reef organisms. Sea grass beds were extensively used in the past for the cowrie and other shell and cone collection. Traditional methods such as using coconut fronds were used to enhance and sustainably harvest money cowrie until the late 70's.

Mangroves

In the absence of estuarine conditions, the mangroves of the Maldives are unique as they are highly adapted to the marine conditions. The types of mangrove ecosystems in the country differ in size and composition, and exhibit a strong geographical correlation. Mangrove systems are more evident on single islanded reefs in the north and their occurrence and flora is distinct from the mangrove systems that occur on multiple-islanded reefs as found in the south of the country.

Mangrove systems apart from exporting nutrients to the reef systems and acting as nursery for many reef fish and other organisms, they offer protection to islands, act as a filter for runoffs and regulate the fresh water lens on islands. Mangrove resources such as wood, fruits and other extractables from parts of plants have been harvested for centuries. The use of mangrove wood for boat-building, for 'pushing' sticks on boats and for hauling the baitfish nets is noteworthy.

Unlike sea grass beds, which have a potential to grow with the addition of nutrients, on populated islands with mangroves they are under increasing pressure and are considered to be particularly threatened ecosystems. With the decline in direct extractable use of the mangroves they are perceived to be unhygienic and unsightly places that breed mosquitoes. The mangrove areas are therefore perceived as ideal spots for disposal of solid waste and for reclamation.

The uniqueness of the true value of the scattered mangroves in the Maldives is not well understood. However the significance of mangroves areas to the coastal and marine fishery is to yet be studied in the Maldives. It is imperative that with the rapid pace of development taking place across the country in particular that of loss of habitats such as coral reefs, seagrass beds and mangroves will either have direct or indirect impacts on the potential of the marine and coastal resources.

Coral and sand

Coral and sand mining in the Maldives dates as far back as 500B.C (Ali, 1991). However, use of *Porites* in the Maldives as a building material began in the mid 1650's. In the early 20th century, coral and sand were mined for housing purposes in Male' mostly, but spread to the other islands by the

1950's. Both massive and branching corals were collected as building material as well as for making lime. The lime is mixed with coral sand and used as mortar or for plastering. Due of the increasing demand for lime in Male', coral was extensively mined in the other islands.

With the development of tourism in the early 1970's, a construction boom set in. Development of resorts, construction of public buildings and private housing accelerated the use of coral and sand. Coral and sand have also been extensively mined for land reclamation, construction of jetties and groynes, making and extending runways and for road constructions.

By late 1980s coral and sand mining was very extensive and obtaining coral in the vicinity of Male' became problematic. The government intervention in banning the use of coral in resort development and reduction of import duty on aggregate and building materials curtailed the demand for coral. Hollow cement blocks became increasingly popular as a general building material. By late 1990s coral mining was reduced across the Maldives, to the extent of non-significance.

Coral mining results in not only the removal of the coral but favour other species to colonize. With a surge in primary algae the possibility of blue-green algae growth which can cause ciguatera or fish poisoning can occur. Brown and Dunne (1988) observed very little grazing, and that coral colonization was impeded by the presence of algae cover in mined areas, mined some 20 to 30 years ago.

Sand mining

With the rapid developments in the construction industry, unlike coral, the demand for sand has continued to increase. Sand is used both for making hollow cement blocks and for plastering. Apart from very localized impacts and except on islands that mine sand from the beach, little or no impact is evident. Since sand is a renewable resource, sand mining from reefs can be considered to be very sustainable. No real figures are available to quantify the amount of sand mining in the country. However, the developments in the construction industry are a surrogate measure to indicate the volume of sand mined. According to the Customs figures the amount of cement imported is 103.1 MT in 2002. With a conservative estimate of 1:4, the amount of sand used is therefore 112 MT, as imported river sand is extensively used for concrete works.

The method utilized in the Maldives for mining sand has ensured minimal environmental damage, particularly with regard to siltation and large scale deterioration of the surrounding area. As sand was normally collected from sand cays, intertidal sand bars, faros and reef flats, with little or no coral cover, the impact on the reef system was minimal apart from affecting a few boring and bottom-dweller communities (Ali, 1991).

3.1.3 Poaching

Poaching can also be considered as a major threat to the marine environment. From the incidents of capture of foreign fishing vessels in the EEZ, poaching and unlawful fishing can be considered to be extensive. The captured vessels are often relatively small in size (under 100m). Surveillance of the EEZ is undertaken regularly by aircrafts and by vessels, but it is limiting both spatially and temporally. Accidental incidents of drifted purse seining and extensive long lining is often picked up by fisherman, suggesting that both seining and long lining on large scales takes place in the vicinity of the country's EEZ.

3.1.4 Domestic and agricultural disposal

Garbage

Solid waste generation has increased many folds throughout the Maldives. Traditionally the solid waste generated were small amounts of leaf litter, kitchen and other domestic wastes. Since these are biologically degradable, they were easily and readily disposed of. Traditionally much of the solid waste was disposed either on designated beach area or into the uninhabited parts of the island where they get decomposed naturally. With the increase in the pace of development and amount of goods imported into the country, the quantity and nature of solid waste generated changed very rapidly. In the absence of an appropriate disposal systems, particularly for small islands, the increase in non-degradables such as plastics, cans and bottles and in particular that of increase in hazardous wastes such as dry cell batteries or hospital wastes are threatening the aesthetics, and health of people on many islands.

An example of the rapid growth in solid waste is exemplified by the amount of plastic bags imported into the country (Table 8). Many of these bags are likely to end up on the house-reefs of many islands.

Table 8. Amount of plastic bags imported (millions)

1994	16.73
1995	15.77
1996	32.30
1997	21.87
1998	18.66
1999	38.85
2000	82.57
2001	77.15
2002	52.97

Source: Maldives Customs Service

Islands with heavy population concentrations are facing similar situations as experienced in Male'. Several options were tried in Male', and eventually an offshore landfill option is implemented for Male'. All resorts are required to install incinerators and compactors to manage the solid waste generated by tourism. However, several resorts and few inhabited islands who can afford to transport the distance of bringing garbage to the landfill site near Male'.

Following the Male' disposal method several islands are trying to pursue similar system. This option is expensive and perhaps ineffective for the outer islands as the quantities are small to make it viable. Several islands have opted to dispose the garbage in confined plots adjoining the island on the house-reef. These may be ad hoc alternatives but does not appear to be a solution. The impacts of excess nutrients and toxic or hazardous substances on the reefs from improper garbage disposal and thus the reef ecology is likely to be adversely affecting the reef resources and their utilisation. For instance, the biomagnification of heavy metals such as mercury, cadmium or lead in the food chain is well documented, and the possibility of such threats in the Maldives is evident from the quantities of dry cell batteries imported into the country (Table 9), of which 180,999 is mercuric oxide batteries.

Table 9. Amount of dry cell batteries imported (millions)

1997	3.4
1998	4.4
1999	3.9
2000	4.4
2001	3.7
2002	4.7

Source: Maldives Customs Service

Sewage and nutrient discharges including toxic and other chemicals are evident to be affecting the reef and the water quality on many islands. However, it is mandatory for resorts to dispose the sewage outside the reef into the open sea. Some resorts undertake primary treatment, while others do not. The infrastructural costs, space required and operational cost are often prohibitive to be utilized on many islands, including resorts. Problems of sewage and nutrient discharges on resorts are therefore non-existent.

The state of knowledge about the domestic and agricultural discharges to the Bay of Bengal area is indicated in section 2.1.3. The combined effects of industrial, agricultural and domestic pollutants in particular heavy metals, organo-chlorides and pesticides are of serious concern. Residues of which may enter the food chain and adversely affect the health of living coastal and marine resources.

3.2 Regional/global level threats

Other specific threats to the marine environment include oil pollution, heavy metals and pesticides, which can occur in the wider Indian Ocean/Bay of Bengal areas. These aspects are discussed in section 2.1. While no comprehensive study on these aspects affecting the marine resources have been studied in the area, limited work carried out indicates presence of such toxins in pelagic fish resources.

3.2.1 Oil pollution, invasive alien species and flotsams

With the increase in size and number of tankers carrying crude oil from the Middle East to the Far East, the route to the north of the Maldives is

extensively used. Oil residues are often discharged with bildge or with ballast water. Although MARPOL regulations attempt to control such discharged, with the increase in traffic and volume the impacts on the marine environment also intensifies. Furthermore, the risk of a possible accident is highly probable. According to the wind data for Male', the wind is usually from a northerly direction, either during the westerly or the easterly season. In the absence of a national or a regional contingency plan for such an event is noted with particular concern. Heavy oil sludge can kill corals and affect the entire reef system, in addition to spoiling the sandy beaches. Oil residues are far more damaging and difficult to clean up on sandy beaches in comparison to other rocky coasts (MARPOL 1990).

The prospect of an invasive alien species discharged through ballast water making its way to the reefs of the Maldives is an increasing possibility. Such species have been reported from India and Sri Lanka. The case of the Zebra mussel in Australian waters is an exemplary predicament of such a possibility.

In the Maldives where the reef system is believed to be in a fairly equilibrium state, an invasive alien species can easily disrupt the functioning and upset the balance of the entire system.

Two other significant marine environmental issues are associated with the increase in tanker and ship traffic in the area. Although MARPOL regulations are increasingly controlling and minimizing the discharge of garbage at sea, evidence indicate that garbage disposal from cargo ships and tankers is a substantial issue (Sen Gupta et al. 1990).

Flotsams carried across the water of the Maldives, such as carcasses and other animal debris can be a source of an alien introduction or a health risk. An outbreak of cholera in the Maldives in 1977 was attributed to such an incident. The sources of such flotsams are usually the river systems in neighbouring countries which carries objects such as dead animals out to the sea particularly during the easterly season.

3.2.2 Domestic, industrial and agricultural discharges

The types of domestic, industrial and agricultural discharges into the Bay of Bengal area has been identified in section 2.1. The indications of the presence of heavy metals, persistent organic pollutants, organo-chlorides, pesticides in coastal and marine resources appear to be of a regional concern. Apart from eutrophication, many of the organic and persistent chemicals in these discharges enter the food chain and with biomagnifications along the chain, top predators such as sharks, tuna and finfish etc. Tend to continue accumulating such chemicals in their muscle tissues. They in turn tend to be of the highest at risk and pose health hazards to humans.

3.2.3 Increased ultraviolet radiation

The effects of the ozone layer depletion and its implications particularly for the tropical areas are not well understood. However, evidence from the available literature suggests possible threats to the marine ecosystem particularly for the reefs. Since increased UV-B is known to adversely affect the plankton and

immune systems of plants and animals (UNEP 2001, Häder *et al*, 2002), this factor may have serious implications on the functioning of the reef system. Since corals survive due to the zooxanthalle (a symbiotic algae) within the coral polyps, increased UV may either cause bleaching or adversely affect the growth and development of the coral. Impacts of increased ultraviolet radiation on larvae and juveniles both of coral and fish, can also affect the viability of the reef system thus with implications for reef resources and eventually for the tuna industry in the Maldives.

Limited work has been carried out in the Maldives and elsewhere to study the impacts of ultraviolet radiation on coral. The results are very conclusive in suggesting that such impacts cause bleaching of the coral (Siebeck, 1988).

3.3 Causes of threats

Causes of the threats identified above include both natural as well as those induced by human. Often human-induced threats tend to make the ecological systems or sub-systems more prone to natural perturbations.

3.3.1 Natural causes

Global warming and increased sea surface temperature

With the increasing concentration of greenhouse gases in the atmosphere, a steady rise in the world's atmosphere temperature is evident. (IPCC,1998). Most global climatic models suggest that global warming is real. According to the Intergovernmental Panel on Climate Change (IPCC), the average global temperature has increased by about 0.4^{o}C in the past 100 years (IPCC,1998).

There is little evidence to suggest a reduction in the net emission of these gases, despite international efforts. The Kyoto Protocol, which is the only legal instrument to address cuts in the amounts of greenhouse gases emitted, is still pending implementation, after nearly 5 years. According to the scientific projections, the global mean temperature will increase by 3°C in the next 100 years (IPCC,1998). The consequences of a much warmer atmosphere is manifested in ecosystem charges, disruptions to rainfall and other climate related precipitation patterns, increased droughts or floods, changes in intensity and frequency of storms. These and other threats such as frequent El Nino events, and sea level rise have serious implications particularly for low lying small islands like the Maldives.

El Nino's caused by changes to global atmospheric temperature and circulation patterns, often raises the sea surface temperatures in the Pacific Ocean during certain periods. These warmer waters move westwards, through Indonesia into the Indian Ocean. In addition, El Nino like conditions were also observed in the Indian Ocean (INDOEX). Under El Nino conditions, tuna migratory patterns are reported to be affected as disruptions to the thermohaline, ocean currents and productivity in the open ocean are altered.

An analysis of the climatic data from the Maldives also suggest that on average an increasing trend in the mean temperature is evident, with an increasing temperature trend for southern, central, and northern regions of the Maldives (ERC unpublished data). According to climate models, heat in a

warmer atmospheric will be eventually transferred to the sea water, thus contributing to the thermal expansion of the sea waters, raising the sea level, globally and increasing the sea surface temperatures in the longer term.

Sea level rise

As a consequence of global warming there is almost consensus view that sea level is rising and is likely to accelerate in the future (Stoddart and Walsh 1990; Warrick Barrow and Wrigley (eds.) (1993); IPCC,1998), although the rate of sea level rise is controversial. The best estimated sea level for the next century is between 1.5-2.6 mm/year (IPCC,1998), which is two to four times higher than the rate experienced during the past 100 years. The impacts of sea level rise have implications for the stability of the islands, more than the resources in the coastal or the marine environments.

Increased water level effectively increases wave height, thus consequently the energy associated with it (King 1972), (as given in the relationship, $E=H^2/16$; where E=energy, H=wave height), and hence, increased ability to move sediments to or from reefs and islands.

Given a global sea level rise of about 1mm per year as has been observed over the past 100 years (Fairbridge, 1966), and if the accumulating material had a porosity of 50%, a net production of 1.10^3 ($gCaCO_3$ /m^2/year) would be necessary to keep up with sea level rise (Chave, Smith and Roy 1972). In the event of a rapid sea level rise, they point out that reefs keep up with sea level, by either altering the community to accommodate a higher production or growing up considerably faster.

Sea level rise has significant impacts mostly on the sediment moving processes, which could have both positive and negative impacts on islands in the Maldives. Even if reefs are predicted to keep pace with the rate of sea rise, the consequences on the transport mechanisms, in affecting the sediment supply or removal will determine the nett effect of sea level rise on the stability of islands.

Coral bleaching

Corals have been reported to bleach by elevated temperatures in response to 1-2 days exposure of 3-4^o above normal maximum, or to several weeks of exposure to elevations of 1-2^o, while a mortality greater than 90% has been reported fro exposures in excess of 4^o for periods as short as a few hours (Coles et al 1976). Extensive bleaching followed by death of 80-90% of corals in shallow reefs of Java Sea occurred with temperature rise of 2-3^{o}C, during the 1982/83 El Nino (Brown and Suharsono 1990). The survival, death and recovery of corals with similar warming are related to the frequency of such events, the intensity and other stresses affecting the corals (Glynn 1984, 1990; Glynn and D'Croz 1990; Goreau and Macfarlene 1990; Jokiel and Coles 1990).

With the El Nino event of 1997-98, where the sea surface temperature of the north western Indian Ocean exceeded 31^{o}C with anomalies of +1 to 3^{o}C sustained over two years (Wilkinson et. al, 1999), did result in massive

bleaching and mortality of corals in the Maldives. El Nino events with elevated sea surface temperatures have been experienced in the Maldives before in 1987and1992.

However, with the possibility of increased frequency and intensity of El Ninos, the impacts on the reefs can be devastating as was the case with the 1997-98 bleaching incident, where mortality of especially branching corals were as high as 98% on some reefs. Massive corals were less impacted, and recovered soon (Edwards et al, 2001). The recovery of the corals especially the branching ones have been extremely slow (3%), and complex (Zahir 2000).

The extent and duration of coral mortality therefore affect the functioning and associated life on reefs. In this regard, the resources associated with the reefs such as baitfish, reef fish are adversely affected. Furthermore, with any reduction of the aesthetic value of the reefs, tourism can be impacted easily and extensively. Since a nett removal of calcium carbonate from a reef results from the effects of bioerosion following massive bleaching and mortality (Zahir 2000a), the stability of the islands are seriously undermined with heavy socio-economic consequences.

According to some published data as reported in Wilkinson and Buddemeier (1994), bleaching also affects giant clams with the expulsion of their symbiotic algae within them, with increase in UV radiation or elevated temperatures. This has implications for any potential clam culture in the future.

Increased storminess
Under global warming, the frequency, intensity and the cyclone belt is expected to change (Hulme and Viner 1998; Royer *et al*. 1998; Walsh and Pittock 1998).

Cyclones cause mechanical as well as biological changes on reefs, with alterations in species composition (the survival of massive species) or colonisation by algae (Stoddart 1971). Such destruction of corals can occur in shallow as well as deeper waters (Harmelin-Vivien 1985), while the impact of a cyclone on reefs varies with coral types too (Stoddart 1971a, 1985). The recovery times for reefs, while dependent upon the intensity of a cyclone (Stoddart 1974), are varied too, ranging from 1.5 to even 20, 30 and 50 years (Stoddart 1971a; Grigg and Maragos1974; Harmelin-Vivien 1985; Mergner 1985; Kinsey and Hopley 1991).

Therefore, mechanical damage to corals and reef structure, or changes in species composition/community structure of a reef after a cyclone incident, can adversely affect the baitfish, reef fish and other resources availability and the resilience of a reef. The duration of the disruption depends on the intensity and extent of cyclone impact. Given that the storm-belt is expected to move further down from the present northerly position, impacts of cyclones need to be considered in understanding the potential of reef resources and utilisation in the Maldives.

Other natural disturbances
Predators like Acanthaster planci can also infest disturbed sites on coral reefs. Several incidents of Acanthaster were reported around the tourist zone, particularly in Male' Atoll. The last incident of such an infestation was reported in 1995. The extent and the impact of this infestation was very marked and costly. Several resorts engaged personnel to physically remove *Acanthaster*. The issue of Druppela, a kind of gastropod was also known to have infested the reefs around Male' Atoll, post 1998, that is, following the bleaching event. These events indicate that perhaps the level of disturbances influence predator colonization.

While an incident like the *Diadema* mass mortality of 1983 in the Caribbean has not been reported from the Maldives, such incidents on reefs are possible under perturbed conditions. This incident reduced the amount of coral cover and increased algae cover substantially (Liddell 1992). Although the causes of such outbreaks are not fully understood, re-colonisation by corals at these sites is reported to be satisfactory, once the stress has been reduced (Done *et al.* 1988; Endean and Cameron 1990; Liddell 1992). However, given that the reefs are becoming increasingly stressed from both natural and human-induced factors, the risk factor increases thus threatening the only resource base of the country.

Ozone layer depletion
With the increase in the use of CFC's and HCFC's in refrigeration, fire fighting, cleaning solvents, and fumigants for cereals and feed stocks, their impacts on the Ozone layer has been made known since the early 1980's. Chlorinated flouro carbons' and Bromo-flouro carbons are extremely stable mixtures allowing the chemicals to be airborne for decades. On reaching the Stratosphere, the Chlorine or bromine atoms are released and they easily combine with radical oxygen atoms, disrupting the natural formation and destruction cycle of ozone in the stratosphere. Gradual loss of ozone in the stratosphere thins the "ozone layer" which filters out the harmful UV-B rays entering the earth. Ozone depletion therefore threatens the human immune systems, the growth and development, and the functioning of plants and animals. In particular increased UVB radiation is predicated in the effect on planktons and thus productivity of the marine and coastal ecosystems.

3.3.2 Anthropogenic

Population expansion
As the population is concentrated on 200 islands of the Maldives, population-related factors on reef damage and degradation is noteworthy. Census figures indicate that population growth was very steady till about the late 1970's, before an exponential growth phase. Growth rate hovered at around 3.8% annually until the end of 1990's, before it declined to 1.9% in 2000. At the same time the Maldives economy on average grew between 10-15% from the 1980's. Though government has been cautious on the environment, the rapid development of the population and economy, have taken some toll on the environment. Consequences of most environment-associated problems are

either directly or indirectly related to the reef. This is particularly noteworthy on islands with large population concentrations, and where issues like garbage or sewage disposal, developmental pressure are most evident.

Development
Such modifications include, coral mining from the house-reef (reef on which the island occurs) and sand mining from the island, cutting channels across reefs to access islands, reclamations and harbour developments. In addition, other major modifications, which have significant longer term impacts on the morphodynamics of the islands include; construction of jetties and groynes, breakwaters and other offshore structures, and channel blastings.

Although coral mining has persisted in the Maldives for centuries, the effects of coral mining are noticeable on most inhabited islands and in particular on the populous islands today. In addition to mining coral from the reef, sand has also been mined from the beaches of islands. Most of the subtidal or intertidal reefs and sand bars around Male' have either been exhausted or has caused extensive damage with little or no recovery, even after 20 to 30 years (Brown and Dunne, 1988). Coral covers of less than 1% and very low number and diversity of reef fish were observed on mined reefs (Brown and Dunne, 1988).

Channel cuttings through the reef to access islands are often made by blasting through the reef. While these channels are an important aspect for the people on the islands, often such channels are not designed or placed with consideration to the reef or island processes in mind. Hence, complications arise with regard to durability and maintenance. Ironically, to reduce erosion associated with both natural and human-induced causes, groynes and breakwaters have been constructed on some of the islands. The results of such structures disrupt the natural flow of sediments and in particular adversely affect the seasonal dynamics on the islands.

The effects of these changes on the islands are conspicuous in their short and medium term developments, with emphatic consequences for the long term developments of the islands.

Land reclamation
The land area in the Maldives is extremely limited. It is interesting to note that relatively large communities often inhabit relatively small islands (eg: Thulhaadhoo. Kandholhudhoo, Dhiggaru, Komandoo) and often these islands are good fishing islands as well. Incentives for shifting the populations on such and other smaller islands have been tried but with very little success. The government has embarked upon the shifting of populations on four islands that are so small to sustain any economy, besides facing considerable environmental stresses such as erosion, and water-logging.

With the boom in population from the late 70's land requirements for housing and other social developments has increased many folds. Several islands face severe shortage of land for housing. Often land reclamation takes place in combination with harbor development. Dredged materials from harbour

construction are used as landfill. Several islands have reclaimed mangrove or inter-tidal marshy areas.

The impacts of dredging the reef flat mostly using backhoe excavators, is visible during the operation. Siltation and sedimentation affects the adjacent reefs. However these impacts are relatively short-lived and recovery depends on the nature of reef slope of the type of corals. Reclamation or harbour dredging on reef flats apart from loss of habitat area has complicating consequences on the stability of the island systems.

Harbour development
Harbour dredging threatens island stability, and coastal resources. Harbours are usually rectangular areas, dredged up on the reef flat, confined on all sides with either one or two openings.

Three sizes of harbours are usually developed dependent upon the developmental objectives. The larger ones measuring 1250 x 250 feet, for atoll capitals and regional focus islands, 750 x 250 feet ones for atoll focus islands, and 500 x 250 feet for primary islands. In this regard, harbour development has taken place on 83 islands throughout the country. The design of the harbours often restrict through flow, thus causing stagnation of the water body within. On some fishing communities where intense use of the harbour is made, increased discharges cause fouling and degradation of water quality.

Lack of proper sewage on many islands is increasing causing near coastal pollution and posing health risks. This is more evident on islands that occur on extensive reef flats. Where sewage is discharged into channel, with fast flowing currents causes rapid dispersion, the problems associated with such discharges are therefore relatively minimal.

On tourist resorts it is mandatory to have proper disposal facilities. Some resorts have installed very expensive biodigestors or comprehensive sewage treatment systems. With such systems the amount of discharge is minimized, saving valuable water resources, and minimizing the amount of waste entering the coastal environment.

Increased contamination of the coastal environment from sewage and other household chemicals is of concern. As populations on islands are increasing and the level of development improving throughout the Maldives, traditional sewage systems are being replaced by piped discharges off the island. As disposal systems on most islands are community initiated, financial constraints and technology often limit the efficiency and safety of such developments.

Lack of alternatives
Being a small island developing state, the Maldives suffers from many drawbacks in terms of resources and developmental potentials in comparison with other larger countries. The consequences are the heavy dependence on imports, which requires enormous foreign currency outlays. Despite the costs

of importing building materials such as river sand, aggregate and cement, the government is committed to the extra cost to protect the environment. As a result coral mining has almost ceased to the extent that only about 13 islands report some amount of mining (ERC unpublished data). Despite the willingness to pay for the alternatives, the difficulties of obtaining them are also a grave concern for the Maldives. River sand and aggregate for instance is purchased under special privileges from a neighbouring country.

The problem facing small developing islands especially those that have very few resources except the natural environment, like the Maldives needs highlighting. The basis of the economy and the survival of the Maldives is exclusively dependent upon the reef systems, but natural and anthropogenic impacts are undermining their functioning and benefits. Furthermore, the limited resources Maldives earn is increasingly being forced to be diverted to protection from the environmental challenges, to mitigate or adapt to the impacts and consequences of climate change. The world economic environment is also unsympathetic to the precarious position small island states like the Maldives is in. global economic restructuring and increasing globalization is increasingly disadvantaging and marginalizing the Maldives and other similar island countries. A combination of economic and environmental vulnerabilities is thus escalating the social vulnerability of such countries.

Competition and resource depletion elsewhere
Of threats identified earlier, the potential cause leading to poaching is often competition and resource depletion occurring elsewhere. Heavy and unsustainable exploitation of many resources has resulted in depletion of coastal and marine resources, such as evident in Gulf of Thailand, Sea of Japan etc. Large fleets therefore often target areas that are relatively under exploited, or relatively unsecured. Illegal fishing is therefore rampant in such areas as evident from Australia and the South Pacific.

Domestic, industrial and agricultural discharges.
Domestic discharges of solid and liquid wastes, by coastal communities unless properly treated will affect the coastal resources. Cummulative effects of coastal community discharges pose environmental and health hazard risks which can be of a regional proportion. Industrial and agricultural discharges, in the coastal areas of the region add to the burgeoning problem. Much of the industrial discharges remain unchecked and standards are either not formulated or not enforced.

Similarly, demand for increasing agricultural output prompts increase in the use of fertilizers. Increased monocropping and use of fertilizers often reduces disease resistance. This necessitates the use of pesticides, herbicides and weedicides. While, they may appear to give desirable impacts, the result is the slow elimination of all potential biological controls. The use of chemicals therefore becomes a necessity. The fertilizers and pesticides are increasingly making their way to the coastal and marine environments.

3.4 Threats that have transboundary effects

Threats that have tranboundary effects include both natural as well as human-induced threats. These issues warrant a regional or a collective approach for effective redress and are therefore dealt in detail in Section 4.6.

Considering that the reef ecosystem of the Maldives is unique in its environmental setting, local stresses reduce the resilience of the system to cope with and respond to natural and other perturbations. The change in frequency and intensity of one or more such incidents can reduce the recovery rates of the components of the ecosystem. Indications from sections 3.1.2, 3.1.4, and 3.2.4, 3.2.5 are that undesirable organisms within the ecosystem may succeed in establishing and becoming dominant in disturbed or affected areas.

Threats that are of special concern to the Maldives and those which have a transboundary effects include:

Global effort to address the issue of global climate and other environmental changes and their consequences,

The increasing threats of persistent organic and heavy metal pollutants to the marine and coastal resources,

Accidental or deliberate oil spill along the tanker route in the region,

Continuous discharge and runoffs of pesticides and other harmful agricultural chemicals,

Risk of alien invasive species that may enter the territorial waters,

Poaching and other destructive fishing methods in the EEZ, and

Straddling and migratory fish stock management.

The threats risks and the consequences of both natural and human induced perturbations on the reef systems have far more serious and wider implications. The socio-economic implications often exceed any quantifiable measures. For the Maldives, which is exclusively dependant upon the coastal and marine resources for survival, development and continued existence, the global threats affecting the functioning of reef and island systems warrants both regional and global responses. Consequences related with global warming therefore transcend all other issues and cummulatively impacts the Maldives more than any other country in the region.

3.5 Ranking of threats

Using a multi-criteria analysis, 14 threats identified in the context of coastal and marine resources were evaluated against seven criteria of most direct

concern. Hence, impacts that have immediate or direct effects are considered in this exercise to gauge the most severe of threats. (Table 10)

Table 10. Multicriteria analysis of threats

	Tuna fishery	Bait fishery	Reef fishery	Tourism	Biodiversity	Human health	Island dynamics
Threats							
Poaching	x						
Loss of habitats		x	x		x		x
Domestic/ sewage discharges			x	x	x	x	
Natural infestations		x	x		x		
Anchor damage		x	x	x	x		
Oil pollution	x	x	x	x	x		x
Invasive alien species		x	x		x		
Sea level rise							x
Coral bleaching		x	x	x	x		
Increased storminess		x	x	x	x		x
Increased UV radiation		x	x		x		
Industrial/ agricultural discharges	x				x	x	
Increased Sea surface temperature	x	x	x		x		
Flotsams						x	

The results show that oil pollution risk is likely to cause the severest of the impacts, affecting six of the seven criteria, while increased storminess affects five criteria used in the exercise. These are followed by five other threats with equal scores. These are loss of habitats from developmental activities, domestic and sewage disposal in the coastal system, anchor damage during bait fishing and other activities. Coral bleaching and increased sea surface temperature, related with global climate change also show as serious threats affecting the entire matrix. Eleven of the 14 criteria affect the biodiversity status, thus the reef fishery and the bait fishery which are directly related with the reef systems. Poaching, sea level rise and flotsam are threats with the least impacts or concern.

3.6 Summary

Reefs are increasingly stressed by anthropogenic activities, such as from land-based run-offs, sedimentation, tourism, exploitation and development in addition to natural disturbances. Human impacts on the reefs such as, reclamation and dredging, channel blasting, garbage and sewage disposal, coral mining or other developments associated with islands increasingly affect the reefs in the Maldives. Such changes can have immediate or delayed effects on the dynamics of reefs and islands.

The effects of both natural and human-induced impacts on reefs have implications on the resource-base of the country with short and longer term environmental, economic and social vulnerability. Some threats warrant redress actions at local, while others require concerted regional or global level actions to protect the livelihoods, resources and biodiversity in the Maldives.

4.0 ADDRESSING THE THREATS

Threats identified here are being addressed at both local as well as national levels.

4.1 Local level actions

4.1.1 Resort-operations

Due to the increasing awareness about the significance of environment to tourism, most resort operators are actively in promoting environmental protection and enhancing the aesthetic value associated with their operations. The significance tour operators attach to environmental considerations in resort operations and provisions, and offers of both international and national awards are making the tourism industry very competitive in this regard.

The President of Maldives annual 'Green Resort Award, the 'Green Globe Award', and the 'Tour Operators Environment Award', are distinguishable awards in the industry.

Many resort operators are paying particular attention to 'value-addition' to their services, by undertaking environmental enhancement projects. Such activities include:

Coral accretion experiment using electrolysis.

Turtle breeding, tagging, and related research,

Sponsoring environmental education trips for students,

Sponsoring initiatives for solid waste disposal in neighbouring inhabited islands,

Supporting environment-related activities undertaken by island communities in the vicinity.

An association for the tourism industry was established in 1992? and this association has been instrumental in promoting environmental awareness at resort level and influencing policy-decisions at government level. This association is represented at many government committees dealing with environment or natural resources management and policy issues.

4.1.2 Island/atoll operations

At the island level, several actions are taken to protect, preserve and sustainably use the environment and natural resources. With increase in awareness about the issues confronting the many local communities, both community and government initiated activities are in place.

Often, the Island, as well as the and Atoll Development Committees in each atoll initiates action with regards to the management of the resources or environment within their financial and other means. Some significant actions include education and awareness programmes for wise use of resources, coastal management and defense or mitigatory measures, or sound waste management programmes.

Awareness and education
Increase in awareness about the protection and sustainable use of the environment and its resources is brought about by governmental and non-governmental and voluntary efforts. Mass media including radio and TV have played a significant role in raising awareness and increasing stewardship in resource and environmental management.

4.2 National level actions

4.2.1 Planning for sustainable development

Developmental Plans
Since 1978, six developmental Plans have been formulated. The Sixth Development Plan envisaged for the period from 2000-2006, is very articulant about the role of fisheries and its future direction. The broad objectives of the National Development Plan include the following:

1. Diversify and expand the economy by further developing existing industries and by exploring new economic activities, while ensuring the sustainability of physical and natural resources.

2. Increase the role of private sector in the development process, particularly in expanding the economic base of the country.

3. Improve the quality and relevance of educational, health and social services, while ensuring that the benefits of development are shared equitably among the population.

4. Increase the human resource capacity and productivity by providing relevant training and employment opportunities.

5. Pursue legislative, regulatory, governance and administrative reform to facilitate rapid economic and social development.

6. Develop a sustainable and cost-effective transportation and telecommunication infrastructure to facilitate economic, social and regional development

7. Ensure socio-political stability and democratic participation of all in the development process, while upholding the national unity and social cohesiveness based on shared social, cultural and religious values.

Aspects related with fisheries in the Sixth National Development Plan include:

The fisheries industry of the Maldives is heavily dependant upon very few varieties with skipjack tuna being the most heavily exploited. This heavy dependence on skipjack alone makes the industry fragile, especially because of the volatility of tuna prices in the international market. As such, measures are needed to diversify the fisheries industry and add value to its products.

The private sector has limited access to credit and finance for large scale investments.

Exploitation of exotic reef fish species, while benefiting many islands from the expansion of such reef fisheries is now feared that continuing exploitation of certain reef species may exceed sustainable levels.

The introduction of large fishing vessels with bigger hulls, more powerful engines, and the ability to venture outer sea has increased the catch in recent years. The capacity to process the catch has being limiting, thus hindering effective utilization. Limitations in the developments of on-board post harvest handling of catch have resulted in an increase in landings of poor quality fish.

Inadequate local technical expertise in production technologies, unavailability of local labour for skilled and semi-skilled jobs, and

Lack of fisheries-related research is both hindering the level and extent of exploitation of the marine and coastal resources of the country.

Policies and strategies
Policy: Diversify the fisheries sector to reduce the economy's vulnerability to external shocks

Through development of mariculture and diversification of wild fisheries by targeting species other than skipjack, such as yellow-fin tuna and reef fish, and promoting product diversification and value addition of fishery products.

Strengthen capacity of the national authority responsible for quality assurance of fish products to monitor and inspect the national quality assurance system.

Policy: Increase participation of the private sector in the fisheries industry

Eliminating the monopoly in secondary production of the skipjack tuna industry.

Establishing necessary regulatory frameworks and providing incentives for attracting private sector investments for large scale and long-term secondary fisheries production, and continue to liberalize the fisheries sector.

Policy: Develop and manage the marine resources of the country in a sustainable manner

Institutional strengthening for regulatory and management of offshore and coastal fisheries revise and implement management plans for marine protected areas. Formulate and adopt harmonised integrated marine policy with respect to the marine resources and environment, and strengthen the scientific basis for fishery management.
Policy: Ensure sustainable socio-economic development of rural fishing communities through greater devolution of resource management authority, supported by indirect interventions, and enable rural communities to gain a greater share of high value secondary production

Formulating a Ten-year sectoral Master Plan, and establishing good governance, training programmes, to meet the needs of the primary harvesting and secondary production sub-sectors, increasing information flow and education to encourage local participation in the implementation of the sectoral development and management programs.

National Environment Action Plans
Two national action plans have been formulated and implemented. The fist being in 1989 emphasized the need for institutional and capacity building though human resource development and training, together with information collection about the status of the environment. The second action plan was implemented in 1999, with emphasis on approaches to issues and threats faced by the country, from local and global causes. Specifically this action plan identified the following environmental issues:

1. Climate change and sea level rise
2. Coastal zone management
3. Biological diversity conservation
4. Integrated reef resources management
5. Integrated water resources management
6. Management of solid waste and sewage
7. Air Pollution and management of hazardous waste
8. Sustainable tourism development
9. Land resources management and sustainable agriculture
10. Human settlement and urbanization

In addition to the above issues the 6th NDP considers the shortage of adequate human and financial resources as two major issues that need to be addressed.

The Sixth National Development Plan specifically outlines policies and strategies to address the environmental issues. In this regard, the policy of *promoting sustainable resource management through preservation of natural*

resources and biodiversity is emphasized with the strategy for developing and implementing the National Biodiversity Strategy and Action Plan to ensure sustainable use of extractive and non-extractive resources.

Also included in the policy is to minimise dangers to the natural resource base and environment due to economic development and the rapid population growth

A key course of action to the environmental threats the country faces is embodied in the policy *to contribute to the international efforts to find solutions to global environmental threats, especially those pertaining to the Small Island Developing States.*

Promotion of wider participation of the community in research, data collection and awareness creation regarding the fragile environment of the Maldives, and continue assessing the vulnerability of the Maldives to the impacts of climate change and the associated sea level rise.

The Plan also includes a policy to *promote integrated planning and administrative practices by developing meaningful principles and procedures for sustainable resource use and environmental protection*. The strategies for implementing the policy include strengthening the legal, technical and management capacity for enforcing natural resources utilization, and environmental monitoring and management.

Health Master Plan
A Health Master Plan was put together for the period 1996-2005. This plan identifies the policies, strategies and targets for providing access to safe water, adequate sanitation, and effective waste disposal. The plan addresses the issues with regards to water, sanitation and garbage, and acknowledges that inadequate sanitation in the atolls continues to be a major cause of concern, and lack of a sound waste management policy is hindering the monitoring, compliance and enforcement.

The Sixth National Development Plan includes specific policies on this matter, and outlines the strategies for *providing adequate water supply, sanitation, safe and environmentally sound management of sewage and solid waste disposal facilities to all islands.*

The strategies include; formulating plans to provide safe water, sanitation and waste disposal to all islands with defined needs and priority actions, developing and enforcing guidelines and operational procedures for sewerage projects, and developing a National Waste Management Strategy and facilitate its enforcement.

The Plan also includes a *policy on improving and establishing new waste management systems in the country* and *ensuring safe management of hazardous waste*.

The Plan identifies the following actions to achieve this:

- develop an integrated solid waste management strategy to manage solid waste at island, atoll and regional levels,
- minimizing import of non-biodegradable plastic products,
- encourage the introduction of biodegradable plastics, and
- provide incentives for biodegradable packaging, composting, recycling, as well as utilization of innovative technologies,
- establishment of regional solid waste management centres.

4.2.2 Protected areas

The issue of protected areas is important for the continual benefit from the marine and coastal resources. The model of protected areas in the Maldives is due largely driven by the demands of the tourism industry. While conflicts were minimal or non existent earlier, pressures on the reef resources increased drastically. Fishers began catching baitfish from the house reefs of resorts, or engage in reef fishery at popular dive spots, and in addition to catching of sharks by fishers from popular dive and feeding points increased the need to protect such sites.

Under these circumstances, protected areas were declared from 1995, by the then Ministry of Planning, Human Resources and Environment. The implementation is undertaken by the Ministry of Tourism, who in turn enlists the resorts to enforce it. To date, a comprehensive management structure is lacking with regards to protected areas. The concept of protected areas is not in compliance with the IUCN classified categories. Furthermore, in the absence of an effective model and a management regime, conflicts in resource utilization in expected to increase in the future.

4.2.3 National Biodiversity Strategy and Action Plan

The Maldives being a signatory to the Convention on Biological Diversity, and as obligated under the convention, has prepared and is currently implementing parts of the strategy and action plan. In this regard, inventorising and developing policy and regulatory framework for sustainable management of biodiversity is underway.

4.2.4 GEF Biodiversity Project

A project is formulated aimed at sustainable management of coral reef resource. This project is expected to be implemented shortly with the approved of funding. Although this project will address, aspects related with coral reefs in two atolls, it will result in the development of a replicable model applicable for resource management, addressing threats and planning for sustainable development.

4.3 Regulatory and legal mechanisms

Laws, Presidential Decrees, and public notices are the major forms of regulatory mechanisms that exist in the Maldives. Laws are passed by the Parliament, often with provisions for formulating subsequent rules and regulations with regards to the implementation of such laws. Residential Decrees are notices set out by the President's Office, and usually deal with issues of day to day running of the Government. A Decree that may have bearing on the fisheries resources may include instruction regarding institutional, management or broad policy issues.

Public notices are issued by the concerned Ministry or government agency and it can cover very broad or very specific issues pertaining to regulatory, management or policy issues. For instance, Public Notices can be issued to address concerns under a passed law, from time to time. It can even advocate banning or restricting access to resources in a particular site, time or extent.

The Fisheries Law of 1987 for instance addresses issues such as fishing in the EEZ by foreign parties, codes of practice, fisheries related research and analysis of fisheries-related data and information. This Law also empowers the Ministry to declare protected species or closure of certain types of fisheries for a specific time periods. The use of dynamite or any other forms of poison, spear guns, using scuba gear for fishing sea cucumbers or lobsters were banned under this Law.

The Maldives have therefore paid very close attention to the management and extent of fisheries resources utlisation. With increasing awareness on the state of resource exploitation, restrictions and bans have been imposed on several marine and coastal resources utilization. Beginning in 1993 several marine species were declared protected. These include whales, dolphins, conch, and giant clams. In 1995 black coral, whale shark, napoleon wrasse were declared protected, while the same year export ban was imposed on rays, eels puffer fish and parrot fish.

Three legislative acts in Maldives have dealt specifically with marine turtles. In February 1978 legislation was passed which prohibits the catching of *Eretmochelys imbricata* under two feet (61cm) in carapace length, and all other turtles less than *2'12* feet (76cm) in carapace length. In 1979, another Bill prohibited the export of any item of *Eretmochelys imbricata* that is in the raw form.

Since 1980, a public notice by the Ministry of Fisheries bans the sale and display for sale of turtles below the size specified by the law in 1978.

In addition, the use of spear guns, spears and explosives was banned in 1970s.

Moratoria have also been in set for resources that may be exploited later, as the present stocks appear unsustainable. These include, a 10-year ban on catching turtles and tortoises.

From 1 January 1995 a ten year moratorium on the collecting of black coral in the Maldives was introduced.

With the Environment Protection Law of 1993, a broad mandate for holistic legal approach to all matters concerned with the environment was established. The law addresses all issues of concern, such as protected areas, transboundary chemical movements, and EIA. Under the Law, the most significant development is the imposition of mandatory EIA on major developmental projects. In addition, it also deals with the establishment of protected areas and protected species that are not addressed under the Fisheries Law. In this regard, 25 dive sites and two islands, one as a bird sanctuary and the other being an atypical island have been declared protected. Seventy species of birds have now been declared protected in the Maldives. These include many migratory as well as resident and endemic birds. The significance of sea birds for fisheries has been discussed earlier.

Other important milestones taken for the protection or sustainable use of the marine and coastal resources include:

Recognizing the economic importance of shark watching to the tourism industry, in 1997 the Government has banned shark fishing within the tourism zones (from Baa and Lhaviyani to Meemu and Dhaal Atolls).

A strict quota is in place for the type and number of aquarium fish exported.
In 1994 The use of diving gear for sea cucumber harvesting was banned.

In 1978, the Government passed a regulation to control the lobster fishery as a precautionary measure against possible over exploitation. Under this regulation, harvesting of small lobsters with carapace lengths less than 25cm and berried lobsters were banned.

4.4 Institutional and Human Resources Development

Fisheries sector in the Maldives is mandated with the Ministry of Fisheries, Agriculture and Marine resources as it is known now. A fisheries ministry has always existed since, the proclamation of a constitution from 1932? The ministry is responsible for policy and management.

A negative perception of the fisheries sector per se has hindered attracting potential recruits and graduates for the sector. However, the perception is slowly changing. The Government has taken several steps to change the perception of fisheries sector and build potential for post secondary and tertiary level education in fisheries science. Fisheries Science as a subject was introduced in 1985?, approved by the University of London as an ordinary level subject for secondary students. Hence, Fisheries Science as a subject is quite popular as an optional subject. In addition, Since 1981 (the fishermen's day has been) to value the contribution of fishers and the fisheries sector to the country.

The absence of academic institutions has limited human resource development and research capacity in the Maldives.

The Ministry has under it the Marine Research Centre, with a mandate to conduct fisheries related research and development. The Maldives Industrial Fisheries Company is the only industrial fisheries agency operating at the moment. While this is a public company operating on a commercial basis, the Ministry is responsible for policy guidance of the company.

The Government established the Marine Research Section, under then Ministry of Fisheries in 1985, which later became Marine Research Center in 1998. This center has benefited largely from the visionary attitude and the continuity of the personal assigned to develop the Center. Several bilateral and multilateral projects, expatriates and consultants and associations with overseas Universities and other research institutions have instilled a research culture and led to a drastic development of the human resources capability within the center. However, the demands of the fishery sector far out ways the developing capacity and capabilities. Suitably qualified and motivated staffs are still talking to address emerging issues of fisheries related aspects, necessary for planning and management development and assessment of coastal and marine resources in the country.

Lack of equipment and financial resources are also hindering the research potentials already developed. Lack of incentives and financial benefits make fisheries research area unattractive for new graduates.

Currently the Center has….. staff of which, two have doctoral level training, one post-graduate and 3 graduate. However, it is encouraging to note that 4 candidates are under going training, one post graduate and two at under graduate level. Within the Ministry, one doctorate, two post graduates and one graduate level personal are involved with the policy and management of the fisheries sector.

Current areas requiring training are:

- Fisheries management (economic policy);
- Fish breeding and culture technology;
- Reef biology and ecology;
- Resource management and planning;
- Fish biology and stock assessment;
- Reef biochemistry;
- Fish technology and quality control.

4.5 Data gaps and further studies

Considering the unique environmental setting of the Maldives, and inadequate human resources capacity limits undertaking several important aspects necessary for policy and management issues. Some of these include inventorizing and documenting the biodiversity and the potential resources,

and undertaking studies to understand the functioning and inter linkages between the various ecological systems and sub systems. Identification of potential coastal and marine resources that can be exploited on a sustainable basis or those that have the potential for further development through appropriate intervention is a priority. In this regard, identification of coastal and marine resources particularly for mariculture and aquaculture, and their suitable habitats and micro-environments is wanting.

The potential medicinal or pharmaceutical products and other resources is another important study area. A sponge from the Maldives has been found to contain elements for a type of cancer treatment. Resources for undertaking such sophisticated research are not forthcoming in the Maldives, but as specified under the Convention on Biological Diversity, fair and equitable benefit sharing is possible with any potential development.

Since baitfishery is mandatory for the tuna fishery, a paucity of knowledge on the biology and stock assessment of this important resource has been identified. The workshop particiapants recommended an international level study on the bait fishery issue, as it may have regional influences or impacts. In addition the implications of reef degradation and stresses on reef systems for bait fishery are important to understand.

Furthermore, knowledge on bait fishery enhancement, using appropriate technology is wanting. Since bait fishery is both seasonal and varies regionally, implications of over exploitation in certain regions can have unprecedented and long term consequences. In this regard, better collecting and analysis of tuna fisheries data and a stronger regime for the management of yellowfin tuna was recommended at the Workshop.

Potential accurate harvests of reef resources and yellow fin tuna fishery in the Maldives will help to over come many uncertainties evident today with regards to their utilization.

On a macro scale, knowledge gaps exist on the following aspects that are closely related with the maintenance or management of the coastal and marine resources of the Maldives. These include:

- role of mangrove contribution to reefs and coastal systems;
- survey of potential coastal and marine resources;
- resilient and robust organisms of the reef systems that can help to maintain vitality and diversity of reefs;
- mariculture and aquaculture potential;
- potential medicinal/pharmaceutical resources of the coastal and marine resources;
- cost effective waste management and treatment systems for small islands;
- baitfish biology, recruitment and stock assessment;
- coral larvae dispersion and recruitment;
- accurate potential harvest of reef resources;
- potential of yellowfin tuna fishery in the Maldives;

- the value of and value addition of protected areas for fishery and tourism;
- potential conflicts and conflict resolution strategies between fisheries and tourism sectors; and
- effective models for protected areas and their management regimes.

4.6 Regional collaborative actions

The EEZ of the Maldives borders India, Sri Lanka and the British Indian Ocean Territory of Chagos. Some natural and anthropogenic threats transbound the Bay of Bengal area that warrant a regional or wider collaborative approach, while others require a global effort for effective redress.

“Ecosystem approach” is an effective methodology that requires collaborative action transcending political borders. The interconnectedness and the interplay between the physical, chemical and biological factors of the ecosystem are often governed by process and actions well beyond the coastal and marine areas. For instance land-based sources of marine pollution, the impairment of the flood or soil control systems upstream from major rivers, impacts and disrupts the governance of freshwater or siltation in these systems.

Controlling these land-based sources of marine pollution or addressing issues that are directly linked with the functioning and health of the coastal and marine ecosystems, require a more comprehensive and holistic effort to produce tangible results. Unless a collective effort is made to minimize and eventually phase out the discharge of persistent organic pollutants, heavy metals or pesticides, the threat to the coastal and marine environments and their resources will continue to escalate. The health of the ecosystems and the populations will be adversely affected, with severe implications on the livelihoods of many communities in the region to combat poverty and to ensure continued resources availability for sustainable livelihood and development, requires the willingness of the countries in the region to work together, to fight against increasing pollution and ecosystem degeneration and breakdown.

The absence of an effective response strategy to the threat of an accidental or deliberate oil spill in the region requires urgent and immediate action at a regional scale.

In the case of the Maldives, where both fisheries and tourism is the major source of livelihood and income based on coastal and marine resources, the impacts and consequences of a spill can be disastrous and long lasting without timely intervention. Since oil pollution appear to be the major risk to the environment and the resources, a greater national effort to prepare a regional response strategy is warranted on an urgent basis.

The protection and management of straddling and migratory stocks of fish of the high seas from threats related to poaching and over fishing and destructive fishing efforts are transboundary in nature that require greater regional cooperation as well. Furthermore, coral larvae dispersal and recruitment patterns may be influenced by the physical or biological characteristics or changes that take place in the wider Bay of Bengal/Indian Ocean region.

Since the Maldives has extensive expanse of the ocean within its EEZ, current resources and effort may not be efficient and effective against these related threats.

4.7 Benefits of the actions

Both national as well as regional/global level benefits are expected to accrue with timely interventions to address threats facing the coastal and marine resources of the Maldives.

4.7.1 National benefits

At the national level appropriate policy, regulatory, management and research tools is expected to raise awareness necessary for planning and sustainable management of these resources.

As tourism is the major player in the economy today, appropriate and timely interventions to protect the environment and its resources will ensure safe guarding a unique premium product that will continue accruing benefit now and for the future.

The benefits of early intervention to address the threats with a holistic outlook will ensure the safety and health of the only resources available for the Maldives to base its development, growth and prosperity. This will then ensure that future generations will be endowed with a healthy and wholesome environment upon which their livelihood and prosperity can be based. With the advancement of science and technology and possibly with adequate appropriate human resource development in the future, Maldivians may accrue more benefits from the coastal and marine resources in the future. This is very much dependant upon the state of the environment that is delivered to the future generations.

Reducing the current stress on the reefs can in turn help to retain or improve the resilience of the reef systems. Since, the Maldives will be in the forefront as victims of global climate change, the only low-cost perhaps one of the most effective adaptive measure is to safe guard the reef systems. The protection of the reefs today therefore far outweighs any engineering solutions to protect the islands.

4.7.2 Regional/global level benefits

Being the only reef system with unmatched diversity in the Bay of Bengal area and the Indian Ocean, regional as well as global benefits are therefore

imminent with early intervention to address the threats to the coastal and marine resources of the Maldives.

Since the state of the environment remains relatively healthy in comparison to many coastal areas of the region and where environmental variability is minimal, this area may hold key benefits for scientific purposes and knowledge and to the fishery of the region. The reef systems of the Maldives are likely to hold and act as a vital gene pool, which can be exploited sustainably for economic, medicinal/pharmaceutical, scientific and educational purposes.

Furthermore, effective management and sustainable utilization of the coastal and marine resources undertaken in the Maldives can provide an effective model that can be replicable or adapted elsewhere with similar environmental settings. Therefore, addressing the threats will ensure the protection of a unique coral reef environment and its natural resources. The actions will also ensure the synergistic benefits of the effective implementation of the convention on Biological Diversity and the UNFCCC by addressing biodiversity conservation and helping Maldives to adapt to the impacts of climate change.

4.8 Summary

Two tier level action, were identified to address the natural and human-induced causes of the threats. Several actions, particularly awareness raising were identified at local level. Appropriate planning, regulatory and monitoring tools were identified at national level to address the threats on coastal and marine resources.

The limitations in the institutional and human resources capacities in addressing the threats, with suggestions for further studies and knowledge gaps required for better management and planning of the resources were also identified. The national benefits of early intervention in addressing the threats will ensure the continuity of accruing benefits from the only resources available for the Maldivians. Regional or global benefits include protection of a unique environment and a vital gene pool, which can have medicinal or scientific benefits, and demonstration of an effective management tool for other areas. Addressing these threats for these benefits is possible with early invention at national level as well as with regional and global collaboration.

Fisheries cannot be managed alone. It has to be in synergy with other economic, social and environment systems prevalent in the country. Furthermore, effective management of the coastal and marine resources requires both regional and global efforts to thwart off possible threats that can have wide ranging and longterm severe implications. Effective implementation of regional and global agreements and collaborative affirmative actions on specific issues will be effective tools to rise against most challenges. The success of most actions depends on approaches based upon visionary, holistic and appropriate strategies.

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(others to be added)

ANNEXES

Annex I. Annex II.

Annex V. LIST OF PEOPLE CONSULTED