Marine Protected Areas Needs in the South Asian Seas Region

Volume 3: Maldives

A Marine Conservation and Development Report

IUCN
The World Conservation Union

Marine Protected Area Needs in the South Asian Seas Region Volume 3: Maldives

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Edited by John C. Pernetta

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1. General Description: Maldives

1.1.1. Geography & geology

Area:	Approximately 300 km^2;
Coastline:	Not known:
EEZ:	843,247 km^2;
Territorial waters:	67,000 km^2;
Population:	214,088 (1990).

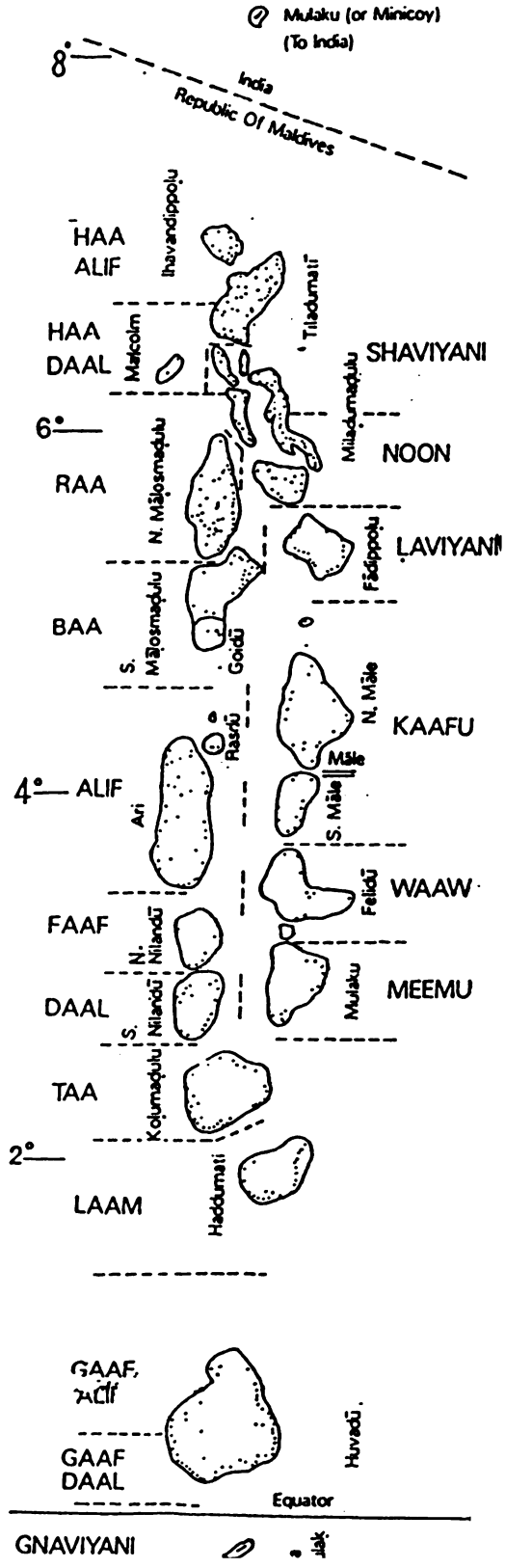
The Maldives form the central and largest section of the Laccadive - Chagos chain which extends southwards from India to the centre of the Indian Ocean. The country consists entirely of a series of coral atolls and associated coralline structures. Although the area of the territorial waters is considerable, covering around 67,000 km^2 and extending 867 km in length, only a small part is dry land (approximately 300 km^2). The atolls rise from a submarine plateau which is generally only 300-450 m deep but descends to more than 2,000 m between the main group of atolls and Huvadhu and Addu in the south. The submarine plateau falls steeply to a depth of 2,500-3,000 m in the east, and to 2,800-9,000 m in the west.

Published estimates of the total number of islands vary from 1,200 to 2,000 (Maniku, 1990). Anon (1984) gives 1,302 islands; Edwards (1989) gives approximately 1,300, the generally accepted total is around 1,200 of which some 202 are permanently inhabited. The majority are small (average 0.7 km^2) with only nine being larger than 2 km^2. The largest of these is 13 km^2, and three of them are larger than 4 km^2. Areas with vegetation cover vary from a few square metres to 6 km^2. Edwards (1989) states that maximum altitude is no more the 3.5 m above mean sea level while Munch-Petersen (1982; 1985) gives a figure of 5 m. Around 80% of the total land area is less than 1 metre above mean sea level.

General descriptions of the archipelago are given in Gardiner (1903-1906), Fosberg (1957), Stoddart (1966b), Salm (1975) and Munch-Petersen (1982). The atolls lie on longitude 73°E, from which no part is further than about 80 km. Descriptions of individual atolls and islands are found in IUCN/UNEP (1988) Gardiner (1903) and Woodroffe (1989). There are 26 geographic atolls covered by 19 administrative units, with the capital city island of Male' counting as a 20th (Table 1; Figure 1). Some administrative units encompass more than one atoll and some atolls are divided between two administrative units. The use of the same names for geographic atolls, villages and in some instances for administrative units leads to some confusion in the literature, which is compounded by the variant spellings used by different authors.

In both the northern and southern ends of the island chain a single chain of atolls is present, whilst in the middle of the archipelago a double chain of atolls runs north to south. Purdy (1981) suggests that lateral expansion of the atolls inwards towards the Maldive's inner sea is occurring and that ultimately the double chain may coalesce. Further discussion of the geological origin of the archipelago is given in Davis (1928) Gardiner (1903) and Woodroffe (1989). The

Figure 1.
Geographic atolls and administrative units of the Republic of Maldives (Pernetta & Sestini, 1989)



northernmost extremity (7° 07'N) is on Ihavandiffulu and the southernmost (0° 42'S) on Addu; the western and eastern extremes are Makunudu (72° 33'W) and Felidhu (73° 45'E). In the north Thiladhunmathi and Miladhunmadulu are considered by some authors to form a single, large, elongated atoll which is divided administratively into four units.

Table 1. Geographic and administrative atolls of the Maldives.

Administrative name	Geographical names of atolls
Haa Alifu	Ihavandiffulu
	Thiladhunmathi (part)
Haa Dhaalu	Thiladhunmathi (part)
	Makunudu
Shaviyani	Miladhunmadulu (part)
Noonu	Miladhunmadulu (part)
Raa North	Maalhosmadulu
	Alifushi
Baa South	Maalhosmadulu
	Goifurfehendu
Lhaviyani	Faadhippolhu
Kaafu	North Male'
	South Male'
	Kaashidu
	Gaafaru
Alifu	Thoddhu
	Rasdhu
	Ari
Vaavu	Felidhu
	Wataru
Meemu	Mulakatholhu
Faafu	North Nilandhe
Dhaalu	South Nilandhe
Thaa	Kolhumadulu
Laamu	Hadhdhunmathi
Gaafu	Alifu Huvadhu (part)
Gaafu	Dhaalu Huvadhu (part)
Gnaviyani	Foammulah
Seenu	Addu

Further south, the double chain of atolls lie on either side of a submerged limestone plateau (350-450 m deep), which continues for nearly half the length of the archipelago, to Kolhumadulu and Hadhdhunmathi. Many of the atolls are classical in structure, with a typical rim of reef flat surrounding a lagoon, but others, notably Ari, are surrounded by a ring of **faros** (see below). Where the double chain terminates near the south, deep channels separate Hadhdhunmathi and

Huvadhu (2011m); and Huvadhu and Addu (2400m). There are a few small islands on more or less isolated platforms, such as Foammulah in the south, and several on the main platform which are intermediate between atolls and **faros**, such as Gaafaru, north of Male'.

The larger atolls vary in form from: open structures with numerous islands, **faros**, patches and knolls in the atoll lagoon and around the rim, such as North and South Male' and Ari atolls; to almost closed ribbon reef structures with few lagoonal knolls and patches and islands concentrated around the periphery, such as Addu, and Rasdhu.

The characteristics of the reefs and reef islands in the Maldives archipelago vary from north to south. In the north, the atolls are elongated with 50-60 m deep lagoons, discontinuously fringed by reefs bearing small sandy islands. Numerous patch reefs and **faros** are found in the lagoons (Figure 2). **Faros**, apparently unique to the Maldives, are ring-shaped reefs,each with their own 15 m deep, sandy lagoon rising from the central atoll lagoon floor (18-55 m). They generally have a rim of living coral of both branching and massive species. Patches rise to 40 m above the lagoon floor and are usually capped with wave-breaking corals; there may be a small lagoon. Knolls rise 20 m above the lagoon floor and do not reach the surface. Some of the patch reefs and knolls support small islets with emergent surfaces capped with vegetation (Fosberg, 1957; Kohn, 1964b). The sides often support profuse coral growth (over 60% coral cover to at least 20 m) and are indistinguishable in biological terms from the sides of normal, submerged knolls (Reefwatch data; Wood, 1984).

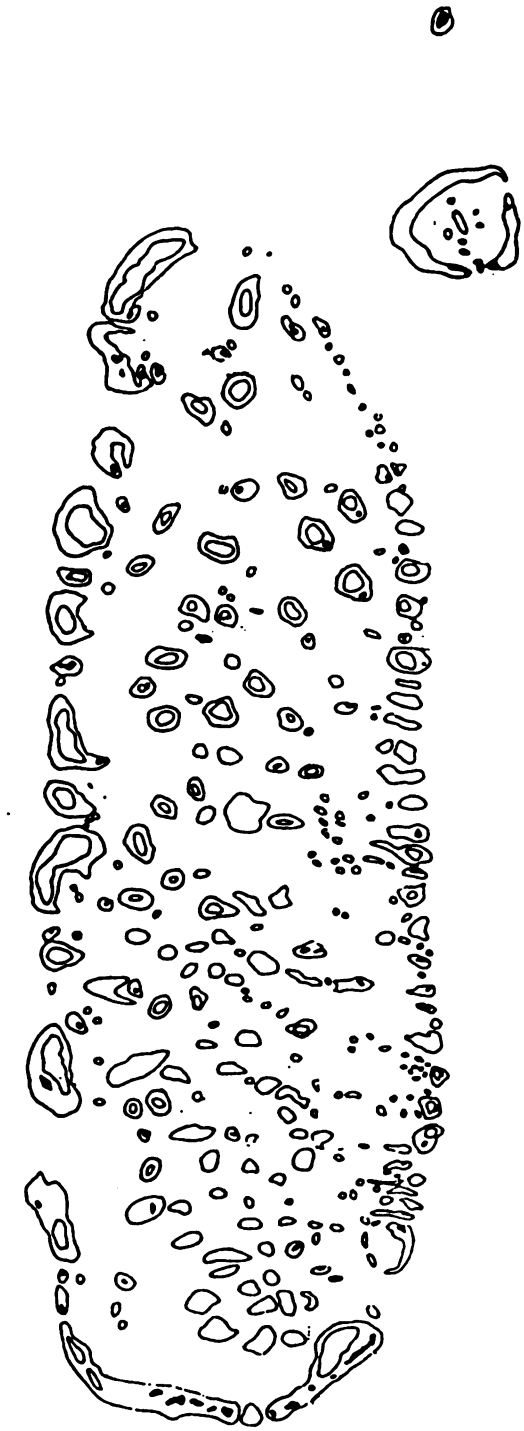
In the south, the lagoons are 80-100 m deep; inner patch reefs are rarer; the continuity of the atoll rim is greater; and, a larger proportion of the perimeter is occupied by islands. These changes may be related to climatic factors since annual rainfall increases from north to south; the impact of storms is greater in the north; and seasonal reversal of the monsoons is more pronounced in the north (Woodroffe, 1989).

1.1.2. Climate

Gardiner (1903-1906) describes climate; more recent data has been put together by Stoddart (1966d) and brief overviews based on the annual reports of the Department of Meteorology are given in UNEP (1986), Edwards (1989) and Pernetta & Sestini (1989). The climate is tropical, oceanic with little diurnal or seasonal temperature variation. Monthly minimum temperatures for Male' range from 24.1 to 26.8 °C; maximum from 29.2 to 32.4 °C. Five yearly annual averages are: minimum 25.8 °C; maximum 30.7 °C (Anon, 1991).

The climate is governed by the southwest monsoon from April to August, characterised by strong southwesterly winds, while the northeast monsoon from October to February has gentler winds. Wind speeds are generally moderate and only the northernmost atolls are affected by tropical storms, devastating effects occurring only about once in 100 years. Rainfall increases from north to south and Edwards (1989) gives figures for annual rainfall of 1,868 mm in the north, 1,977 mm at Male' and 2,470 mm on Gan. Most rainfall occurs between August and December (180 - 270 mm a month) and least from January to March (30 - 90 mm a month). The five year average annual rainfall for Male' is 1,855 mm yr^{-1} (Anon, 1991) with inter-annual variation from 1,619 to 2223 mm.

Figure 2.
Ari atoll, showing general structure and location of Faros and patch reefs (Pernetta & Sestini, 1989)



Freshwater is found on most islands in the form of a freshwater lens or aquifer, floating on the salt water below. Owing to the permeable nature of the underlying geology and the action of tidal pumping the freshwater is generally mixed with seawater at the base of the aquifer and depending on island size, height and underlying geology/geomorphology the lenses on individual islands may range from a few centimetres to several metres in depth. In general northern islands support shallower lenses than those of the south and seasonal changes in aquifer depth occur during the dry and wet periods.

1.1.3. Oceanographic features

Tides are mixed, mainly semi-diurnal, and with small ranges, from about 0.7 m in the north to around 1 m in the south (Couper, 1983; Stoddart, 1971). Nerland (1986) and Edwards (1989) give tidal ranges of nearer 1.0 - 1.5 m. The tides generate strong currents, especially in the deep channels between the atolls and in channels connecting atoll lagoons with the open ocean.

Water temperatures are fairly constant throughout the archipelago, ranging from 25 to 29 °C (27.5-29 °C according to Edwards, 1989). Ocean currents generally flow eastwards during the southwest monsoon, westwards during the northeast monsoon and velocities may reach 1 m sec^{-1}. Waves of high amplitude are rare but are occasionally generated by storms as in the case of the 1987 flooding events in Male' which resulted from long distance wave transmission from a storm centre in the southern Indian Ocean (Goda, 1988). Further information on waves and tides around the capital, Male' is given by Lanka Hydraulic Institute (1988a; 1988b).

Hydrographic conditions around the Maldives are characterised by a seasonally fluctuating mixed layer of relatively saline water from the Arabian Sea (around 36‰) and less saline water from the Bay of Bengal (around 34‰). Two hydrographic sections were surveyed in 1983 by the Institute of Marine Research, Bergen, Norway; one in the Kudhuvadhoo channel and one in the Kaashidhoo channel. These showed no anomalies in respect of the general features of the region. The surface temperature varies between 28 and 29 °C with a slightly decreasing gradient from south to north. A rapid downward decrease in temperature to below 20 °C occurs at around 90-100 m depth. All salinities observed down to 500 m fell within the range 35-36‰, and at 500 m the oxygen content was 1.2 ml l^{-1}, the minimum value recorded.

2. Marine and Coastal Ecosystems

2.1.1. Mangroves

Pioneering mangroves colonise the lagoonal beaches of Feladhoo, Kelaa and Kuludhuffushi. The main species are *Avicennia marina, Bruguiera cylindrica, Rhizophora mucronata, Sonneratia caseolaris* and *Sonneratia alba* (UNEP, 1986; Moutou, 1985a; 1985b). Mangroves are often found around small lakes, swamps or **'kulis'** in the southern atolls. Known sites with mangroves include Goidhoo (Goifurfehendu) which has a small lake fringed with *Pemphis* and *Rhizophora,* Hoadedhdhoo (Huvadhu) also has a small lake fringed with mangrove (Woodroffe, 1989). The distribution of mangroves is inadequately documented at present, and little information is available on the ecology of these ecosystems in the archipelago.

2.1.2. Marshes and wetlands

Marshy areas are small and generally insignificant due to the limited land area and small tidal range, they are more common in southern islands and absent from the north. Two freshwater swampy areas or **'kulis'** occur on Foammulah while one on Thinadhoo was recently breached and is now saline.

2.1.3. Coral reefs

The Maldivian archipelago is found in a stable oceanic environment where the development of a major system of reefs has occurred in the absence of seismic or tectonic activity, terrestrial influences, cyclonic storms and large tidal ranges (Kenchington, 1985).

Along the latitudinal gradient of atolls from the Lakshadweep Archipelago (Laccadives) in the north, through the Maldives to the Chagos in the south (spanning over 18 degrees of latitude) there is a broad trend of increasing coral generic diversity (Sheppard, 1981). Nine genera of hermatypic corals are recorded from the main Lakshadweep archipelago; 32 from Minicoy; around 41 from northern Maldives (Maalhosmadulu); 55 from southern Maldives (Addu); and 60 from Chagos (IUCN/UNEP, 1988). Over 1,200 coral reef fish and around 240 species of hermatypic corals are now recorded from the Maldives. Lists of corals from the Maldives are provided by Gardiner (1904; 1905), Wells & Davies (1966), Rosen (1971) and more recently by Pillai & Scheer (1976) who recorded 241 species in 75 genera. Stoddart (1984) states that 66 genera of scleractinians have been recorded, of which 55 are hermatypic. The Maldives may have the greatest coral diversity of reefs in the western Indian Ocean (Rosen, 1971).

The following reefs have been studied in some detail: Gan, Midu, Addu, Hitaddu (Stoddart, 1966a; Stoddart *et al.*, 1966; Spencer Davies *et al.*, 1971); Xarifa Reef (Scheer, 1971; 1972); Fesdhu (Scheer 1971; 1972); Faadhippolhu (Scheer, 1971); Bandos (Holliday, 1982); Baros (Wood, 1984); Rasfaree, Hithi Knoll, Tulusdu (Matteuci & Russo, 1980); reefs near Male' (Brown & Dunne, 1986, 1988); Little Hura (Bakus *et al.*, 1988); South Maalhosmadulu -

Kunfunadhoo (Scheer & Obrist, 1986); Rasdhu and Weligandu (Scheer, 1960b; 1971; 1972; 1974; 1978). Descriptions include details of zonation, coral growth form and diversity under differing environmental conditions.

Stoddart *et al.*, (1966) provide descriptions of the major reef and lagoon habitats of Addu Atoll and these descriptions form the basis for much extrapolation to other atolls in the archipelago. These authors recognised distinct communities based on depth and exposure and followed Eibl-Eibesfeldt (1966) in defining seaward reef and slope communities; seaward reef edge; seaward reef flat; lagoon reef flat and slope communities which differed in different parts of Addu atoll in terms of their community structure and species composition.

Reef molluscs are described by Smythe & Phillips (1971) and those of the family Conidae by Kohn (1968) and Kohn & Robertson (1966). Barthel (1981) describes the reef boring mollusc *Lithophaga obesa* in South Male'. Predatory gastropods around Gan (Addu) are described by Taylor (1978). Marine fish are extremely abundant and over 1,200 species have been recorded from the reefs and surrounding ocean, making it one of the most species rich marine areas in the world (Munch-Petersen, 1982; 1985). The status of most species is entirely unknown.

2.1.4. Seagrasses and algal communities

Extensive seagrass beds are rare but there are a few exceptions: a large area of *Thalassia hemprichii* and *Syringodium isoetifolium* exists east of Thuladhoo (Baa); beds of *T. hemprichii* with smaller patches of *Thalassodendron cilliatum* are also found on the east and south sides of Laamu. The area between Funadhoo and Baraasilhoo is reported to be a feeding ground for green turtles so may have seagrass beds (Frazier & Frazier, 1987). Hackett (1977) reportedly found that flats of *Cymodocea* and *Thalassia* were rare in the nine atolls he studied and sea grasses were found mainly on seaward reefs or adjacent to channels crossing the atoll rim. Hackett (1977) and Tsuda & Newhouse (1966) describe marine algae: there are 21 Cyanophyceae (blue-green); 163 Rhodophyceae (red); 83 Chlorophyceae (green); and, 18 Phaephyceae (brown) currently recorded.

2.1.5. Beaches

The superficial geology and geomorphology of the islands is poorly known. The islands themselves are formed of bioclastic material derived from hermatypic coral and other skeletal materials. On several islands are outcrops of more consolidated materials: cay sandstone, a limestone layer 0.3-0.5 m thick usually lying at 1 - 1.2 m depth formed near the freshwater table; beach rock, consisting of cemented inter-tidal sands and gravel; and reef rock consolidated reef matrix. Beach sands are generally fine grained and well sorted. On the reef flats between the islands and their surrounding living reef edge, coral rock is overlain by a thin veneer of poorly sorted, coarse bioclastic material. The lagoon floors are generally composed of fine-grained, poorly sorted calcareous sediments.

Individual island beaches are generally highly dynamic and sands shift around the perimeter of the islands under the influence of the opposing monsoonal wind directions. Sands lost from the reef platform, either to the deep ocean or to the lagoon floor are lost from the island sub-system

and changes to beach and island form occur both naturally under the influence of episodic events and as a consequence of coastal construction and attempts to stabilise beach form, particularly on tourist resort islands.

2.1.6. Islands

The islands are coralline "cays" or "motu" consisting of unstable piles of bioclastic sand and rubble which shift and change shape under the influence of seasonal monsoonal winds. Episodic events such as storms and long distance wave transmission result in the loss of some islands and formation of others (Maniku, 1990). Surprisingly little is known about the detailed topography of individual islands, although Woodroffe, (1989) provides detail for some islands. Stoddart *et al.* (1966) identified reefrock, relict reef rock, cay sandstone and beach rock on Addu atoll. Most island coasts are dominated by sandy beaches although rubble beaches occur on the seaward side of some islands on the atoll rims.

The southern islands are generally more fertile and Foammulah in the south is well known for its relatively rich vegetation. On most islands there is little soil other than a shallow surface layer of coralline sand mixed with some organic matter. Gardiner (1903 - 1906) describes a number of islands. Brief descriptions of the vegetation of some islands is available such as Rasfari in North Male' atoll which is dominated by *Pandanus* and *Scaevola* scrub; Huraa also in North Male' which has a mangrove fringed lake; Goidhoo; the largest island on Goifurfehendu, is dominated by coconut woodland, with a lake and a wide belt of scrub on the lagoonward shore; Hithadoo island on Addu has some *Thespesia* woodland); the low-lying central area of Foammulah has two small lakes and areas of pit cultivation of taro; scrub on beach ridge crest is backed by *Calophyllum* woodland; Hoadedhodhoo island has a mangrove fringed lake while Thinadhoo also has a small lake. A number of the islands have storm deposited beach ridges with scrub vegetation but in general woodland areas have been extensively exploited for fuelwood and boat construction timbers and many islands are dominated by planted coconut groves.

The terrestrial flora is a relatively depauperate (Fosberg *et al.*, 1966; Sigee, 1966). Forest of *Pisonia grandis* probably covered much of the land before clearing for settlements and agriculture occurred (Spicer & Newbery, 1979). The vegetation is typical of small islands and Indo-Pacific coastal plant communities. Endemism could be more important than previously thought (Moutou, 1985a) but the only recorded endemics are five species of *Pandanus* (St John, 1961). Fosberg (1957) lists four ferns, one cycad, 322 angiosperms (many of which are introductions). Fosberg *et al.* (1966) list five ferns, two gymnosperms and 135 angiosperms from Addu. Stutz (1982) lists 123 taxa in Male', Bandos and Thulaagiri and provides notes on their uses.

Feare (1984) describes the status of seabirds breeding in the Maldives, but does not differentiate between islands. Eleven, and possibly fourteen, species are known to nest including the terns *Sterna sumatrana, Sterna albifrons, Sterna anaethetus, Sterna dougalii, Sterna bergi, Sterna bengalensis and Sterna fuscata, Sterna saundersi*; two species of noddy *Anous stolidus* and *Anous tenuirostris*; the white tern *Gygis alba* which is known to breed only on Addu Atoll; the lesser frigatebird, *Fregata ariel*; the white-tailed tropicbird, *Phaeton lepturus*; and possibly

also *Gelochelidon nilotica, Sula leucogaster* and Audubon's shearwater, *Puffinus lherminieri.* Hackett (1977) reported a tern rookery on Filadu Island in Thiladhunmathi atoll. Phillips & Sims (1958) reported a lesser frigatebird colony in Maalhosmadulu atoll, from which birds were caught to be sold live; more recently Maniku reported a lesser frigatebird roost on Hithaadhoo in Gaafu Alifu atoll (North Huvadhu).

The terrestrial avifauna is described by Phillips (1963), and Phillips & Sims (1958). The birds of Addu are described by Strickland & Jenner (1979). A new checklist is being compiled by Ash & Shafeeg (in prep.).

There are two geckos (*Hemidactylus* spp.) commonly seen on islands in North Male atoll; two agamid lizards including the common garden lizard or blood sucker, *Calotes versicolor*; the snake skink, *Riopa albopunctata*; and, the common wolf snake, *Lycodon aulicus* (Phillips, 1958). These terrestrial species are probably all introduced, possibly from Sri Lanka. No sea snakes are recorded from the archipelago.

3. Economic Aspects of Marine and Coastal Resource Use

The population of 213,215 (1990 census) is distributed throughout the archipelago on around 200 islands. The largest concentration is on Male' which has a population of 55,130 giving a density of 31,600 people km^{-2}. High concentrations of population are also found in Thiladhunmathi, Miladhunmadulu and Maalhosmadulu in the north and on Huvadhu and Addu atolls in the south (Anon, 1991). Non-permanently inhabited islands have a floating population consisting of small groups of people tending palms and many smaller islands are visited for short periods for collection of firewood and coconuts (Kenchington, 1985). Enclave tourism has developed on some 64 islands with plans for further expansion of this number in the immediate future. 25 islands have populations of over 1,000 people; population growth rate is in the region of 3% per annum; and, the total population is expected to reach 250,000 by 1995 (Anon, 1991)

3.1.1. Fisheries

The main livelihood has traditionally been marine based and Munch-Petersen (1985) describes the historical use of marine resources. The collection and export of the money cowrie (*Cypraea moneta*) was previously important and dried fish, tortoise-shell and semi-precious coral, formed the bulk of Maldivian exports well into this century. Trading of Maldive fish for rice with Ceylon and southern India was well established in the 11th century at the time of Ibn Battuta's visit to the archipelago.

Information on the fishing industry is available in Munch-Petersen (1978), Sathiendrakumar & Tisdell (1986; 1988), Christy *et al.* (1981), Anderson & Hafiz (1985), Sivasubramaniam (1985) and in the annually produced Statistical Yearbooks published by the government (Anon, 1991). Fishing provides about 60% of export earnings, employs about 25% of the work force and provides the primary source of dietary protein. Traditionally 'Maldive fish', boiled, salted and dried tuna accounted for 90% of the country's total exports. Tuna is now frozen and canned for export and motorization of the fishing fleet has been encouraged since 1974/75 and subsidised by the Government. Tuna boats still operate within 25 km of the outer atoll reef and the fishery is "dolphin friendly" being entirely pole and line.

The total fisheries catch in 1988 was 56,900 mt (double the late 1970s catches of about 30,000 mt), of which 17,300 mt was consumed locally and 37,800 mt was exported. By 1990 total catch had risen to 76,373 tonnes of which skipjack, *Katsuwonus pelamis,* comprised 78%; yellowfin *Thunnus albacares* 7%; other tunas and related species 7%; and, other marine fish 8%. Over 90% of the catch is pelagic, the remainder demersal, mainly reef species. Skipjack is taken mainly from the east side of the atolls, and yellowfin mainly from the west side. Troll fishing is carried out for other tuna-like fish such as *Neothunnus macropterus, Auxis thazard* and *Euthynnus affinis* (UNEP, 1986; Sivasubramaniam, 1985).

Table 2. Fisheries export statistics (tonnes) 1983 - 1989.

	1983	1985	1987	1989
Frozen skipjack	7,853	17,091	13,670	19,688
Dried skipjack	285	796	1,214	1,987
Dried sharkfin	17	20	24	13
Salted dried reef fish	1,151	1,894	1,439	626
Salted dried skipjack	778	1,814	2,836	1,228
Canned fish	43	722	1,919	5,535
Sea cucumber	-	-	410	
Live fish (number)	44,921	65,065	69,216	53,853
Shark Oil (litres) 63,400		53,400	69,216	1,9002
Cowries	42	17	30	11
Red coral	5	84	6	24

Fisheries are artisanal in nature, based on traditional Dhonis which were originally sailed but are now largely motorised. Previously Huvadhu and Maalhosmadulu atolls were the most productive with annual landings of 6,400 and 5,300 tons respectively (UNEP, 1986). The main fishing atolls now are North Thiladhunmathi (Haa Alifu), North and South Maalhosmadulu (Thaa), Hadhdhunmathi (Laamu) and Huvadhu (Gaafu), which between them account for almost 75% of the annual catch (Edwards, 1989). In 1986 there were 1,200 fishing boats (Nerland, 1986) and in 1990 some 1,433. A fish canning factory opened in 1978 on Felivaru Island in Lhaviyani atoll and processes 15-20 tons of tuna a day for export (UNEP, 1986).

Deep-swimming tuna resources are not yet exploited although they are possibly poached by foreign fishing boats as the Maldives lacks the technical capability to monitor its EEZ. These species are only found in the Maldivian EEZ for 2-6 months of the year and the Marine Research section of the Ministry of Agriculture and Fisheries is carrying out an offshore Exploratory Tuna Fishing Project, with some support for the Bay of Bengal Fisheries Project to determine oceanic fisheries resources (Anderson, 1988). Further information on the tuna fishery is given in Anon (1985), Sathiendrakumar & Tisdell (1988; 1990) and Sathiendrakumar (1988). The main fishing grounds are fairly intensively exploited and it is thought that increased production can only come from expansion of the range of vessels or greater emphasis on reef fishing (Sivasubramaniam, 1985).

In general, collection of reef resources for food is carried out on only a small scale and reef fish, turtles, molluscs, crustaceans (spiny lobsters) and octopus are traditionally only eaten when tuna is not available. With the development of the tourist industry, the reef fishery has become more important, but is still considered under-developed. The government has declared a sectoral objective to develop the catch of high value reef fish, and there is potential for the export of reef fish to Singapore, Europe and the Gulf States (Brown *et al.*, 1989). A UNDP-funded project on reef fish resources is being implemented by the FAO Bay of Bengal Programme (Van der Knapp, 1988; 1989). Survey work has focused on North Male'. Reef fish are caught predominantly to supply the tourist resorts and many of the reef fishermen contracted by resorts

to supply fish are from Ari atoll. A variety of species are taken by hook and line methods including small tunas, jacks, barracuda, sailfish, wahoo, rock cod and snappers. There is no history of ciguatera in the Maldives.

Livebait fishing, mainly of caesionids and *Chromis spp*, for the tuna industry is also important (Van der Knapp, 1989), and a tuna baitfish research project is underway in collaboration with CSIRO Marine Laboratories, Cleveland, Australia (Blader, 1988). An experimental FAD (Fish Aggregating Device) project is also underway with FAO support (Naeem, 1988).

Some gastropod molluscs such as *Strombus gibberulus, Atactodea striata, Turbo argyrostomus* and *Nerita* spp. are important for food while some of the larger gastropods such as *Cassis cornuta, Lambis* spp., and the bivalve *Athrina vexillum* are occasionally collected (Munch-Petersen, 1985). Giant Clams *Tridacna maxima* and *Tridacna squamosa* are not eaten by islanders. Sharks are caught for their liver and the oil is extracted and exported. Dried shark fins are also exported to Hong Kong and Japan, and more recently export of sea cucumbers to Singapore and Hong Kong has commenced (Van der Knapp, 1989).

3.1.2. Aquaculture

So far no aquaculture has been attempted in the Maldives but there is considerable potential for future developments in this field. (UNEP, 1986; Kenchington, 1985).

3.1.3. Other living marine resource use

Around 100 species of small reef fishes are collected for the aquarium trade. Some marine invertebrates such as the large anemones, *Radianthus* and *Stoichactis* together with their symbiotic clown fish, and smaller starfish such as *Linckia* and *Fromia* are also exported (Wood,1985; Edwards, 1986). Most specimens are despatched to Sri Lanka for re-export but some are also despatched direct to Europe. In 1988 there were two aquarium fish businesses employing about 25 people.

Shells and corals are collected for the souvenir trade and black and "red" coral and tortoise-shell are processed for export (UNEP, 1986). In the 1970s, considerable quantities of red coral were exported to India, but this trade has declined (Brown & Dunne, 1986); of 54 tonnes exported in 1986, 4 tonnes went to Pakistan and the rest to India, mainly to Tuticorin. This is the organ-pipe coral, *Tubipora musica*, reportedly collected from the beach rather than collected live. This species is used for medicinal purposes in India. A limited amount of *Acropora* is burnt to make lime for chewing with betel nut (Brown & Dunne, 1986), and live coral is extensively mined for construction material.

Coral 'rock' from living colonies, has traditionally been used for houses and in the construction of buildings of significance such as mosques. It is now the main building material in the archipelago, particularly in Male', Addu and the tourist resorts, and is also used decoratively in the interior design of tourist resorts. The massive species, *Porites lutea, Goniastrea retiformis* and *Platygyra lamellina,* are the most important species but dead coral rock of *Acropora humilis* is also used, the living part being thrown away. Coral is usually mined from

the rim of shallow **faros** and mostly from inside the atolls, but more recently outer rim reefs mainly in North and South Male' atoll have been mined as lagoon supplies have diminished. It has been estimated that a minimum of 54,000 m^3 of coral rock have been extracted over the last 13 years on Male', much of it by the islanders of Maamigili and Thimarafushi. 270,000 cu ft were extracted in 1985 (UNEP, 1986; Brown & Dunne, 1986, 1988).

3.1.4. Tourism

The fishing industry was affected by the fall in world tuna prices in the mid eighties but is currently expanding, and the state shipping sector was adversely affected by stagnation in the world cargo trade hence the country has relied in recent years on rapid expansion of the tourist industry (Anon, 1991; Nerland, 1986; Edwards, 1989).

Since the early 1970s, tourism has developed rapidly, boosted by the construction of the international airport in 1966 and its subsequent enlargement. National income from tourism has surpassed that of fishing since the 1980s (Domroes, 1985; Munch-Petersen, 1985; and Tisdell, 1985; UNEP, 1986) and in 1986 tourism generated foreign currency earnings of $42 million. Tourist resorts multiplied from two in 1972 (Kurumba and Bandos) with an annual visitor total of 1,097; to 58 in 1988 with an annual visitor total of 155,758; to 65 in 1990 with an annual visitor total of 195,156 (Anon, 1991). Most resorts are located on North and South Male' atoll due to the proximity of the International airport and the lack of air transport in the archipelago. Upgrading of the runway on Gan, the introduction of scheduled flights and the opening of a new airport in the north of the country will lead to expansion of tourist resorts in these areas.

The peak season is between December and May and although the number of tourist arrivals has shown steady growth since inception of the industry it has suffered setbacks as a consequence of the political unrest in neighbouring Sri Lanka and during the Gulf War. Government policy is to lease uninhabited islands to resort developers and normally the hotel facilities are the only buildings on the island. Male', the First Tourism Zone has reached saturation and Ari atoll has been designated for development as the Second Tourism Zone (Brown & Dunne, 1986; Edwards, 1989).

3.1.5. Agriculture

Only about 2,600 ha of the 4,498 cultivable land on 86 islands is currently cropped. The limited area of cultivable land; poor soil fertility; and low freshwater availability has meant that agriculture was never been a major activity in Maldivian society. Land clearance for coconut plantations and to supply fuelwood and construction timber has been a major contributing factor to vegetational changes on most islands. The economy of the country is entirely marine based: with fishing, shipping and coastal tourism being the mainstays of the modern economy (Tisdell, 1988).

4. Conservation Issues and Problems

4.1. Habitat destruction and degradation

The greatest threats to the environment of the Maldives result from population growth and migration combined with the relatively rapid establishment and growth of the tourist industry. The Maldivian population has tripled since the mid sixties to its present level of 214,000 and it is still increasing at a rate of 3.4% *per annum*. Edwards (1989) discusses the implications of population density and distribution, which are important issues in the context of coastal management in the country. Nine islands have been chosen as centres of development under the Selected Islands Development Scheme in an attempt to reverse the trend towards increasing aggregation of the population in and around the capital Male'. As a consequence of migration to Male' in search of employment, education and health care the growth rate of the capital city is nearly double that of the country as a whole.

4.1.1. Coral reefs

Land reclamation and coastal construction

Lack of space has resulted in a number of land reclamation schemes based on the creation of new land by pumping sand from the atoll lagoon floor onto reef flats. Male' island has been effectively doubled in surface area by infilling the seaward reef to a height or around 1 metre above mean sea level. Such land reclamation activity directly destroys reef flat communities and adversely affects neighbouring coral reef communities through enhancing the levels of suspended sediments. By changing the shape of the islands wave refraction patterns are altered with consequent changes to local wave and current regimes and enhanced rates of coastal erosion.

The construction of piers, wharves, seawalls, groynes, breakwaters and jetties, to prevent erosion of beaches, improve facilities for tourists and improve access to the islands for both tourists and fishing boats has caused locally severe disturbance to some fringing reefs and erosion of the islands. On some of the tourist islands, walls of coral are built along the reef top and a passage is cleared out from the beach to the reef front. This provides a sandy lagoon free from coral for swimming and easy access to the reef, but these activities seriously affect the reef through alteration of water circulation, and enhance beach erosion and sedimentation problems.

One of the best documented cases of erosion is in Addu, where the construction of solid causeways between the islands has caused significant alterations to shoreline, and in some places an increase in seagrass growth (Kenchington, 1985; Woodroffe, 1989; Edwards, 1989). Studies are currently underway to find a solution to the problem and a recent mission has recommended replacing one of the four causeways with a piled structure. It is salutary to note that when first constructed by the British forces in the early nineteen forties these causeways

were piled and erosion problems only arose following their replacement with solid structures in the early nineteen seventies. Similar erosion problems have been recorded on Hithadoo, Meedhoo and Hulhudhoo in the northeast of Addu (Kenchington, 1985); in Laamu (Oakley, 1988); and on numerous resort islands in North and South Male'atolls.

Coral mining

Coral mining has caused significant damage to living reef communities. Reef sites which have not been mined have coral cover from 11 to 60 % and mixed communities dominated by *Pocillopora verrucosa* and *Acropora humilis*. At mined sites, coral cover is only about 1% and diversity is greatly reduced; in some cases living coral is totally depleted and there is generally a reduction in reef fish diversity and abundance, including important bait fish such as *Chromis spp*. Although a little regeneration has been found at some sites, recovery after 10 years was found to be minimal. The reefs may take a minimum of 50 years to recover to optimum conditions and some may not recover at all. Surfacing of 16 miles of road on Male' used about 1,496,000 cu ft (42,362 m^3) of coral rock as hard core, and atoll chiefs were ordered to collect 6,000 cu ft (170 m^3) from each inhabited island. Extrapolations have suggested that North Male' will loose all its shallow reefs by the year 2014 (Brown & Dunne, 1986; 1988; Brown & Wells, 1989) if the present rates of exploitation continue unabated.

Coral mining reduces the micro-topographic complexity of the reef surface and hence affects the settlement rate of benthic species and reduces the food availability, numbers and biomass of resident reef fish. These are primarily species of importance to the aquarium fish trade and as baitfish for the tuna industry (Brown *et al.*, 1989). Coral mining also significantly impedes the active growth of the reef flats and lowers their effectiveness as barriers against high wave energy. This could be of considerable significance in an era of predicted sea level rise (Brown & Wells, 1989).

Coral mining is declining in some areas in favour of sand mining for manufacture of construction blocks. Although dredging for lagoon sand takes place regularly it is well regulated but has caused siltation in some areas particularly around Hululele, during construction and subsequent expansion of the airport and associated boat landing areas (UNEP, 1986). Collection of beach sands for local construction purposes, particularly on some resort islands has resulted in significant erosion problems and loss of tourist amenities.

Crown of thorns starfish

Crown of thorns starfish *Acanthaster planci* were first recorded in the Maldives in 1963 and a recent survey found the starfish at 29 of 190 sites in North Male', at six sites in South Male', and eight sites in Ari. Outbreaks occurred in Ari atoll in the 1970s; and in 1986 in North Male' atoll, the most serious being in the Hembadhoo - Makunudhoo area. The Hembadhoo outbreaks started in mid-1986 and despite major efforts by the local diving school in collecting them, large parts of the reef have been destroyed. Similar damage was found at Reethi Rah Resort in 1987 and Nakatcha Resort in 1988, where divers are also collecting them. An outbreak in the Bodu-Hithi area was reported in 1989 (Adam, 1989).

Coral bleaching

In 1987, bleaching of hermatypic and soft corals was recorded at various sites in Male' Atoll, Ari, Felidhu and Wattaru. This was correlated with an Indian Ocean sea surface temperature anomaly of 1.5°C and is documented by Engineering Geology Ltd and Tropical Coastal Management Consultants Ltd (1987).

4.1.2. Sea level rise

The possible impact of predicted climate change and sea level rise has been the subject of a number of recent missions and reports (Woodroffe, 1989; Edwards, 1989; Pernetta & Sestini, 1989; Hulsbergen & Schroeder, 1989) because of the potential seriousness of potential impacts in such a low-lying country. These reports provide a broad overview of the potential impact in the Maldives on climate, oceanographic features, coral reefs, agriculture, tourism, airports, industry and groundwater supplies. The exact magnitude of sea level rise is particularly critical since the maximum elevation in the country is 3.5 m above MSL; most human habitation is between 0.8 and 2.0 m above MSL; and 80% of the land area is less than 1m above mean sea level.

It may be 15-20 years before serious problems occur, but much current environmental damage will exacerbate the effects of sea level rise if not controlled. For example, sea level rise may cause an increase in salinisation of ground water supplies, but these are already over-exploited and are becoming saline as a result of overdraw. The natural sea defenses of the Maldives are the coral reefs and on protected reef flats where coral growth is currently constrained by exposure to low tides, reef growth will increase as sea level rises until maximum growth rates are attained. In areas of heavy seas and strong wave action, such as the seaward sides of atoll rims, there may not be such an immediate response to a rise in mean sea level. Site specific information is needed on coral growth rates before any detailed conclusions concerning the likely responses can be made. Edwards (1989) uses the general information available on reef growth rates and conditions in the Maldives, and suggests that it is unlikely that the potential sea-defence protection offered by coral reefs will be much use beyond the year 2050. In the meantime they have considerable potential to delay the worst effects of sea level rise by both their sea-defence and sediment generating functions; studies on reef growth rates and erosion rates in the Maldives are essential to quantify this potential.

Increased incidence of storms and high waves are also anticipated. Recent incidents have already caused serious damage: flooding in 1987 caused damage on Male', Hulhule, Gulhi, Guraidhoo, Thulusdhoo, Dhiffushi and resort islands on the south-east facing sides of North and South Male' atolls. Flooding and wave damage occurred in 1988 on the western side of the archipelago, especially on Thulhadhoo (Baa) which is a particularly low-lying unstable island which was experiencing problems even in the 1890s (Gardiner, 1903; Pernetta & Sestini, 1989).

4.1.3. Overfishing

Traditional fishing methods and a system of government monopolies (for example, the Sultan used to have a monopoly on turtle shell and black coral) helped to prevent overexploitation of

marine resources in the past. However, motorized sea transport has had a major impact as the entire archipelago can now be reached (Kenchington, 1983; Munch-Petersen, 1985). Small islands are now more frequently visited, and turtles, shells, black coral, spiny lobsters and other marine curios and foods are collected to satisfy the demands of the tourist industry around North Male' (Burchett, 1982; Moutou, 1985a; Munch-Petersen, 1985; Salm, 1975). At present there is no evidence of overfishing of the tuna or other finfish resources although some reef species have declined locally as a consequence of local demand for fresh fish from tourist resorts.

Turtles, mainly hawksbill and green, are collected for sale to tourists and for export as preserved specimens, particularly to Sri Lanka and Singapore (Frazier & Frazier, 1987). Exploitation of the green turtle has increased over the last two decades and numbers have declined on Mulhadu in the extreme north which was once the most important nesting site. Declines are reported more frequently in the north than in the south and the total decline is estimated at 82%. Kunfunadhoo, an important nesting site, now has a tourist resort (Frazier & Frazier, 1987). Frazier & Frazier (1987) provide a detailed review of turtles in the Maldives; Didi (1983; 1984) also provides recent information. The export of raw turtle shell is banned, although worked tortoiseshell may be exported. Nevertheless trade statistics show that Japan imports large quantities of raw shell from this country.

The construction of the airport promoted exports of corals and fish (Munch-Petersen, 1985). The collection of fish for the aquarium trade is well regulated (Wood, 1985; Edwards, 1986) but may increase if controls are introduced by other exporting countries.

Although huge quantities of money cowries were traditionally exported, only mature, thick shelled specimens were collected and there is little evidence of overexploitation. The trade is still large with thousands being shipped to India for jewelry, but it does not occur on as large a scale as in the past (Moutou, 1985a; 1985b; Munch-Petersen, 1985).

Spearfishing by European tourists was said to have had a noticeable impact on reef fish populations in the 1970s (Salm, 1975).

4.1.4. Pollution

Domestic pollution is increasing with population growth and increasing numbers of visitors. The only public sewerage system in the country is that on the capital city of Male' where untreated sewage is discharged directly to the sea on both the lagoon and ocean sides of the island. Effluents from septic tanks and raw sewage are discharged directly into the sea from tourist islands and on more isolated islands open beaches are frequently used (UNEP, 1986). There is an increasing problem on many outer islands of faecal contamination and programmes are underway to install appropriate toilet facilities.

Other potential threats include pollution from fish processing factories now being built on some islands; increased shipping traffic with the associated risk of oil spillages and dumping; and inadequate solid waste disposal particularly in the case of Male' and heavily used tourist islands. The fish canning factory on Lhaviyani produces up to 5 tons of waste a day which is discharged untreated into the sea; the impact of this source of pollution will need evaluation during future

factory construction. There is potential oil pollution from the increasing mechanisation of fishing boats particularly in and around fishing ports and harbour areas. Shipping traffic around the capital has increased over the last two decades and although no large tankers pass through the atolls, there has been one limited oil spill. Tar balls are occasionally found on beaches, especially in the northern atolls nearest the northern shipping lanes.

4.1.5. Island degradation

The natural vegetation of tourist resort islands is often cleared to make the islands 'more attractive' and leaf litter is regularly removed, leaving a canopy of coconut palms over plain coral sand and a mixture of ornamental plants. On several islands the organic litter is burned and is lost to the island ecosystem. Since few birds visit such islands, there is minimal organic input from that source and there is thus, a break in the organic and nutrient recycling process. On inhabited islands clearance of vegetation for housing, access and agricultural activities has, particularly in more densely populated islands, resulted in complete loss of natural vegetation. The use of uninhabited islands to supply fuelwood and construction timber and for agricultural activities including the growing of coconuts has significantly altered natural vegetation patterns on many islands.

The freshwater aquifers of smaller islands are currently suffering depletion with consequent effects on the natural vegetation. The freshwater lens on Male' has decreased in depth from 20 m in 1973 to 6-8 m in 1983 and is now less than 3m. On many tourist islands, water becomes sulphurous and saline as the water lens drops, even in the centres of the island. The natural carrying capacity of tourist islands such as Bandos and Kurumba (Vehamanafushi) has already been exceeded and expensive desalination plants have been installed to supply visitors to these and many other islands.

4.2. Species of Conservation Concern

In the following paragraphs species listed by IUCN (1990) as globally threatened are considered individually. Other species, including those considered threatened regionally or nationally are discussed in the general paragraphs. Status categories follow the IUCN definitions, namely: endangered (E); vulnerable (V); rare (R); indeterminate (I); insufficiently known (K); threatened (T) and commercially threatened (CT).

4.2.1. Mammals

Cetaceans have been recorded, but whales rarely enter the atolls. Five species are listed as occurring in the Maldivian area by Silva (1987): the common dolphin, *Delphinus delphis*; the spotted dolphin, *Stenella attenuata*; the spinner dolphin, *Stenella longirostris*; the striped dolphin *Stenella coeruleoalba*; and, Risso's dolphin, *Grampus griseus*. Coastal Indian Ocean populations of the three *Stenella* species are at risk (Perrin, 1989), but the status of those around the Maldives is not known. Klinowska (1992) mentions a record of the Melon-headed whale *Peponocephala electra* and the common dolphin has been recorded from Male' (Deraniyagala,

1956, cited in UNEP, 1986).

Dugong dugon, the dugong (V)
Recorded according to Snow (1970), no longer occurs and this record is dubious.

Other mammals:
Two fruit bats, *Pteropus ariel (P. giganteus ariel)* and *Pteropus hypomelanus maris*, are the only native mammals (Hill, 1958). *P. ariel* is now considered an endemic subspecies and is considered a major pest of certain fruits, such as almonds, guava and mangos. In 1986, an FAO project was initiated to develop control programmes for *Pteropus ariel* and for the introduced black rat *Rattus rattus*. It was found that numbers of bats can be fairly precisely managed on an island with modest investment effort, using netting methods, ideally in March and April in order to remove pregnant females. The aim of the project is to manage bat populations and reduce fruit loss rather than to exterminate the subspecies. Fruit bats may play an important role in pollination and seed dispersal for certain trees in the Maldives as they do elsewhere. *P. hypomelanus maris* is known only from Addu atoll and has been recorded only once (Hill, 1958; Moutou 1985a; 1985b).

4.2.2. Birds

The Maldivian pond heron *Ardeola grayii phillipsi* is common on Addu and is sometimes considered an endemic subspecies of the Indian pond heron (Scheer, 1960a).

There are no known threatened bird species in the Maldives, but there is concern that the current rapid development of the islands is having a disruptive affect on existing populations and may lead to increased persecution of birds for food and for pets, a traditional Maldivian pastime (Ash & Shafeeg, in prep.). The government's policy to eliminate the house crow *Corvus splendens* which is very often a pest would, if successful, inevitably result in the elimination of its cuckoo-parasite the common koel *Eudynamys scolopacea*, although it could have a beneficial effect in permitting other species, such as the white tern, to spread and breed more successfully and allow visiting raptors to become resident thus exerting some pressure on other pests such as rats and fruit bats.

4.2.3. Reptiles

Caretta caretta, loggerhead turtle (V)
Occasional records only (Frazier & Frazier, 1987).

Chelonia mydas, green turtle (E)
Reported to nest on beaches of almost all uninhabited islands and on a few inhabited islands. Major documented nest sites include: Thiladhunmathi (Mulhadhoo), Baa (Kunfunadhoo, Maadhoo, Olhugiri, Kanufushi; formerly Dhunikolu, Fares, Maarikilu, Miriyandhoo), Ari (Hukureulhi = Hukurudhoo), Meemu (island in southwest), Thaa (Kanimeedhoo), Laamu (Gaadhoo). All other atolls probably have some turtle islands (Frazier & Frazier, 1987). Rough estimates suggest that between 870 and 1,300 green turtles nest each year.

Eretmochelys imbricata, hawksbill turtle (E)
This species breeds regularly and occurs throughout the archipelago. Nests on Baa (Kunfunadhoo) and North Male' (Baros). Individuals have been seen in Baa, North Male', South Male', Laam, Vaavu and the species probably nests on many uninhabited islands in all atolls. Commonly seen on northern reefs of Goifurfehendu Atoll, reefs near Raannaalhi (South Male') and Mahibadhoo (Ari). Probably not more than 500 individuals nesting annually in the Maldives; decline reported on 83% of islands (Frazier & Frazier, 1987).

Lepidochelys olivacea, olive Ridley turtle (E)
Does not appear to be common but recorded fairly regularly and known from only 25% of all islands in the deeper parts of lagoons. No nesting of this species is recorded in the archipelago (Frazier & Frazier, 1987):

Dermochelys coriacea, leatherback turtle (E)
Known from occasional records only in 39% of islands (Frazier & Frazier, 1987).

Catching of turtles in Male' Atoll is banned; elsewhere there are size limits and the use of spearguns is banned (Groombridge & Luxmoore, 1989).

4.2.4. Amphibians

Although no indigenous amphibians are recorded from the Maldives a small bufonid used to breed on Male' Island (Pernetta, pers. obs.).

4.2.5. Invertebrates

Spiny lobsters *Panulirus spp.* are exploited to supply the tourist industry and may be commercially threatened in areas such as North Male' Atoll. Information on the status and distribution of most invertebrates is not generally available. The status in the Maldives of the giant clams *Tridacna maxima* and *Tridacna squamosa*, listed as Insufficiently Known and Indeterminate by IUCN, and of the giant triton, *Charonia tritonis*, listed as Rare, is not known. Other molluscs of economic value which may occur but for which information has not been obtained include *Trochus niloticus*, *Turbo marmoratus* and *Pinctada spp.* Black coral considered commercially threatened by IUCN (IUCN, 1990) is still fairly common although it continues to be exploited for the jewelry and curio trade.

4.2.6. Plants

The vegetation is inadequately documented and the status and distribution of the five endemic species of *Pandanus* (St John, 1961) are not known.

5. Environmental and Conservation Legislation

Sanitation Code for Tourist Resorts
Lays out the regulations for water supply, sewage and solid waste disposal, pest control and personal hygiene to be observed at resorts. Under the government's tourism policy, a tourist resort may only be developed on an island which is not to be used agriculturally; must result in no economic disadvantage to neighbouring inhabited islands; and within each atoll a maximum of one third of the uninhabited islands may be developed as resorts (Domroes, 1985). Incinerators and compactors have been mandatory at each resort since November 1987.

Housing Code, 1987
Ensures the proper sanitary and hygienic conditions for Male'.

Bill No. 24/78 of February 1978
Prohibits the catching of *Eretmochelys imbricata* under 2 ft (61 cm) in carapace length and all other turtles less than 2.5 ft (76 cm) in carapace length. A regulation of the Ministry of Fisheries in 1980 bans the sale and display of turtles below the size specified in Bill 24/78, but this is rarely enforced (Frazier & Frazier, 1987).

Bill No. 31/79 of 1979
Prohibits the export of any part of hawksbill turtles *E. imbricata* in raw form, but permits the export of manufactured articles.

National Environment Action Plan
This comprehensive policy document provides a framework for environmental planning and management in the country as a whole. Under this legislation, approved by Presidential decree in 1990 and by the Majilis in 1991, provision is made for environmental research, monitoring and control, for training of personnel and for the enforcement of agreed environmental standards.

Other legislation:
Broad based environmental legislation is currently before the Majilis to enable the Ministry of Planning and Environment to control and enforce agreed standards and prosecute offenders.

Particular areas for coral and sand mining are designated by the Ministry of Planning and Environment. Mining is forbidden around inhabited islands and tourist resorts and may only take place on the 'reefs'. Islanders may use local coral and sand for their own purposes.

Ministry of Tourism guidelines require that all future resort construction must use concrete blocks rather than coral (Brown & Dunne, 1986) and these guidelines specify the maximum percentage of area of an island that may be devoted to accommodation and other facilities in

order to regulate carrying capacity. New tourist developments must have desalination plants to prevent groundwater depletion.

Since 5 June 1988, an Environmental Impact Assessment must be carried out for any development activity, but penalties for non-compliance and mechanisms for implementing this decision have only recently been put in place.

Netfishing was previously only permitted for bait collection; in 1984 this regulation was relaxed and driftnetting is now permitted (Sivasubramaniam, 1985). All fish catch particulars must be reported to island chiefs.

There is a minimum size for the collection of spiny lobsters but this is rarely enforced. Black coral may only be sold or exported as finished, manufacture products.

The import of spearguns is forbidden. The use of spearguns, spears (harpoons) and explosives is banned (Sivasubramaniam, 1985; UNEP, 1986; Frazier & Frazier, 1987).

The collection of marine organisms is supposedly prohibited around all tourist islands by tour operators and diving instructors who are generally interested in maintaining the health of the reefs for the tourist industry (Munch-Petersen, 1985; Salm, 1975). On Raannaalhi, steep fines have been established by the resort management to discourage collection by tourists (Frazier & Frazier, 1987).

The Ministry of Trade and Industry has imposed a quota - 100,000 - on the number of live fish which may be exported for the aquarium fishtrade annually (Edwards, 1986). Collectors may not operate within 3,000 ft radius of tourist islands (Wood, 1985).

The Maldives is party to the International Convention for the Prevention of Pollution of the Sea by Oil. A Merchant Shipping Act was drafted in 1978 but has not yet been enacted.

The Maldives has ratified the World Heritage Convention.

6. Institutional Infrastructure

6.1.1. Governmental Organisations

National Commission for the Protection of the Environment, (previously the National Environment Council)
Established in 1986 as an advisory body under the Ministry of Home Affairs and subsequently strengthened as the body responsible for all aspects of environmental management and planning in the country.

Ministry of Home Affairs
The Environment Division was originally established within this Ministry and subsequently transferred to the newly created Ministry of Planning and Environment in 1989.

Department of Tourism
Responsible for implementation of government policies concerned with tourism development and expansion this Department sets standards for resort construction and environmental quality and is responsible for enforcing and implementing policy decisions in these fields.

Ministry of Fisheries and Agriculture
Includes a Marine Research Section, responsible for all marine environmental matters including monitoring of environmental conditions on and around reefs, stock assessment and fisheries research. The agriculture section is responsible for pest control programmes and enhancing agricultural and forestry production.

Ministry of Planning and Environment
Includes an Environment Section operating under a Director of Environmental Affairs concerned with policy development in the areas of environmental management and planning; environmental legislation and enforcement. The recently created Environmental Research Unit is responsible for the preparation of an environmental database and monitoring environmental quality.

Ministry of Health
Responsibilities in the environmental field cover environmental health, water supply and sanitation.

Ministry of Transport and Shipping
Will be responsible for enforcement of the Merchant Shipping Act when this becomes law; this agency will also be the lead agency for marine pollution control and for implementation of the contingency plans developed to cope with oil spillages (Nerland, 1986).

Ministry of Education
Responsible for all aspects of environmental education in the formal sector.

President's Office
Ultimately responsible under Maldivian Law for all environmental and conservation legislation and its implementation. Authority is delegated to other departments and ministries via delegation and presidential decree.

National Security Services
Responsible through the National Commission for the Protection of the Environment for all disaster planning and prevention.

Voice of Maldives (Broadcasting Services)
Responsible for non-formal environmental education and public awareness.

Maldives Water and Sanitation Authority
Responsible for planning and management of freshwater resources.

Ministry of Public Works and Labour
Responsible for construction of sea defenses, coral mining, coastal engineering, and physical infrastructure development.

Office for Physical Planning and Design
Responsible for planning and design of settlements, buildings and physical infrastructure.

Department of Meteorology
Operates meteorological stations in Male' and Gan, and tide gauges under TOGA programme.

Ministry of Atolls Administration
Responsible for all developments in atolls and islands outside the capital. The Atoll Chiefs are responsible for enforcing legislation through the respective island heads. Local problems including conflicts of resource use are often settled through discussions at the village level and through mutual consent. On inhabited islands, the Island Chief can set a policy to regulate resource utilization. For example, on Gaadhoo (Laamu) no nesting turtle may be killed and only eggs may be collected; when boats of other islands visit, the islanders check that no turtles are taken (Frazier & Frazier, 1987).

6.1.2. Non-governmental Organisations

Bluepeace
The Maldivian equivalent of Greenpeace this non-governmental organisation is involved in pressure group activities designed to effect change in various aspects of environmental management in the country. Active also in public awareness raising.

Forum of writers on the Environment
A recently formed body of authors and journalists concerned with improving environmental awareness and information in the Maldives.

7. Conservation and Environmental Management Activities

7.1.1. Current research

Stoddart (1966c) provides a bibliography of work in the Maldives up to that date. Early studies include Agassiz (1903), who visited the islands in 1901/1902 and Gardiner (1902; 1903-1906), the latter being a detailed account of an expedition in 1899 and 1900 with descriptions of the marine and terrestrial fauna and flora. Sewell (1936a; 1936b) described Horsburgh and Addu in considerable detail, following the John Murray Expedition of 1933-34. Fosberg (1957) provides a general account of the Maldives.

Edwards (1989) provides references to other sources of data including Admiralty charts and unpublished consultants reports and in reviewing the existing environmental information Pernetta & Sestini (1989) and Woodroffe (1989) emphasise the need for an environmental database containing basic information on all the islands such as types, use, morphology, geology, vegetation and soil etc.

The "Xarifa" Expedition visited the Maldives in 1957-1958 and reported on fish (Klausewitz, 1972a; 1972b; 1973; 1974; Klausewitz & Eibl-Eibesfeldt, 1959) and corals (Franzisket, 1964; Hass, 1962; Pillai & Scheer, 1972), some 80 papers resulting from this expedition. Popular accounts of the expedition are given in Hass (1965) and Eibl-Eibesfeldt (1966; 1982). A brief description is given in Kohn (1964a). Scheer (1971; 1972; 1974; 1978) describes reefs on Addu and atolls in the central and northern part of the archipelago, especially on Rasdu. Stoddart (1966a) describes the 1964 University of Cambridge expedition to Addu. General information on the Maldives is given in Moutou (1985a; 1985b). North Male' has been visited by several diving expeditions in recent years.

In 1984, the Ministry of Fisheries opened a Marine Research Section with five fishery officers (UNEP, 1986). This is currently carrying out research on tuna and reef-associated fisheries and coral reef ecology, degradation and crown-of-thorns infestation, with a number of projects underway in association with Institutions in Canada and the UK. Pilot projects in the use of remote sensing have been undertaken. Aerial photos of the atolls are available, taken during a survey by the British Royal Air Force in 1969. Lautieri (1987) reported on the use of satellite data for agriculture and land use mapping. Woodroffe (1989) stresses the value of such mapping and remote sensing projects in the long term management of the environment.

In 1985, a field station of the International Institute for Submarine Research, Vaduz, Liechtenstein, was set up on the island of Kufunadhoo in South Maalhosmadulu with the cooperation of the local diving resort with the aim of stimulating further research in the atolls but this was subsequently abandoned.

7.1.2. Coastal zone management

Activities are limited at present owing to the absence of appropriate databases and expertise. However pier and wharf construction is now regulated and resort developers are being encouraged to minimise physical interference with island coastlines. Numerous activities being developed under the National Environment Action Plan are being developed which will contribute to improved coastal zone management including training, monitoring, provision of advice to other government departments and the private sector and development of appropriate legislation and standards.

Mining of reefs surrounding inhabited islands and tourist resorts has been banned and designated mining sites in each atoll are being identified by the Ministry of Planning and Environment in consultation with the local Atolls administration. Import duty on building aggregate was reduced to encourage its importation and use in place of coral blocks but unfortunately supply and transport problems have limited the effectiveness of this measure.

Since most fisheries resources show little sign of over-exploitation at the present time management efforts are currently directed towards resource identification and assessment of the levels of sustainable yields from different stocks. Some qualitative evidence suggests a local decline in spiny lobster stocks in North Male' atoll. Spearfishing has been banned and the importation of spearguns for sports fishing is prohibited.

A Male' Water Supply and Sewerage Project undertaken in 1989/1990 has reduced pollution of the Male' aquifer but results in localised pollution of the marine environs of the island. Groundwater quality is intermittantly monitored. Conservation of existing freshwater, prevention of its pollution, and increasing freshwater supplies through improved catchment and storage of rainwater and desalination are all high priorities (UNEP, 1986; Wells & Edwards, 1989; Edwards, 1989). No action has been undertaken to date to manage or control waste related marine pollution problems although an oil spill contingency plan has been developed and is in place.

7.1.3. Existing protected areas

There are no marine protected areas in the archipelago.

All land is the property of the state, but uninhabited islands may be rented out by the government to persons of importance (Munch-Petersen, 1985). Twenty three small uninhabited islands have been leased by the Dept of Tourism at 2 Rf/year each to keep them from being developed: Huragadu, Hathikolhu Finolhu, Raiyfalhu Hura, Boahuraa, Kanuhuraa, Kalhuhura, Kohdhipparu, Iruvaa Kaduhura, Akirifushi, Oidhuni Finolhu, Maniyafushi, Malmagu Finolhu, Furahani, Fuhgiri Finolhu, Feydhoo, Foojaadi Finolhu, Dhoonihoali, Dhefinolhudheatherey Finolhu, Tholhimaraa Hura, Aanugadu Finolhu, Hikey Finolhu (Galufalhugaionna), Kohdhippary Finolhu, and Vaagali (Frazier & Frazier, 1987).

8. Recommendations for Future Action

Numerous consultants' reports and recommendations have been prepared for the Maldives, covering various aspects of environmental management and conservation. Many of the recommendations overlap and many are impractical within the socio-economic and development context of the country.

8.1.1. Proposed protected areas

The need for a marine park in the Maldives was emphasised in the Corbett Action Plan (Objective 3.3) (IUCN, 1985) and the Government sought advice on this in the early 1980s (UNEP, 1986). Two reports (Kenchington, 1983; 1985) were produced which recommended zoning and development of marine parks and protected areas. A 1983/84, mission was undertaken on behalf of UNESCO at the request of the Government of the Maldives to identify priority sites for conservation and a biosphere reserve; the report emphasised the need for a full zoning strategy. It concluded that the size of the Maldivian Archipelago and its central location in the tropical Indian Ocean, isolated from continental land masses, make it a biogeographical feature of world importance which should be represented within the Biosphere Reserve system and probably also on the World Heritage List (Kenchington, 1985). Regrettably the recommendations were made solely from the viewpoint of conservation needs and out of the context of planned developments, current island use and land-ownership and usufruct rights. While the specific recommendations of these reports relating to the establishment of protected areas were not implemented, the general recommendations concerning the development of environmental capabilities within the government were implemented as was the recommendation for establishment of an advisory body (NEC and NCPE).

The Danish Consultancy survey recommended that a protected area system be established comprising 'strict nature reserves' (open only for scientific purposes) and nature reserves (open to tourists and local people), zoned to take into consideration whether or not islands are permanently inhabited, and the requirements of local people (Munch-Petersen, 1985).

The following areas have been recommended for protection or as part of a zoning scheme by the above and other consultants reports:

1. Ari - Atoll recommended as Biosphere Reserve within the zoning plan proposed in Kenchington (1985); this would include a national park across the atoll in the Fesdhu area, two other national park areas, and several strict nature reserves within these. Hurasdoo island recommended by Frazier & Frazier (1987) for protection of vestiges of original vegetation (*Pisonia grandis*) and nesting sea birds; Hukureulhi (Hukurudhoo) has major *Chelonia mydas* nesting site. Feridhoo was recommended as a potential site for a Marine and Agriculture Research Station, providing access proved feasible (Edwards, 1989). Major plans exist for development of Ari for tourism. Reefs around Fesdhu (now a resort) have been described; site account for Ari in IUCN/UNEP (1988/89).

2. Rasdu - Zoning plan proposed by Kenchington (1985) with two national parks. Small atoll, some reef research; some tourism; site account in IUCN/UNEP (1988).

3. North Male' - Kenchington (1985) recommends a zoning plan to include two national parks and several sanctuaries; Edwards (1989) suggests that this atoll might be more appropriate for the development of a Marine and Agriculture Research Station because of access e.g. Meerfenfushi or Villingili. North Male' is the main centre of development and tourism etc. and natural resources may be most threatened here; - there would seem to be a need for some protected areas within the atoll; site account in IUCN/UNEP (1988).

4. South Male' - zoning plan proposed by Kenchington (1985) to include national parks and strict sanctuaries in the south of the atoll.

5. Faadhippolhu (Lhaviyani) - the northeast reef area, including the island chain from Guraidhoo to Maidhoo and Bodu Huraa recommended as a strict nature reserve; A broad central area, including a number of northern and eastern islands, and the southern island of Aligaa as a nature reserve (Danish survey); these areas have received little scientific attention (see IUCN/UNEP, 1988/89 for site account).

6. The Danish survey referred to above recommended establishment of reserves at: Felidhu (including Wataru, Vaavu); Makunudu (South Thiladhunmathi, Haa Dhaal); Mulakatholhu (Meemu); North and South Nilandhe (Faafu and Dhaalu); Hadhdhunmathi (Laamu) and Kolhmadulu (Thaa).

8.1.2. Species protection

One recommendation by a Danish consultancy in the early 1980s was for a survey of the wildlife of the islands, particularly turtles and seabirds and to develop plans for the establishment of a Wildlife and Conservation Unit (Kirby, 1986). The turtle survey of Frazier & Frazier (1987) resulted from this recommendation. Areas recommended by Frazier & Frazier (1987) for protection of vestiges of original vegetation (*Pisonia grandis*) and nesting sea birds are:

1. Olhugiri (Baa).
2. Suvadiva atoll.
3. Small uninhabited atolls such as Vattura.

Other recommendations given in Frazier & Frazier (1987) include to:

1. Carry out further survey and research work to establish actual status of populations and their exploitation.
2. Create protected areas, especially in feeding and nesting areas, and islands that still have vestiges of original vegetation (*Pisonia grandis*) and nesting sea birds e.g. Hurasdoo (Ari), Olhugiri (Baa) and Suvadiva atoll - also perhaps small uninhabited atolls such as Vattaru.
3. Ban killing of all nesting female turtles for 15 years; prohibit or monitor sale of turtles and eggs in Male'; establish closed seasons for egg collection and quotas that can be taken from each island; monitor all exploitation.

4. Establish appropriate fines and system of incentives for support of a sea turtle recovery programme.
5. Prepare educational material for tourists and local people and schoolchildren.
6. Investigate the potential of ranching hawksbills to supply tortoiseshell for a cottage craft industry.

In the case of aquarium fish, banning of exports has been suggested but Wood (1985) points out that if regulated, the trade could be sustainable. Recommendations for such regulation are given in Edwards (1986):

1. Replace quota system with licensing system.
2. Designate official collecting areas.
3. Introduce special export controls for selected species such as *Chaetodon meyeri, C. trifasciatus, C. triangulum* and *C. trifascialis* that are known to be difficult to keep in captivity.
4. Establish monitoring programmes.

For other marine species the Danish survey made the following recommendations (Munch-Petersen, 1985):

1. Collection of molluscs (other than food species and the money cowrie) which are popular in the marine curio trade such as *Charonia tritonis, Cassis cornuta, Cypraecassis rufa* and *Lambis spp.* should be controlled.
2. Collection, sale, resale and consumption of undersized and berried spiny lobsters should be banned.
3. Restrict the collection of black coral to areas with an established local tradition of exploitation and prohibit collection within tourist zones.

In the case of the bat control programme it is recommended that bat populations are not reduced below 0.25 bats/ha on an island i.e. 10-20 bats for a typical 40-80 ha islands (Dolbeer *et al.*, 1988).

8.1.3. Reef protection and coral mining

Brown & Dunne (1986 and 1988) recommended:

1. One Government Department be responsible for coral reefs (at present the Ministry of Fisheries, Department of Tourism and Department of Public Works are all involved).
2. Establishment of a three year research project to formulate a management policy for reefs and to train Maldivians in reef management.
3. Attempts should be made to reestablish corals in heavily mined areas, possibly by building artificial reefs or transplanting corals.
4. The use of alternative building materials, particularly coral blocks of coarse coral sand and cement, should be encouraged.
5. Potential for using an entire inner atoll submerged reef for mining, rather than the superficial layers of many reefs, should be investigated. A feasibility study, funded by the British Overseas Development Administration was carried out in 1990 in South Male'; it

has been estimated that this method could supply enough material to satisfy demand over the next 100 years.

Of the five recommendations only the first has not been implemented, in part since the distinction is not made by Brown & Dunne between resource use, habitat use and management functions which are the essential divisions in terms of the present functions of the different government departments. Hence the ministry of fisheries and agriculture is primarily responsible for living marine resources; works and labour for development of coastal infrastructure and non-living resource use; and, Planning and Environment for the management of the entire Maldivian environment.

8.1.4. Other recommendations

In relation to planning for sea level rise and climate change, Woodroffe (1989) recommends:

1. Actual sea level rise in the Maldives should be determined by analyzing corals and installing permanent monitoring facilities e.g. tidal gauges.
2. The Environmental Section of the Ministry of Planning and Environment should be expanded (see also below under training).
3. Studies should be carried out to establish patterns and rates of reef growth and island sediment budgets.

Recommendations in relation to sea level rise have also been made by Pernetta & Sestini (1989) following a UNEP mission in December 1988 to assess the impact of climatic change; Hulsbergen & Schroeder (1989) following a mission by the Delft Hydraulic Institute; Oakley (1988) following a Disaster Preparedness Mission in October 1988 by the UN Disaster Relief Office, focusing on the threat of tidal surges; and Edwards (1989).

Recommendations concerning pollution control and managent are given in Nerland (1986). Kenchington (1985) and Munch-Petersen (1985) recommended the development of a sewerage system for Male' and collection and disposal systems for solid wastes on the capital and hotel islands. Subsequent feasibility studies for different alternative solid waste disposal options have proved too costly to implement. The development of pollution control measures for urban and commercial development, oil pollution and waste disposal controls for shipping and contingency measures for oil spill emergences are also being developed.

Various consultants have recommended that the tourist carrying capacity of the islands must be studied in greater detail; that greater attention should be paid to the selection of dive sites; and that fixed mooring buoys should be established to prevent anchor damage (Munch-Petersen pers. comm., 1985).

Most of the consultancies mentioned above stress the need for improving environmental legislation, natural resources and environmental management, and the environmental information base; for developing the necessary skilled manpower; and for improving environmental education and awareness. These recommendations have been adequately addressed through the development of the National Environment Action Plan and its associated work programme activities.

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