COMMERCIAL EXPLOITATION OF REEF RESOURCES: EXAMPLES OF SUSTAINABLE AND NON-SUSTAINABLE UTILIZATION FROM THE MALDIVES

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ABSTRACT

Sustainable Maldivian reef fisheries include the tuna livebait fishery, the historical money cowry fishery and the export of marine aquarium fish. Non-sustainable export fisheries include those of sea cucumber, giant clam, deepwater shark and grouper. The tuna livebait fishery has been in existence for over one thousand years and mainly targets small pelagics. Money cowries were exported for hundreds of years to Asia and Africa. These fisheries share the characteristics of large resource base, low unit value and wide distribution of low-impact fishing effort. The sea cucumber, giant clam and the deepwater shark fisheries share the characteristics of small resource base, low population turn over rates, ease of collection and high unit value. The grouper and aquarium fisheries have intermediate characteristics. The aquarium fishery may be sustainable because it has a large resource base and limited entry. The grouper fishery may not be sustainable because both fishing effort and unit value are high.

INTRODUCTION

The Republic of Maldives is an archipelagic small island nation lying south west of the Indian subcontinent. It forms the central and largest part of the Chagos-Laccadives atoll chain. There are some 1200 small coral islands in the Maldives, spread among 26 natural atolls which are divided into 19 administrative units (Figure 1). The total land area of the Maldives is less than 300 km^2, but the total atoll area is about 21,500 km^2 (Anderson et al. 1992).

Despite the enormous reef area available, Maldivians have traditionally turned to the open ocean and to tunas as their main source of fish. The famous Arab traveler Ibn Battuta gives a clear account of the importance of tuna fishery at the time of his visits in 1343-1344 and 1346 (Gray 1889). There is also evidence that tuna fishing was carried out in the Maldives before the conversion to Islam in 1153. Even today the tuna fishery provides the major source of the country's export earnings, employment and of protein for the people.

As a result of Maldivians' preference for tuna, reef resources were little used in the past. Only two reef resources were traditionally exploited on a large scale: tuna livebait and money cowries.

The Maldivian tuna fishery is a pole and line fishery. This requires large quantities of small live baitfish to attract the tunas to the fishing boats. The livebait fishery targets small reef-associated pelagic fishes. At present about 10,000t of livebait are caught annually, to be used exclusively in the tuna fishery (Anderson 1996).

The money cowry (*Cypraea moneta*) trade thrived for about 1000 years, from the 9th to the 19th centuries. At its height, money cowries were used as currency from West Africa to China. As the major supplier, Maldives played a key role in the money cowry trade, with hundreds of tonnes being exported annually.

Reef fishery resources other than livebait and money cowries were not exploited in Maldives until recently. In the 1970's the introduction of tourism and the mechanization of the fishing fleet brought rapid economic and social development to the country. The tourism industry created new demands for reef resources, and a reef fish fishery soon developed to supply the tourist resorts. In the 1980s, export oriented fisheries such as those for aquarium fish, deepwater shark, *beche-de-mer*, and giant clam were initiated. In 1993 an export orientated live grouper fishery started.

The livebait and money cowry fisheries survived for centuries despite relatively high levels of catch and effort. In contrast some of the recently developed export orientated reef fisheries have collapsed within just a few years. The Government of Maldives has tended to adopt a laissez-faire attitude towards management of these fisheries, in part because it lacks the human resources to monitor and control the fisheries. However, the export of giant clams was banned in 1991, and that of Napoleon wrasse (*Cheilinus undulatus*) was banned in 1995.

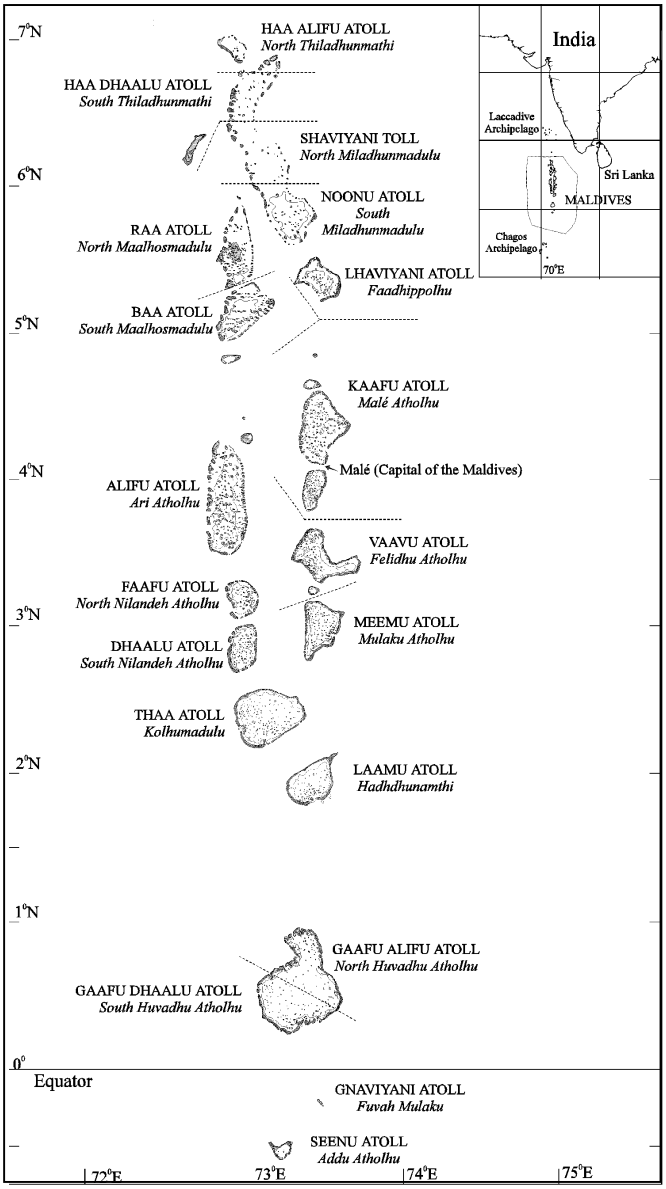

Figure 1: Location map of the Maldives, giving modern and traditional (italicized) names.

The aim of this paper is to contribute towards an understanding of the reasons why some reef fishery resources are so easily overexploited while others are not. Each fishery and its current status are briefly described, and then the key factors influencing its sustainability in Maldives are discussed. Both biological and socio-economic factors influence

sustainability; the latter may vary between countries, and so a fishery that has proved to be sustainable in Maldives may be unsustainable elsewhere, and vice versa.

MATERIALS AND METHODS

Catch data are not available for the fisheries discussed in this paper. However, detailed export data are collected by the Maldivian Customs Department, and compiled on an annual basis by the Economic Planning and Coordination Section (EPCS) of the Ministry of Fisheries and Agriculture (MOFA). Data for 1995 are provisional, and may be subject to revision. Export values are mostly presented in Maldivian Rufiyaa (MRf); exchange rates have declined from about MRf7 = US$1 in 1983 to MRf11.7 = US$1 in 1995. In some cases catch estimates have been made from export data, or from catch sampling. With the exception of the historical money cowry fishery, the authors have extensive first hand experience of all of the fisheries discussed.

RESULTS

The Livebait Fishery

The tuna livebait fishery is an ancient one dating back hundreds of years. Early notices of the tuna fishery were given by Ibn Battuta in the 14th century and Francois Pyrard de Laval in the 17th century (Gray 1889). Small reef-associated pelagic fishes are caught throughout country to supply livebait for use in the pole and line tuna fishery (Anderson and Hafiz 1988; Anderson 1996). Tuna fishermen carry out day trips, leaving early in the morning to catch livebait from reefs inside the atolls, and then travelling offshore in search of tunas, returning home in the late afternoon or evening. The livebait are caught using a simple liftnet, deployed over the side of the fishing boat. The livebait are either lured into position above the net with fish paste, or driven there with sticks or palm fronds. The major varieties taken are sprats (*Spratelloides* spp.), juvenile fusiliers (family Caesionidae), cardinalfishes (family Apogonidae) and anchovies (*Encrasicholina heteroloba*). Light fishing at night is not practiced.

In the 1950's nylon bait nets were introduced and replaced traditional cotton nets (Anderson and Hafiz 1988). More recent improvements include the introduction of diving masks which allow swimmers to locate bait schools and to deploy the bait net, and the introduction of mechanical pumps with consequent improvement of baitwell circulation (Anderson 1996). These developments have made livebait catching and maintenance much easier than it was in former times. At the same time there has been a trend for fishing vessels to get larger. The net result is that livebait catches have increased dramatically in recent years (Table 1), in parallel with tuna catches.

Table 1: Estimated annual utilization of livebait in the Maldivian pole and line tuna fishery (after Anderson 1996).

Time period	Livebait used (t)	Original source
1978-1981	3000 ± 800	Anderson and Hafiz (1988)
1985-1987	4800 ± 1200	Anderson and Hafiz (1988)
1993	10500 ± 2600	Anderson (1994)
1994	10600 ± 2700	Anderson (1996)

Despite the record catches of livebait in recent years, and some complaints from fishermen about livebait shortages, there are no clear signs of overfishing. When shortages do occur they tend to be local, short-term phenomena associated with natural seasonal, regional and inter-annual variations in livebait abundance (Anderson and Saleem 1994 and 1995).

The Historical Money Cowry Fishery

Money cowries (*Cypraea moneta*) were exported from the Maldives in large quantities from at least the 9th century, although there are earlier notices of their use in India and China (Gray 1889; Heinmann 1980). Early exports were mainly to Bengal but later direct exports were also made to Africa, southeast Asia and Europe. The Indian Ocean component of the trade was dominated successively by the Arabs, Portuguese, Dutch and British (Heinmann 1980). Production, however, remained in Maldivian hands, with the Sultan having monopolistic control of exports.

The traditional method of collecting cowries was more akin to aquaculture than fishing. Bundles of coconut palm fronds were placed in shallow lagoons and on sea grass beds, where a thin film of algae would grow on them. Money cowries were attracted onto the fronds to feed. From time to time the palm fronds would be pulled up on to the beach and the cowries shaken off. The cowries were then buried in sand to de-flesh them. Accounts of this collection method were given by Suleiman in the 9th century, Ibn Battuta in the 14th and Francois Pyrard de Laval in the 17th (Gray 1889).

One estimate suggests that in the 1720's at the height of the African slave trade (in which cowries were an important trading commodity) almost 1,000,000lb of cowries (i.e. about 450t or about 480,000,000 cowries) were imported annually into West Africa alone (Johnson, 1970). In 1735 a letter from the Maldivian Sultan to the Dutch authorities in Colombo stated that cowries had become more scarce (Heinmann 1980). While this may be an indication of overfishing, it may also have been a ploy to increase prices or to circumvent Dutch attempts at establishing a trading monopoly. In any case the trade continued unabated.

The use of cowries as official currency survived in some parts of Africa into the beginning of this century, but the cowry trade effectively died out during the 19th century. This was not due to any shortage in supply, but rather to international economic and political changes. The widespread introduction of metal coins and the suppression of the African slave trade spelt the end of the cowry trade. Today only a few tonnes are exported annually to India and other Asian countries, mainly for ornamental use. The palm frond collection method is no longer used; instead cowry shells are individually hand-picked during low spring tides on seagrass beds.

The Aquarium Fish Fishery

The export of marine aquarium fish from the Maldives started in 1980 (Edwards 1988; Edwards and Shepherd 1992; Adam 1995 and 1996). Entry to the fishery has been limited by the need for financial investment in holding facilities, and the need for technical expertise in catching and holding. There are currently 17 registered exporters, mostly based in close proximity to Malé international airport. The companies are Maldivian owned, but employ a relatively high proportion of foreigners (mostly Sri Lankan divers and aquarium workers). Aquarium fish are collected by SCUBA divers and snorkelers using hand nets. Catches are maintained in holding facilities prior to export by air to Sri Lanka (for re-export), Europe, Japan and the USA.

Catches have been increasing recently, to a total of 312,000 fish exported in 1994. Crude estimates of maximum sustainable yields of aquarium fish within close proximity of Malé were made by Edwards (1988) and Edwards and Shepherd (1992). Ten species of aquarium fish were found to be being exploited at close to local maximum sustainable levels. Quotas for selected species were established in 1989, and are supposed to be reviewed every year by MOFA and the Ministry of Trade and Industries, but in practice have not been enforced. In view of the recent growth of aquarium fish exports, and possible conflict with the tourism industry, further monitoring and regulation of this fishery has been recommended (MRS 1995; Adam 1995).

Table 2: Exports of marine aquarium fish, 1980-1995.

Year	Number	Export Value (MRf)	Export Value (US$)
1980	42,128	153,958	---
1981	43,929	214,607	---
1982	38,332	242,014	---
1983	44,921	372,699	53,243
1984	37,255	296,823	42,102
1985	65,065	555,290	78,231
1986	86,312	805,078	112,587
1987	69,216	902,758	97,882
1988	68,012	1,589,212	180,909
1989	53,925	1,312,037	145,124
1990	54,572	1,216,000	127,873
1991	112,918	3,450,000	336,500
1992	161,918	3,156,000	298,603
1993	184,233	3,746,171	341,901
1994	312,483	7,028,295	606,630
1995	203,221	4,412,126	373,276

The Deepwater Shark Fishery

Several species of deep benthic shark are caught by deep vertical longline in about 200-600m on the outer atoll slopes. The main targets are spiny dog fish or gulper sharks (*Centrophorus* spp., Family Squalidae). The only product obtained is their high value squalene-rich liver oil, which is exported to Japan. Their fins and meat are not used. The fishery started in 1980 following a show of interest from Japanese buyers, and peaked in 1982-84 (Table 3). The fishery was reviewed by Anderson and Ahmed (1993), who concluded from export data and interviews with fisherman that the deepwater shark stock had been overfished, especially in the north of the country where catch rates had declined dramatically. Since that review, deepwater shark catches have continued to decline. This can partly be attributed to a drop in international prices as a result of increased production in other countries, as well as product substitution. Nevertheless it is believed that the resource has been overfished. Since deepwater sharks stocks are believed to have a long recovery times, a ban on shark oil exports of at least 15 years has been recommended in order to let stocks recover (MRS 1995).

Table 3: Deepwater shark oil exports and catch estimates, 1980-1994 (after Anderson and Ahmed, 1993).

Year	Quantity (Kg)	Value (MRf)	Unit value (MRf/kg)	Est. shark catch (t)
1980	8,160	60,129	7.37	35
1981	23,120	349,275	15.12	101
1982	74,290	1,106,353	14.98	323
1983	53,890	1,796,010	33.33	234
1984	67,490	2,411,641	35.73	293
1985	45,390	1,890,751	41.66	197
1986	28,390	1,242,230	43.76	123
1987	34,000	1,040,168	30.59	148
1988	22,100	640,747	28.99	96
1989	16,152	724,297	44.84	70
1990	21,760	1,203,382	55.30	95
1991	33,800	1,814,530	53.68	147
1992	23,730	865,801	36.49	103
1993	3,480	196,054	56.40	15
1994	1,445	140,300	97.09	6

The Beche-de-Mer Fishery

An export oriented fishery for sea cucumber or beche-de-mer aimed at the Chinese markets of the Far East started in 1985 (Joseph 1992; Ahmed et al. 1996). Sea cucumbers are collected mainly by hand, either from shallow reef and lagoon areas at low tide, or from deeper areas by snorkeling or SCUBA diving. Heavily weighted fishing hooks are sometimes used to snag sea cucumbers. Processing is carried out ashore, where the sea cucumbers are boiled and sun dried, before sale to local exporters.

Table 4: Exports of beche-de-mer, 1985-1995.

Year	Quantity (kg)	Value (MRf)	Value (US$)	Unit value (US$/kg)
1985	31	200	28	--
1986	2,557	182,613	25,540	9.99
1987	33,886	3,115,632	337,921	9.97
1988	553,114	39,477,757	4,496,327	8.12
1989	410,286	15,775,881	2,240,892	5.45
1990	745,925	31,584,050	3,307,230	4.43
1991	404,511	20,522,634	1,988,627	4.92
1992	118,807	8,408,634	795,579	6.70
1993	71,574	6,524,719	595,490	8.32
1994	66,200	5,015,800	432,770	6.54
1995	93,814	8,316,827	703,623	7.50

The sea cucumber resource has been grossly overfished. The fishery peaked in 1988-90 (Table 4). Since then catch rates and sizes of all species, but particularly the most valuable ones, have fallen (Joseph 1992; Ahmed et al. 1996). A ban on the use of SCUBA diving gear for the collection of sea cucumber was introduced in 1993, but this has not been enforced. There is an urgent need for effective regulatory action to protect the remaining stock and to allow recovery. A ban on the export of sea cucumber of at least ten years duration has been recommended (MRS 1995)

The Giant Clam Fishery

An export fishery for giant clam meat (adductor muscle) aimed at the Taiwanese market started in 1990. A total of 20.0t of frozen clam meat was exported during 1990-91, which was equivalent to over 125,000 clams (MRS 1995; Ahmed et al. 1996). A survey of the resource and fishery was carried out in 1991 (Barker, 1991). There are two species of giant clam in the Maldives, *Tridacna squamosa* and *Tridacna maxima*. Despite its name *T. maxima* is a small species of no commercial value. The fishery was based entirely on *T. squamosa*. The fishery started in Raa Atoll in the north but rapidly spread to other atolls. On virgin reefs giant clam abundance was about 10 per hectare (Barker 1991). On reefs that had been fished there were either no *T. squamosa* left, or their densities had been reduced to such a low level that it was unlikely that reproduction could occur (Barker 1991). It was found that *Tridacna squamosa* lives about 15-20 years and does not reach a harvestable size until about 8 years in the Maldives (Barker 1991). Thus, initial population size and population turn over rates were low. It was clear that the fishery was progressing at a non-sustainable rate and that *T. squamosa* would be wiped out in a relatively short period of time.

Taking into account the non-sustainable nature of the fishery, the need to preserve broodstock for mariculture, and the damage done to some coral reefs by the fishery, MOFA decided to stop the fishery. This was done through the Ministry of Trade and Industries, which, in July 1991, stopped issuing licenses for the export of giant clam products, and also announced that existing export licenses would not be renewed once they had expired. From June 1995 it has also been illegal to collect giant clams (Ahmed et al. 1996).

The Grouper Fishery

Groupers have been fished at moderately low levels in the Maldives for at least two decades as part of a general reef fish fishery supplying Malé, the local resorts and low value salt dried fish export markets (Anderson et al. 1992). A specific fishery for the export of live or chilled grouper aimed at the Chinese markets of the Far East started in 1993 (Shakeel 1994 and 1996).

Grouper fishing is carried out from all types of vessels, from wind surf boards to large mechanized pole and line tuna fishing vessels. Handlines are the main gear used in the fishery. These are normally

baited with either livebait (fusiliers) or cut pieces of tuna or scads. There is no firm evidence of cyanide being used so far in the fishery, and efforts have been made to prevent its introduction. The groupers are kept alive in the flooded holds of the fishing vessels, or in small pens held alongside. On return from each days fishing, fishermen sell their catch to buyers who stock the groupers until export in large cages moored in island lagoons. Export is either by air (chilled) or by sea (live). Exports increased from less than 20t in 1993 to more than 1000t in 1995 (Table 5).

Table 5: Reported exports of groupers from the Maldives, by product category, 1993-1995.

	1993		1994		1995	
Grouper	Qty (t)	Value (MRf)	Qty (t)	Value (MRf)	Qty (t)	Value (MRf)
Live	16.7	1,575,576	108.5	4,899,200	645.8	24,527,288
Fresh chilled	---	---	76.5	1,718,200	375.6	21,694,757
Frozen	1.1	44,481	2.2	131,400	0.1	1,454
Frozen dried	---	---	34.5	939,200	---	---
TOTAL	17.8	1,620,057	221.7	7,688,000	1021.5	46,223,499

Grouper exports underestimate total catch, because there is some local consumption (mainly on tourist islands and in Malé); some export of salt dried grouper (in which form they are not recorded separately); and some wastage. It is suggested that total catch in 1995 may have been of the order of 1300t. On the basis of pre-exploitation survey data (Anderson et al. 1992), Shakeel (1994) made provisional estimates of maximum sustainable yield (MSY) of grouper by major habitat (although the limitations of the MSY concept are acknowledged) as follows:

Shallow reef areas	810 ± 370 tyr^{-1}
Atoll basins	960 ± 320 tyr^{-1}
Deep reef slopes	60 ± 15 tyr^{-1}
TOTAL MSY	1800 ± 700 tyr^{-1}

Current grouper catches may have already reached total estimated MSY, but if current trends continue catches will undoubtedly exceed the estimated MSY in the very near future. Furthermore, catches to date have been concentrated in just a few atolls (notably Vaavu, Meemu and Alifu) which have been heavily fished, and where catch rates are now reported to be much reduced. To date catches in most other atolls have been relatively low, but the fishery is now spreading.

It seems clear that the grouper fishery will not be sustainable at the present rate of expansion. Individual atolls are being overfished one by one, even though total catch has not exceeded the estimated MSY. The fishery is so profitable for the buyers that they have been able to increase prices paid to fishermen in order to maintain their interest as catch rates decline. Thus, the price paid to fishermen for one *Plectropomus* in 1993 was MRf14; in early 1996 it was MRf120-150. There is an urgent need for management action. MOFA has initiated a grouper holding cage registration scheme but returns to date are incomplete.

DISCUSSION

The Maldivian livebait and historical money cowry fisheries both thrived for hundreds of years. These two fisheries share several characteristics that would seem to have promoted this sustained utilization. In both cases the resource base appears to be very large (Anderson 1996; pers. obs.), and at least in the case of livebait stocks to have high natural mortality rates and high intrinsic rates of population increase (Dalzell 1993). As a result, high levels of fishing effort can be sustained (Gulland 1983). Also in both cases the catch has a low unit value. As a result there would be little incentive to continue fishing if catch rates declined. In the case of money cowries, despite the profits made by foreign merchants, the price paid for cowries in Maldives was always very low (Heinmann 1980). In addition, the Sultan's export monopoly may at times have helped to limit exploitation. In the case of livebait, there is no trade at all, each tuna fishing boat catching its own daily supply. Fishermen therefore attach no monetary value to livebait.

In contrast, the giant clam, sea cucumber and deepwater shark fisheries have all proved to be non-sustainable. All of these fisheries have a relatively high unit value and small resource base. The initial size of the deepwater shark stock may have been particularly small because these animals are restricted to no more than a thin ribbon of habitat encircling the country (Anderson and Ahmed 1993). In addition, deepwater sharks have a low intrinsic rate of population increase (Anderson and Ahmed 1993), and those of sea cucumbers and giant clams may not be particularly high either (Munro 1993; Preston 1993). Also, giant clams and sea cucumbers may be especially susceptible to overexploitation because they are sedentary and very easy to harvest.

The grouper and aquarium fish fisheries show characteristics intermediate between the two groups described above. However, it seems likely that while the aquarium fish fishery will prove to be sustainable, the grouper fishery will not. The species targeted by the aquarium fish fishery are mostly small, abundant and have high population turnover rates (Adam 1995 and 1996; Pyle 1993). Although average unit value is moderately high, fishing effort is limited by the high financial and technical investment required. In the case of the grouper fishery the resource base and intrinsic rates of population increase are both moderate (Shakeel 1994 and 1996; Shapiro 1987). However, unit value is high and increasing rapidly. Furthermore, the groupers' shallow habitat and voracious feeding habits, together with their site specificity, make them particularly vulnerable to overfishing (Heemstra and Randall 1993).

The relatively simple picture painted above is complicated by the fact that several of the fisheries are multi-species ones. Within a species group, stocks of those species with the highest value are likely to prove the least sustainable. In the case of sea cucumbers, the most valuable species (notably the prickly redfish *Thelenota ananas* and the white teatfish *Microthele nobilis*) were preferentially harvested, leading to rapid overexploitation (Joseph 1992). As a result, unit value of exports decreased dramatically between 1986 and 1990 (Table 4). The sea cucumber fishery now survives on the more abundant but less valuable species (notably the lollyfish *Holothuria atra*). In the case of the aquarium fish fishery, current levels of fishing effort may deplete stocks of a few species that are of particularly high value and are uncommon and/or easy to catch (e.g. the rare angelfish *Apolemichthys armitagei*, and the Maldivian anemonefish *Amphiprion nigripes*) while other species are unaffected (Adam 1996). However, in the case of the livebait fishery, where all species are of more-or-less equally low value, the multispecific nature of the fishery may promote sustainability

because fishermen will tend to target the most abundant species at any particular time or location.

Another complicating factor is that most reef fisheries are not carried out uniformly across all atolls. High fishing effort in one atoll or area may lead to local overexploitation, even though total catch and/or exports may be relatively low. To some extent this may be a historical artifact; fisheries that have been in existence for a long time may have spread to all atolls, while new fisheries will tend to be restricted to just a few atolls. Nevertheless, there are profound implications for developing fisheries. In the case of the grouper fishery, high levels of fishing effort in a few atolls appear to be leading to a situation where atolls are being overfished one by one; the whole country could be overfished before the estimated national MSY is ever reached. In the case of the aquarium fish fishery, most fishing effort is restricted to the area around Malé international airport. This results in conflict with other reef users (notably tourist divers) in this relatively congested zone, and may also lead to local overexploitation of some species. In the case of the deepwater shark, early fishing effort was concentrated in the north of the Maldives, where catch rates had fallen significantly by the mid-1980's. The rise in shark oil exports in the early 1990's can be attributed to an increase in fishing effort in the south of Maldives, where catch rates are still reasonable.

developed as a means of protecting each island's money cowries and other local resources.

A further complicating factor is that the individual fisheries discussed here do not exist in isolation. The Maldives has a relatively small population (about 250,000), and so the number of businessmen and fishermen in the country is limited. The fall in aquarium fish exports in 1995 can be attributed partly to the transfer of entrepreneurial interest to other more profitable activities. Fishermen readily transfer between fisheries (with the exception of the aquarium fish fishery) to take advantage of high returns. Thus, otherwise full-time tuna fishermen will transfer to sea cucumber or grouper fishing when tuna catches are low. Some reef resources are also of importance to the large tourism sector. Many tourists visit Maldives to snorkel or dive on the coral reefs, and object to the removal of reef animals by fishermen. The bans on exports of giant clams and Napoleon wrasse were introduced in part because of pressure from the tourist industry.

In addition, all export oriented fisheries are ultimately controlled by international prices. Most of the export oriented reef fisheries are driven by demand in the Far East, notably from Japan, Singapore, Hong Kong, Taiwan and China. If the economies of these countries continue to boom, demand for seafood products will also grow. Since many of the items exported to these markets from Maldives are essentially luxury foods, unit price will undoubtedly

Table 6: Summary of fishery resources characteristics influencing sustainability

Resource	Size of the resource base	Unit value	Intrinsic rate of population increase	Control of export	Area of exploitation	Sustainability of fisheries
Livebait	V. large	Low	High	No export	Through Maldives	SUSTAINABLE
Money Cowry	Large	Low	Moderate	Monopoly	Throughout Maldives	SUSTAINABLE
Aquarium fish	Large	High	Moderate	No control	Local, centered around International airport	SUSTAINABLE (?)
Deepwater shark	Small	High	Low	No control	Originally limited to some atolls	NON-SUSTAINABLE
Sea-cucumber	Small	High	Low	No control	Originally limited to some atolls	NON-SUSTAINABLE
Giant clam	Small	High	Low	No Control	Localized to some atolls	NON-SUSTAINABLE
Grouper	Moderate	V. high	Moderate	No Control	Localized to some atolls	NON-SUSTAINABLE (?)

In the historical money cowry fishery, harvesting of cowries was carried out by women and would have been largely limited to the shallow lagoons adjacent to inhabited islands. Therefore, although harvesting was carried out throughout the archipelago, there would have been many areas left unexploited. Species exploited in modern export oriented fisheries have no such refugia: not only are harvesting methodologies not restricted to the proximity of inhabited islands, but also mechanization of the fishing fleet in the 1970's opened the way for easy movement between atolls. Furthermore, Maldivian fishermen are free to fish in any atoll because the Maldives does not have a traditional system of reef tenure of the kinds seen in many south Pacific island nations. This is perhaps because the Maldives has traditionally been a tuna fishing nation, as a result of which most reef resources had little value. Indeed, restrictions on reef access would have been counterproductive for the tuna fishery, since the occurrence of livebait is highly variable in space and time (Anderson and Saleem 1994 and 1995). The only constraint on reef access is that the lagoon and reef immediately adjacent to an inhabited island are reserved for the use of the people of that island only. This tradition presumably

increase too. Without some form of management control, the Maldivian beche-de-mer and grouper resources are likely to be increasingly overexploited, reducing potential income to the country even as prices rise. This suggests that the limited management resources in the Maldives should be devoted to the control of the grouper fishery and the rehabilitation of the beche-de-mer fishery.

In conclusion, species with a large resource base and high intrinsic rate of natural population increase which have a low unit value and limited markets, and for which fishing effort is spread over a large area, are likely to support sustainable fisheries. In contrast, species with a small resource base and low intrinsic rate of natural population increase which have a high unit value and open markets, and for which fishing effort is concentrated but mobile, are unlikely to support sustainable fisheries.

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REFERENCES

Adam MS (1995) Review of Aquarium Fish Trade of the Maldives with Proposals for Monitoring and Regulation. Unpublished report, Marine Research Section, Ministry of Fisheries and Agriculture, Malé. 29pp.

Adam MS (1996) The Aquarium Fishery of the Maldives. Paper presented at a Workshop on Integrated Reef Resources Management held in Malé, Maldives 16-20 March 1996. IRRM/NW/02, 17pp.

Ahmed H, Mohamed S, Saleem MR (1996) Exploitation of Reef Resources: Beche-de-Mer, Reef Sharks, Giant Clams, Lobsters and Others. Paper presented at a Workshop on Integrated Reef Resources Management held in Malé, Maldives 16-20 March 1996. IRRM/NW/04, 23pp.

Anderson RC (1994) The Size of the Maldivian Tuna Livebait Fishery. Rasain (Annual Fisheries Journal of the Maldivian Ministry of Fisheries and Agriculture) 14: 208-203.

Anderson RC (1996) The Maldivian Tuna Livebait Fishery - Status and Trends. Paper presented at a Workshop on Integrated Reef Resources Management held in Malé, Maldives 16-20 March 1996. IRRM/NW/01, 20pp.

Anderson RC, Ahmed H (1993) The Shark Fisheries of the Maldives. MOFA, Malé and FAO, Rome. 73pp.

Anderson RC, Hafiz H (1988) The Maldivian Livebait Fishery. Indo- Pacific Tuna Programme, Colombo. IPTP Collective Volume of Working Documents, 3: 18-26.

Anderson RC, Saleem MR (1994) Seasonal and Regional Variations in Livebait Utilization in the Maldives. Rasain 14: 182-162.

Anderson RC, Saleem MR (1995) Interannual Variations in Livebait Utilization in the Maldives. Rasain 15: 216-193.

Anderson RC, Waheed Z, Rasheed M, Arif A (1992) Reef Fish Resources Survey in the Maldives - Phase II. Bay of Bengal Programme, Madras. BOBP/WP/80: 51pp.

Barker JR (1991) Giant Clams in the Maldives - a Stock Assessment and Study of their Potential for Culture. Bay of Bengal Programme, Madras. BOBP/WP/72. 37pp.

Dalzell P (1993) Small Pelagic Fishes. In: Wright A, Hill L (eds) Nearshore Marine Resources of the South Pacific. IPS Suva, FFA Honiara and ICOD Canada. Pp.98-133.

Edwards AJ (1988) Preliminary Report on the Aquarium Fish Export Trade in the Republic of Maldives. Unpublished report, Centre for Tropical Coastal Management Studies, University of Newcastle upon Tyne, U.K. 22pp.

Edwards AJ, Shepherd ARD (1992) Environmental Implications of Aquarium Fish Collection in the Maldives with Proposals for Regulation. Environmental Conservation 19(1): 61-72.

Gray A (1889) The Voyage of Francois Pyrard of Laval to the East Indies, the Maldives to the Moluccas and Brasil: Translated into English from the Third French Edition of 1619, and Edited with Notes by Albert Gray Assisted by HCP Bell. Vol. 2. Hakluyt Society, London.

Gulland JA (1983) Fish Stock Assessment: a Manual of Basic Methods. FAO/Wiley Series on Food and Agriculture. Vol.1. Wiley and Sons, New York. 233pp.

Heinmann J (1980) Small Change and Ballast: Cowry Trade and Usage as an Example of Indian Ocean Economic History. South Asia 3(1):48-69.

Heemstra PC, Randall JE (1993) FAO Species Catalogue, Vol. 16. Groupers of the World. (Fam: Serranidae, Subfamily: Epinephelinae). An Annotated and Illustrated Catalogue of the Groupers, Rock Cod, Hind, Coral Grouper and Lyretail Species Known to Date. FAO, Rome, 382pp.

Johnson M (1970) The Cowry Currencies of West Africa (Parts 1 and 2). Journal of African History. 11: 17-47 & 331-353.

Joseph L (1992) Review of the Beche de Mer (Sea Cucumber) Fishery in the Maldives. Bay of Bengal Programme, Madras. BOBP/WP/79. 31pp.

MRS (1995) Executive Review of the Status of Maldivian Fishery Resources, 1994-1995. Unpublished report, Marine Research Section, Ministry of Fisheries and Agriculture, Malé. 28pp.

Munro JL (1993) Giant Clams. In: Wright A, Hill L (eds) Nearshore Marine Resources of the South Pacific. IPS Suva, FFA Honiara and ICOD Canada. Pp.431-449.

Preston GL (1993) Beche-de-Mer. In: Wright A, Hill L (eds) Nearshore Marine Resources of the South Pacific. IPS Suva, FFA Honiara and ICOD Canada. Pp.371-407.

Pyle RL (1993) Marine Aquarium Fish. In: Wright A, Hill L (eds) Nearshore Marine Resources of the South Pacific. IPS Suva, FFA Honiara and ICOD Canada. Pp.135-176.

Shakeel H (1994) Study of Grouper Fishery and Live Grouper Holding Operations in the Maldives. Unpublished report, Marine Research Section, Ministry of Fisheries and Agriculture, Malé. 53pp.

Shakeel H (1996) Exploitation of Reef Resources: Grouper and Other Food Fishes. Paper presented at a Workshop on Integrated Reef Resources Management held in Malé, Maldives 16-20 March 1996. IRRM/NW/03, 16pp.

Shapiro DY (1987) Reproduction in Groupers. In: Polovina JJ, Ralston S (eds) Tropical Snappers and Groupers: Biology and Fisheries Management. Westview Press, Boulder, Colorado. Pp. 295-327.