Prices paid by tourists in shops also vary considerably. Price depends on jaw size, tooth size, species and willingness to pay. A small, ordinary set may sell for MRf 10. A large set of Mako jaws may sell for over US$ 1000. High prices are also paid for large jaws from Tiger Shark and Smailtooth Sandtiger Shark (the name 'Smalitooth' being somewhat misleading in this case).

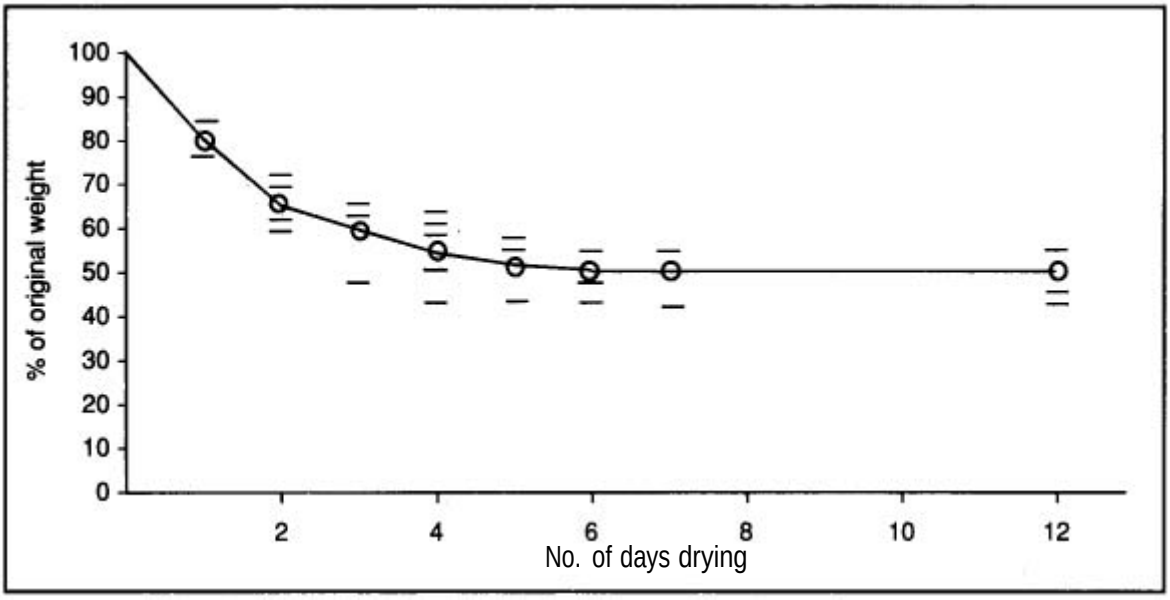
4
Shark Fishery Statistics

4.1 *Yields of shark products*

DRIED SHARK FINS

The yield of shark fins depends on several factors, including species and size of shark, type of cut and degree of drying. In order to determine weight loss due to drying, five sets of fresh shark fins were purchased from fishermen and dried to constant weight. Details are given in Figure 8. After drying, the fins weighed an average of 46 per cent of their original weight.

Fig. 8 Weight loss of fins during sun drying (n=5 sets)



There are three independent sets of data available from the Maldives relating to the yield of fins from shark. The first is from the exploratory offshore fishing survey (Anderson and Waheed, 1990). Unpublished data are available from four cruises at the end of which shark were sold to a buyer who paid for fins separately from the rest of the carcasses. The fins were removed by the buyer with an 'L-cut'. From 112 shark caught during the four trips, the average yield of wet fins was 3.18 per cent (range 3.01 - 3.56 per cent). The shark were mostly large (average weight 48kg). The main species involved was the Silky Shark (n = 96), but Oceanic Whitetip Shark (n = 15) and one Tiger Shark were also caught. The dried, fin yield is calculated as follows:

(1) Yield of dry fins = Yield of wet fins x Yield after drying
= 3.18 x 0.46 = 1.46%

The second data set is from the reef fish resources survey (Anderson *et al.,* 1992). Unpublished data on fin yield is available from one fishing trip to Laamu Atoll. Twenty small shark (average weight 5.3kg) of six species were caught. Their total weight was 111.2kg and they yielded 1.6kg of straight-cut dried fins. Thus

(2) Yield of dry fins = 1.44%

Finset of Snaggletooth Shark (Hemipristis elongatus)

Cutting up a Grey Reef Shark on deck

The third set of data was collected during this survey. Twentyone shark of eight species and a wide range of sizes (average weight 25kg) were cut up and their various components weighed (Table 9).

Table 9: Percentage weight composition of Maldivian shark

					Percentage contribution to total weight				
No.	*Species*	*L (cm)*	*Sex*	*Total weight (kg)*	*Head*	*Meat*	*Fins*	*Liver*	*Remainder*
	Nebriusferrugineus	93	F	4.3	16.5	51.8	5.8	4.7	21.2
2	"	107	F	5.6	17.9	51.9	4.3	7.2	18.7
3	"	162	M	18.8	18.1	49.1	6.1	5.3	21.4
4	C. albimarginatus	134	F	15.8	19.6	49.4	3.2	5.1	22.7
5	"	173	M	35.7	17.9	57.1	3.1	5.6	16.3
6	"	227	F	91.4	14.4	57.8	3.4	6.2	18.2
7	"	229	F	85.3	16.2	53.3	4.2	8.7	17.6
8	C. amblyrhynchos	127	M	12.2	18.0	51.7	3.3	9.0	18.0
9	"	140	F	18.0	18.9	52.2	4.4	6.7	17.8
10	"	144	F	21.0	13.8	51.4	4.3	9.5	21.0
II	*C. falciformis*	100	F	4.6	17.6	57.1	5.5	4.4	15.4
12	"	125	M	9.0	16.7	64.4	4.4	2.2	12.3
13	"	142	F	14.0	14.9	63.3	4.6	2.8	14.4
14	"	143	M	17.6	13.6	61.4	4.0	3.4	17.6
15	*C. longimanus*	167	M	25.3	15.0	60.1	8.3	5.1	11.5
16	*C. melanopterus*	114	F	8.2	14.8	61.5	2.8	8.6	12.3
17	"	118	F	10.4	15.5	59.9	3.4	4.8	16.4
18	*C. sorrah*	108	M	6.9	16.0	61.0	3.0	5.5	14.5
19	"	109	M	6.6	15.9	61.9	3.2	4.7	14.3
20	"	110	M	7.4	14.9	64.8	2.8	4.7	12.8
21	Negaprionacutidens	249	F	107.9	13.3	37.9	5.7	11.9	31.2
	Unweighted average	—	—	25.0	16.2	56.1	4.3	6.0	17.4
	Weighted average	—	—	25.0	15.4	52.4	4.5	7.5	20.2

Note: 1. All finsets comprise four fins except in the case of the 229cm *C. albimarginatus* (six fins), the *C. longimanus* (six fins) and the *N. acutidens* (eight fins).
2. Shark nos. 7, 10 and 21 contained embryos to weighing 0.9kg, 1.1 kg and 10.4 kg respectively.

Of these shark, three were Nurse Shark which do not yield exportable fins. The remaining 18 shark yielded an average of 4.5 per cent of wet fins. These fins were round cut with meat on, by fishermen interested in maximizing weight. Such fins have to be trimmed to an 'L-cut' by Male buyers before exporting. Weight loss during trimming is substantial. Commercial data shows that the average loss is about 33 per cent. However, for the five sets of fins (from this sample of 18) that were used to estimate weight loss during drying, the further weight loss during trimming was 31 per cent.

Thus:

(3) Yield of dry fins = Yield of wet fins x Yield after drying x Yield after trimming

= 4.5 x0.46 x 0.69 = 1.43%

The three estimates of dry fin yield from Maldivian shark are in remarkably good agreement. It is, therefore, suggested that the average yield of dried fins from Maldivian shark is about 1.44 per cent.

DRIED SHARK MEAT

The weighted average yield of fresh shark meat according to Table 9 is 52.4 per cent, the unweighted average 56.1 per cent. The difference is largely due to the presence of several small but high-yielding shark *(C. falciformis* and *C. sorrah)* and one very large but low-yielding shark *(N. acutidens)* in the sample. As a first approximation it is suggested that the average yield of fresh meat from Maldivian shark is 54 per cent.

In order to determine weight loss during processing, two pieces of shark meat (7.1kg and 4.5kg, fresh weight) were weighed daily during salting and drying. After two days salting and seven days drying the larger piece was reduced to 58 per cent of its original weight, while the smaller piece was reduced to 49 per cent. The larger piece of meat was rather thick, and the drying it received was thought to be slightly inadequate. As a first approximation it is therefore suggested that the average weight loss during salting and drying is 50 per cent. Therefore:

Yield of salt dried shark meat = 54 x *0.5*
= 27%

SPINY DOGFISH OIL

Due to poor weather during much of the survey period there was very little deepwater shark fishing. As a result, only seven Gulper Shark *(Centrophorus)* were caught. Details are as follows

Catch	*No.shark*	*Shark weight (kg)*	*Liver weight (kg)*	*Liver oil(l)*	*Oilyield (l/kg)*
a	I	4.0	0.94	0.95	0.238
b	5	82.1	23.2	22.5	0.274
	I	19.5	5.1	4.7	0.241
Total	7	105.6	29.24	28.15	0.267

Thus, the average yield is about 0.267 litres/kg, which is equivalent to about 0.23kg oil/kg shark (with a conversion factor of 1 litre oil = 0.85 kg). Liver weight averaged 27.8 per cent of body weight, slightly more than the 23.3 per cent noted for *Centrophorus* from Taiwan by Wu *et al.,* (1980).

4.2 *Shark product exports*

There are three major shark products that are exported from the Maldives: dried shark fins, salt dried shark meat, and squalene-rich shark oil. Separate export statistics are maintained by the Customs Department for shark fins (see Table 4) and shark oil-(see Table 7). Shark meat exports are lumped with reef fish exports under "salt dried reef fish". Note that only shark meat from "shallow water" reef and oceanic shark is exported; the meat from deep water shark is very soft and/or oily and is unsuitable for salt-drying. The quantity of shark meat exports can be estimated in one of two ways.

First, knowing the average yield of dried fins, the total catch can be estimated. The yield of dried shark meat can then be estimated using the appropriate conversion factor. However, it should be noted that fins are not taken from some shark *(e.g.* Nurse Shark, nor from very small individuals), and that small quantities of fins might be lost or spoilt during processing. The quantities involved are thought to be very small and on the basis of field observations are thought to amount to about 2 per cent of the total. Thus, for 1991

Total dried shark fin exports = 18.726 t
Dried fin yield = 1.44%
Shark catch yielding fins = (18.726 x 100)/1.44
= 1300t
Total shark catch = 1300 x 1.02
= l326t
Dried shark meat yield = 1326 x 0.27
= 358t

Dried shark meat exports can be estimated in a second way, using the export invoices held by the Customs Department of private sea food trading companies. Not all exporting companies record dried shark meat separately from reef fish in their export invoices. However, a review of the 1991 records reveals the following information from ten exporting companies

	Quantify **(t)**	*Value ('000 US$)*
Salt-dried shark meat	200	287
Salt-dried reef fish	636	713
Total salt-dried fish	836	1000
Percentage shark	24%	29%

836t was 62 per cent of the total 'salt-dried reef fish' exports in 1991(1340t). Assuming that the value of 24 per cent shark is representative

Total dried shark exports in 1991 = 1340 x 0.24
= 322t

The difference between the two estimates is about 10 per cent. This is not very much considering the as.sumptions made and approximate nature of some of the conversion factors used. In fact, the first estimate (358t) is of total potential production, and so it should be greater than the second estimate (322t) which is of actual exports. The reasons for the difference include the following

- **There is a little local consumption of shark meat in the Maldives. A** few resorts offer 'shark steaks' in their restaurants; fresh shark meat is sold in Male fish market, almost entirely to expatriates; salt-dried shark meat is sold in Male dried fish market, mainly to Shri Lankans.

- **There** is some, **but very limited, 'finning' of shark,** i.e. taking the fins and discarding the carcass. Fishermen in Addu Atoll report doing this sometimes because of difficulties in marketing salt-dried meat. It may also happen elsewhere on rare occasions, when processing the meat is a problem.

- A limited quantity of meat is spoilt during processing and so is not exported.

It should be emphasized that these three factors are all relatively minor and, together, probably amount to no more than 10 per cent of the shark catch. Thus, the two estimates are, in fact, in very good agreement, which suggests that the conversion factors used and assumptions made are appropriate. Since detailed export invoices are not available for all years, and are, in any case, extremely laborious to compile, salt-dried shark meat exports for years prior to 1991 are estimated solely from dried shark fin export quantities (Table 10) using the following relationship

Salt-dried shark meat exports = 0.27 x 0.9 (shark fin exports x 100/1.44 x 0.98)

= 17.22 x shark fin exports

where 0.27 = yield of dried salt meat from fresh shark

0.9 = proportion of shark catch that yields exported meat

0.98 = proportion of shark catch that yields exported fins

1.44 = percentage yield of dried fins from fresh shark

It should be noted that this approach assumes that the conditions in 1991 applied in earlier years too. This might not be the case. For example, as fin prices have increased (Table 4), it is likely that fins are being taken from smaller and smaller shark, and that the incidence of 'finning' may have increased. In addition, local consumption of shark meat is likely to have increased; it certainly has done in Male. HOwever, these are probably relatively minor effects.

The export values of salt-dried meat can be estimated knowing the total export value of the 'salted dried reef fish' Customs category (Table 11); the ratio of shark to true reef fish in that category (Table 10); and the relative values of the two products. From the export invoice data summarized above, salt-dried shark meat is estimated to be worth 30 per cent more per kilo than salt-dried reef fish. This price differential is consistent with that between STO's shark meat and dried reef fish purchasing prices over the last decade (MOFA, 1989, 1992), and so is used as a first approximation in the calculation of export values of these two products (Table 11).

Estimates of shark meat exports (quantity, value and unit value) are summarizel in Table 6. Total values of shark product exports are summarized in Table 12. Note the erratic increase in export earnings from shark products over the last decade. Despite this increase, the contribution of shark products to the total export earnings of fisheries products (Table 13) has actually decreased over the same period: shark products brought in 15 per cent of all fisheries export earnings in 1982, but only 3 per cent in 1991. The enormous growth of export earnings from the existing tuna fishery, and the development of a new Sea Cucumber fishery are largely responsible for this relative decline in the importance of shark exports.

Table 10: Estimation of total shallow-water shark catches and salt-dried shark meat exports. (All figures in metric tonnes(t))

(A) Year	(B) Exports of dried shark fins	(C) Estimated shark catch	(D) Estimated dried shark meat exports	(E) Total 'salted dried reef fish' exports	(F) Estimated Export of actual salt-dried reef fish
1979	19,260	1364	332	N/A	N/A
1980	27,702	1962	477	1590	1113
1981	15,374	1089	265	1032	767
1982	19,988	1416	344	1320	976
1983	17,403	1233	300	1151	851
1984	10,600	751	182	683	501
1985	20,785	1472	358	1895	1537
1986	18,434	1306	317	1671	1354
1987	24,383	1727	420	1440	1020
1988	15,576	1103	268	582	314
1989	13,094	927	225	627	402
1990	17,826	1263	307	751	444
1991	18,726	1326	322	1340	1018

Sowre: Columns B and E are from Customs export statistics Column C = B x 70.83 *(i.e.* 1.02B x 100/1.44)
ColumnD = Cx 0.243(i.e.0.9C x 0.27) ColumnF = E-D

Table 11: Estimated export values of dried salted shark meat and salted dried reef fish. ('000 MRf)

Year	Shark meat value	Reeffish value	Total
1980	1247	2237	3484
1981	844	1879	2723
1982	1341	2927	4268
	1459		
1985	2328	7687	10015
1986	2331	7658	9989
1987	3428	6404	9832
1988	2280	2054	4334
1989	2002	2752	4754
1990	2959	3291	6250
1991	4073	9904	13977

Note: 'Total' value refers to category 'salted dried reef fish' as collected by Customs and compiled by MOFA. This category in fact includes salt-dried shark meat as well as salt-dried reef fish. Values of these two categories are apportioned as described in the test.

Table 12: Export value **of shark products ('000** MRf)

Year	Dried fins	Liver oil	Salted dried meat	Total
1980	1363	60	1247	2670
1981	889	349	844	2082
1982	1373	1106	1341	3820
1983	1887	1796	1459	5142
1984	1015	2412	868	4295
1985	2103	1891	2328	6322
1986	2346	1242	2331	5919
1987	5925	1040	3428	10393
1988	5105	641	2280	8026
1989	3856	724	2002	6582
1990	1799	1203	2959	5961
1991	6183	1815	4073	12071

Table 13: Declared **FOB export** values **of major fisheries products ('000,000** MRf)

Year	Tuna	Shark	Reeffish	Sea cucumber	Aquarium fish	Others	Total
1980	21.8	2.7	2.2	—	0.2	1.9	2&8
1981	23.3	2J	1.9	—	0.2	0.3	27.8
1982	17.6	3.8	2.9	—	0.2	0.7	25.2
1983	38J	5.1	3.2	—	**0.4**	**2.8**	**49.6**
1984	66.9	4.3	**1.8**	—	**0.3**	**0.8**	**74.1**
1985	95.0	**6.3**	*1.7*	**0.0**	**0.6**	**0.6**	**110.2**
1986	98.1	5.9	**7.8**	**0.2**	**0.8**	**0.7**	**113.5**
1987	**151.5**	**10.4**	**6.5**	**3.1**	**0.9**	**0.1**	**172.5**
1988	**211.8**	**8.0**	**2.0**	39.5	**1.6**	**0.1**	263.0
1989	279.1	6.6	2.7	15.8	1.3	5.2	310.7
1990	318.1	6.0	3.2	31.6	1.3	1.2	361.4
1991	331.4	12J	99	20.5	3.5	1.6	379.0

Source: Customs data compiled by **MOFA**

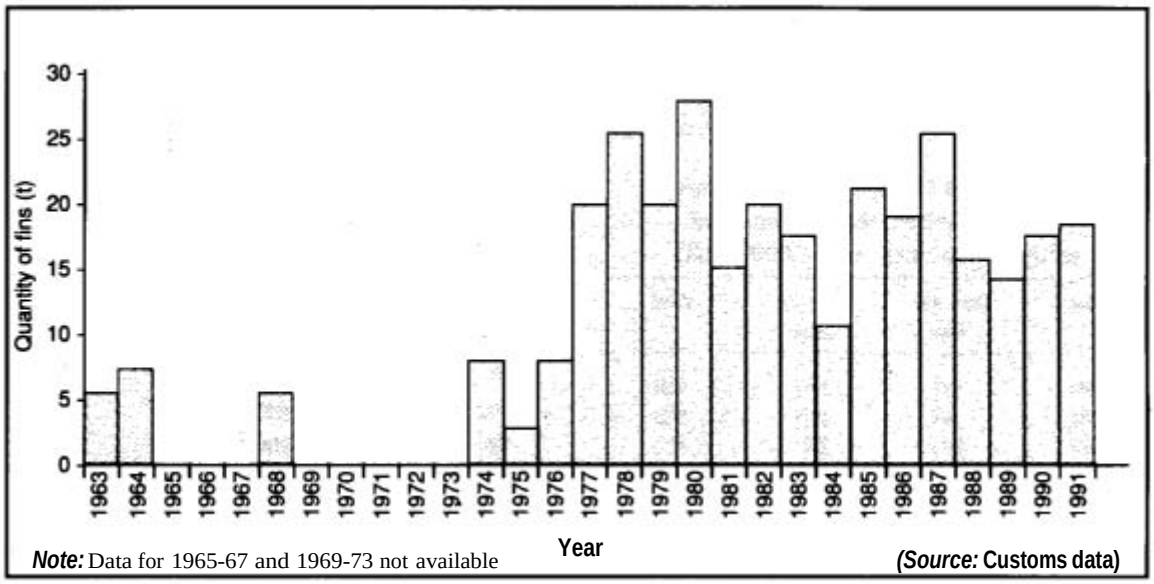
Notes: 1. Customscategory'SaltedDriedReefFish' containsbothsharkmeatandreeffishandhasbeendividedasexplainedinthetext.
2. Numbers may not add up **due to rounding** off.

4.3 Shark catches

OCEANIC AND ATOLL-ASSOCIATED SHARK

As pointed out in the previous section, dried shark fin export figures can be used to estimate the total catches of shark from the reef shark and oceanic shark fisheries combined. Estimates of the total shark catches by these two fisheries for the years 1979 to 1991 are presented in Table 10. Since dried shark fin exports are assumed to be directly related to the size of the 'shallow water' shark fisheries, Figure 9 provides a useful picture of the relative size of these combined fisheries over the last three decades.

Fig. 9. Annual exports (tonnes) of dried shark fins from the Maldives



Note: Data for 1965-67 and 1969-73 not available *(Source:* Customs data)

Prior to 1977, shark catches were relatively low. For the years for which data are available, shark catches appear to have averaged about 460t/yr. **In** 1977 there was a sudden increase in shark fin exports. This is believed to be attributable to three factors

- Introduction **of** gillnetting. This followed Maldivian fishermen finding pieces of drifting gillnet from other countries. After some experimentation in local lagoons, these fishermen were able to adapt the nets for bottomset reef shark fishing, and soon learnt to make their own nets. Shark net fishermen interviewed in 1992 usually said that this fishery started **"about** 15 years **ago",** although **a few said it** started earlier, while others said it was later. The activities of a foreign fishing and fish exporting company (ICP Bangkok), which operated in Ari Atoll during 1976-1979, may also have assisted this development.

- Motorization **of the** ***masdhoni*** fleet. This started in 1974 and was well established by 1977 (Anderson, 1987). Motorization allowed more efficient longlining, and may well have been **a** necessary condition for the successful adoption of shark gillnetting.

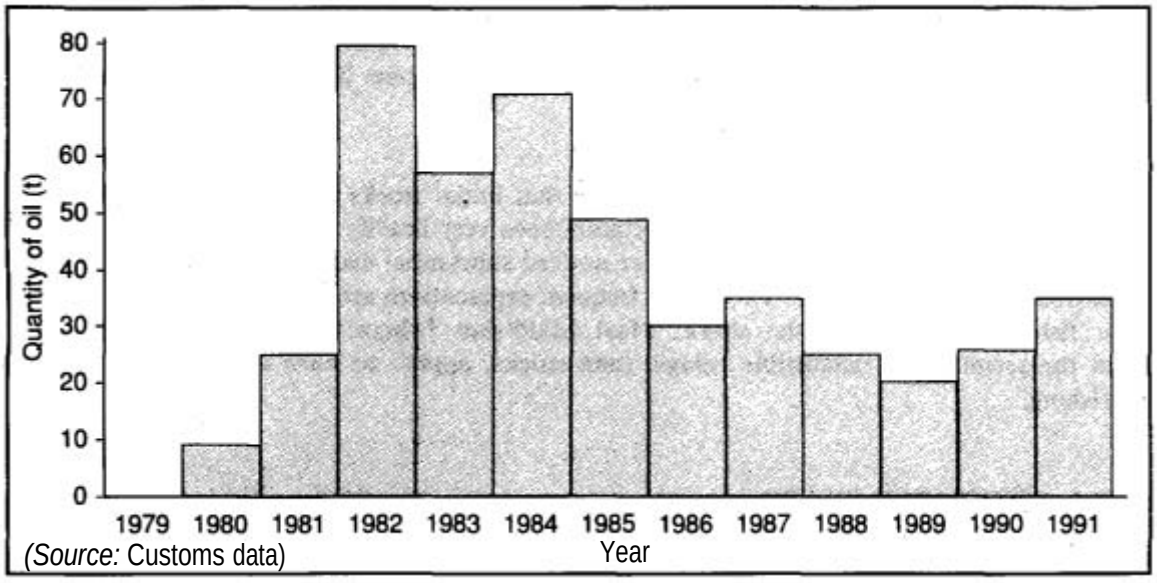
- **Price Increase. The price paid for** shark fins increased substantially in 1976 (see Table 4), **presumably encouraging more fishermen to go shark fishing.**

The average annual **shark catch since 1977 has been about 1340t/yr. There** has **been considerable variation about** this **average value, but without** any **obvious trend (see Figure 9). There is a suggestion that shark catches might have declined since 1977-80, but the data are too variable for** any certainty **about this.**

DEEPWATER BENTHIC SHARK

If it is assumed that the exports of high-value shark liver oil (see Table 7, Figure 10) are directly related to the size of the catch of Gulper Shark, then oil exports can be used to estimate shark catches. These peaked at about 330t/yr in 1981, declining to a low of about 70t/yr in 1989, since when there has been a slight increase again.

Fig. 10. Annual exports (tonnes) of high-value shark liver oil from the Maldives.



(Source: Customs data)

Only squalene-rich oil is exported. Therefore these catch estimates apply only to shark (notably Gulper Shark) which yield squalene-rich oil. Other deepwater shark (notably Bluntnose Sixgill Shark) are not included in these estimates. At present there is insufficient data to estimate the size of the non-squalene shark catch. AU that is known is that out of four sampled landings, totalling 12 shark, ten were *Centrophorus* and two were 'non-squalene' shark.

5
Status of Stocks

There are three major Maldivian shark fisheries, based on three major shark resources, namely

- the offshore pelagic shark,
- the atoll-associated shark, and
- the deepwater benthic shark.

All three are multispecies fisheries. No catch and effort data are available. It is, therefore, impossible to make a rigorous assessment of stock status. Nevertheless, some useful insights can be obtained from export data and anecdotal evidence.

DEEPWATER BENTHIC SHARK

Deepwater shark stocks appear to be fished very heavily, and have probably been overfished, at least in some areas. The fishery for Bluntnose Sixgill Shark *(madu miyaru keyolhu kan)* was probably carried on for centuries, but with a low level of fishing effort. The fishery for deepwater Gulper Shark *(kashi miyaru keyolhu kan)* started in 1980, but expanded rapidly, peaking in 1982-84, since when oil exports have declined (Table 7, Figure 10). Fishermen consistently report that catch rates are now very much lower than before, and that they have to fish much deeper than before. These trends appear to be most marked in the north Maldives, where this fishery started and fishing effort has been greatest. However, they are also reported from the south. The upturn in shark liver oil exports in 1990-91 (Figure 10) is attributed, in part, to a rise in prices – encouraging further fishing in already heavily fished areas – and partly to an expansion of fishing effort in the south.

There are two further factors of relevance to this consideration of the status of deepwater benthic shark stocks

- Because they live in a cold and, possibly, food-limited environment, deepwater shark may have slower-than-average growth and reproduction rates, making them potentially even more prone to overfishing than shallow water shark.

- In the Maldives, the deepwater shark appear to be confined to the deep outer atoll slopes. This is little more than a thin ribbon of habitat encircling the country. The total area of this habitat is likely to be quite small, thus putting an upper limit on the initial size of the deepwater shark stocks.

What little evidence there is, therefore, suggests that initial stocks of deepwater Gulper Shark were not very large, and that these have certainly been very heavily fished, if not overfished. It is worth noting that although fishermen have noticed substantial declines in catch rates, they do not attribute this to overfishing. Their most frequent explanations are inadequate baiting, and too much fishing "disturbing" the shark. Most Maldivian fishermen, who have traditionally fished the seemingly inexhaustible pelagic tuna stocks, appear to have almost no concept of overfishing.

ATOLL-ASSOCIATED SHARK

Reef shark and other atoll-associated shark are fished by gilinet, handline and longline. Fishermen report somewhat lowered catch rates by gillnet over the last 15 years in the most heavily fished areas. There is a suggestion of a slight decline over the same period in dried shark fin exports (Figure 9), to which gillnet catches contribute. A minority of diving instructors report reductions in the numbers of reef shark at some dive sites over the last few years. This is little enough evidence to go on, but it does suggest that reef shark are being fished at a moderate level of fishing effort, which is probably sustainable, but that an increase in fishing effort would adversely effect stocks.

PELAGIC SHARK

The exports of dried shark fins come from both the pelagic (oceanic) and atoll-associated shark fisheries. While they provide some measure of the size of the two fisheries combined, export data do not provide any information about their relative sizes. It is, therefore, difficult to say much about pelagic shark catches. However, there has been little obvious trend in shark fin exports over the last 10-15 years, and if there has been a trend it is a decline that can be explained by reduced atoll shark catches. It seems likely that pelagic shark catches have not changed dramatically over this period.

The latest survey revealed that fishing effort on pelagic shark is relatively low, and also that it does not appear to have changed much over the last 10-15 years. These observations are consistent with the reports of fishermen who say that there have been no obvious changes in longline catch rates of pelagic shark. Taking into account the fact that oceanic shark stocks are likely to be relatively large, it is concluded that pelqgic shark stocks in Maldivian waters are underutilized, and that there is scope for increasing fishing effort on these resources.

It should be noted, however, that even pelagic shark stocks can be overfished (Bedford, 1987; Casey *et* al., 1992). This applies to the 'nearshore' pelagic shark such as the Bignose Shark and, perhaps, the Scalloped Hammerhead, the initial stock sizes of which may be limited by the relatively small size of their habitat. It also applies to the 'offshore' pelagic shark which, although they may have large initial stock sizes, are wide-ranging and, therefore, potentially subject to fishing effort by several fisheries. Pelagic shark are already heavily fished by Far Eastern longliners and Shri Lankan gillnet-cum-longliners in the Indian Ocean.

Fishermen from B.Dhonfanu and N. Manadhoo between them may take less than twenty Whale Shark a year nowadays. The catch for the whole of the Maldives is unknown, but may be less than thirty Whale Shark a year. Fishermen from B. Dhonfanu report that, ten years ago, Whale Shark were more common and they themselves would take about thirty a year.

The Whale Shark is undoubtedly rare in the Maldives, as it is elsewhere. Silas (1986) considered the Whale Shark to be vulnerable in Indian waters. Casey etal. , (1992) considered the Whale Shark to be at potential risk from pelagic fisheries. IUCN (1990) lists the Whale Shark as endangered, vulnerable or rare, but lacks sufficient information to say which of the three categories is most appropriate. Given the international concern about the status of the Whale Shark, it may be appropriate to consider the banning of all fishing for this species in Maldivian waters. The following factors could be borne in mind:

- The existing fishery is not very valuable in monetary terms. Meat and fins are not used. Fishermen report taking 100-200 litres of oil per shark. The oil is rarely sold, but has a nominal value of about 10 MRf/litre. Thus, each shark is worth about MRf 1500, and the entire fishery no more than MRf 45,000 *(i.e.* about US $ 4000). This is, in fact, a somewhat inflated estimate, as fishermen from B. Dhonfanu and N. Manadhoo could buy fish oil from the cannery at Lh. Felivaru at 3.50 MRf/litre if Whale Shark oil were not available. Using this figure, the total monetary value of the fishery may be less than US $1500 a year.
- Although the fishery is not very significant in monetary terms, the removal of thirty Whale Shark a year may have a significant impact on the local population.
- Many tuna fishermen state that Whale Shark often aggregate tuna schools, making it easy to catch the tuna. The association between Whale Shark and tuna is well known in other areas *(e.g.* Silas, 1986; Au, 1991).
- Whale Shark are a significant attraction for tourists.

6
Sharks and Tourism

6.1 *Background*

Tourism is the largest contributor to GDP in the Maldives and is a major contributor to Government revenue (MPE, 1992). Furthermore, the importance of tourism continues to increase, with 1992 bringing record numbers of tourist arrivals.

While the peaceful tropical island environment is a major attraction, so too is the marine environment. It is estimated that some 80 per cent of all tourists go snorkelling while in the Maldives, and that some 30-35 per cent of all tourists go diving *(source:* MATI and SAM). There are now some 70 island resorts, most of which have diving bases, and numerous 'safari' boats, many of which take divers out either part-time or full-time. For divers, the major attraction of the Maldives (over and above the warm, clear waters and rich coral reefs) is big fish, particularly Manta Ray and shark.

Shark in the Maldives do not have the exaggerated man-eating reputation that they have in some other countries. Although there are a few known cases of fishermen being bitten by shark during the course of their fishing activities, there are no recorded incidents of unprovoked attacks on tourist snorkellers or divers. As a result, shark-watching by divers has become a major activity in the

Maldives. It has been described as the "ultimate thrill" for many divers. There are three main shark species involved:

- Grey Reef Shark *(Carcharchinus amblyrhynchos).* This is a powerful, impressive looking animal which occurs in groups at specific sites, often near channel entrances. A close encounter with ten or more adult Grey Reef Shark is a thrilling experience for most people. These sharks are normally very shy, but some diving instructors, particularly in the past, have fed them so that they will readily approach divers. The best known sites for divers to see Grey Reef Shark are Fish Head (properly Mushimasmingili Thila) in Ari Atoll and Lion's Head in North Male Atoll. These two sites have shark resident year-round. Other sites in channels tend to have shark present at reasonable depths and in good numbers only when the current is onshore. Thus, Miyaru Kandu, Guraidhoo Channel and Emboodhoo Channel are good for Grey Reef Shark-watching only during the Northeast Monsoon season. On the other hand, Kuda Boli and Rasfari are best during the Southwest Monsoon season. (See Figure 19 for location map). It is most often mature females that come up to investigate divers; males and juveniles tend to stay deeper.

- Whitetip Reef Shark *(Triaenodon obesus).* One, two or, occasionally, more Whitetip Reef Shark can be seen at many Maldivian dive sites. This is a small species, not nearly as impressive as the Grey Reef Shark, but its widespread distribution means that it is probably seen more often and by more divers than any other shark species.

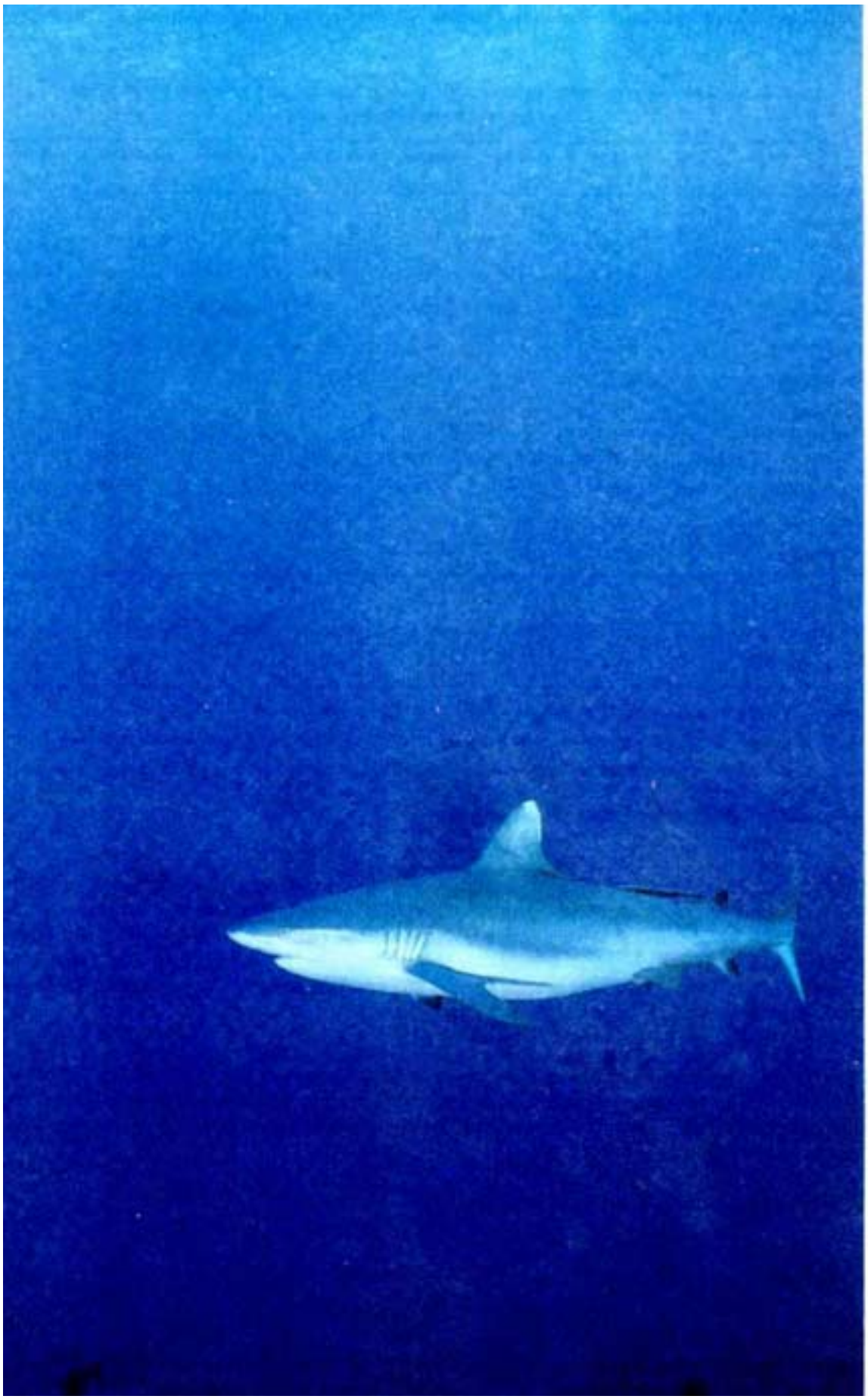
- **Scalloped Hammerhead Shark** *(Sphyrna lewini).* There are a few sites where Hammerhead are sometimes seen, but the major attraction for divers is the more-or-less permanent school of Scalloped Hammerhead at Rasdhoo Atoll. Dozens, or even hundreds, of these large shark can be seen very early in the morning off the reef outside Madivaru (Figure 19).

Other species that are seen occasionally include the Blacktip Reef Shark *(Carcharhinus melanopterus),* the Tawny Nurse Shark *(Nebrius ferugineus),* the Variegated Shark *(Stegostoma fasciatum),* the Silvertip Shark *(Carcharhinus albimarginatus)* and, very rarely, the Whale Shark *(Rhincodon typus).*

6.2 *Revenue from shark-watching*

The ability of diving tour operators to guarantee safe but exciting shark-watching in the Maldives is undoubtedly a major selling point. However, putting a monetary value on shark-watching is far from straightforward. Shark are only a part of the overall Maldives dive package. White sand beaches, sunshine, palm trees, clear water and colourful reef fish are also important. Assigning separate monetary values to all these components is clearly impossible. Nevertheless, as a first approximation the revenue generated from divers visiting specific shark-watching sites can be roughly estimated.

Interviews with 32 experienced diving instructors produced a list of 35 diving sites that are visited specifically to watch shark. Seven of these sites are used regularly by at least five of the instructors interviewed. Twentyseven sites are used regularly by only one or two of the instructors interviewed. One intermediate site (Banana Reef in North Male Atoll) was mentioned by four instructors, but this reef is frequented as much, or more, for its underwater scenery and reef fish



Grey Reef Shark as seen by divers in the Maldives

as for its shark. The average number of dives made at each of the seven most 'popular' shark-watching sites was estimated from information supplied by the diving instructors (Table 14)

Table 14: ApproxImate estimates of diving **activity and revenue ('000 US$) at major shark-watching sites**

	Fish Head	*Maaya Thila*	*Madivaru*	*Lion's Head*	*Guraidhoo Channel*	*Kuda Faru*	*Rasfari*
High season (Dec-April, 151 days)							
No. boats/day	7(3-15)	3(1-5)	1.5(0-4)	3(1-8)	3(0-5)	2(1-4)	—
No. divers/boat	15(8-20)	12(8-20)	12(8-15)	12(7-20)	10(6-14)	10(8-16)	—
No. dives/day	105	36	18	36	30	20 x 0.5	—
No. dives/season	15855	5436	2718	5436	4530	1510	—
Low Season (May-Nov. 214 days)							
No. boats/day	3(0-5)	1(0-3)	1(0-2)	1(0-4)	—	2(0-3)	1(0-3)
No. divers/boat	10(4-16)	10(4-16)	8(2-12)	8(4-20)	—	8(6-12)	10(4-17)
No. dives/day	30	10	8	8	—	16 x 0.5	10
No. dives/season	6420	2140	1712	1712	—	1712	2140
Total							
No. dives/year*	22275	7576	4430	7148	4530	3222	2140
Revenue/year	670	230	130	210	130	100	60

Note: 1. The estimated mean numbers of boats and divers is given, followed by the ranges in parentheses.

2. Guraidhoo Channel is good for shark-watching in the high season only; Rasfari has a good shark population only in the low season.

3. Kuda Faru is not just a shark-watching site; the number of shark-watching dives is considered to be equal to half of all dives made there.

* No. shark-watching dives at 7 sites = 51,300 per year.

It is stressed that there is considerable variation in site usage from day to day, depending on weather, current, client numbers, shark numbers etc. Therefore, averages are hard to determine and these figures must be considered as very rough approximations only. They do, however, clearly show the importance of Fish Head as a major shark-watching site, as well as of Maaya Thila, Lion's Head and Madivaru. Kuda Faru is undoubtedly an important site too, but it is visited for its coral and reef fish as well as its shark.

The annual average number of shark-watching dives at the remaining sites is also difficult to estimate accurately. As a first approximation, it is assumed that each site has shark present for only half the year; each site is visited by one boat with ten divers a day; only half of the dives made at each site are specifically to see shark. Thus

No. shark-watching dives at 28 sites = 28 x 0.5 x 10 x 365 x *0.5*
= *25,550* per year

No. shark-watching dives at *35* sites = *25,550* + 51,300
= 76,850 per year

MAT! and SAM (pers. comm.) estimate that about 500,000 dives are made annually in the Maldives. If about 77,000 of these are shark-watching dives, this implies that the average diver making two dives per day will make at least two shark-watching dives per week. This appears to be a reasonable figure.

The average cost of a dive varies between operators and also depends on what kind of package the diver is on. However, US $ 30 is the rough average cost for a dive including boat trip. Thus

Estimated direct revenue from shark-watching dives = 30 x *76,850*
= US $ 2.3 million/yr

6.3 *Shark-watching and shark-fishing*

Whatever the inadequacies of the above analysis, it is clear that diving operators have a considerable financial interest in the maintenance of healthy reef shark stocks. It is not surprising, therefore, that diving operators have made vigorous protests on occasions when they have seen fishermen operating at popular dive sites. Particular cases have involved alleged incidents of net fishing at both Fish Head anà Lion's Head, and handlining at several sites.

From early February to late June 1992 there were no shark at Fish Head, which caused considerable concern among diving operators. Many suspected at the time that the shark had been caught by fishermen. However, the same shark did return after *4-5* months. The shark at Fish Head do seem to disappear for a few weeks every year some time between February and May, perhaps for breeding. In retrospect, it seems that the disappearance in early 1992 was just a longer version of this annual phenomenon. Nevertheless, considerable concern remains about the potential damage that could result from uncontrolled reef shark fishing at the most popular shark-watching dive sites.

Various parties have called for a ban on all shark-fishing in the Maldives, a ban on shark-netting and, more realistically, a ban on fishing at these sites.

There is a little doubt that a Grey Reef Shark is worth very much more alive at a popular dive site than dead on a fishing ***dhoni.*** If we assume that there are twenty mature shark that are regularly seen by divers at Fish Head *(i.e.* excluding the smaller shark that are normally out of sight), then the value of each shark can be roughly estimated as

One living Grey Reef Shark = Shark-watching revenue/20
= 670,000/20
= US $ 33,500 per year at Fish Head

Making similar assumptions for the country as a whole we have

One living Grey Reef Shark = (Total revenue/20)/35 sites
= US $ 3300 per year

The value of dead Grey Reef Shark can also be estimated. Assuming a very large mature shark weighing 30 kg, the proportions noted in Table 9, the product yields noted in Section 4.1, and the prices noted in Section 3.6, then

Yield of salt dried meat = 30 x 0.52 x *0.5*
= 7.8kg
Value of salt dried meat = 7.8 x 12
= MRf94
Weight of dried fins = 30 x 0.044 x 0.46
= 0.6kg
Value of dried fins = 0.6 x 400
= MRf240
Nominal value of jaws = MRf 10
Nominal value of liver oil = MRf 10
Total value of dead shark = MRf 354
= US $ 32 appx.

In round figures, one Grey Reef Shark may be worth 100 times more alive at a dive site than dead on a fishing boat. At the most popular shark-watching site (Fish Head), it may be worth 1000 times more alive than dead. These are annual values. Since Grey Reef Shark may live to at least 18 years (Radtke and Cailliet, 1983) and these shark in the Maldives may stay for several years at the same site, their cumulative value may, in fact, be several times greater.

The total estimated direct revenue from shark-watching (US $ 2.3 million) is twice as great as the total export earnings from all three major shark fisheries (US $ 1.17 million, ref. Tables 12 and 13). If it is assumed that the oceanic shark fishery and the reef shark fishery each contribute 50 per cent to the export of fins and salt-dried shark meat, then each of these fisheries was worth about MRf 5.1 million (US $ 0.5 million) in 1991. The catch of reef shark for the entire country is, thus, roughly estimated to be worth less than one quater of the revenue generated by shark-watching in the tourism zone. Once again, it must be stressed that these figures may not be particularly accurate. **They** are **simply intended to show the order of magnitude of the difference** between the values **of one** resource **exploited in two different** ways. Nevertheless, these results are comparable to findings from elsewhere. For example, DiSilvestro (1991) shows that a living elephant in Kenya may be worth US $ 900,000 over its lifetime in terms of income from tourists. The ivory from an average elephant was worth about US $ 1000 to poachers before the international ban on the ivory trade in January 1990.

It is important, however, to consider not only how much money is being generated, but also whom it benefits. Fishermen are among the least well off members of Maldivian society, and rely directly on their catches for their income. They would not benefit directly from any restrictions on reef shark fishing.

This is not to say that they do not benefit both directly and indirectly from diving activity in the Maldives. For example, an average of about US $ 8 from every US $ 30 spent on a dive goes on the cost of the boat. The boat may be owned or chartered by the resort. In either case, it provides employment for crew who might otherwise be working as fishermen. As a case in point, between July 1991 and August 1992, seven of 19 *dhonis* from A. Dungati left shark fishing to take employment at newly-opened resorts nearby.

The diving school also provides employment for Maldivians, as does the resort in other departments. The diving school pays import duty on all diving equipment. The resort pays bed tax, import duties and, in some cases, lease fees to the Government. Diving, thus, directly and indirectly, contributes significantly to Government revenue, a major proportion of which is directed to health, education and other social development programmes. Fishermen and their families do, therefore, benefit indirectly from diving.

Although an estimated US $2.3 million is generated annually in direct shark-watching dive income, some of this income would presumably have bten spent on diving even if there were no shark in the Maldives. Therefore, a final factor to be considered is whether or not a significant drop in reef shark numbers would adversely affect diving tourist arrivals. There is, of course, no way of knowing for sure, but most diving instructors agree that it would cause a drop in diver arrivals. They note the number of divers who return to the Maldives specifically for shark-watching; the disappointment of divers who do not see the expected numbers of shark on particular dives or during their holiday as a whole; and the many other diving destinations internationally that do not have nearly so many shark as the Maldives but are cheaper and more accessible. This last is an important point.

The Maldives currently has a competitive advantage over many other diving destinations because of the abundance of its fish and shark life. This is in large part due to the lack of spearfishing and reef fishing. If major reef fish and reef shark fisheries are not developed, then this advantage will be retained, or even extended, if other countries overfish their reefs.

6.4 Night fishing

Many resorts offer night fishing excursions for their guests. With new East Asian tourist markets being tapped, night fishing, with simple single hook handlines, has become especially popular in the last year or so. Small shark are sometimes caught. They are sometimes released, but they are also often killed and brought back to the resort where, normally, no use is made of them. This waste could be avoided if guests were encouraged or instructed to return all shark to the sea alive. Returning the shark alive would allow the possibility of them being

- caught again by tourists;
- caught by commercial fishermen;
- seen underwater by divers; and/or
- growing to maturity and reproducing.

7
Interactions between Fisheries

7.1 *Pelagic shark and tuna-fishing*

Tuna-fishing is the most important fisheries activity in the Maldives. Oceanic shark, particularly Silky Shark, regularly associate with tuna schools. This behaviour is well documented in other tuna-fishing areas *(e.g.* **Au,** 1991). Juvenile Silky Shark *(oivaali miyaru)* associate with tuna under floating objects; adults *(ainumathi miyaru)* associate with free swimming schools.

It is almost universally accepted among Maldivian fishermen (most of whom have at least some experience of both tuna and shark fishing) that taking shark from tuna schools disturbs the tuna, causing them to stop feeding and to go deep or disperse. Many fishermen further believe that tuna are actively led by large shark, and that removing the shark can have a long-term adverse effect on tuna-fishing. Since pelagic shark eat tuna, this seems unlikely. A minority of Maldivian fishermen believe that tuna follow shark, not because they need a leader but because they want to keep an eye on potential predators!

In view of the importance of tuna-fishing in the Maldives, the Ministry of Fisheries issued a notice on November 10, 1981 (I'laan no. 48/81/34/MF) banning livebait lining, longlining and shark-fishing in general during the day in tuna-fishing areas. On February 10, 1986, the Ministry of Defence and National Security issued a notice warning that action would be taken against fishermen found to be breaking these rules. Some restrictions on the exporting of shark products were also introduced in 1986 (shark meat and oil exporting was restricted to STO), but these were relaxed after a couple of years. Subsequently, on May 19, 1992, the Ministry of Fisheries and Agriculture issued a further notice (I'laan no. 16/92/29/FA.A1) revoking the earlier rule, but still banning livebait line fishing on tuna schools when pole-and-line fishing is being carried out.

These rules, and their own observations, mean that many tuna fishermen object to any form of pelagic shark fishing. However, pelagic shark stocks are the ones showing greatest potential for increased exploitation. Any development of an offshore shark longline fishery will have to take the attitudes of the tuna fishermen into account.

7.2 *Shark gillnetting* vs *tuna livebait fishing, diving, and reef-fishing*

Bottom-set gillnets are one of the major gear used for shark fishing in the Maldives. As such, shark-netting is a major source of income for fishermen and the country. Of particular significance is the fact that many gillnetters operate full-time. Despite, or perhaps because of, the importance of gillnetting there are several objections to it.

The great majority of tuna fishermen object to shark-netting as they believe that it "disturbs" the tuna livebait, resulting in reduced livebait catches. This general opposition is compounded by the fact that shark-netters move between atolls. Tuna fishermen have strong objections to fishermen coming from other areas and fishing on "their" reefs. As a result, gillnet buoys are often stolen and nets tampered with. Open confrontation, although far from common, is not unknown.

Divers also object to shark-netting. They see it as potentially the most damaging form of fishing to reef shark stocks. They also stress the dangers that nets pose for divers, but, given the clarity of Maldivian waters and the heavy construction of Maldivian shark nets, this danger is perhaps overstated.

At present, gillnet fishermen target shark but they do take other species (notably reef fish) as by-catch. There are plans on Dh. Bandidhoo to introduce 6" mesh nylon multifilament nets, specifically to take more reef fish (see page 8). If this trend spreads to other islands, the nature of the gillnet fishery could change, from one targeting shark to one targeting reef fish. Admittedly this is unlikely to happen overnight as long as shark fin prices are high and salt-dried reef fish prices are low. Also, reef fish stocks are at present underexploited, and there is room for expansion of the reef-fishing effort (Anderson *et. al.,* 1992). However, the experience of many other countries is that uncontrolled gillnetting can be extremely detrimental to coral reef fish stocks.

7.3 *Manpower requirements for shark* vs *tuna fishing*

With a population of only 230,000 **and a booming economy, the** Maldives is unusual among South Asian countries in having an acute labour shortage. Much foreign labour is imported. Within the Maldivian work force itself, there has been a shift from the less attractive fisheries sector to other more attractive sectors. As a result, the fisheries workforce is aging and declining in relative importance, despite a high population growth rate of about 3.4 per cent per annum (MPE, 1982).

Within the fisheries sector the fact that the fisheries are not saturated allows fishermen to shift between fisheries in order to maximize earnings. However, the Government of Maldives has made substantial investments in infrastructure for tuna exports. There is, therefore, much interest in keeping fishermen in tuna fishing.

Because of manpower shortages, at least one fishing island (H.A. Maarandhoo) has recently stopped shark-fishing. On several other islands, manpower shortages result in less shark-fishing than there would otherwise be. This in itself is not a problem; indeed, it means that shark resources are less likely to be overfished. For the country as a whole, however, the manpower shortage is undoubtedly causing reduced fisheries production and export earnings.

8
Conclusions and Recommendations

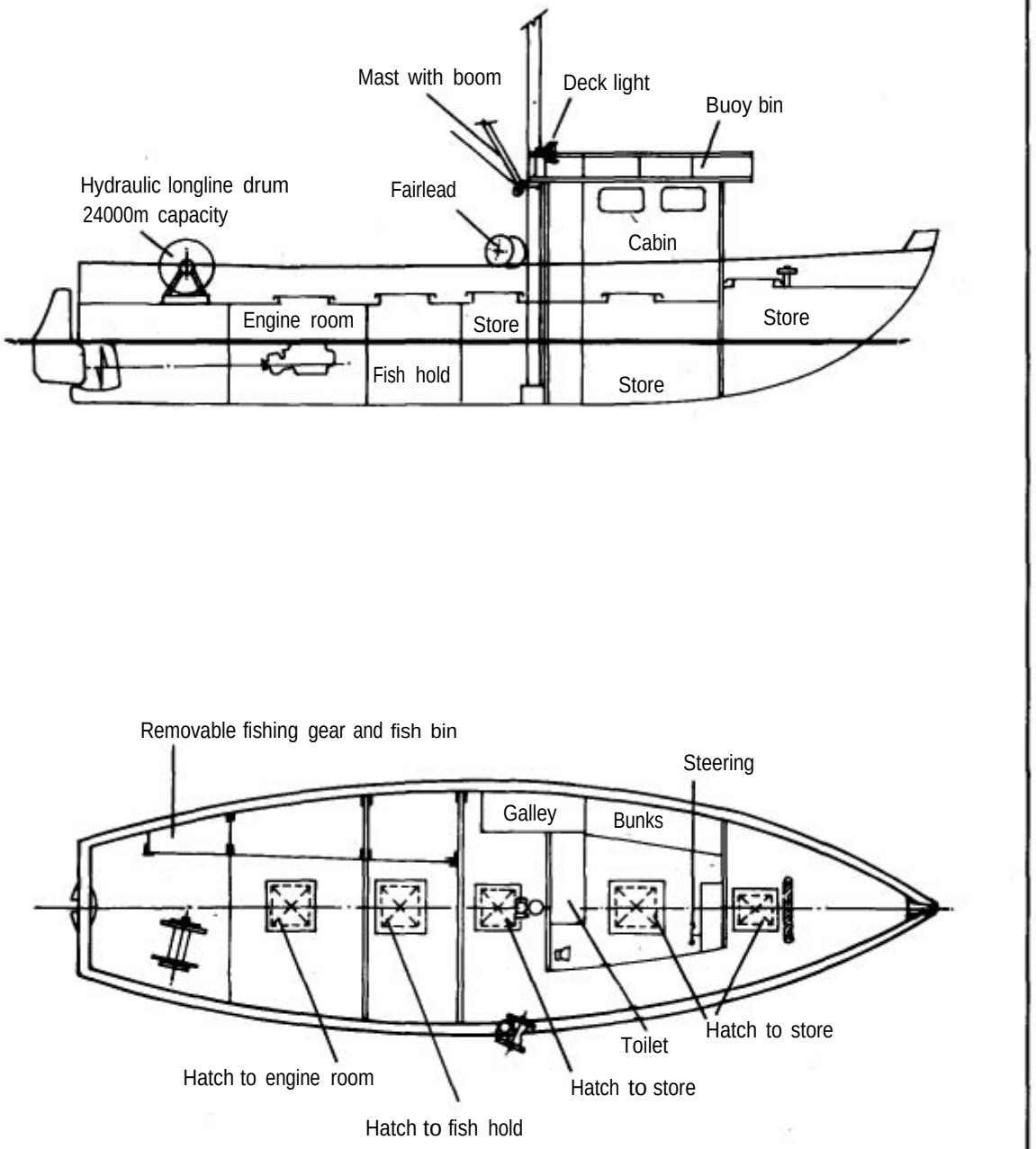
8.1 *Pelagic shark fisheries*

The oceanic shark resource is relatively largà and underexploited. There is scope for expansion of the offshore shark fishery. Fishing survey results (Anderson and Waheed, 1990) show that substantial shark catches can be made using shark longline. Fishing is best carried out from a relatively small vessel, perhaps 11-14m LOA. A modified *dhoni* is ideal; a larger vessel would require much higher investment costs and a larger crew.

The *dhoni* could be modified in two ways. First, by installing a self-winding hydraulic longline drum. This would allow a crew of about four to handle with relative ease a longline of about 400 hooks. Such a longline should produce catches in excess of one tonne a night. As the vessel may be out for three or four nights, or more, at a time, the second modification required is some form of crew accommodation. A wheelhouse with bunk space, a small galley and toilet should be sufficient.

If the shark meat is salted on board there may be no need to carry ice, although if ice were available it could be used for bait storage. As the vessel would be operating some distance offshore, due consideration should be given to crew safety. An outline sketch showing one possible configuration for such a vessel is given in Figure 11 (see facing page).

Fig. 11 Suggested configuration for an offshore shark longlining vessel, based on a second generation *dhoni* hull.



Length overall 12.80 m
Beam overall : 3.60 m
Draft to DWL : 0.90 m

It is recommended that MOFA encourages private fishing businesses to develop offshore shark longlining, using small -vessels of the type described above. MOFA could do this by broadcasting information about the potential of this fishery, and providing detailed technical information and assistance to interested parties.

There is potential for conflict with existing tuna fisheries. However, if regulations were introduced, the difficulties in monitoring and enforcing them would be enormous.

It is recommended that MOFA simply advises that any newly developed commercial shark longlining operations be restricted to fishing beyond a certain distance (for example 12 miles) offshore in order to minimize disturbance to the tuna fishery.

8.2 *Reef shark fisheries and tourism*

In the central part of the Maldives (particularly in An and Male Atolls), reef shark resources are being exploited by two competing users : shark fishermen and tourist divers. Diving brings very much more money into the country than shark fishing.

It is recommended that, as a first step, MOFA should recommend to the National Environment Commission that the country's most outstanding shark-watching site (Fish Head, or Mushimasmingili Thila, in Ari Atoll) be considered for protection. This protection should be in the form of a ban on all types of fishing within a radius of at least 1 km from the main reef.

Since shark can and do move considerable distances from their 'home' reefs, such protection may not by itself be entirely effective.

It is recommended that the use of gilinets within the tourism zone be reviewed (see pp. 41, 42, 45).

It is recommended, in view of the high frequency of diving at Fish Head, and the likelihood that this will increase if the site is protected, that MOFA suggests to the Ministry of Tourism that it request the Maldives Association of Tourism Industry (MATI) and the SCUBA Association of Maldives (SAM) to draw up a code of conduct for divers and dive boats visiting Fish Head, in particular, and dive sites, in general.

It is recommended that MOFA, through the Fisheries Advisory Board, asks the National Environment Commission to request the Ministry of Tourism to draw up a list of other priority dive sites to be considered for protection.

It is recommended that MOFA, through the Fisheries Advisory Board, and after discussion with the Ministry of Tourism, the Ministry of Planning and Environment, and MAT!, should consider banning the landing of shark by night-fishing resort parties.

8.3 *Deepwater Gulper Shark fisheries*

The deepwater Gulper Shark *(kashi miyaru)* stocks are very heavily fished, and probably overfished in many areas. This fishery would almost certainly benefit from a reduction in fishing effort. However, the difficulties of monitoring and enforcing fisheries regulations mean that there are really only two practical methods of controlling such a fishery: banning it or controlling exports. Banning the fishing of Gulper Shark is at present considered to be unnecessary and inappropriate.

It is recommended, as a first step, that MOFA disseminates information on the current status of the Gulper Shark fishery through radio broadcasts. The aim of these broadcasts should be to prevent any further investment by fishermen and boat-owners in the Gulper Shark fishery.

It is recommended, that the Economics Unit of MOFA, in consultation with MRS, study the various economic options *(e.g.* imposition of export duties or quotas for high-quality shark liver oil) as a means of regulating the fishery. Such a study would require some estimate of sustainable yields.

8.4 Monitoring and assessment of shark resources

The Maldivian shark resources are valuable and merit regdlar monitoring in order to provide information necessary for management advice. Detailed data on catch, fishing effort, species composition, size frequency, reproduction etc. need to be collected. A first priority must be the collection of biological data from the deepwater Gulper Shark fishery. The inclusion of a 'shark' category in the fisheries statistics collection forms is a step in the right direction, but this data must be compiled by gear if it is to be of any value.

In the long term, there is a fundamental need for further training of Marine Research Section staff, in order that data collected may be analyzed and interpreted, and management recommendations made.

It is recommended that priority be given to the training of MRS staff in fields related to fishery stock assessment and management.

It is recommended that as trained manpower becomes available, MRS should assign a fisheries biologist full-time to shark resource monitoring and management. The long-term managçment of oceanic shark resources will undoubtedly require international cooperation; MRS should endeavour to participate in any future international pelagic shark management activities.

8.5 *Extension*

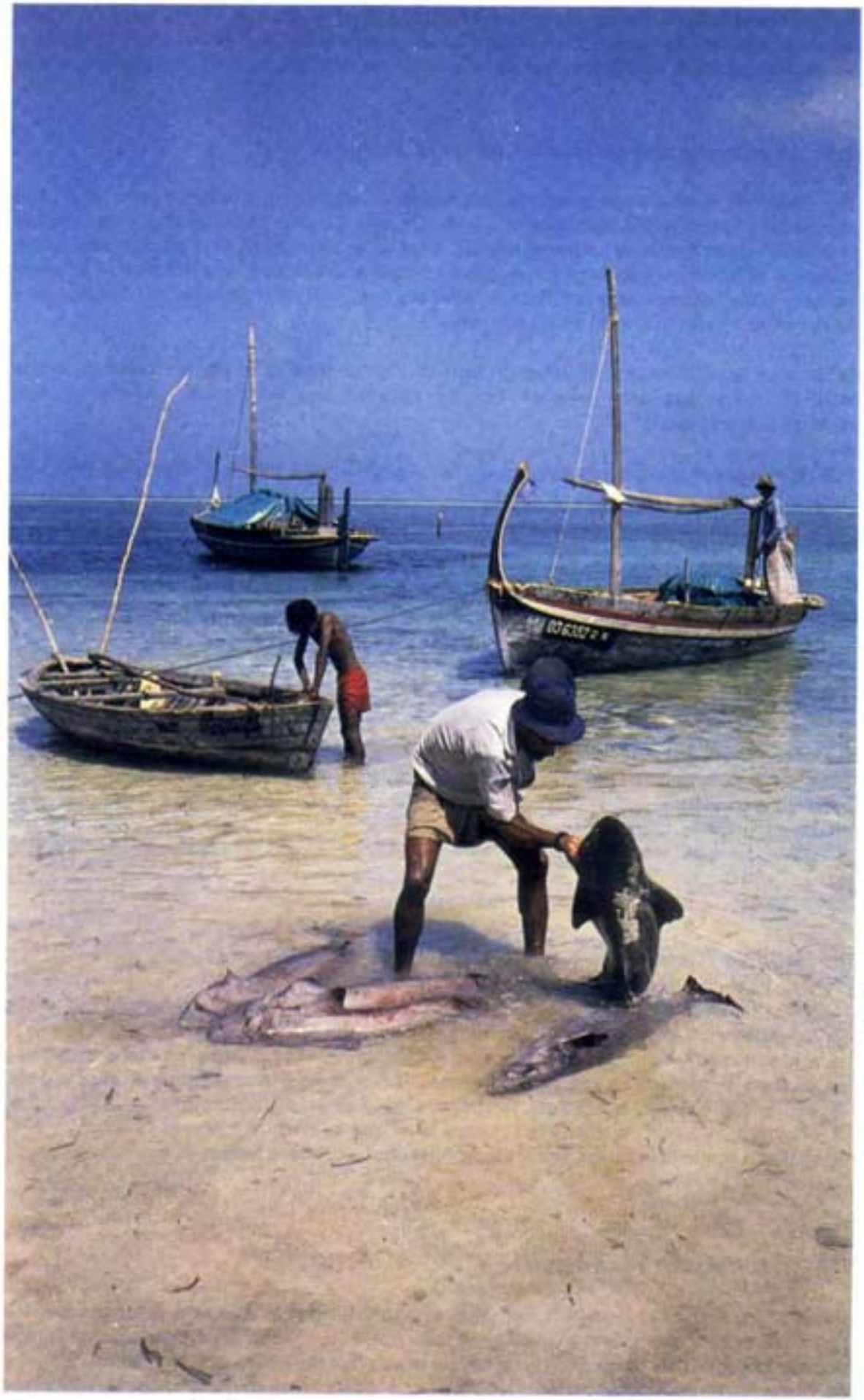
It is recommended that the Extension Section of MOFA, after consultation with MRS, should prepare extension material (for printing and broadcasting) to inform fishermen of the dangers of overfishing in general, and of the problems of the shark fisheries in particular. The potential of offshore shark longlining and correct shark processing techniques should also be disseminated. A booklet on shark, describing all these issues, could be prepared for distribution to fishermen and schools.

8.6 *Gillnet fishing*

In view of the strong opposition to shark gillnetting expressed by both tuna fishermen and tourist diving operators, it is recommended that MOFA give careful consideration to the future of shark-netting, particularly within the main tourism zone. It should be noted, however, that there are two major shark-netting islands (A. Dungati and A. Himendhoo) within the central tourism zone. A possible first step could, therefore, be the banning of gillnet fishing in Alifu and Kaafu Atolls by fishermen from other atolls. Consideration could also be given to means of encouraging atoll development committees to report fisheries problems and conflicts to MOFA with recommendations for action to be taken.

8.7 *Whale Shark conservation*

Whale Shark are rare and, perhaps, endangered, in the Maldives as elsewhere. It is recommended that MOFA give consideiation to banning all fishing of Whale Shark, taking into account the low monetary value of the existing fishery, the serious impact that the fishery may nevertheless be having on Whale Shark stocks, and the possible benefits of Whale Shark to the tuna fishery and to the tourist industry.



Landing Gulper Shark from a small dhoni *at Th. Vilufushi*