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PAPER 1

THE MALDIVIAN TUNA LIVEBAIT FISHERY — STATUS AND TRENDS

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ABSTRACT

The Maldivian livebait fishery is a traditional one that has been carried out for centuries. It is practiced throughout the country, and is the most important reef fishery in the Maldives. Current catches are of the order of 10,500t of livebait per year, which are used to catch almost 100,000t of tuna. Major management issues include livebait habitat destruction by coral mining, black coral collecting and as a result of livebait collection itself; the reportedly negative effects of reef fish fishing; the use of SCUBA diving gear and lights for livebait collection. There has been no concerted stock assessment, so the status of the Maldivian livebait resource is poorly known.

INTRODUCTION

Tuna pole and line fishing is the most important fisheries activity in the Maldives. It is a traditional activity, which has been carried out on a large scale for centuries. The great Arab traveller Ibn Battuta gives a clear account of the importance of tuna in the Maldives at the time of his visits in 1343-44 and 1346 (Gray, 1889). There is also evidence that tuna fishing was carried out in the Maldives before the conversion to Islam in 1153.

The livebait pole and line fishery has traditionally been the major source of employment, the major and preferred source of animal protein, and the major source of export earnings for the entire Maldives. With the development of tourism, of new fisheries, and other economic activities, the relative importance of the tuna fishery has declined over the last two decades. Nevertheless, the fishery remains of crucial importance. In 1994 some 96,800t was caught by pole and line, which was 93% of the total recorded fish catch (MOFA, 1995). Pole and line fishing is carried out from local wooden fishing vessels of some 10-15m LOA, known as *masdhonis*. The entire *masdhoni* fleet was mechanized in the late 1970's.

The pole and line fishery in fact comprises two separate fisheries: an offshore one for tunas and an inshore one for livebait. Without livebait there would be no pole and line tuna catch. It is no exaggeration to say that the well being of the Maldives depends on the success of the pole and line tuna fishery. The success of this fishery depends in turn on the availability of livebait. Tuna livebait are therefore the most important reef fish resource in the Maldives.

Overview of previous studies

Despite the importance of the Maldivian livebait fishery, there has not been a comprehensive study of the fishery and its resource base. However, several smaller studies have been undertaken. A number of early descriptive accounts of the Maldivian fishery included some information on livebait (Jonklaas, 1967; Munch-Petersen, 1980). Accounts of livebait fishing methods are given by Anderson (1983 & 1995), Liews (1985) and Waheed and Zahir (1990). The major livebait varieties used are described by Anderson and Hafiz (1984). A brief review of the Maldivian livebait fishery was provided by Anderson and Hafiz (1988), and later reprinted in a revised form (Maniku, Anderson and Hafiz, 1990). The biology of some Maldivian livebait species (including information from studies of reproduction, growth and predation) is discussed by Blaber et al. (1990) and Milton et al. (1990a & 1990b). Seasonal, regional and interannual variations in the utilization of livebait within the Maldives are described by Anderson and Saleem (1994 & 1995); the data sheets prepared for these studies have been bound and stored at MRS (Anon, 1995a). Estimates of the size of the Maldivian livebait fishery are provided by Anderson and Hafiz (1988) and Anderson (1994). Management issues are discussed by Anderson and Hafiz (1988), Wright (1992) and Anon (1994 & 1995b). A summary of research on livebait undertaken by the Marine Research Section is given in MRS (1995). Dhivehi translations of some of this information have been provided by Hafiz (1985 & 1995).

The Maldivian livebait fish and fishery show many similarities with those in the Indian Lakshadweep Islands to the north. In fact the people of the southernmost island of the Lakshadweep group, Minicoy, speak Dhivehi and have traditionally had a pole and line tuna fishery as in the Maldives. The livebait fishery of Lakshadweep has been studied by several authors, including Jones (1958 and 1962), Kumaran et al. (1989), Madan Mohan and Kunhikoya (1985), Pillai et al. (1991) and Thomas (1962).

THE LIVEBAIT CATCH

Species composition

The Maldivian livebait fishery is a multispecies one. Small species (i.e. about 3-10cm in length) that school close to reefs are targeted. The major varieties used are listed in Table 1. More information on the species used is given by Anderson and Hafiz (1984 & 1988). Average species composition of the total Maldivian catch has been roughly estimated by Anderson (1994) and is summarized in Table 2.

Table 1. The main livebait varieties used in the Maldives

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

Table 2. Average composition of the Maldivian livebait catch

Species / Family	*Local Name*	*Percentage*
Spratelloides gracilis	*Rehi*	38 ± 10 %
Caesionidae	*Muguraan*	37 ± 9 %
Apogonidae	*Boadhi & Fatha*	10 ± 3 %
Engraulididae	*Miyaren*	7 ± 2 %
Spratelloides delicatulus	*Hondeli*	5 ± 1 %
Atherinidae	*Thaavalha*	1 %
Pomacentridae	*Bureki & Nilamehi*	1 %
Others	—	0.2 %

It should be emphasized that there are considerable fluctuations in the availability of different varieties from year to year (Anderson and Saleem, 1995). For example, Cardinalfish abundance and utilization was unusually high in 1993-94. There are also considerable regional and seasonal variations in livebait availability (Anderson and Saleem, 1994). Regarding regional variation, in the southern Maldives (i.e. south of the Kudahuvadhoo Channel at about 02°40'N) livebait species composition is very different from that in the north and centre of the country, and livebait species diversity is greater (see Fig. 1 for location map). Regarding seasonal variations, there appear to be three main patterns of variation in livebait abundance and utilization in the Maldives:

1. Common on the east coast during the Northeast Monsoon season (December to April), and on the west coast during the Southwest Monsoon (June to October). Examples include Blue Damselfishes, Silversides, and to a large extent Fusiliers.

2. Common on the east coast during the Southwest Monsoon season, and on the west coast during the Northeast Monsoon. Examples include Silver Sprats and Blue Sprats.

3. Common during the intermonsoon periods. For example, Anchovies.

Catch size

The Maldives has an excellent fisheries statistics system for tuna catches, but not for livebait utilization. However, some information on the major varieties of livebait used by *masdhonis* on a number of islands is collected by MOFA field officers and MRS tuna research project samplers. This information for 1994 has been summarized in Table 3, and is used as a basis for the estimation of the national livebait catch for 1994. Note that data for Malé are from Anon (1995a); data for G.Dh.Thinadhoo from the same source have been supplemented with additional data collected by the MOFA field officer on the island.

Anderson and Saleem (1994) note that the livebait species composition in the south of Maldives is very different from that in the north and centre. Livebait utilization data presented in Table 3 are assumed to be representative for the two regions. It is recognized that this may well not be the case (especially as the data are dominated by Malé catches) and that in future much more sampling of livebait utilization should be carried out.

Following Anderson (1994), it is assumed that the average daily catch of Sprats and Anchovies is 60kg, while that of other varieties is 45kg. Sprats and Anchovies are rather delicate and can only be used on the day of capture. Other varieties are more hardy and can be kept from one day to the next if they are not used. Therefore, number of days utilization will be less than the number of catches. To try to account for this Anderson and Hafiz (1988) and Anderson (1990) assumed that the number of days on which hardy livebait species are fished is 5% less than the number of days on which they are used. Anderson, Hafiz and Shiham (1996) noted that poor estimation of the frequency of livebait reuse may be a major source of error in estimating total livebait catch. Therefore, in 1995 MRS initiated some sampling of livebait reuse, using MRS tuna research project field officers. The results are summarized in Table 4:

Table 3. Reported livebait utilization during 1994 at selected islands in the Maldives (Reported numbers of days used by masdhonis)

Atoll	*Island*	*Months*	*Silver Sprat*	*Blue Sprat*	*Fusilier*	*Cardinalfish*	*Anchovies*	*Damselfish*	*Silversides*	*Others*	*Total*
H.Dh.	Kulhudhoofushi	Jan-Dec	0	0	112.5	23	0	0	0	0.5	136
N.	Manadhoo	Sep-Nov	5	0	196.7	17.5	0	1.3	0	3.5	224
R.	Alifushi		0	0	18.5	4.5	0	0	0	0	23
R.	Ungoofaru	Feb	8	0	2	9	0	0	0	0	19
K.	Male	Jan - Dec	3586.5	9.5	817.5	2321.5	0	0	1	0	6736
M.	Maduveri	Jan - Dec	11	10	138	55	50	0	3	0	257
Dh.	Kudahuvadhoo	May - Nov	0	0	41.5	6.5	0	0	0	0	48
Subtotal North & centre			**3610.5**	**19.5**	**1326.7**	**2437**	**50**	**1.3**	**4**	**4**	**7443**
L.	Maamendhoo	Jan-Dec	2	0	38	55	0	0	0	1	96
G.A.	Villingili	Feb-Dec	7	0	38.8	84.4	0	7.8	0	1	139
G.Dh.	Thinadhoo	Jan-Dec	199	107.8	296.8	373	3.4	0.5	11.5	14	1006
Subtotal South			**208**	**107.8**	**373.6**	**512.4**	**3.4**	**8.3**	**11.5**	**16**	**1241**
TOTAL			**3818.5**	**127.3**	**1700.3**	**2949.4**	**53.4**	**9.6**	**15.5**	**20**	**8684**

Table 4. Summary of frequency of reuse of delicate and hardy livebait varieties

	Number of days used as livebait				*Total days used*
	Sprats & Anchovies		*Hardy species*		
Used on day of capture	130	(100%)	220	(73%)	350
Reused on subsequent day	0	(0%)	80	(27%)	80
Total	130	(100%)	300	(100%)	430

It thus appears that livebait utilization data may overestimate hardy livebait catches by as much as 27%. However, there is reason to suspect that this figure may be too high. From the log sheets filled by the field officers it is sometimes not possible to distinguish days on which only baitfishing was carried out from those on which baitfishing was carried out followed by unsuccessful tuna fishing. The true rate of reuse of hardy livebait varieties may therefore be something between 27% and 5%. As a rough estimate an intermediate figure of 15% is used here, although it is recognized that further sampling will be required to refine this estimate.

In 1994 a total of 223,095 days fishing by mechanized *masdhonis* and 1138 days fishing by sailing *masdhonis* was recorded (MOFA, 1995). Although the great majority of *masdhonis* go for pole and line tuna fishing, an unknown minority do not. Furthermore, there is some under-reporting of tuna catches (Parry and Rasheed, 1995; Anderson and Hafiz, 1996) and presumably also of tuna fishing effort. As an approximation it is assumed that the recorded fishing effort by mechanized *masdhonis* is a good estimate of the actual pole and line fishing effort.

Of the 223,095 days fishing recorded by mechanized *masdhonis* in 1994, 161,565 were recorded from the northern and central atolls, and 61,530 from the southern atolls. Given the estimated species composition from each region (Table 3), the average catch weight of hardy and of delicate species, and the estimated frequency of reuse of hardy species, the following national catches are estimated:

Table 5. Estimated Maldivian livebait catch by variety during 1994

	Livebait Variety	*Estimated Catch*
Silver Sprats	*Rehi*	5330 ± 1330
Cardinalfishes	*Boadhi*	2980 ± 750
Fusiliers	*Muguraan*	1830 ± 460
Blue Sprats	*Hondeli*	330 ± 80
Anchovies	*Miyaren*	80 ± 20
Silversides	*Thaavalha*	25 ± 10
Damselfishes	*Nilamehi & Bureki*	15 ± 10
Others		30 ± 10
Total		10620 ± 2660

Following Anderson and Hafiz (1988) and Anderson (1994) a confidence interval of 25% is assigned to these estimates. This is an arbitrary figure, which is intended mainly as a reminder of the considerable uncertainties associated with these estimates.

Catch trends

The total annual catches of livebait were estimated for 1978-81, 1985-87 and 1993 by Anderson and Hafiz (1988) and Anderson (1994). These estimates used a figure of 5% for the frequency of reuse of hardy livebait varieties, rather than the 15% used here. The quantities of livebait used have been recalculated using a reuse rate of 15% (which results in a decrease of about 6% in estimated total livebait catch), and are summarized in Table 6:

Table 6. Revised estimated quantities of livebait used annually in the Maldivian pole and line tuna fishery

Time Period	*Livebait Used*	*Modified From*
1978-1981	3000 ± 800 t	Anderson and Hafiz (1988)
1985-1987	4800 ± 1200 t	Anderson and Hafiz (1988)
1993	10500 ± 2600 t	Anderson (1994)
1994	10600 ± 2700 t	This study

It should be noted that there are considerable uncertainties associated with these estimates. Despite this it is clear that there has been a major increase in livebait catches in recent years. In part this can be explained by the steady increase in fishing

effort over the last 15 years (Fig. 2). The period 1978-81 marked the low point of pole and line fishing effort, and therefore of livebait utilization, during the transition of the fleet from sail to engine power. There has also been an increase in the quantity of livebait used per day. This is largely due to an increase in average size and associated fishing power of pole and line vessels in recent years (Anderson, 1994). The quantity of livebait used per day by pole and line vessels is roughly estimated as follows:

Table 7. Estimated daily livebait utilization by Maldivian pole and line vessels

Note: Fishing effort data from MOFA; data for 1978-81 include both sailing and mechanized *masdhonis*, while in other years only mechanized *masdhonis* are included.

Time Period	*Livebait Used (t)*	*Mean number days fished*	*Livebait used per day (kg)*
1978-81	3000 ± 800 t	101,400	30kg
1985-87	4800 ± 1200 t	161,042	30kg
1993	10500 ± 2600 t	222,548	47kg
1994	10600 ± 2700 t	223,095	48kg

Catch per unit bait

There may well be significant regional differences in livebait utilization. For example, fishermen from Lhaviyani Atoll are reported to use particularly large amounts of bait while those in Addu Atoll have to make do with much smaller quantities. Furthermore, there are undoubtedly periods in every atoll when livebait is scarce, and has to be used sparingly. Nevertheless, average tuna catch per unit bait (CPUB) does give a useful index of the effectiveness of livebait utilization.

Table 8. Estimated average tuna catch per unit bait in the Maldives.

Note: Tuna catch data from MOFA; data for 1978-81 include catches by both sailing and mechanized *masdhonis*, while in other years only mechanized *masdhoni* catches are included.

Time Period	*Livebait Used*	*Annual Tuna Catch*	*Catch per unit bait*
1978-81	3000 ± 800 t	24,097 t	8.0 kg tuna / kg bait
1985-87	4800 ± 1200 t	50,997 t	10.6 kg tuna / kg bait
1993	10500 ± 2600 t	76,735 t	7.3 kg tuna / kg bait
1994	10600 ± 2700 t	87,293 t	8.3 kg tuna / kg bait

Maldivian tuna catch per unit bait is comparable to CPUB rates in the central and eastern Pacific (Sakagawa, 1987) but rather low compared to CPUB rates from the western Pacific (Sakagawa, 1987) and very low compared with estimated rates in Lakshadweep (Pillai, 1991). Reasons for this include the Maldivian fishermen's profligate use of livebait when it is available in abundance, and the fact that total livebait catch has been estimated in the Maldives not the quantity actually used as is apparently the case elsewhere.

Status of livebait resources

There has been no livebait stock assessment. It is therefore not possible to comment on the status of Maldivian livebait resources with any confidence. Anecdotal evidence might suggest that there are some problems, since fishermen regularly complain about lack of livebait and consistently state that baitfishing was better in previous years than it is now. However, closer questioning usually reveals that fishermen believe that any livebait shortage is likely to be a short-term, seasonal problem. Furthermore, in a bait fishing log book survey carried out by MRS in 1987, lack of bait was cited as the reason for not going tuna fishing on only one out of 389 days during which no fishing was carried out. A similar survey was carried out in 1993-95 (Table 9). MOFA field officers on three islands (N.Manadhoo, R.Ungoofaru and G.Dh.Thinadhoo) completed baitfishing logsheets, on which were recorded reasons for not going tuna fishing. Lack of livebait was the least important reason for not going tuna fishing (although it should be noted that Addu Atoll, where baitfishing is poor but tuna fishing is good, was not included in this survey).

Table 9. Reasons for not going pole and line tuna fishing cited by fishermen.

Reason for not fishing	*No. days recorded*	*% days recorded*
Fridays	222	38.2
Religious festivals	25	4.3
Community work	52	9.0
Personal work	50	8.6
Vessel maintenance	79	13.6
Engine repairs	30	5.2
Lack of crew	20	3.4
Disputes	9	1.5
Poor weather	48	8.3
Poor tuna fishing	42	7.2
Poor bait fishing	4	0.7
Total	**581**	**100**

Source: MRS logbook survey, 1993-95.

THE LIVEBAIT FISHERY

Livebait catching

Traditionally livebait fishing was carried out using a hand made cotton lift net, deployed over the side of the sailing *masdhoni* using four long poles (Fig. 3a). Fish paste was used to attract livebait over the net. This paste would be smeared on the end of a fishing pole and deposited above the net with a sharp jabbing motion. Coconut oil would be flicked on to the sea to improve through-surface visibility.

A major change that occurred during the 1950's was the introduction of nylon bait nets to replace the traditional cotton ones (Anderson and Hafiz, 1988). The new nets were lighter and could be made much larger. They were also cheaper, easier to maintain, and longer-lasting. Subsequently, over the last two decades a number of other improvements to livebait catching have been introduced. These include:

- The use of diving masks. These were introduced to the Maldives on a large scale following the start of organized tourism in 1972. Their use spread rapidly throughout the country. Masks make it much easier for fishermen to locate bait schools on the reefs, and to catch them once they have been located. The use of snorkels and fins is becoming more common now, but they are still not universally used.

- The use of swimmers to deploy the bait net. This development followed the introduction of diving masks, which allowed fishermen to see what they were doing and encouraged them to enter the water. The bait net is now deployed without the use of poles, but with lines tied to each corner (and sometimes in the middle of the sides as well). The corners of the net are weighted with coral or concrete blocks (Fig. 3b). When fish paste is used to attract the livebait it is deposited over the net by a swimmer.

- Use of SCUBA diving equipment. This is a very recent development, and its use is still not widespread but largely confined to the Malé area. There have, however, also been a number of recent reports of fishermen using diving gear for livebait catching in Addu Atoll. The use of diving equipment is apparently particularly helpful in catching deep swimming varieties such as Cardinalfishes.

All of these developments have made livebait catching much easier than it was in former times. At the same time *masdhonis* have been getting larger. As a result daily livebait catch per *masdhoni* has increased (Table 7).

Livebait maintenance and utilization

When a haul of livebait is made the fish are flicked in to the flooded hold of the *masdhoni*. Fresh seawater is allowed into the hold through holes in the hull. Circulation used to be maintained by hand bailing. With mechanization of the *masdhoni* fleet in the late 1970's the main engine was used as a pump to maintain circulation. In the early 1980's the use of large holes in the hull was introduced; angled plastic pipes inserted in these holes are used to maintain circulation while the *masdhoni* is underway.

The chummer (Dhivehi: *enkeyolhu*) stands over the baitwell, just astern of the mast. When a tuna school is spotted, livebait are scooped up from the hold and thrown out to either side of the stern of the masdhoni to draw the tunas towards the stern fishing platform. At the same time, water is sprayed from the stern of the *masdhoni*. This not only helps to hide the fishermen from the tuna but also creates the impression of many small fish jumping at the surface. Traditionally the splashing was done by hand, with two crew members assigned to the task. The use of mechanical pumps for spraying started in 1990 and quickly spread throughout the country (Anderson and Waheed, 1990). Petrol pumps have been widely used, but diesel pumps were introduced in 1995. Two crew members can be replaced by the use of a mechanical water sprayer, a major consideration for boat owners now that obtaining sufficient crew is a major problem in many islands.

At the end of the day's fishing, any remaining livebait may be either discarded or kept overnight (if they are of hardy species and tuna fishing is planned for the next day). Livebait were traditionally kept overnight in slatted wooden bait boxes (Dhivehi: *lubari*, *enkoshi* or *masge*) moored in the lagoon. These have now been replaced with net enclosures. Sometimes a special cage with net walls is used. Other fishermen use the bait net, rigged in a wooden frame, either floating in the lagoon or suspended from the side of the *masdhoni*. A few fishermen in the south do not use a separate container at all, but moor their *masdhonis* in exposed positions and rely on the rolling of the vessel and the large holes in the bait well to maintain adequate overnight circulation.

Remuneration for livebait catching and utilization

It has long been the tradition in Maldives that at the end of the day's fishing the tuna catch is divided between the boatowner, the crew, and any others who have contributed to the success of the fishing operation. In the old days, maintaining the cotton baitnet was a laborious task that might take several hours of work in the evening. The bait net owner was therefore entitled to a share of the tuna catch. Similarly, the bailing of the livebait hold to maintain circulation was a demanding job that was rewarded with an extra share. With the introduction of cheap nylon nets and mechanical pumps these extra shares are no longer paid. However, swimmers now make a major contribution to bait catching and so they often receive an extra share. The chummer, as always, receives an extra share or half share for his efforts.

MANAGEMENT ISSUES

Stock assessment

As noted above, there has been no stock assessment, so the status of livebait stocks is unknown. In general it is believed to be rather difficult to overfish stocks of small, highly fecund pelagic fishes such as the Sprats on which the Maldivian livebait fishery heavily depends. There are no clear signs of overfishing so far, and it is far from obvious what management measures could realistically be introduced if overfishing were to occur.

Nevertheless, given the enormous importance of the livebait fishery, it would be prudent to initiate stock assessment activities. At present lack of catch and effort data is a major constraint which needs to be overcome. The current system of data collection is inadequate. It is therefore recommended that consideration be given to incorporating livebait catches in MOFA's existing tuna catch statistics forms.

Coral mining

Coral mining is widespread in the Maldives, and perhaps the major cause of reef degradation. Since most coral mining takes place on reef flats, while most baitfishing takes place on reef slopes, the effects of coral mining on the baitfishery have not been too severe. There is an exception to this generalization: Damselfishes such as the Blue Chromis (*nilamehi*) and Fusilier Damselfish (*bureki*) are associated with reef

flat corals. Coral mining is known to reduce reef flat fish populations (Dawson Shepherd et al., 1992), and the abundance of these Damselfish species may have been adversely affected by coral mining.

Anderson and Hafiz (1988) suggested that some 140t Damselfishes were used annually as livebait in the Maldives during 1985-87, which was something of the order of 3% of all bait used. Anderson (1994) suggested that some 120t of Damselfishes were used in 1993, which was about 1% of all livebait used. It is therefore possible that there has been a decline in the utilization of these species, and further that this decline may be associated with habitat destruction caused by coral mining. However, there are considerable sources of error associated with these estimates, so this interpretation may not be correct.

Comprehensive regulations for the control of coral mining have recently been developed. However, coral mining was already banned on major livebait fishing reefs, following a President's Office decree of September 1990, promulgated by the Ministry of Atolls Administration (circular number B-90/3). Lack of effective data collection and monitoring makes it very difficult to assess the impact of coral mining on the livebait fishery.

Black coral collecting

Many tuna fishermen say that the collecting of black coral (Dhivehi: *endheri*) reduces the abundance of some varieties of Cardinalfishes (*boadhi*) which swarm by day among the branches of the black coral trees. In earlier times black coral was presumably abundant on Maldivian reefs. However, over the last two decades large quantities were removed, to make jewellery and other souvenirs for tourists. From 1 January 1995 a ten year moratorium on the collecting of black coral in the Maldives was introduced by the Ministry of Fisheries and Agriculture.

Destructive livebait collection methods

Baitfishing itself can cause damage to the coral reefs. The collection of species, such as Cardinalfishes and Damselfishes, that are closely associated with the corals can be particularly destructive. In such cases the net may be spread over the corals with which the livebait are associated. Any livebait remaining under the net may be chased out using poles, or a 'scarer' (such as a palm frond or a steel chain) on the end of a rope. The livebait are then chased back onto the net. This can result in much coral

damage, and in particular branching corals in which livebait shelter may be smashed. In the case of essentially pelagic varieties such as Fusiliers, Sprats and Anchovies the net is generally kept off the bottom, and the livebait are lured into the required position with fish paste, so reef damage is minimal.

Another cause of reef degradation associated with baitfishing is anchor damage. Each pole and line vessel deploys at least two heavy steel anchors while baitfishing. Vessels may move positions several times during the course of one baiting operation. Depending on wind and current directions, the anchors may be deployed on the sandy lagoon bottom or on the coral reef itself. The extent of damage caused in such cases is unknown. However, sometimes many boats from a single island concentrate on one reef to collect bait over a period of days or even weeks. At such times anchor damage must be significant. Since tuna fishing is becoming concentrated on fewer islands, and vessels are getting larger, this problem may be getting worse.

Traditionally, Maldivian fishermen used locally made coral and stick anchors (*fanaa*) for anchoring while baitfishing. Although these anchors were relatively small and light, it is not clear that they would have caused less damage than the steel anchors now used, because they cannot grip on sand and have to be deployed on a rocky (i.e. coral) bottom. *Fanaa* were used in the past because steel anchors were expensive and difficult to make. The use of *fanaa* was largely phased out during the 1970s.

There is a need for greater awareness among tuna fishermen about the potentially damaging effects of their livebait fishing activities. Radio broadcasts by the Ministry of Fisheries and Agriculture discussing the problem would be an excellent first step. In the longer term, the effects of the more destructive means of catching Cardinalfishes and Damselfishes should be investigated, to assess the damage and to suggest options for resolution of this issue.

Reef fish fishing

Reef fish fishing was traditionally not an important activity in the Maldives. In recent years, however, it has increased greatly in importance, largely as a result of the development of new domestic and export markets. The great majority of the reef fish species taken are carnivores. Intuitively it seems obvious that the removal of increasing numbers of potential predators from the reefs should be beneficial for baitfish populations. In practice things do not seem to be so simple. First, many of the reef fish species caught do not appear to be major consumers of tuna baitfish (Blaber et al., 1990).

Secondly, many Maldivian tuna fishermen say that reef fishing harms baitfishing because predatory reef fishes tend to keep the baitfish in tight, stationary schools. If predatory reef fish are removed the schools tend to disperse, and baitfish are difficult to catch. This is said to apply to many reef fish species, including groupers and sharks (particularly the whitetip reef shark, *Triaenodon obesus*). Tuna fishermen also say that shark nets deployed on or near reefs tend to cause bait schools to disperse.

A somewhat different problem connected with the development of reef fisheries relates to the size of the fishing population. Although the population of Maldives as a whole is increasing rapidly, the population of active fishermen is stable. As a result the proportion of fishermen in the population is decreasing, largely because of their low socio-economic status. As new fisheries develop fishermen are attracted to them by the opportunity of high earnings. In consequence the number of fishermen available for the livebait tuna fishery is reduced. There has been enormous Government investment in infrastructure for tuna exports over the last decade. In order to service these investments there must be a large and active fishing population. To achieve this there is a need to make fisheries in general, and tuna fishing in particular, more attractive to young people.

Utilization of livebait species for other purposes

Relatively small quantities of some bait species, notably *Spratelloides gracilis* and adult Fusiliers, are used for human consumption in the Maldives. Some tuna fishermen believe that this will harm baitfish stocks, but the quantities involved are relatively small so this seems unlikely. A few bait species, notably *Chromis viridis* (Adam, 1995) but also some other Damselfishes and Cardinalfishes, are taken by aquarium fish collectors for export. Again, the quantities involved are very small.

The Ministry of Fisheries and Agriculture recognizes the importance of the baitfishery, and the potential damage that might be done if an export market were developed for any of the livebait species. Therefore, as a precautionary measure, the export of any bait used for pole and line fishing has been banned by MOFA.

Conflicts with tourism

Tuna fishermen sometimes visit the house reefs of resorts or diving sites to collect livebait. Tourists and dive operators object to this, saying that anchoring destroys the corals and that bait fishing removes many attractive schools of fish from the reefs. It

is widely accepted in Maldives that tuna fishermen have a right to take livebait from anywhere. In recognition of this right, livebait fishing is the only fishing activity allowed on the 15 marine protected areas (dive sites) declared in June 1995. At present fishermen are not supposed to fish on the house reefs of uninhabited islands (a definition that includes resorts) without permission of the leasee/owner. In practice there is a lot of confusion over this regulation and it is often ignored. Greater public awareness (among both tourists/divers and tuna fishermen) would go a long way towards minimizing conflicts between these two groups.

The use of SCUBA diving equipment

As mentioned above, the use of SCUBA diving equipment during livebait fishing operations has recently started around Malé, and in Addu Atoll. There have been some complaints from other fishermen that this reduces their bait catches. A more serious consideration is likely to be the health and safety of divers. Fishermen who using diving equipment without adequate training are at a very high risk of suffering a serious diving accident. There are now two diving schools in Malé offering training to Maldivians. Consideration should be given to banning the use of diving equipment for livebait fishing and/or setting minimum legal standards for fishermen-divers.

The use of lights for livebait fishing at night

Maldivians are unusual among pole and line fishermen in that they catch their livebait during the daytime. Most other pole and line fishermen catch livebait at night, using powerful lights to attract the livebait to their nets. The reasons for this difference may be historic: in the old days in Maldives it would have been very difficult to operate sailing boats among the reefs at night particularly on moonless nights when livebait catches are best, and also there would have been no suitable source of artificial light. This tradition has been continued right up to the present day, and in fact the use of lights for livebait fishing at night is prohibited under a legal notice from the Ministry of Fisheries issued in 1987 (MF-B/34/87/27). This ban was introduced following complaints from fishermen not using lights about other fishermen who were using lights and allegedly affecting livebait catches on subsequent days. There is, however, still some night livebait fishing being carried out in Addu Atoll, where livebait is notoriously scarce.

There is a need for a review of the current extent of night livebait fishing and catches, and of its effects on daytime catches of livebait, in order that rational management options can be formulated.

Utilization of Silversides

Silversides or Hardyheads (*thaavalha*) are seasonally very abundant. They are also relatively easy to catch, and are particularly hardy. However, they are not used very often by fishermen as tuna livebait. The reason for this is their poor chumming ability. Although fishermen usually get a good initial chumming response with *thaavalha*, especially on drifting objects when the tunas may be particularly hungry, the tuna soon stop feeding and disperse. There are two explanations for this. First, some fishermen say that *thaavalha* swim down and away from the fishing vessel, leading the tunas behind them. The second, and far more prevalent explanation is that the hard scales and 'stony' head of this bait make it very difficult for the tunas to digest. As a result the tunas stop feeding after an initial strong chumming response.

Whatever the reason for *thaavalha's* poor chumming ability, its use is strongly opposed by some fishermen. If one tuna fishing vessel is using *thaavalha* as a bait it may cause the school to disperse, resulting in poor fishing for any other vessels fishing on the same school. This is sometimes a source of conflict between fishermen. In 1993 Laamu Atoll Development Committee banned the use of *thaavalha* for pole and line fishing around fish aggregating devices (FADs) near Laamu Atoll (Anderson and Saleem, 1994). Naeem and Latheefa (1994) noted that the use of *thaavalha* (which they called 'silverline') near an FAD in the Watteru Channel between Vaavu and Meemu Atolls apparently reduced tuna catches there.

The Ministry of Fisheries and Agriculture has made radio broadcasts about this issue to fishermen, in order to increase their awareness.

Dumping excess livebait at sea

At the end of the day's tuna fishing, fishermen are sometimes left with some unused livebait, especially if tuna fishing has been poor. This livebait may be kept for use on the next day. However, if there is no fishing planned for the next day (for example if it is a Friday), or if the livebait are thought to be in poor condition, the excess livebait will be dumped at sea. There are no estimates of the quantity of livebait wasted in this way, but it may amount to several hundred tonnes per year. The Ministry of Fisheries and Agriculture has made several radio broadcasts to fishermen asking them to dump excess livebait close to a reef rather than in the open ocean, in order to minimize these losses.

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Figure 2. Annual Maldivian pole and line fishing effort and estimated livebait utilization

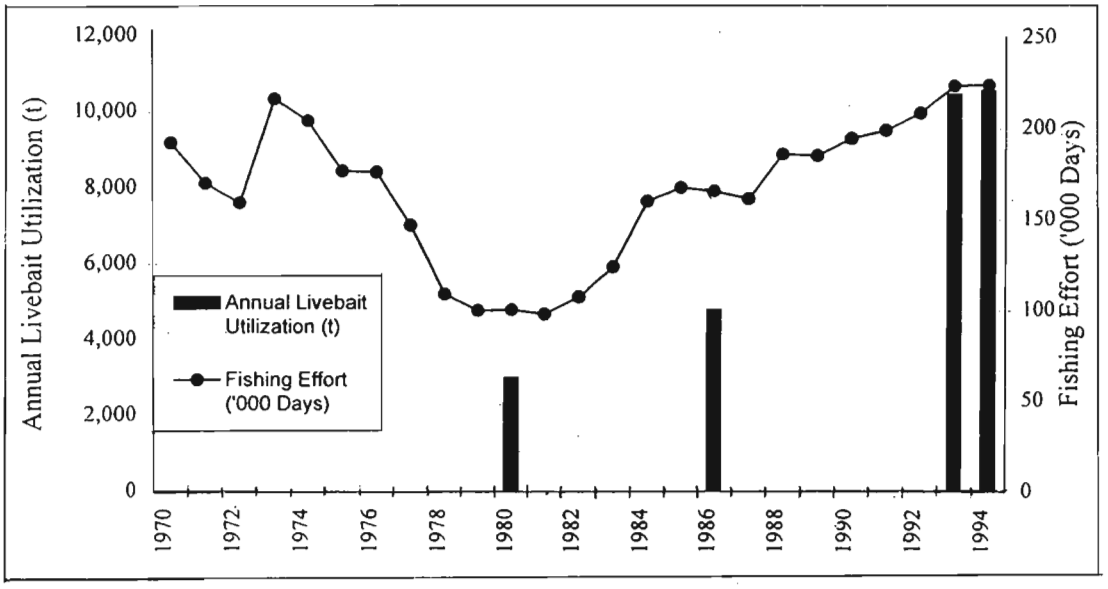


Figure 1. Location map of the Maldives showing places mentioned in the text

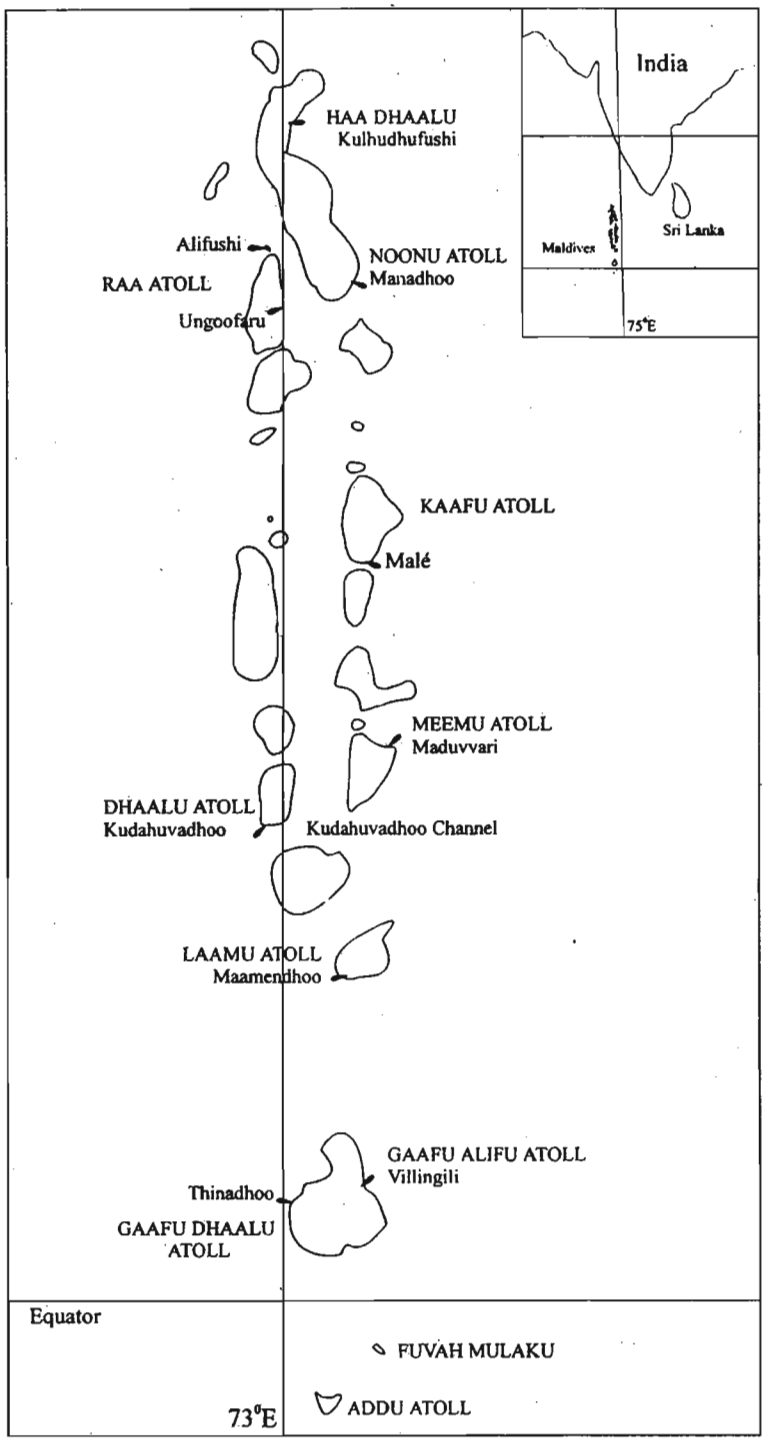
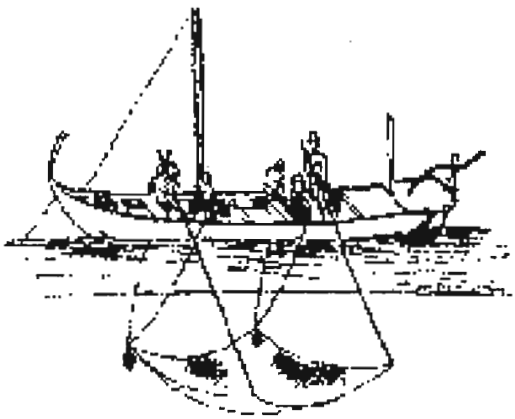
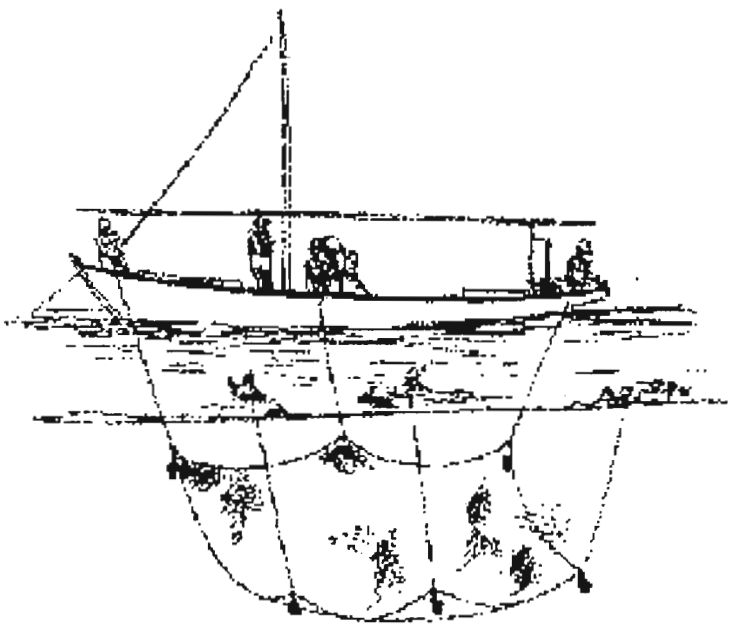


Figure 3. Sketch diagrams of Maldivian livebait fishing activities (original drawings by Hussein Zahir)



a. Livebait fishing c.1975. Long poles are used to spread the net.



b. Livebait fishing c.1995. The net is much bigger and is spread by swimmers in the water.