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TECHNICAL ASSISTANCE TO BAIT FISHERIES MONITORING

FINAL REPORT

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Note: The Terms of Reference for this Technical Assistance require the production of a Final Report in two parts, namely a ñBait Fisheries Management Frameworkò and a ñBest Practice Guide and Code of Conductò. Both are included within this single report, which also includes a summary of activities undertaken during the third and final TA consultancy mission.

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TECHNICAL ASSISTANCE TO BAIT FISHERIES MONITORING

EXECUTIVE SUMMARY

Livebait is essential for the prosecution of the pole and line tuna fishery, and as such it is the most important reef fishery in the Maldives. The fishery has been expanding since the early 1980s, and therefore requires adequate monitoring and appropriate management. The Marine Research Centre of the Ministry of Fisheries and Agriculture is executing a bait fisheries monitoring programme, with funding from IDA under the Maldives Environmental Management Project. The MEMP is focussed on four northern atolls: Noonu, Raa, Baa and Lhaviyani.

This is the third in a series of consultancy reports summarising activities undertaken during 2009. It also presents a ñBait Fisheries Management Frameworkò and a ñBest Practice Guide and Code of Conductò.

While there were particular concerns about the status of baitfish resources in some atolls during 2003-06, pole and line fishing effort has fallen about 25% since that time, with a consequent reduction in bait catch. Nevertheless, given the great value of the resource, there remains a need for monitoring. To carry out bait fisheries monitoring within the MEMP area, MRC has contracted six fishermen as field officers. This monitoring programme needs to be expanded by MRC to the southern atolls, where conditions are different. Other sources of data are highlighted, and these need to be fully exploited. Compilation, analysis and publication of existing data, from a baitfish research programme carried out by MRC during 2000-04 need to be completed. A preliminary analysis of primary productivity and its relationships to baitfish production should be extended. MoFA needs to collect and compile catch and effort data on the pole and line and the handline fisheries separately. Exploratory fishing for potential new sources of baitfish outside the atolls should be conducted. MRC and MoFA have insufficient human resources to carry out monitoring and to execute fisheries management; there is a clear need for much further staff training.

If required, management options could include the introduction of Marine Protected Areas, and/or some form of quotas, perhaps ITQs. Any management activities proposed for baitfish will need to involve the fishermen themselves from an early stage. Maldivian fishermen have a very strong belief in their right to fish anywhere. They will not easily accept restrictions on that perceived right, and Maldives lacks the capacity to enforce unpopular regulations.

A proposed Best Practice Guide and Code of Conduct emphasises the need to use bait more efficiently, to minimize environmental damage, and to improve governance.

Abbreviations

BFAD	Bait FAD
EIA	Environmental impact assessment
EPA	Environmental Protection Agency
FAD	Fish aggregating device
IDA	International Development Association (of the World Bank)
IOTC	Indian Ocean Tuna Commission
ITQ	Individual transferable quota
MEMP	Maldives Environmental Management Project
MoFA	Ministry of Fisheries and Agriculture
MPA	Marine protected area
MRC	Marine Research Centre
PMU	Project Management Unit
t	Metric tonne (1000 kg)
TA	Technical assistance

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1. BAIT FISHERIES MANAGEMENT FRAMEWORK

INTRODUCTION

The pole and line tuna fishery is by far the most important fishery in the Maldives. It is the main source of employment in the outer atolls, the main source of animal protein for the Maldivian population and a crucial source of export earnings. The pole and line fishery depends totally on a regular and substantial supply of small live baitfishes, which are caught within the atolls and are used to catch the tunas. Without the baitfish, there would be no tuna catch. The bait fishery is therefore by far the most important reef fishery in the Maldives.

For many years there have been complaints from fishermen that bait is in short supply. Further investigation usually revealed natural seasonal variability as the underlying cause, with abundant bait returning in due course. But pole and line catches increased dramatically from the early 1980s up to 2006, and with increased tuna catches there was inevitably increased demand for bait. It was clear that bait catches could not increase indefinitely. At the same time there are increasing calls for all fisheries to be managed sustainably, both to meet international obligations, and to qualify for óeco-labellingô which should bring enhanced export revenues.

With this background, the Marine Research Centre (MRC) of the Maldivian Ministry of Fisheries and Agriculture (MoFA) started a bait fisheries monitoring project in 2009, with technical assistance (TA) from the IDA-funded Maldives Environmental Management Project (MEMP). This section of this report presents a bait fisheries management framework, following the structure outlined in the TA terms of reference.

THE BAIT FISHERY AND RESOURCE

The bait fishery

The livebait pole and line fishery actually consists of two separate fisheries: one for livebait and one for tuna. Baiting is carried out inside the atolls using a simple liftnet. Tuna fishing is carried out in the ocean, outside the atolls, using hook, pole and line.

The Maldivian livebait pole and line fishery has been in existence for centuries, indeed almost certainly for more than 1000 years. It was mentioned by the great Arab traveller Ibn Battuta, who described the preparation and consumption of Maldive fish at the time of his visits in the 1340s (Gray, 1889; Gibb, 1929). A later Portuguese visitor, Valentin Fernandes, gave a clear description of the fishery in 1507 (Fitzler, 1935). François Pyrard de Laval, a Frenchman who was shipwrecked in the Maldives in 1602 and left the most comprehensive early account of the islands, also noted the fishery (Gray, 1889).

Traditionally, baiting was carried out first thing in the morning. A simple, cotton lift net was used, and deployed from one side of the *masdhoni* (Maldivian fishing boat) using four long poles. Scraped fish paste might be used to lure the bait school over the net, when it was rapidly hauled and the captured fish transferred into the flooded hull of the *masdhoni*. Circulation of water within the bait hold was maintained by hand-bailing, a laborious task at which crew members took turns.

Starting in the 1970s a number of developments and innovations have revolutionised the livebait fishery (Table 1), even though the essentials remain unchanged: bait is still caught with a simple rectangular liftnet, and is still kept alive in the flooded hull of the *masdhoni*.

Box 1. Time line of significant developments within the livebait fishery

Early 1970s	Replacement of traditional cotton liftnets with nylon nets. The new bait nets were much lighter and stronger, so could be larger and were easier to use and to maintain. These larger, non-rotting nets were also suitable for overnight bait holding; as a result the use of traditional bait cages (*lagari*) died out by the mid-1980s.
1974	First *masdhoni* mechanised. By the early 1980s the entire active *masdhoni* fleet had converted from sail. Mechanisation paved the way for many developments in the fishery, including improvements in bait holding.
Mid-1970s	Diving masks introduced, following arrival of tourism in 1972 (Anderson, 1983). These allowed fishermen to see what was happening underwater, and eventually led to the replacement of long poles to deploy the bait net with swimmers in the water. This in turn allowed the use of larger nets.
1981	First visit to Maldives by two Hawaiian masterfishermen (Walter Paulo and Richard Kinney) who demonstrated several innovations for bait holding and use (Wilson, 2005). Among other things, they introduced the use of much larger holes in *masdhoni* hulls and the use of angled plastic pipes in the holes to improve water circulation and thus livebait survival. Now universal.
Late-1980s onwards	Increasing size of *masdhonis*. The original mechanised *masdhonis* were simply converted from sailing boats. Once conversion of the originally sailing fleet was complete, new purpose-built mechanised vessels started appearing. The ósecond-generationô *masdhonis* started the trend of increasing size, but it continues to this day, with vessels in excess of 30m now being commonplace. This has considerably increased the daily bait requirement of individual boats.
1990	First use of mechanical sprayers (replacing hand spraying) for tuna fishing (Anderson and Waheed, 1990). This required the use of pumps, which can also be used to improve water circulation in the baitwell. Started in Raa Atoll and rapidly spread throughout the country.
1995	Use of lights for night baiting spreads (Anderson *et al.*, 1997). Although first used in Addu Atoll as early as 1971, the use of lights did not spread to other atolls for many years. In 1995, fishermen in Huvadhoo Atoll started using lights, and from there it spread to Malé in 1997, after which the use of lights rapidly became established throughout the country.
2001	First bait fish aggregating device (BFAD) deployed, in Addu Atoll (Maajid, 2001). The effectiveness of BFADs remains to be demonstrated.

The use of lights for baiting at night is now widespread (although within the project area, most fishermen in Baa Atoll do not use lights which they feel disrupt bait supplies). For the country as a whole, it is likely that over three-quarters of all livebait for the pole and line fishery is now taken at night.

The baitfish resource and its use

The bait fishery is a multi-species one. Over 40 different species have been recorded, but less than a dozen dominate catches. The single most important bait species is the silver sprat (*rehi*). Other important varieties, in approximate order of catch include several species of fusiliers (*muguraan*), an anchovy (*miyaren*), cardinalfishes (*boadhi*) and the blue sprat (*hondeli*).

Table 1. Major varieties of Maldivian bait fish

English name	Species	Maldivian name
Silver sprat	*Spratelloides gracilis*	*Rehi*
Blue sprat	*Spratelloides delicatulus*	*Hondeli*
Anchovy	*Encrasicholina heteroloba*	*Miyaren*
Fusiliers	Caesionidae	*Muguraan*
Cardinalfishes	Apogonidae	*Boadhi, fathaa*
Blue-green damsel	*Chromis viridis*	*Nilamehi*
Fusilier damselfish	*Lepidozygous tapeinosoma*	*Bureki*
Silversides	Atherinidae	*Thaavalha, hithiboa*

There is considerable variability in catches of different bait varieties, by season, by region, and also depending on day or night fishing (Table 2). In addition there are significant inter-annual variations (Anderson and Saleem, 1995). In general, the southern atolls show more species diversity than the northern and central atolls, and anchovies (*miyaren*) in particular are more important there than further north. In the northern and central atolls the silver sprat (*rehi*) is most abundant in the atolls on the downstream side of the Maldives, i.e. in the western atolls during the NE monsoon and in the eastern atolls during the SW monsoon (Anderson and Saleem, 1994). Since the development of light fishing, sprats and anchovies have come to dominate catches, since other species (fusiliers in particular) are less attracted to lights.

Table 2. Species composition of livebait catches in different regions, by day and night

Bait variety	Centre & North (Daytime)	Centre & North (Night-time)	Southern Atolls (Daytime)	Southern Atolls (Night-time)
Silver sprat	23-43%	26-100%	20-59%	50-90%
Anchovy	0-4%	0-10%	3-35%	4-12%
Blue sprat	0-8%	0-71%	12-30%	3-38%
Fusiliers	30-53%	0	8-29%	0
Cardinalfishes	8-28%	0-16%	0-8%	0
Others	1-3%	0-10%	0-8%	0-3%

Note: The percentages are from samples of several boats, not of species compositions in individual catches
Sources: Anderson and Saleem (1994); Anderson et al. (1997); MRC unpublished data

As it happens, the species that are most attracted by lights (sprats and anchovies) are the least hardy bait species. Thus, although they can be caught easily, they cannot be kept for use on subsequent days, and new catches must be made every night.

Quantities of livebait used in the pole and line fishery have been calculated for various periods (Table 3).

Table 3. Published estimates of annual livebait utilization in the pole and line fishery
Modified from: Anderson and Hafiz (1988), Anderson (1994 & 1997) and Adam (2006) and data from this project

Period	Pole & line effort (days/year)	Average catch (MT tuna / y)	Est. bait catch (MT / year)	Bait utilization (kg bait /day)	(kg tuna / kg bait)
1978-81	101,400	24,097	3,250 ±800	32 kg	7.4
1985-87	161,042	50,997	5,100 ±1,300	32 kg	10.0
1993-94	222,822	82,014	11,000 ±2,700	49 kg	7.5
2003	208,471	143,327	15,000	72 kg	9.6

In addition to the pole and line fishery, livebait is also used in the yellowfin tuna handline fishery. The main species used are different from those used by pole and line fishermen, and are listed in Table 4. The only overlap is in the use of fusiliers, pole and line fishermen using small juveniles, handline fishermen using larger individuals. The quantities used in the handline fishery have not been adequately estimated, although Adam and Jauharee (2009) do provide information on relative importance of different bait species, by year. Use of juvenile red-tooth triggerfish was particularly high in 2008-09, following a population explosion of this species in 2007. Many pole and line tuna fishermen object to the use of this species, since it apparently causes tunas to stop feeding and to dive, perhaps because its is spiny and causes internal irritation.

Table 4. Major varieties of livebait used in the Maldivian **yellowfin tuna** handline fishery

English name	Species	Maldivian name
Bigeye Scad	*Selar crumenopthalamus*	*Mushimas*
Round Scad	*Decapterus macarellus*	*Rimmas*
Fusiliers	Caesionidae	*Muguraan*
Red-tooth Triggerfish	*Odonus niger*	*Rondu*

Descriptive account of baitfish stock status

The status of baitfish stocks is not well known. There has been no formal, quantitative stock assessment of any stock. Indeed, there are insufficient data for any such assessment. However, there are some qualitative indicators.

- Experience elsewhere, notably in the Pacific, suggests that livebait resources are difficult to overfish (e.g. Rawlinson et al, 1992; Dalzell, 1993). However, one reason for this, which does not apply in the Maldives, is that pole and line fleets in the Pacific are highly mobile, and can move to new baiting grounds if catch rates decline.

- The major baitfish species (notably silver sprat, blue sprat and Indian anchovy) are fast growing, fast reproducing fishes with high rates of natural mortality (Lewis, 1990; Dalzell, 1993). In such cases, classic fisheries assessment advice has been that catches can be high relative to biomass with little fear of overexploiting the resource. This appears to have been the case for the Maldives fishery.

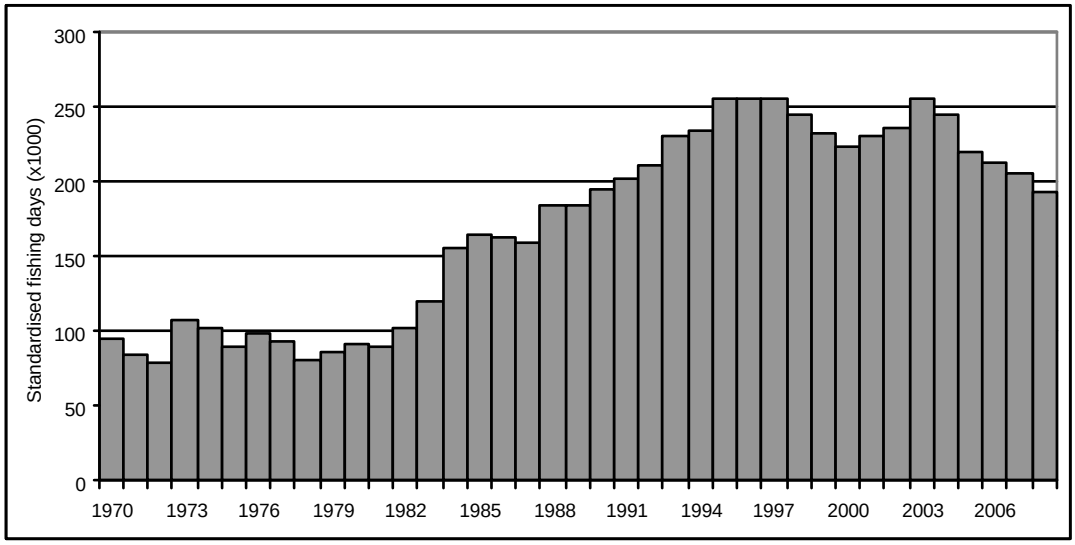
- Maldivian fishermen regularly report shortages in bait supply. However, bait availability is naturally very variable, with considerable seasonal, regional and inter-annual fluctuations in abundance (e.g. Anderson and Saleem, 1994, 1995). It is difficult to distinguish between ónormalô shortages related to such natural fluctuations, and potentially more serious reductions in abundance resulting from high levels of

exploitation. Surveys of baitfishing carried out by MRC show that the number of days fishing lost due to lack of bait is very small (usually less than 1%). In only one case (on the island of G.Dh. Thinadhoo during 2001-2003) was lack of bait apparently more serious, contributing 6.4% of the lost fishing days (Anderson, 2006).

- An initial study of the relationship between primary productivity and livebait production suggested (as a first approximation only) that the maximum sustainable yield of livebait from the Maldives might be something of the order of 13,000 ± 2,000 t (Anderson, 2006). At about that time, total annual catch of baitfish was estimated to be something of the order of 15,000 t (Adam, 2006). While these results were recognised as being of a preliminary nature, they did at the very least suggest that Maldivian livebait resources were being exploited at a high level and that due caution should be exercised with any plans to expand the tuna fishery.

In summary, prior to about 2003-06 there were few serious concerns about the status of baitfish stocks. At that time, some concern was expressed about the high levels of fishing effort, and the apparent increase in shortage of bait in some atolls on some occasions. However, since that time, the pole and line tuna fishery has peaked and declined: standardised *masdhoni* fishing effort is now at the lowest level it has been in two decades (Fig.1).

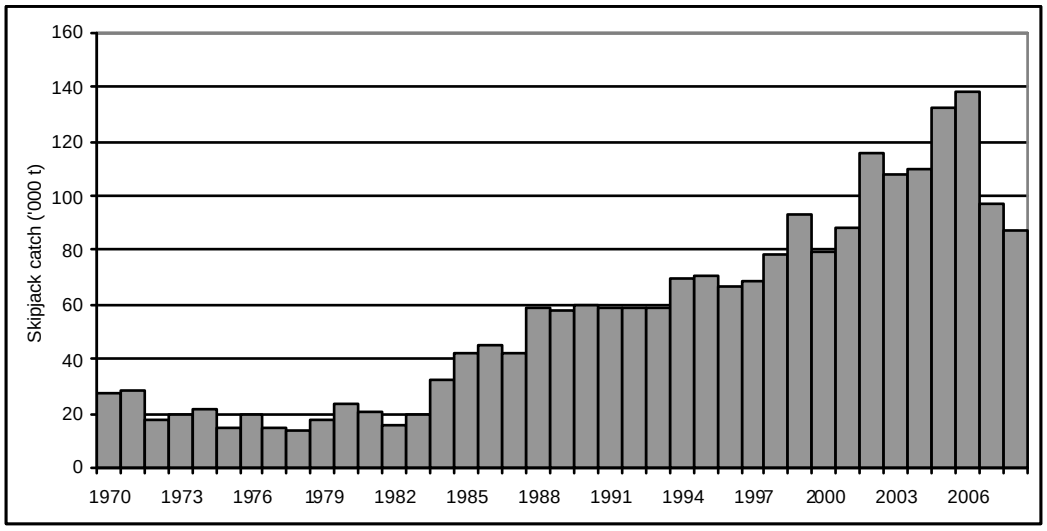
Figure 1. Estimated annual standardised *masdhoni* fishing effort (standard mechanized *masdhoni* days). (MoFA data). Note: Sailing *masdhoni* days divided by 2 up to 1989, thereafter set to zero. Mechanized *masdhoni* days increased by 1% per year from 1990 to take some account of increased fishing power.



Fishing effort in 2008 was 75% of fishing effort in 2003. Previous estimates of bait catch have been based directly estimates of fishing effort. The implication is that bait catch is something of the order of 25% less than it was at its peak in about 2003. Over a similar period there has been a decline in skipjack tuna catches (Fig. 2). In 2008, skipjack catch was at the lowest level since 2000.

The decrease in *masdhoni* fishing effort has undoubtedly contributed to the decrease in the landings of skipjack tuna (the main catch of the pole and line fishery) over the same period. However, decreasing fishing effort alone cannot explain all this change. Standardised fishing effort in 2008 was 87% of that in 2005, but reported skipjack catch in 2008 was just 63% of the peak catch in 2005. Other factors that are likely influencing skipjack catches in the Maldives include:

Figure 2. Skipjack tuna annual recorded catches of in the Maldives. (MoFA data).



- Catch rates of skipjack, particularly large skipjack (*godhaa*) appear to have declined, likely reflecting a decrease in abundance. This in turn likely reflects high levels of fishing mortality in the Indian Ocean as a whole. This is a serious early warning of possible overexploitation of the regional skipjack stock, and needs to be addressed by IOTC as soon as practical (the IOTC Working Party on Tropical Tunas has set skipjack assessment as a priority for 2010).

- Many *masdhonis* are now targeting large yellowfin tuna (mostly by handline) rather than operating as pole and line vessels. As a result pole and line effort has been reduced. However, data on type of tuna fishing carried out by *masdhonis* is not routinely compiled by MoFA, and so the extent of this issue cannot be assessed. There is a need for MoFA to compile handline and pole and line catch and effort data separately. The logbook system currently being introduced should go a long way to addressing this issue, but retrospective re-compilation of island reports may be required to obtain estimates of catch and effort by gear type for recent years.

Understanding the dynamics of the skipjack fishery contributes to understanding the dynamics of demand for livebait, because there are feedback mechanisms. Thus, if there is less bait available there are likely to be reduced skipjack catches. Less obviously, if there is less skipjack there is likely to be a reduced catch of bait. This is especially the case now with the increasing number of large *masdhonis*. These large boats have high running costs, so most do not go out fishing (and therefore do not take any bait) unless a reasonable catch of tuna is assured. For this reason some understanding of the reasons behind the increasing size of *masdhonis* is useful.

Fewer fishermen, larger boats

Over the past two decades there has been a slow but persistent trend among boat owners to build bigger *masdhonis*. As a result, there are very few if any *masdhonis* operating in the pole and line fishery now of the size that was typical in the 1970s and 1980s (i.e. 10-12m). Indeed there are now many *masdhonis*, particularly in the south, in excess of 30m.

There is a perception among some (e.g. World Bank, 2007: page 48) that the trend towards fewer, larger *masdhonis* in the tuna fishery has contributed to a decrease in employment

opportunities for fishermen. The opposite appears to be the case. It is the shortage of men, particularly young men, willing to go fishing that has forced boat owners to invest in bigger and better *masdhonis*, in order for them to be able to attract and keep crew. This competition for crew has resulted in an ôarms raceô with owners having to build bigger and bigger vessels, at greater and greater cost. While these large vessels certainly catch more in absolute terms than smaller vessels, it is not clear if the increased investment required has resulted in a proportionate increase in returns, particularly since both capital and running costs are much higher for larger vessels.

There are several reasons behind the unwillingness of young men to enter the fishery. However, the major factor is the increased aspirations among the younger generation. With universal education, most young men are leaving school with expectations of a ôgoodô job, and absolutely no expectation of becoming a fisherman. Income is not the determining factor, since many fishermen make very good incomes, whereas many school leavers would rather be unemployed than go fishing. While there are of course some exceptions, and some young men are going fishing, on the majority of fishing boats now the average age of the crew is over 40. Foreign workers (typically from India or Bangladesh) are now found on many *masdhonis*, a situation that was entirely unthinkable even five years ago.

It is important that the real reasons for (and costs of) the increasing number of large *masdhonis* are understood, because the implications of this trend for the pole and line fishery are profound. The immediate result of the lack of young men entering the fishery is a stagnation, indeed a decline, in fishing effort, with consequent decrease in catch of tuna. The longer-term economic implications for the fishery are not good, and do need to be studied. In the case of bait, there is also likely to be a net decrease in total catch, which from a stock conservation perspective can be seen as a positive outcome. However, there is a complication. As mentioned above, these larger vessels have such high running costs that they do not go fishing unless there is a reasonable assurance of a good tuna catch. So when they do go fishing they take as much bait as they can, because they do not want to miss out on the chance of catching as much tuna as possible. On many days, when less that full loads of tuna are caught, this results in much wastage of bait. More generally, because these larger vessels require larger quantities of baitfish, they may in some cases be contributing to local depletion.

Within the four MEMP atolls, there is a diversity of responses to the changing socio-economic conditions in the pole and line fishery. Fishermen in both Baa and Noonu Atolls are not developing with the fishery. Young men are not entering the fishery. Most boats are still less than 20m long. Most fishermen in Baa have not taken to light fishing for bait at night, while in Noonu many fishermen prefer daytime baiting, and tuna fishing very close to the atoll. Some fishermen are abandoning the fishery, and in Noonu the recent opening of two new resorts has presented alternative employment opportunities (and the promise of a regular income) that is drawing boats and fishermen away from pole and line fishing. In contrast, in Raa and Lhaviyani Atolls, fishermen are moving with the times. Bigger boats are being built, and on some islands at least, young men are joining the fishery. Nearly all fishermen are optimistic about their futures.

Status of baitfish data collected and reports

A review of baitfish data and reports was given in this TAôs Inception Report (Anderson, 2009a); it is not repeated here. MRC has recognised the importance of the bait fishery since its inception, and has consequently maintained some level of research for many years. A particularly intense period of baitfish research and data collection by MRC was carried out during 2000-04. Unfortunately, these data have never been properly worked up and they remain unpublished. The main reason for this lack of completion was the transfer of the chief investigator to MoFA in 2004. Some progress has been made during this TA in checking and

(where necessary) recompiling these data. However, lack of counterpart time prevented completion of this task. This work does need to be completed. The baitfish monitoring programme initiated under this TA will generate further baitfish data. This too needs to be compiled as it comes in, and reported upon in a timely manner.

BAIT FISHERY MANAGEMENT

Current issues with baitfish management

Stock status

There has been some concern expressed about the status of baitfish resources in the Maldives, with evidence of high levels of fishing in some atolls (Anderson, 2006). However, as mentioned above, most of the prime baitfish varieties are small pelagic species with very high rates of natural population turnover. Such stocks are in general considered to be difficult to overfish. At the same time, the recent decline in pole and line fishing effort, and of skipjack catch, suggest that total bait catch must also have decreased. (The bait monitoring activity started under this TA will provide the data needed to quantify this).

Taken together this suggests that livebait resources are likely to be in a reasonable state at present. However, there are still some reports of bait shortages in the southernmost atolls. It is ironic that the four atolls involved with this TA include two of the most productive in terms of livebait in the entire Maldives (Raa and Lhaviyani). There is a need for MRC to expand bait monitoring to these southern atolls (Addu and Huvadhoo).

Yellowfin tuna fishery

Nearly all pole and line fishermen have some objection to yellowfin tuna fishing. There are two main bait-related objections. First, the use of triggerfish (juvenile red-toothed triggerfish *Odonus niger, rondu*) for bait when targeting large yellowfin is widely felt to be undesirable. Triggerfish sometimes puncture the stomachs or guts of the yellowfin. Use of triggerfish reportedly causes the large yellowfin to dive deep or depart. Skipjack often follow, so they are lost to the pole and line fishery. (This is comparable to the use of *thaavala* in the pole and line fishery). Secondly, many fishermen believe that much bait enters the atolls from the open sea. Large yellowfin tuna (and other large pelagics) help to ôherdô the bait into the atolls. By removing these large fish the supply of baitfish within the atolls is diminished. Pole and line fishermen also object to yellowfin tuna fishermen fishing (illegally) on FADs, although this is not a bait issue.

By-catch

Most fishermen report low or zero by-catch amongst their bait catches. However, a few fishermen do note that sometimes when night baiting with lights large catches of what appear to be fish larvae are taken, and inevitably most died. They feel that this must have some impact on reef fish stocks. Sampling by MRC during 2000-04 suggested an extremely low level of by-catch. However, it is likely that large by-catches are taken on rare occasions. This needs to be quantified, and MRC bait monitoring field officers will be able to assist.

Interactions with reef fish fishery

Bait fish species are food for many other species of reef fish. The removal of large quantities of bait may thus have implications for other members of the atoll ecosystem, although none have yet been quantified. Theoretically at least, high levels of bait fishing may locally reduce

bait stocks, leading to reduced food availability for reef fish. Alternatively, removal of top predators might potentially result in decreased mortality on smaller-sized carnivores, and hence increased predation on bait species. One interaction for which there is some evidence, albeit anecdotal, is that the removal of predatory fish (notably certain groupers and white-tip reef shark) reduces bait catchability (since these fish corral the baitfish making them easier for fishermen to catch).

Interactions with tourism

The tourism industry is of prime economic importance in the Maldives, and to a very large extent depends on the same reefs that the bait fishermen exploit. Tourism has now spread to every atoll in the country. The potential for conflict between resource users is increasing. One management tool that tends to be favoured by the tourism sector is the use of Marine Protected Areas (MPAs). These may not be the optimal tool for managing bait fishermen, since the prime bait species are mobile and highly seasonal and therefore the fishermen need open access.

Regulations and institutional arrangements

The proposed new fisheries law has yet to be debated by Parliament. And the new regional councils have yet to take full effect. It is therefore premature to comment on how these changes will impact on the bait fishery. Nevertheless, there is a clear trend towards decentralisation of institutions and responsibilities. That will undoubtedly draw fishermen more closely into the management process, which can only be a good thing.

By long tradition, Maldivian tuna fishermen have the right to fish for bait almost anywhere. In the past, fishermen from one island would not normally fish for bait (or anything else) in the immediate vicinity of another inhabited island. In recent times this restriction has also come to be applied to resort house reefs. But apart from these limitations Maldivian tuna fishermen strongly believe that they do have a right to fish for bait wherever they want. To a large extent this no doubt reflects the seasonal and mobile nature of bait resources, and was a rational approach to utilization of those resources. However, some (particularly within tourism) now see marine protected areas (MPAs) as the most effective means of managing reef resources. Tuna fishermen will take some persuading to agree.

MoFA is currently in the process of introducing a new logbook catch and effort recording system for fishermen. This opens the possibility of introducing quotas, perhaps individual transferable quotas ITQs, at some time in the future. Again, this will not be a natural concept for Maldivian fishermen, and if considered would require much preparatory work. There is clearly scope for a national debate on the best way forward with marine resource management.

Goals of baitfish management

The goal of baitfish management should be to prevent over-exploitation of the resources.

However, any management system introduced to meet this goal will need to be very robust and simple. The biological resources on which the fishery depends are multi-species and complex. The fisheries themselves are ancient ones, with long-established traditions that will be difficult to change. The human resources available for monitoring and management are extremely limited. In short, it is unrealistic to expect MRC to conduct classic stock assessments for each baitfish species or for MoFA to be able to introduce and operate any but the most basic management system anytime in the foreseeable future.

> *... professionals ... are sometimes discouraged when faced with fisheries management systems that are less than perfect, unaware, perhaps, that there is no other kind.*
> Johannes (2002)

Objectives to be met in order to achieve that goal, include improved governance (including adequate monitoring of the fishery), more efficient use of existing livebait resources and exploration for new sources of livebait.

Overall baitfish management strategies and modalities

Improved governance

The management of the baitfish fishery, if it is to be effective, should not be treated in isolation, but must be coordinated and integrated with the management of other fisheries and resource users. Thus, while the livebait fishery may be arguably the most important reef fishery, it is only one among several. At the same time there are also strong demands on reef resources from the tourism industry. The development of a management plan for baitfish must therefore take place within the wider context of an integrated management plan for all reef resources. In addition, the livebait fishery is essential for the prosecution of the valuable oceanic tuna fishery. Any management measures directed at the livebait fishery will impact upon the tuna fishery (and vice versa).

Management of the bait fishery does not require management of bait resources as such, but of the fishermen who exploit them. This will require community participation. There is also a need for social and economic inputs, and that requires political decisions to be made.

Fishermen's perceptions

As part of the process of improving fisheries governance, fishermen themselves need to be much more involved. Maldivian fishermen have a vast knowledge of the marine resources of their atolls and the surrounding ocean, and they must be more involved. However, Maldivian fishermen generally have little concept of overfishing. Their main experience, over many centuries, has been with tuna. These fish are highly abundant; they are also highly mobile and come and go more or less regularly, with periods of high abundance often followed by complete absence. To a large extent the same applies to bait fish, most of which are small pelagic species. They too show very large variations in abundance between seasons and between years, but (so far at least) always return in good numbers after a period of shortage. Most Maldivian fishermen therefore feel that fisheries resources are effectively unlimited, and that times of plenty will always return after times of shortage. As a result, after commercial reef fisheries started, in the 1970s and 1980s, fishermen did not appreciate the significance of falling catches. For example, when reef shark and deepwater gulper shark numbers declined during the 1980s and 1990s, many fishermen believed that there were still plenty of sharks but that they had ómoved awayô perhaps because of too much disturbance. This attitude remains widespread (although it is changing, as the reality of the status of several reef fisheries becomes increasingly apparent). If the fishermen are to cooperate in any bait fisheries management programme, they will first need to be persuaded of the need for such management, and for many that will require a change in their fundamental misconception regarding the infinite abundance of marine resources. This is not a trivial matter, and it is likely that much effort will need to be spent changing attitudes.

Management options

The decline in pole and line effort over the past few years appears to have reduced pressure on the baitfish stocks. It is not clear yet if this is part of a longterm decline, or if catch and effort will rebound in the next few years. If the latter, then some form of management control of baitfish catches will be required. Options will need to be debated nationally, but likely possibilities include MPAs and ITQs. Neither will come naturally to Maldivian fishermen, and, as mentioned above, much work will be needed to persuade them of the benefits.

Exploration for new sources of baitfish

Generations of experience have made Maldivian fishermen among the best in the world at finding and catching livebait within the atolls. There may be some improvements that can be made, but they are likely to be minor. However, Maldivian fishermen do not catch bait outside the atolls, and there may be additional resources that could be exploited. These potential new sources of livebait include:

- Nearshore pelagic resources including pelagic fusiliers, *Dipterygonotus balteatus*, which occurs in large baitballs outside the northern atolls in the NE monsoon season. And anchovies (*miyaren*) which are reported to occur outside the atolls, particularly in the south.

- Mesopelagic fishes which appear to occur in very large numbers on the downstream side of the atolls (ie just outside the western atolls during the NE monsoon and outside the eastern atolls during the SW monsoon).

MRC should initiate experimental trials for locating, catching and testing the chumming ability of these species.

Improving the efficiency of baitfish utilization

Maldivian tuna fishermen are the least efficient in the world when it comes to baitfish utilization. They take on average something of the order of 9kg of tuna per 1kg of bait, compared to 12-30 kg of tuna taken elsewhere (Table 5). One contributing factor may be that bait is so plentiful in (most) Maldivian atolls that fishermen do not have be to niggardly with its use. Another factor may be that a high proportion of Maldivian bait is of delicate species that do not last more than one day in captivity, so there is a need to catch more each day. It is also undoubtedly the case that Maldivian fishermen, from generations of experience, are among the very best at finding and catching bait in atoll environments.

Table 5. Tuna catches per unit bait from various pole and line fisheries

Country	Tuna catch per unit livebait (kg/kg)	Sources (listed in Maniku et al, 1990; and Anderson, 2009a)
Maldives	8.6 (7.4-10.0)	Anderson (2006); Adam (2006)
Solomons	12.1 (9.9-15.0)	Nichols & Rawlinson (1990)
Hawaii	12.1	Yoshida et al. (1977)
Kiribati	14.8 (7.1-21.3)	Rawlinson et al. (1992)
Japan	15.9	Isa (1970)
PNG	22.4	Anon (1984)
Solomons	30.4	Argue & Kearney (1982)

Whatever the case, it is apparent that is should be possible to improve the efficiency of bait utilization. Possible means of increasing tuna catch per unit bait include:

- Initiate an awareness campaign among fishermen to improve their understanding of the issue and encourage less wastage. This is covered further in the accompanying Code of Conduct and best practice guidelines.
- Employ the services of two pole and line master fishermen from the Pacific (with experience of a high yield skipjack fishery) to demonstrate their bait holding and utilization techniques.
- Employ the services of a pole and line masterfisherman from the Atlantic (with experience of boat-associated fishing). Boat-associated fishing involves using the fishing boat itself (or more usually two, which can take turns) as a FAD. This has proved to be a particularly efficient means of fishing, with tunas often being caught without any livebait at all. The new large *masdhonis*, which do stay out in the ocean overnight, could prove ideal for such fishing.

Priority training needs and awareness messages

Fishermen would benefit from training in the more efficient utilization of livebait, and also from improved awareness of issues impacting the bait fishery. This is dealt with in Section 2.

At the national level, both MRC and MoFA have a chronic shortage of trained technical staff. This is not something that can be easily or quickly addressed. The issue has been well known for more than 20 years. If MoFA wants to receive informed scientific advice to inform management, and to have competent staff to initiate and run meaningful management regimes, then it needs to place a far higher priority on staff training.

Box 2. The value of marine research

MRC lacks the trained staff to conduct the level of research needed to adequately monitor and provide management advice on Maldivian fisheries, including the bait fishery. A major reason for this is lack of funding for tertiary training, which might in part be attributed to lack of political appreciation of the value of marine research. This is perhaps not surprising since many research activities bring benefits which are difficult to quantify, especially in the short-term. However, there are examples of work by MRC that are bringing considerable benefits to the country, including:

Tuna Fisheries

The Maldivian skipjack and yellowfin tuna fisheries are currently undergoing assessment for Marine Stewardship Council (MSC) certification. This certification, if granted, guarantees the sustainability and ecological soundness of the fisheries. In Europe, in particular, there is a growing market for such ógreen productsô and as a result they command a premium price. In round figures, Maldivian tuna exports are currently worth about US$100 million per year. The potential added value that might be achieved following MSC certification may be as much as 10%. MSC certification could not be achieved (and if granted will not be maintained) without an active research programme on tunas that provides the required information on e.g. stock status and bycatch. In other words, research by MRC has directly contributed to the MSC certification process, which may potentially bring benefits of the order of US$10 million per year.

Baitfish

The bait fishery is an integral component of the pole and line tuna fishery. Lack of information on the status of baitfish stocks and lack of adequate management plans have been raised as potential shortfallings in the overall sustainability of pole and line tuna fisheries (Greenpeace, 2009). Without adequate monitoring and research on the Maldivian livebait fishery being carried out by MRC it is likely that assessment of the tuna fisheries for MSC certification would fail, again jeopardising potential benefits of about US$10 million per year.

Parrotfish and Manta Rays

In the mid-1990s MRC staff reviewed priorities for protecting marine species. As a direct result, several species were protected from fishing and/or export. These included all parrotfishes and all rays. Parrotfishes were protected because of their key role in reef ecology. Rays were protected because of the importance of manta ray watching to tourist divers and snorkellers. Since then, international research has highlighted the essential role of herbivorous parrotfishes in maintaining coral reef health and resilience (Hughes et al., 2003). Recent research in the Maldives has estimated that manta ray watching by tourist divers and snorkellers is worth about US$9 million in direct revenue each year (Anderson et al., in press). Although not inevitable, it is certainly likely that fisheries for parrotfishes and manta rays would have started if the export bans recommended by MRC had not been in place. (Indeed there was an attempt to start a manta fishery in order to export skins). The ecological and economic benefits of these two protective measures are the direct result of those interventions by MRC researchers.

Habitat protection and restoration

The species of baitfish used in the pole and line fishery are all atoll-associated. Some are quite closely linked to coral reefs (e.g *boadhi*, *muguraan*, *nilamehi*), others (particularly those species caught at night using lights such as *rehi*, *hondeli* and *miyaren*) are more pelagic, being found inside atoll basins and sometimes close to reefs but not tightly reef-associated. It has been established that healthy coral reefs are important for reef-associated species (e.g. Feary et al., 2007). The importance of reef structure for the more loosely associated atoll species is not clear. However, it is reported from Addu Atoll that habitat degradation (in the form of causeways built between islands, which disrupted water flow) contributed to the collapse of *hondeli* stocks there (Anderson et al., 1997). Whatever the specifics, it can be assumed that habitat protection is one key to maintaining the health of baitfish stocks.

Maldivian coral reefs have been suffering from a number of causes of degradation, both acute (El Nino associated bleaching and mortality) and chronic (widespread waste disposal as well as more localized pollution and direct damage). In regard to the bait fishery specifically, there are two issues:

1. Anchoring on coral reefs. Boats may sometimes anchor when baiting, thereby potentially causing damage to corals. In fact, while anchoring was the norm in the past, it is now the exception (due to both the use of more powerful engines making the *masdhonis* more manoeuvrable, and to the frequent night-baiting when bait occur away from the reefs). Even when boats do anchor (for example when there is strong wind or current making it impossible to hold the *masdhoni* in place any other way), the bait is usually on the upstream side of the reef, which requires placing anchors in the sandy atoll floor well away from the reef. This issue is dealt with in the Code of Conduct (section 2 of this report).

2. Marine protected areas. One option for habitat protection and the conservation of marine resources, including bait stocks, is the use of marine protected areas (MPAs). As noted

above, Maldivian fishermen believe very strongly that they have a right to fish almost anywhere. MPAs may be a tool of choice for environmental considerations (eg to protect coral reefs). However, if MPAs are to be used, persuading fishermen to stop fishing within these areas will require a lot of community-based preparatory work.

Future data collection and monitoring recommendations

- A major component of this TA has been the setting up of a bait monitoring system in the four project atolls. The bait monitoring field officers will require regular supervision from MRC if they are to produce useful data. They should be visited in January, immediately after starting their duties, and again regularly every couple of months. Data should be checked and compiled as it comes in, and analysed periodically (at least annually).

- The bait monitoring programme must be extended to the southern atolls. Conditions are different there from the MEMP project atolls (i.e. species composition is different, *masdhonis* are larger, and there are persistent complaints of bait shortages) Such monitoring will be outside the scope of this TA, but MRC should find the resources to make it happen.

- There is now a large range of sizes of *masdhonis* operating in the pole and line fishery. It will be necessary to sample bait from the full range of sizes (this has been done in the project area atolls, but larger *masdhonis* are operating in the south, and they too need to be sampled). It will also be essential for MoFA to compile data on *masdhoni* sizes, including not only numbers of *masdhonis* by size but also catch and effort by size category. This is necessary because the total number of fishing trips must be stratified by vessel size. Only then can bait utilization by different size categories be raised to estimate the national total.

- The new MoFA fishermensô logbooks should include information about bait fish catches, and be compiled on a regular basis.

- It would be useful to conduct a biannual perception survey of experienced masterfishermen. Sentiment regarding current status of bait availability, and change over previous five years should be recorded. (This has already been successfully carried out for skipjack tuna and silky sharks, and could be extended to other species too).

- Use of the standard MRC bait fishery monitoring form, which has been in use for many years, should be continued. It is distributed to MRC tuna catch sampling field officers, but they do not always trouble to fill and return them. This needs to be followed up regularly. Data should be compiled as they come in, and analysed at least annually.

- Recording of baitfish utilization by the MoFA Malé market sampler should continue. Data collected should be analysed at least annually.

- Preliminary analysis has shown a relationship between primary productivity around the atolls and baitfish production (Anderson, 2006). This analysis should be further developed, using remote sensing data, to investigate the relationship more closely and elucidate regional, seasonal and inter-annual variability.

- The large quantity of bait fishery data collected by MRC during 2000-04 needs to be written up and published.

- The MRC data includes information on bait fishing locations. This should be expanded to include all baiting locations in the MEMP area, and detailed bait fishing maps compile and published. These would be of use, for example, in EIA and mitigation of dredging and reclamation activities.

> *The choice is not between giving perfect or imperfect advice to managers. It is between giving imperfect advice or none at all.*
> Johannes (1998)

Bait FADs

Fish aggregating devices (FADs) have been widely, and successfully, deployed in the Maldives (and elsewhere) for the enhancement of tuna catches. The reasons why fish aggregate under floating objects are still under debate. Nevertheless, in the case of tunas they clearly do aggregate, and fishermen take advantage of this by searching out natural floating objects, or deploying artificial objects as FADs. MOFA now maintains a network of some 50 tuna FADs, spread right around the entire Maldives.

The use of FADs to attract bait is less well established. It should be noted that the operating conditions for tuna FADs and bait FADs are very different. Tuna FADs are deployed in the open ocean, where, for whatever reason, they act as an attractant for tunas in the vast and relatively featureless ocean. Bait FADs are deployed inside the atolls, where there are many other attractants (reefs) nearby.

Nevertheless, the use of óshade luresô for bait attraction (i.e. bait FADs) was recommended half a century ago by Cole (1960). However, the idea was not taken up until relatively recently, with the first BFAD being deployed inside Addu Atoll in 2001 (Maajid, 2001). A total of six BFADs have been deployed (Table 4).

Table 4. Summary of information on bait FADs deployed in Maldives

Atoll	Location	Position	Dates deployed & lost		Comment
Seenu	N of Gan		11.5.01	NA	Vandalised and lost
Seenu	N of Gan	0°38.6S 73°09.8E	18.4.04	31.5.05	Lost after 287 days
G.Dh.	N of Vaadhoo	0°16.8N 73°16.8E	17.8.04	-	Still functioning
G.A.	NW of Vilingili	0°49.7N 73°22.4E	13.8.04	-	Still functioning
Lh.	E of Naifaru	5°25.5N 73°23.9E	13.7.06	12.8.06	Lost after 29 days
Sh.	NE of Komandhoo	6°07.6N 73°06.1E	15.7.06	-	Vandalised

Source: Maajid, 2001; MOFA

There has been no monitoring of BFADs, so it is impossible to make an objective assessment of their value. Tuna fishermen in the MEMP area did not speak highly of them. Most Lhaviyani Atoll fishermen we interviewed had not bothered to visit the BFAD in their atoll. One fishermen interviewed had used the BFAD twice, but said that he said that he obtained no more bait than he would have caught anyway. More than one fishermen said that the Lhaviyani BFAD was deployed next to one of the best baiting reefs in the atoll, and that it would have been better positioned where bait was normally scarce. The Raa and Noonu Atoll fishermen interviewed were aware of the BFAD in Shaviyani, but none we spoke to had felt the need to visit it.

The BFAD in Addu Atoll was visited by a team from MRC (Ismail Haleem, pers. comm.). No bait were seen during the course of one day dive. Fishermen reported that the BFAD did work well initially, while its lighting system was functioning, but later when the lighting system failed it was ineffective. It was also reported that this BFAD was vandalised, allegedly due to some conflict been local fishermen and visiting fishermen from Huvadhoo Atoll.

There is a need to review the objectives and achievements of the BFAD programme and discontinue or modify the deployment and monitoring strategy as appropriate.

2. BEST PRACTICE GUIDE AND CODE CONDUCT FOR BAIT FISHERMEN

USE BAIT MORE EFFICIENTLY

(1) Minimize bait wastage

When bait is abundant, Maldivian fishermen will often take more than they need for a dayôs fishing. This is particularly true of the new very large *masdhonis*. These boats can hold very large catches of tuna, so the fishermen do not like to be short of bait, even though the largest tuna catches are only made on a few days each year. As a result, on many days fishermen take too much bait, which (if it is a delicate variety such as *rehi*, *hondeli* or *miyaren*) will inevitably die. When fishermen do have excess bait which is still alive when tuna fishing is finished, they will often throw it overboard while still out at sea. It is almost inevitable that such bait will be eaten relatively quickly. It would be better to throw it overboard when the *masdhoni* is back inside the atoll, so that the bait has a higher chance of survival.

Key messages: Do not take more bait than you need. If you have live bait left once tuna fishing is finished and are going to throw it overboard, throw it inside the atoll, where it will have a better chance of survival than out at sea. If everyone wastes bait today, there will be less for all tomorrow.

(2) Maximize bait utilization

In terms of quantity of tuna caught per unit of bait used, Maldivian fishermen have perhaps the highest rate of bait utilization in the World. In Maldives the average catch is about 7-10 kg of tuna for 1 kg of bait. Elsewhere in the World pole and line fishermen catch 10-22 kg of tuna for 1 kg of bait. It is not clear why Maldivian fishermen are so much less efficient than fishermen elsewhere (see section 1). Nevertheless, it is clear that more efficient utilisation of bait would

Key message: Make the best use of the bait you have. It is possible to catch more tuna using less bait.

MINIMIZE ENVIRONMENTAL DAMAGE

(3) Coral anchoring

Traditionally, *masdhonis* would anchor near or on a reef in order to catch bait. This inevitably resulted in damage to the coral reef. Nowadays, mechanized *masdhonis* are highly manoeuvrable, and usually do not anchor (although they will do so when they need to maintain position and there is much wind or current). Typically bait is most abundant on the upstream side of a reef, so if a *masdhoni* does anchor it will tend to place its anchors well away from the reef on the upstream side. There are some occasions, however, when *masdhonis* do drop anchors on corals. This needs to be avoided.

Key message: If you have to anchor for baiting, avoid anchoring on corals. Corals are important in many ways (they build the reefs that protect the islands, and they provide shelter for bait fish). So breaking corals is bad for all.

(4) Avoid bycatch

The Maldivian livebait fishery takes relatively little bycatch. Nevertheless, it does occasionally happen during night baiting that quantities of small non-target species, including fish larvae (*funi*), are attracted to the lights. Most fishermen are able to avoid catching such unwanted bycatch by moving the boat slightly before hauling the net. However, some *funna* are sometimes caught, and inevitably are killed.

Key message: If there are *funi* attracted to the lights while night bait fishing, take necessary measures to avoid catching them. These small animals are the juveniles of other reef fishes.

IMPROVE GOVERNANCE

(5) Maintain logbooks

The Ministry of Fisheries and Agriculture is introducing a new logbook recording system for all fishermen. This will provide key information towards sustainable management of the fisheries, including the livebait fishery. In addition, it is increasingly a requirement for exports to Europe that source fisheries must be properly monitored and managed. Therefore, proper compliance with logbook requirements will be necessary to achieve the full financial benefits from export markets.

Key message: Keep proper logbook records of your fishing activities. It is important both to help ensure sustainability of fish resources, and to achieve best prices from exports.

(6) The message of sustainability

Most Maldivian fishermen do not have a good grasp of the concept of overfishing. This is perhaps because generations of Maldivian fishermen have fished for highly migratory tuna species, which may be present one day but gone the next. As a result, Maldivian fishermen often feel that a decline in abundance of any fish species is just a result of it ómoving awayô and that it will return in due course. However, this is not the case with many reef resources, which are being overexploited. Increasing numbers of fishermen are realising that sea cucumbers have been overexploited, so this could be used as an example to explain what happens when too many fishermen exploit the same finite resource. More generally, there is a need for dissemination of information about responsible fishing and the need for proper management of all fisheries.

Key message: Marine resources are not infinite, and all can be overexploited. If we want to keep healthy fisheries for the next generation, we need to take care of what we have now.

DELIVERY MECHANISMS

For these messages to reach the fishermen a variety of innovative approaches will be required. These could include:

a) Posters

A competition among schools should be organised to produce bright and eye-catching posters, dramatically presenting the key messages for best practice in the bait fishery. In addition to the information presented here, school children should be encouraged to ask their fathers and grandfathers about problems in the bait fishery to be used as materials in their posters. To be organised by MRC in cooperation with the Ministry of Education.

b) Television

A short TV documentary could highlight the major issues in the bait fishery, and in particular show the wastage of bait that occurs when excess bait is caught. MRC already has relevant video material. To be produced by MRC and TVM.

c) Radio

Short drama segments, perhaps in the form of an on-going ósoapô, could by used to highlight issues in the bait fishery in an entertaining format. To be produced by MRC and Voice of Maldives.

TRAINING OPTIONS

Fishermen respond best to practical, not classroom, training. It is therefore proposed that experienced master fishermen should be contracted to provide training for Maldivian fishermen in the best practice efficient utilization of baitfish. It is proposed to employ the services of two pole and line master fishermen from the Pacific (with experience of a high yield skipjack fishery) to demonstrate their bait holding and utilization techniques. And to employ the services of a pole and line master fisherman from the Atlantic to demonstrate the technique of boat-associated fishing.

TECHNICAL ASSISTANCE TO BAIT FISHERIES MONITORING

3. FINAL ACTIVITIES REPORT

SUMMARY

This report summarises the activities of a consultancy mission, 27 September to 20 December 2009, to continue technical assistance for bait fisheries monitoring with the Marine Research Centre (MRC), under the IDA-funded Maldives Environmental Management Project. The main aims of this mission were: to complete the recruitment and training of bait fisheries monitoring field officers; to produce a Bait Fisheries Management Framework; and to produce a Best Practice Guide and Code of Conduct for Bait Fishermen.

One field trip to the project atolls was undertaken, during which potential bait monitoring field officers were interviewed and briefed. They will start official bait monitoring duties on 1 January 2010. A field trip to the project atolls to ensure that the new field officers are conducting their duties correctly is being planned by MRC for January 2010.

Three bait fishing trips were undertaken, during which the bait catch was weighed. All three baiting operations were conducted during daytime. The average catch was 55 kg, which is much less than the amounts weighted during night baiting in June. A day trip was made to K. Himmafushi to observe a yellowfin handline fishing boat; those fishermen used mainly scads as bait.

Two samples were obtained of the most important single variety of baitfish that has not previously been scientifically identified (the ‘red-baitô of the northern atolls); it was identified as the pelagic fusilier *Dipterygonotus balteatus* (known locally as *raiy rehi* or *kura muguram*). Compilation and analysis of bait fishery data collected by MRC and MOFA was continued, but could not be completed due to lack of counterpart inputs.

INTRODUCTION

Tuna fishing is the most important fisheries activity in the Maldives, currently accounting for roughly 90% of the total recorded catch. Both pole and line fishing (for skipjack and small yellowfin tuna) and handline fishing (for large yellowfin tuna) require large and regular supplies of small fish to be used as bait. Without the livebait there will be no tuna catch. It is therefore imperative for the Maldives that livebait resources are utilized in a sustainable manner.

The main aim of this TA is to provide technical support to the Marine Research Centre (MRC) in developing a bait fishery monitoring scheme that will provide inputs to sustainable fisheries management, and in developing a code of best practice for efficient use of baitfish.

This report provides a summary of activities undertaken during September to December 2009, during the third and final consultancy input.

FIELD TRIPS

In addition to the two field trips undertaken in June, a third field trip to the project atolls was carried out by the consultant and MRC project counterparts, 3-10 December. A separate trip report was produced, and that is not repeated here. The main aim of this field trip was to

initiate the training of potential bait monitoring field officers. That was completed successfully (see below).

There was again some reluctance on the part of fishermen to allow weighing of bait, because it was felt that this would result in unacceptably high mortality. However, this is not the case, and once bait weighing had been demonstrated, fishermen were happy to collaborate.

As on previous field trips, fishermen in the project atolls reported no major problem with the bait fishery. Indeed fishermen from both Raa and Lhaviyani Atolls maintained that their atolls were the most productive for bait in the northern region, if not the entire Maldives. All fishermen felt that there was no need for government intervention or management of the bait fishery. They rejected any suggestion that there could be any restrictions on what they perceived to be their fundamental right to find and catch bait.

Due to a number of problems, bait fishing could only be carried out with three of the six potential bait monitoring field officers. Details of boats and catches are given below (together with results form two trips carried out in June).

Table 2. Estimates of bait catch by five pole and line vessels

Island	Date	Masdhoni	Bait weight	Main species
R. Meedhoo	8 June 2009	Fazaa, 25.3m	170 kg	*Rehi*
Lh. Naifaru	26 June 2009	Lily-2, 22.7m	296 kg	*Boadhi*
N. Manadhoo	5 Dec 2009	Vidhuvaru, 13.4m	74 kg	*Rehi*
N. Holudhoo	6 Dec 2009	Namoona, 16.7m	34 kg	*Rehi*
R. Maduvveri	8 Dec 2009	Meemas, 18.0m	56 kg	*Rehi*

Note that both baiting operations in June were carried out at night (with lights) while all three in December were carried out in daylight. The average catch from two night operations was 233kg, whereas the average catch from three daytime operations was just 55 kg. In all five cases, the fishermen said that the bait catch was less than maximal but sufficient for a dayôs fishing. This was especially the case in December, when tuna fishing was relatively poor, so the fishermen were not expecting to use a large quantity of bait.

For comparative purposes, these data are presented in Table 3, together with summaries of data from previous sampling programmes.

Table 3. Estimates of bait utilization by Maldivian pole and line vessels

Period	Average bait utilization	Number of catches weighed	Source
1985-87	32 kg/day	3	Anderson & Hafiz (1988)
1993-94	49 kg/day	6	Anderson (1994 & 1997)
2000 (day)	127 kg/day	47	MRC unpublished data
2000 (night)	125 kg/day	100	MRC unpublished data
2009 (day)	55 kg/day	3	This report
2009 (night)	233 kg/day	2	This report

With so few bait fishing operations monitored so far under this programme, it would be premature to suggest that these data can be used to provide meaningful mean estimates for the entire Maldivian fleet. However, it is already apparent that larger quantities are taken by larger *masdhonis*, and that larger quantities are taken using lights at night than during daytime. These are important issues for the bait monitoring programme. Care needs to be taken to ensure both that bait monitoring adequately covers these variables, and also that data are compiled (by MoFA) on vessel sizes and day/night baiting to ensure appropriate raising of sample data.

BAIT MONITORING

Under this project, there is a requirement to recruit community bait fishery field monitors in the project area. Between the second and third consultancy missions, MRC staff arranged advertising for these posts, readvertised when too few initial responses were obtained, and made a preliminary pre-assessment of potential candidates (based on a spread of locations, and favouring active *masdhoni* skippers, who have the best access to the bait). The main aim of the field trip conducted in December was to assess potential field officers, brief them on bait monitoring methodology, and provide them with books of monitoring forms. This was completed successfully with 5 of the 6 potential field officers being confirmed to start bait monitoring on 1 January 2010. The sixth potential field officer was injured and unable to go fishing in December. He will be revisited in January and recruited as soon as he is fit to resume fishing.

MRC is currently arranging contracts for the new bait monitoring field officers, and also shipping of bait monitoring equipment (balances and toches). They will be recruited initially for a period of one year, and paid a nominal amount of MRf 1200 per month. (With 10-15 crew on most boats, this payment will not amount to much, if shared according to standard practice. However, it does put the monitoring on a professional footing, and places an obligation on the field monitors to complete their sampling).

The duties of the bait monitoring field officers will include: weighing bait (3x per week, 12x per month); recording bait weights and other information on the data forms provided by MRC; and returning data forms to MRC via the island office at end of each month. Samples of the bait forms and instructions are given in Annex 2.

The bait monitoring will require regular oversight by MRC staff. It will be necessary to carry out a field trip in January 2010 (February at the latest) to ensure that all new field officers are conducting their work correctly (and to complete the recruitment of the sixth field officer from B. Eydafushi). Subsequently there will be a need to travel to the project atolls regularly (perhaps once every 2 months) in order to ensure that a good standard of reporting is being maintained.

OTHER PROJECT ACTIVITIES

Activities carried out during earlier consultancy missions and reported previously (Anderson, 2009a & b) are not reported again here. However, for ease of reference, summaries of key activities are summarised.

Comparison with bait fishery management practices in other areas

International bait fishery management practices were reviewed, in order to identify any common themes or practices that might be applicable in the Maldives (Anderson 2009b). In three areas where bait fishing for pole and line is (or was) carried out, namely Japan, SE Asia

and Oceania, very different traditions and practices apply. In Japan there has been a long tradition of ownership of nearshore sea areas. Coastal fisheries are controlled by fisheries cooperative associations, which have the rights to nearshore marine resources, but also have the responsibility to manage them. Offshore, migratory resources are under regional or national control. In SE Asia, countries such as Indonesia and Philippines have open access fisheries and massive fishing populations, leading to gross overfishing in many areas. A recent trend has been the delegation of responsibility for coastal management to local bodies, and the widespread adoption of marine protected areas (MPAs). In Oceania, there was a long traditional of strong marine ecological knowledge and of distinct area-based rights to fisheries resources. For the most part, livebait pole and line fishing was not traditionally practiced in this region, and it did not become widespread until introduced by the Japanese, mainly in the 1970s. Some countries (such as Solomon Islands, Fiji and Papua New Guinea) developed royalty systems under which commercial pole and line vessels had to pay a fee (normally a set amount per night's baiting) for access to traditional fishing areas. Commercial pole and line fishing is now in decline across Oceania and being replaced by purse seining, which is more profitable for foreign companies and does not rely on sometimes unreliable sources of bait.

Development of separate bait fishery

Reasons for the failure to develop a separate bait fishery in the Maldives were reviewed by Anderson (2009b). Fishermen in some atolls did occasionally use a separate boat for baiting up until the early 1980s. Up to that time there were many small *masdhonis* in most islands, making task-sharing feasible. There are fewer, larger boats now, which makes this less practical. Furthermore, the main species caught now (using lights) is the silver sprat (*rehi*). This does not survive well in captivity. The main species targeted before (blue-green chromis, *nilamehi*) is hardy, but occurs in relatively low densities and amongst corals (which were sometimes broken to drive the fish out), so it is not an appropriate target for modern *masdhonis*. In short, fishermen are well aware of the possibility of dedicating a separate boat to the catching of bait; the fact that they do not do so is a good indication that this is not a feasible option under current economic conditions.

Identification of bait species

As noted in the project Implementation Report (Anderson, 2009a: page 7) there are a number of unresolved issues regarding identification of some bait species. The most pressing of these was the identification of the "red-bait" common in the north of the Maldives during the NE monsoon. Two samples were obtained:

Location	Date	Local name
Lh. Naifaru (night baiting)	26 June 2009	*Kura muguram*
K. Malé market	15 Oct 2009	*Raiy rehi*

Both samples were identified as the Mottled Fusilier, *Dipterygonotus balteatus* (family Caesionidae). This is the first time that this species has been properly identified in the Maldives. Unlike all other fusiliers (*muguraan*) this species is not reef-associated, but is a nearshore pelagic. Indeed it appears to be a significant component of the nearshore pelagic ecosystem in the northern Maldives, where it occurs in large "bait-balls" and appears to be an important source of food for yellowfin tuna during the NE monsoon.

Workshop

According to the project TOR, the consultant and MRC were required to run a local workshop to discuss possible modalities for co-management with local stakeholders and MOFA/MRC staff. During the two field trips in July (and again in December), meetings were held with

numerous fishermen, both in groups and individually. Numerous issues relating to the bait fishery were discussed during these meetings, and at the same time it emerged there was little support among fishermen either for any government control of bait fishing effort or for any workshop to consider such measures. Therefore, in discussion with MRC and with the PMU it was agreed that a workshop would not be held (confirmed in email of 16 June 2009), provided that all issues were widely discussed with a representative number of fishermen in the target atolls. This has been done.

Population growth and tourism

People have lived in the Maldives for at least 2000 years. For most of that time their living standards were probably low, but they were clearly sustainable. However, over the past century the population has increased dramatically, and so too have living standards. The historical, long-term average population of the Maldives is unknown, but was undoubtedly less than 50,000 people. The current population is over 300,000, which is several times the historically sustainable level; living standards too are at an all-time high. At the same time, tourist numbers have increased rapidly over the past three decades, with over 683,000 arrivals in 2008. The demand for marine resources has never been higher, and the ability to exploit those resources has never been greater. In this context, the appearance of sustainability is maintained by the flow of tourist dollars. If that flow were to stop, the truly unsustainable nature of todayôs Maldivian society would all too rapidly become apparent.

BAIT FISHERY DATA REVIEW

During 2000-04, MRC conducted a locally funded baitfish research project. A large quantity of data was collected, most of which was compiled. However, these data were never fully analysed nor were the results written up, mainly because the chief investigator was transferred from MRC to the then Ministry of Fisheries, Agriculture and Marine Resources (MoFAMR) in 2004.

Checking and analysis of these data was initiated under this TA. Several problems were identified with the data, notably in the way that some of it had been compiled. Although much progress has been made, this work could not be completed yet. The main reason for this lack of completion was the lack of time available from project counterparts to devote to the task (due to their numerous other commitments).

It is estimated that an addition 25 person-days will be required to complete the recompilation, analysis and writing up of these data.

PROJECT ARRANGEMENTS

Mission timing

Under the TA contract, this third and final consultancy mission was to have been completed by 18 October 2009. However, due to other work commitments, on the part of both the consultant and the main MRC counterpart, this proved unachievable. For example, the consultant, at the request of MRC, took part in two meetings of the Indian Ocean Tuna Commission in Mombasa in October 2009; both were of long-term interest to the Maldives. As a result, and after consultation between MRC and the PMU, the consultantôs contract deadline was rescheduled to 20 December 2009 (without any extra cost to the project). The

Counterparts

The TA contract (Annex A, section 9) specified that MRC would provide one full time counterpart. In practice, due to other commitments and shortage of technical staff, MRC was unable to do this. Instead MRC initially provided two part-time counterparts (Mr. Riyaz Jauharee and Ms. Sofia Ahsan Adnan). Sofia resigned from MRC in early October 2009, and was not replaced. A former MRC staff member who had gone to Australia for training to B.Sc. level, returned in July. He was to have been appointed as the main counterpart for this project, but was transferred to MoFA (where there is also an acute shortage of trained staff).

Due to pressure of other work, during the inter-mission period (July-September 2009) project counterparts were able to complete the project tasks detailed in the TA Work Activities Report of July 2009 (Anderson, 2009b). These tasks included: checking of bait fishery data from MRC 2000-04 survey; preparation of bait fishing location maps; compilation of bait data from MoFA Malé market sampling logbooks; and collection and compilation of relevant meteorological data. In fact, none of this work was done.

This is not intended as a criticism of the individual counterparts, nor of the MRC director, all of whom have worked hard to give the maximum support that they have been able to provide to this project. Rather, this is an indication of the serious and on-going problem that MRC has with lack of trained staff.

At present MRC has five graduate staff; this is exactly the same as 15 years ago (MRC, 1995). Next year, when two senior staff members go overseas for further training, MRC will have only three graduate staff members (in addition to the director). Even now, MRC has only one single graduate staff member working on pelagic fisheries (including the bait fishery). That staff member will be leaving for M.Sc. training in Australia in February 2010, and will be away for 18 months. Maldivian tuna exports are worth something of the order of US$100 million per year. Tuna also constitutes the largest source of animal protein for the Maldivian population. It seems somewhat shortsighted for Maldives to entrust its national research on this vital and valuable fishery to just one single scientist (even someone as competent as the current incumbent). It is frankly ridiculous that for 18 months during 2010-11 MRC will have not one dedicated scientist working on this fishery.

Actions Required

Actions to be carried out by MRC staff over the next few weeks include:

1. Sign contracts with bait fish monitoring field officers. Distribute monitoring equipment (weighing balances, torches).
2. Organize field trip to visit all six bait fish monitoring field officers before end of January. Go out bait fishing with each one. Check their work and correct if required. Sign contract with field officer at B. Eydafushi.
3. Starting February 2010, at the beginning of each month confirm receipt of bait monitoring forms from all field officers for the previous month. Chase up if required. Check and compile.
4. Plan and carry out visits to all six bait monitoring field officers once every 2 months, to check on their work and to maintain their enthusiasm.
5. Ensure bait fishery weekly record forms are distributed to every (other) MRC field officer. Ensure forms are completed correctly, returned regularly, and compiled.

Annex 1

Schedule of travel and work (3rd consultancy mission)

Saturday 26 September 2009
Arrive in Malé from UK

Sunday 27 September to Thursday 8 October 2009 (10 working days)
At Marine Research Centre, Malé
27 Sept: Commence work at MRC
5 Oct: Project meeting at MoFA
6 Oct: Project meeting with PMU

[10 October to 1 November 2009 in Kenya. Attending Indian Ocean Tuna Commission meetings in Mombasa, at request of MRC. Followed by one week extra in Kenya]

Monday 2 November to Wednesday 2 December 2009 (11 working days)
At Marine Research Centre, Malé
[4-8 Nov: private visit to Mysore, India]
17 November: visit to K. Himmafushi to meet yellowfin handline fishermen

Thursday 3 to Thursday 10 December 2009 (8 days)
Field trip to Lhaviyani, Noonu, Raa and Baa Atolls

Sunday 13 to Sunday 20 December (6 days)
At Marine Research Centre, Malé

Tuesday 22 December
Planned departure for UK

Summary: A total of 35 days work on this project was completed between 27 September and 20 December 2009.

Annex 2

Baitfish monitoring form and explanation sheet

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