

MALDIVES TUNA TAGGING MANUAL

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ABBREVIATIONS

BOBP	Bay of Bengal Programme (for fisheries management, based in Madras/Chennai)
CMFRI	Central Marine Fisheries Research Institute (India)
FL	Fork length (of fish, measured in cm)
FPID	Fisheries Projects Implementation Division
IOTC	Indian Ocean Tuna Commission (based in Seychelles, from 1996)
IPTP	Indo-Pacific Tuna Development and Management Programme (based in Colombo, 1980-1996)
MIFCO	Maldives Industrial Fisheries Corporation
MOFAMR	Ministry of Fisheries, Agriculture and Marine Resources
MRC	Marine Research Centre (MRS until 1998)
MRf	Maldivian Rufiyaa
MRS	Marine Research Section (MRC from 1998)
NARA	National Aquatic Resources Agency (Sri Lanka)
OTC	Oxytetracycline
PDT	Plastic dart tags
SKJ	Skipjack tuna, <i>Katsuwonus pelamis</i>
TVM	Television Maldives
YFT	Yellowfin tuna, <i>Thunnus obesus</i>

1. INTRODUCTION

Tagging is an extremely useful technique for studying several facets of the biology of tunas, and other fishes, including:

- Migration patterns
- Interactions between fisheries
- Stock sizes
- Population turnover rates
- Growth rates

Information on all of these is essential for a full understanding of tuna biology, and for stock assessment. Although tagging can certainly provide this information, tagging is not without its problems. Proper care must be paid to all stages of any tagging experiment if the full benefit is to be obtained from the work carried out. Broadly speaking, the main stages are:

Planning. The problems to be studied must be identified. Since it is not normally possible to study everything, it is necessary to define selected objectives. A workplan and budget must be drawn up, tags and other equipment ordered, manpower allocated, forms and posters printed, etc.

Tagging. Field trips must be carried out according to the workplan. This requires close liaison with the targeted fishing islands, and the assembly of a suitably trained and motivated tagging team. Great care must be taken to ensure the quality of the fish tagged, and of the data recorded.

Recovery. Arrangements must be made for the return of tags from recaptured fish (and in some cases the fish themselves) to MRC. Money or other incentives must be available to reward the fishermen for their returns. Publicity is essential. Care must be taken in the compilation and validation of recovery data.

Analysis and reporting. A full report of the tagging experiment and results of migration and growth analyses must be produced as soon as possible (i.e. once the tag recovery rate has dropped to a minimal level, which may be one year after the last tag releases). Analysis and reporting of some aspects of population dynamics may require outside assistance and take a bit longer.

The actual tagging is physically the most demanding part of the process; it can also be the most enjoyable and the highest profile. But it is only one part of the total experiment. Without proper planning there can be no tagging. Without adequate arrangements for recovery, analysis and reporting there is no point in doing any tagging.

The aim of this manual is to give a step-by-step guide to the entire process of carrying out a tuna tagging experiment in Maldives, in order to facilitate future tagging studies. This manual is based on the experience of those MRC staff who carried out the first two tagging experiments in Maldives during 1990 and 1993-95. It aims to give a fairly comprehensive account of those experiences, but cannot possibly cover all potential future situations. This manual should therefore be used as a guide only, and not as a substitute for intelligent planning and execution of tagging studies.

2. PLANNING

2.1 STATEMENT OF OBJECTIVES

The first step is to identify the problem(s) that need(s) to be solved. The objectives of the programme can then be specified. Without a clear understanding of aims and objectives it will not be possible to plan, execute or report a meaningful tagging experiment. The objectives of the first tagging programme were:

- To study the migrations of skipjack and yellowfin.
- To study the growth of skipjack and yellowfin.
- To study the population turnover of skipjack.

The objectives of the second tagging programme were:

- To study the possible differential migration of 'inshore' versus 'offshore' skipjack.
- To study the growth of skipjack through tetracycline injection.
- To provide further data for enhanced skipjack population turnover analysis.
- To study the migration of large yellowfin tuna.
- To study the growth of juvenile yellowfin tuna using tetracycline injection.

2.2 WORKPLAN

Once the objectives have been decided, a workplan can be drawn up. In general, it is unlikely that field work can start in less than one year from the identification of the need for the tagging programme. In addition at least one year should be allowed after the completion of field work for the return of recaptured tags. Thus a programme involving tagging over a complete one year cycle will actually last for a minimum of three years. A simplified and hypothetical outline workplan for such a programme is given below.

Table 1. Simplified workplan for three year tagging project involving one year of field work.

ACTIVITY	Year 1				Year 2				Year 3			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Identify problems	xxx											
State objectives	xxx											
Prepare workplan		xxx										
Prepare budget		xxx										
Identify funding		xxx	xxx									
Order equipment			xxx									
Prepare forms etc.			xxx	xxx								
Publicity				xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	
Tagging					xxx	xxx	xxx	xxx				
Tag recovery					xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
Data compilation						xxx	xxx	xxx	xxx	xxx		
Analysis									xxx	xxx	xxx	xxx
Reporting									xxx			xxx

It will be necessary to determine how many tag releases are required in order to obtain enough recoveries to answer the questions being asked. Recovery rates from the first two tagging programmes may give some help here. For example, if it is decided that 1000 tag returns are required to test a particular hypothesis about skipjack, then it is likely that at least 10,000 skipjack will have to be tagged and released. For more complex or larger scale tagging problems computer modelling may be required to estimate tag numbers required. Note that there was considerable variability in tag returns from different tagging trips.

Table 2. Recovery rates from the two tuna tagging programmes

Tagging programme	Species	Tag type	Number released	Percentage recovered after			
				1mo	6mo	1yr	2yr
1	SKJ	All	8033	7.7	9.6	9.7	9.7
1	SKJ	Offshore	3101	2.0	2.3	2.3	2.3
1	SKJ	Inshore	4932	11.2	14.2	14.3	14.3
1	YFT	All	1908	2.3	4.1	4.2	4.2
2	SKJ	All	6474	3.9	7.0	8.0	8.2
2	SKJ	Double	504	4.4	8.1	9.7	9.9
2	SKJ	Tetracycline	494	5.1	10.3	11.3	11.5
2	SKJ	Offshore	4404	4.8	8.2	9.0	9.1
2	SKJ	Inshore	2070	1.9	4.5	6.0	6.3
2	YFT	All	1303	0.8	1.5	1.7	1.7
2	YFT	>80cm FL	483	0.6	2.1	2.1	2.1
2	YFT	<80cmFL	83	8.4	12.1	14.5	14.5
2	YFT	Tetracycline	737	0.5	0.5	0.5	0.5

Notes: 1. A few additional tags were returned with no date or with incorrect date (ie date of recapture reported as being before date of release). These averaged 0.3% of releases, 3.4% of recaptures.
2. There were no returns after 2 years.

2.3. BUDGET

Budget outlines from the first two tagging programmes are given in Appendix 1. These are not especially accurate, because it has not been possible in all cases to distinguish between expenditures on different project components (e.g. on tuna length frequency sampling rather than tuna tagging) and because it has not always been possible to determine how much of each budget line was actually spent.

These outlines can be used as a template for preparing future budgets, but due attention must be paid to the unique features of each programme, and to the general points below. Approximate exchange rates during the projects were:

1990	US\$ 1 = MRf 9.5
1994	US\$ 1 = MRf 11.5
2003	US\$ 1 = MRf 12.85

2.3.1. Rates of payment for released fish

At the beginning of the first tagging programme it was decided not to charter a vessel for tagging, but to pay fishermen premium rates for all tunas actually tagged and released. This method of operation has proved to be highly successful. The great advantage of this approach is its cost-effectiveness.

During the first tagging programme, a fee of MRf 27/- was paid per fish tagged and released. This was about three times the commercial (FPID) rate, and was found to be satisfactory. During the second tagging programme a fee of MRf 50/- was initially paid for skipjack. This was over four times the commercial (MIFCO) rate. It was found to be too high, because it made some fishermen greedy and caused too many arguments. As a result the fee was cut to MRf 40/- per skipjack for the second half of the second tagging programme. Rates for large yellowfin during the second tagging programme were MRf 100/- for fish between 80-100 cm FL, and MRf 150/- for fish in excess of 100 cm FL. These rates were satisfactory. However, during a large yellowfin tagging trip to Fuvah Mulaku in April 1995 catches were low and prices were high, so rates were increased to MRf 175/- for fish between 80-100 cm FL, and MRf 250/- for fish greater than 100 cm FL.

2.3.2. Rewards for returned tags

During the first tagging programme, rewards of one printed T-shirt and three Japanese tuna hooks were given for each tag returned. Total cost was about MRf 80/-. It was felt that the organisation of the rewards involved too much work. Therefore for the second programme cash rewards were introduced. These were:

- MRf 25/- for a tag without full information.
- MRf 50/- for a tag with full information.
- MRf 100/- for both tags and information from a double-tagged fish.

MRf 200/- for a tetracycline-injected fish (with orange tag, fish and full information).

Cash rewards were found to be relatively easy to disburse. Rates were satisfactory, although they were perhaps a bit low. This was especially so for the tetracycline-injected fish, which should have been higher. Note also that a small cash reward may provide little incentive to a large crew.

During the second tagging programme a 'lucky dip' was held on two Fishermen's Days (10 December). In 1994, numbers of all tags returned during the previous two years were entered. In 1995, numbers of every tag returned during the previous year were entered. In both cases a total of ten tag numbers were drawn, each receiving a cash prize of MRf 1000/- (about US\$ 85).

During both programmes, T-shirts were given as rewards for overseas tag recoveries. During the first tagging programme English language versions of the standard reward T-shirts were used for foreign rewards. They cost MRf 21/- each. During the second programme 150 T-shirts were printed specifically for foreign rewards at a cost of MRf 70/- each. Towards the end of the second tagging programme, it was reported from Sri Lanka that the reward of a single T-shirt was insufficient to encourage tag returns there. It was suggested by NARA staff that rewards of 5 T-shirts per tag would allow more of the recapturing crew to benefit from the reward, and thus increase tag returns.

2.3.3. Special allowance

Because tagging field work can be very arduous (particularly when the weather is bad) it is sometimes difficult to get enough staff to take part in tagging trips. It is therefore helpful to have an incentive in order to attract the more competent and active staff. During the first tagging programme a special allowance of MRf 50/- per day was paid. During the second tagging programme this was increased to MRf 150/- per day. In both cases these allowances were in addition to any Ministry food and sea duty allowances.

2.3.4. Other items

If one of the planned outputs of the project requires some analysis that is beyond the scope of available MRC staff, then allowance must be made for funds for overseas expertise.

Allowance should also be made in the budget for any additional items that may be appropriate to the project and to the funding agency, but are not perhaps directly related to the execution of the tagging project. These might include capital equipment for MRC or training for MRC staff.

2.4. EQUIPMENT

Equipment required must be listed, quotes obtained, and orders placed in good time for the fieldwork to start. This will take several months. An equipment list is given in Appendix 2, and addresses of suppliers are given in Appendix 3.

2.4.1 Tags

Quotes for tags should be obtained from both Hallprint and Floy Tag (see Appendix 3 for addresses). At least 10% more tags than needed should be ordered to allow for breakages and losses. During both tuna tagging programmes plastic dart tags (PDT) manufactured by Hallprint were used. The following types were used:

a. First tagging programme

For skipjack and small yellowfin

Tag type: PDT 10cm × 1.5mm
 Tag colour: Yellow
 Tag numbers: MA0001-MA10000
 Legend: No. MA... MIN. FISH & AGRI. MALDIVES No. MA...

b. Second tagging programme

For skipjack and small yellowfin

Tag type: PDT 10cm × 1.5mm
 Tag colour: Yellow
 Tag numbers: MDV1201-MDV8200
 Legend: No. MDV... MIN. FISH & AGRI. MALDIVES.
 FAX (960) 326558. No. MDV... SEND LENGTH.
 LOCATION. DATE. SPECIES.

For large yellowfin

Tag type: PDA-T 12.5cm × 2.0mm
 Tag colour: Yellow
 Tag numbers: MDV0001-MDV0650
 Legend: No. MDV... MIN. FISH & AGRI. MALDIVES.
 FAX (960) 326558. No. MDV...

For tetracycline injected skipjack and yellowfin

Tag type: PDT 10cm × 1.5mm
 Tag colour: Orange
 Tag numbers: MDV0651-MDV1200 (skipjack)
 MDV8201-MDV9300 (yellowfin)
 Legend: No. MDV... MIN. FISH & AGRI. MALDIVES.
 FAX (960) 326558. No. MDV... COLLECT OTOLITH.
 LENGTH. LOCATION. DATE. SPECIES.

Tag numbers should be printed at both ends of each tag, in case one end is broken off.

Note that orange has been used exclusively for tetracycline marked fish. It is recommended that this convention is adhered to in order to avoid confusion among the fishermen.

Stainless steel tag applicators remaining at MRC should be counted. Sufficient new applicators should be ordered to allow at least 200 applicators for each tagging team. There should be a further 100 or more spares in hand to allow for losses.

For rapid tagging, large numbers of tags have to be set out in their applicators in a ready to use container. At the start of the first tagging programme a wooden block with holes drilled in it was used. However, it was unsafe to have sharply pointed applicators exposed in this manner, and this method was not used again. Instead, plastic-canvas ‘aprons’ (into which thin pockets were sewn to hold the applicators) were used. These could be rolled up tightly when not in use.

2.4.2. Measuring Boards

During both tagging programmes, wooden measuring boards with 1m stainless steel rulers were used for measuring most tunas during tagging. 1.5m stainless steel rulers were better for large yellowfin, but are cumbersome. Stainless steel rulers may be available in Malé; if not they can be bought in Colombo and in the past were obtained through IPTP. They can be embedded in wooden measuring boards in Malé. All sharp edges and corners were rounded.

During the first tagging programme, a plastic canvas measuring cradle was tried, but was found to be too bulky to use on Maldivian pole and line vessels. Calipers were also tried, but measuring was found to be too slow. Therefore wooden measuring boards were adopted. Although these were found to be very easy to use, it has subsequently been suggested that their hard surfaces may have contributed to increased mortality of tagged fish in some cases. The use of padded measuring boards or cradles should therefore be re-considered for any future tagging experiment.

2.5. PUBLICITY

Plenty of publicity is the key to obtaining a high rate of tag returns from fishermen. A prime example is the return of Japanese tags from the Maldives. Japanese fisheries training vessels have carried out tuna tagging in the central Indian Ocean since 1980. Not a single Japanese tag was returned by Maldivian fishermen prior to 1990. In 1990 the first Maldivian tuna tagging programme was carried out, with considerable publicity. Since then there have been several Japanese tags returned by Maldivian fishermen.

2.5.1. Local Publicity

The best means of informing fishermen throughout the Maldives is by radio. The following programming options have been exploited: news releases (e.g. at the beginning and the end of each tagging trip); the ‘Radio *Haveeru*’ Friday Fishermen’s programme; and the early morning programme ‘*Baajjaveri Hedhunu*’. The ‘lucky dips’ for tag returns in 1994 and 1995 both received advanced radio publicity and the actual draws received live radio coverage.

Posters are another good means of local publicity. Examples of the posters used during the first two tagging programmes are shown in Appendix 4. They should be distributed to every atoll and island office (with extra posters to the top 20 fishing islands); Felivaru cannery; all freezer plants; every collector and freezer vessel.

Other means of local publicity include local newspapers (e.g. features in *Haveeru*), *Rasain* journal, and news releases on TVM. T-shirts for the tagging teams, and for rewards, can also be used to give information about the programme.

Two possibilities that have not been tried in the past are a radio drama on the theme of tuna fishing and tagging, and a short explanatory video to be shown on the fishing islands during tagging trips. In addition, it is recommended that prior to any future tagging programme, a team from MRC visits the 10-20 major fishing islands to explain the programme to the fishermen and elicit their assistance in returning tags.

2.5.2. International publicity

Use can be made of regional fisheries newsletters (see Appendix 3 for some addresses) to broadcast information about tagging. Information can be disseminated in papers, talks, and informal discussions at IOTC, BOBP and other international fisheries meetings.

Posters can be distributed to relevant authorities in all major fishing countries. Posters were sent to many individual purse seiners during the second tuna tagging programme through the Seychelles Fishing Authority. One problem is that English language posters will not be effective in some countries. During the second tuna tagging programme IPTP produced posters in Sinhalese for distribution in Sri Lanka. Dhivehi posters can be sent to Minicoy either via the Administrator of the U.T.Lakshadweep, or directly to the CMFRI Research Centre there.

T-shirts sent as rewards should be printed with information about the tagging programme.

2.6. RECORDING FORMS

It is essential that all necessary information regarding tuna releases and recaptures is recorded. The easiest and most reliable way of doing this is to have pre-printed recording forms for all occasions. Some or all of the following types of form may be required:

- a. Daily trip summary forms
- b. Tag release forms
- c. Tagging summary forms
- d. Tag recovery forms
- e. Livebait weight forms
- f. Length frequency forms (standard MRC form)
- g. Length-weight forms (standard MRC form)
- h. Yellowfin-bigeye sampling forms

The forms relating specifically to tagging are reproduced in Appendix 5, including where appropriate examples from both tagging programmes. These can be copied for future tagging programmes, although they should be modified if additional information is required. Note that the tag recovery forms have a map on the reverse side on which the recapture position should be marked; instructions requesting the recoverer to mark them in this way were accidentally omitted when the forms were printed.

3. TAGGING

3.1. PRE-TRIP ARRANGEMENTS

Start making arrangements for each tagging trip more than one month before the scheduled departure date. Inform the Atoll and the Island Offices of the intended trip through the Ministry of Atolls Administration. Request the Island Office to inform MRC of the status of tuna fishing. Keep checking on this, and be ready to leave when fishing and weather are good. Experience has shown that it is better to wait for good fishing and weather conditions than to go on a pre-arranged date when conditions may well be poor.

Reconfirm the trip with MRC and MOFAMR. Confirm availability of required number of staff. Inform the Budget Section in good time of the money required (for tag releases, tag recoveries, field allowances, food allowances, transport costs); inform them of the date on which the money is required.

Make arrangements for transport to the target island. If going by sea it will be necessary to book a yacht *dhoni*. If going by air it will be necessary to book flights well in advance; to book alternative dates; to arrange transport from the airport to the target island; to send heavy equipment and formalin in advance by sea; and to make provisional return bookings.

3.2. ARRIVAL ON THE ISLAND

3.2.1. Meeting with the island chief

On arriving on the target island meet with the *katheeb* (and/or as appropriate with the *atholhu verin* or *kuda katheeb*). Explain the programme, and the requirements of the tagging team. Make arrangements for meeting the island's fishermen that night. To minimise problems ask the *katheeb* to prepare a list of the *masdhonis* that will be used for tagging each day. Confirm arrangements for the accommodation of the tagging team.

3.2.2. Meeting with the fishermen

Outline the importance of the tagging study for the Maldivian fishery. Outline the potential effects of foreign fishing on migratory tuna stocks. Inform the fishermen of the prices being paid for released fish, but do not emphasise this point as it may tend to incite greed and create conflicts. Instead stress the importance of the work for the country.

Request the fishermen to collect bait the day before it is their turn to take the tagging team. They should be happy to do this as it will maximise their fishing time.

State clearly what will be required from each *masdhoni*: how the tagging team will operate and what assistance will be required from the crew; what food and drink should be provided;

any restrictions on fish to be tagged (e.g. only certain sizes or species; only away from FADs; or only offshore). Also make it clear that the choice of which *masdhonis* will be used each day rests with the *katheeb*.

3.2.3. Briefing the tagging teams

It is important to brief all members of the tagging teams thoroughly. Teams must be allocated, and each team member must fully understand his role. It may be appropriate to obtain some dead tunas for the taggers to practice on. The recorder must be familiar with all the forms in use, and how to fill them. All team members must understand exactly what fish are to be tagged, and from where.

3.3. TAGGING TRIPS

Before tagging starts the fishermen must be thoroughly briefed on their roles. They must be instructed to land the fish as gently as possible. One or two crew members should be co-opted to ‘catch’ the hooked fish and gently pass them to the tagging team. If fishing is good it is best to take fish caught on only one side of the boat. Fishermen on the other side can pole their fish directly into the fish hold.

Take walkie-talkies on every trip. They are extremely useful for communicating between tagging teams on different boats. Also pre-arrange schedules for communicating using the *masdhonis*’ radios. One team may encounter good fishing, and is then able to inform the others. On other occasions, prearranged plans might be changed during the day, and again it becomes necessary to inform the others.

3.3.1. Damage limitation

To minimise damage to the fish, keep the deck and measuring board wet at all times. Shave any sharp corners or edges from the measuring board. Use two hands to pick up the fish. Do not hold the fish by the tail alone, as this will cause damage. Do not let the fishermen hold the fish like this either.

3.3.2. Tagging procedures

It is easiest to work with a three man tagging team. One holds and measures the fish; one inserts the tag; the other records the data. The holder and tagger can sit on the engine cover; the recorder can sit in front of the *kunbu kafi*. It is best if the same individuals keep the same roles throughout the tagging trip.

It is helpful to wear cotton gloves to hold the fish. The gloves must be wet when used. Suitable footwear, e.g. diving boots, should be worn for protection from fin spines.

The tags should be inserted close to the second dorsal fin. They should be inserted parallel to the tuna’s long axis, and at about 45° to the vertical. The barb of the tag should penetrate

about 2cm so that it passes between, and gets caught under, the small bones (pterygiophores) projecting from the backbone.

Forms must be kept dry. Use a plastic cover at all times. To minimise spray from the fish hold ask the crew to bail out the water before fishing starts. Consider the possibility of using small voice activated tape recorders for the tagger to record data. Keep all recording materials in a waterproof container while not being used.

No damaged fish should be tagged. The fishermen will be interested in maximising tag releases so they will try to pass all fish (including heavily bleeding or even near-dead ones) to the tagging team. The tagging team must firmly reject any damaged fish. Make a point doing this very vocally at the start of the tagging; the fishermen will soon get the idea. If one team member says that a fish is damaged, the other team members should not contradict him. If in doubt about the quality of a fish, reject it.

If fishing is very good, and fish start accumulating on the deck to be tagged, reject them.

The tagger should call out the number of each tag as it is used so that the recorder can keep track. If fishing is very good and tagging is very fast it is vital that tag numbers are called out at least every five tags. If a tag is missed, note it. Mark the tagging form very clearly to indicate those tunas whose tag numbers may be incorrect.

If the tag is poorly inserted do not release the fish. If the fish is released, a note must be made of the poor quality of tagging. During the second tagging programme in 1993-95, it was found that skipjack tags which were well placed were nearly four times as likely to be recovered as those which were poorly placed.

Try to return the fish to the water head first, and with its head pointing towards the bows of the *masdhoni*. That way the fish is most likely to swim away from the boat via the bows. If they swim away from the boat via the stern they may disturb the feeding school.

It is very difficult to estimate tagging time without actually timing it. The recorder should therefore time several complete tagging operations, from the moment of hooking through landing, handling and tagging to release. This should be done at the beginning and the end of each tagging trip.

3.3.3 Hygiene

There is the potential for tunas to become infected at the site of tag insertion. This will affect their chances of survival, and hence the results of the tagging experiment. It is therefore important that every effort is made to ensure hygienic tagging.

Before each tagging trip tag applicators should be sharpened and thoroughly cleaned. Before each day's tagging all applicators must be sterilised by boiling in water for at least 15 minutes.

Tags should not be removed from their plastic wrappers until the day they are to be used. Any tag taken out but not used should be rinsed in rain water.

During tagging operations do not touch tag heads or applicator points with dirty hands or cotton gloves. If applicators have to be used twice on the same day wash them with washing powder, then rinse thoroughly with several changes of fresh seawater before reusing. Wash hands thoroughly before inserting new tags in the applicators. Keep the tagging 'aprons' away from all sources of contamination, especially spray from the fish hold.

3.3.4. Double tagging

Putting two tags into one fish is a useful method of estimating tag shedding rates (from the proportion of double tagged fish that are recaptured with only one tag). Estimates of tag shedding rates are important in order to correct tagging analyses.

During the second tagging programme nearly 500 skipjack were doubled tagged. Consecutively numbered pairs of normal yellow tags were used. The first (lower numbered) tag was inserted in the normal place, i.e. dorsally on the left side adjacent to the second dorsal fin. The second (higher numbered tag) was inserted dorsally on the right side, just 1-2cm posterior to the first one.

By always putting a known tag (in this case the first of the pair) in the normal tagging site, and another known tag (in this case the second of the pair) in a 'suboptimal' site, it should be possible to estimate tag shedding rates from the normal tagging site.

3.3.5. Dummy tagging

When live tunas are measured during tagging, their muscles are tensed. When they die their muscles relax. As a result tunas measured when alive will tend to be slightly shorter than when dead. To estimate the magnitude of this effect some tunas were 'dummy tagged' during the second tuna tagging programme. Live tunas were tagged and measured as normal, but then thrown into the fish hold instead of the sea. Later they were remeasured.

3.3.6. Limiting tag releases

During the second tagging programme, on two tagging trips, the number of tunas tagged and released from each *masdhoni* was limited to a maximum of 200. The aim of this limitation was to ensure a more equitable distribution of tag releases (and hence monetary payments) to each *masdhoni*, thereby reducing conflict between crews.

In practise this did not work. There were still differences in numbers of fish tagged between *masdhonis*, and still arguments between crews. This limitation did, however, reduce the number of fish tagged and released on some days. Limiting tag releases was not a helpful practice, so it was discontinued.

3.3.7. Length frequency data collection

At the end of each day's fishing, the fish that have been retained should be measured. In many cases the fishermen will lift the fish out of the fish hold and stack them on deck as they head for home; this is a convenient time to measure them. Measure every fish. Only in cases of

very large catches (i.e. more than 1000 fish) should a subsample be taken. If a subsample is taken, ensure that the sample is representative, and that the total number of fish caught is recorded.

3.4. EVERY EVENING

All equipment should be rinsed thoroughly in fresh water. Tag applicators should be sterilised by boiling in clean fresh water. All forms must be checked, completed, and transcribed on to new sheets if required. Complete sets of forms from each tagging trip should be stapled together and filed.

Each team should ensure that it has at least 200 tags set out in applicators ready for the following morning, and that sufficient new forms have been obtained.

The team leaders should confirm with the skippers of the *masdhonis* scheduled for tagging the following day that they are ready for fishing. Tagging teams should be allocated to *masdhonis*. The skippers should be asked to wake up their tagging team at an agreed time.

3.5. RETURN TO MALÉ

Before leaving the island to return to Malé all the objectives of the tagging trip must be completed. Occasionally very bad weather or poor fishing will make it impossible to complete the planned tag releases. More often, however, there may be just a small shortfall in the number of tunas tagged by the planned return date. It is much better to delay returning to Malé until all the work has been completed than to return to Malé on schedule with the work unfinished.

Boats and/or flights must be reconfirmed in good time for the return journey. Flexibility should be maintained to allow for possible delays.

Before leaving the island payment must be made to all skippers for tag releases. It is best to do this only once or twice per trip, perhaps on a Friday and the last day. All payments must be signed for. If more tunas have been tagged than expected and there are insufficient funds to pay for all the releases, it may be possible to arrange extra money through a MIFCO vessel.

All equipment must be thoroughly cleaned and dried before being returned to Malé. In Malé it must be properly aired before being stored.

In Malé the balance of the tag release money, plus receipts, must be returned to the budget section. A news release should be prepared for Radio Maldives. A trip report must be written.

4. SPECIAL TOPICS

4.1. OTOLITH SAMPLING

Fish otoliths (ear bones) have ‘daily’ rings, like the annual ring of trees. Examining otoliths is therefore extremely useful in the study of fish growth and age. However, tuna otoliths are particularly small and delicate. Extracting them is therefore rather difficult, and requires much practice and care. Below is an outline of the required procedure:

- a. Record all necessary data about the fish on the appropriate form, including: species, tag number, length to nearest mm, weight, date of capture, location of capture, sex and otolith tube number.
- b. Ensure that the tuna is frozen solid. This prevents soft tissues (and with them the otoliths) being dragged out of position during cutting.
- c. Cut off the head just behind the operculum. A hacksaw is an ideal tool.
- d. Make a small cut across the cut end of the head, just above (i.e. dorsal to) the top of the vertebral column.
- e. Stand the head vertically, and saw off its top. Start the cut just above and in front of the eyes. Aim to miss the eyes externally so that you just cut off the tops of the eyeballs internally. End the cut at the mark you made in (d).
- f. Gently wash the newly cut surface to expose the brain. Stand to one side to thaw.
- g. Remove the brain, with a pair of coarse forceps.
- h. Just underneath the place where the most posterior part of the brain was are two small, elongated holes on either side of the start of the vertebral column. These holes contain the otoliths.
- i. Remove the otoliths with a pair of watch makers forceps. Remember that they are very delicate and easily broken.
- j. Put into a numbered vial.
- k. Under a low-powered binocular microscope clean the otoliths with fine forceps and fine brush, removing any adhering membranes. This is best done in water or a 10% bleach solution.
- l. Rinse the otoliths in fresh water.
- m. Dry and store safely in a numbered tube for later study.

4.2. TETRACYCLINE INJECTING

Tetracycline is a commonly used antibiotic. It is harmless to people and to fish. It is incorporated into growing bone. Fish injected with (or soaked in) tetracycline will show a mark in their otoliths corresponding to the day on which they were exposed. This mark can

be seen under UV light. Tetracycline is therefore a very useful method for confirming (or disproving) the daily nature of otolith rings.

If tunas are injected at the time of tagging (and if suitable arrangements are made for the recovery of the fish and otoliths) it is possible to obtain otoliths that have been growing for a known number of days since marking with tetracycline. During the second tuna tagging programme 500 skipjack and 700 yellowfin were tagged and injected with tetracycline. The following procedures were used:

- a. It is not practical to use a separate syringe for every fish. Therefore an auto-injector must be used. The model used during the second tagging programme was the Phillips 2mL Mk III auto-injector.
- b. Always carry a spare injector and a spares kit on each tagging/injecting trip. The most likely cause of malfunction is improper seating of the black O-ring that seals the front end of the clear plastic barrel. At the end of each day's tagging, dismantle the injector and clean it thoroughly in fresh water. At the end of each trip, lubricate the injector lightly with castor oil before storage.
- c. It is not practical to change needles for every fish. One needle can be used for several fish. It should be changed whenever it is bent, or whenever there is a lull in the tagging. Needles should be short and have a wide bore.
- d. The injector can be connected to the tetracycline bottle using PVC tubing of about 5mm diameter. This type of tubing is used for aquarium air lines and for fishing hook lures so is widely available in Malé and on most islands. A length of about 1.2 m is sufficient to allow plenty of manoeuvrability during injecting. The end of the tube can be inserted through a slit (made with a tag applicator) in the rubber top of the tetracycline bottle.
- e. For skipjack, oxytetracycline hydrochloride (OTC) of 100 mg/mL was used. Target dosage was 50 mg (i.e. 0.5 mL) of OTC per kg skipjack body weight. In practice it was not possible to adjust the dosage for each fish. Therefore about 1 mL (100 mg) of OTC was injected into each skipjack. An exception was made for very large skipjack, when two 1mL injections were made. For yellowfin, OTC strength was 200 mg/mL. Target dosage was 100 mg of OTC per kg yellowfin body weight. The dose injected was about 0.7 mL per average-sized yellowfin. Note that in many cases there was some seepage of OTC from the injection site, so the exact amount injected was unknown.
- f. Injections are made intramuscularly, in the dorsal muscles above the pectoral fin. Do not inject near the lateral line; this may damage the lateral line system or puncture the underlying blood vessel, causing considerable bleeding.
- g. Tetracycline is broken down by light. Therefore it should be kept in the dark (i.e. in an ice box) except when in use. While being used, the bottle can be kept cool and partially darkened by standing it in a wet cotton glove.
- h. Tetracycline-injected fish must be marked with a distinctive tag so that fishermen can easily recognise them when recaptured. During the second tagging programme bright orange tags were used, which were distinctly different from the normal pale yellow tags. The tag is inserted normally.

- i. Injections are not always completed successfully, for example due to the needle breaking when the tuna fights. Therefore, the tag should only be inserted once the injection is completed.
- j. Arrangements must be made with MIFCO (and other parties) to collect, freeze and deliver all tetracycline-injected fish to MRC.
- k. If fishermen cannot sell their recaptured tetracycline-injected fish to MIFCO (or others), the tag should still be returned to MRC. If the fish is preserved by salting, the otoliths will almost certainly be lost or damaged.
- l. When a tetracycline-injected fish is returned to MRC, all the required information should be confirmed, and the fish kept frozen with tag in place until ready for otolith removal. This should be done as soon as possible, as there is some chance that the OTC may be degraded by freezing.
- m. Otoliths should be removed as detailed in section 4.1. The first dorsal spine and 3-4 vertebrae should also be removed. Because tetracycline is broken down by light these samples should be kept in the dark.
- n. As an alternative to oxytetracycline, alizarin red can be used to mark otoliths.

4.3. BIGEYE TUNA SAMPLING

Bigeye tuna (*Thunnus obesus*, known as *loabodu kanneli*, *anhen kanneli* or *hirimi kanneli*) look very similar to yellowfin tuna (*Thunnus albacares*, known as *kanneli*), especially when young. These two species are not separated in Maldivian fisheries statistics. Fishermen sometimes recognise them as two separate varieties, but often do not.

It is important for scientific studies that the two species are distinguished. If 'yellowfin' are being tagged, any bigeye tuna must be properly recorded to species or rejected.

Bigeye tuna and yellowfin tuna can be distinguished on a number of features, including the following:

- a. Shape. Bigeye tuna tend to be deeper bodied and more stocky than yellowfin tuna of the same size.
- b. Lateral marking. Bigeye tuna have about 7-10 pale bars on their sides. These tend to be straight (vertical) and unbroken. Yellowfin tuna have about 15-20 thin pale bars on their sides. These tend to be bent backwards on the ventral side, and unbroken bars alternate with broken ones.
- c. Caudal notch. Yellowfin tuna have a distinct indentation in the centre of the trailing edge of the tail fin. They also have two pairs of keels on the caudal fin. In contrast, bigeye tuna have little or no indentation, and only poorly developed keels. These differences are, however, poorly developed in juveniles.

- d. Eye size. Eye diameter is larger in bigeye tuna than the yellowfin tuna of the same size. However, the difference is too small to be of much practical value.
- e. Fin length. Large yellowfin tuna have greatly elongated second dorsal and anal fins. These fins are 'normal' sized in bigeye tuna. Pectoral fins tend to be longer in bigeye tuna than in yellowfin, but this varies with size and so is of limited practical value.
- f. Liver morphology. In yellowfin tuna the right liver lobe is greatly elongated, and the ventral surface of the liver is unmarked. In bigeye tuna the right lobe is not elongated, and there are fine striations on the posterior edges of the ventral surface of the liver. Distinguishing the species by liver morphology can only be used on dead fish, so is of no direct use for tagging. However, it is of use when training taggers, to confirm the species of fish that have been identified by external characteristics.

4.4. BAIT WEIGHING

The fishery for livebait to be used for catching tuna is the most important reef fishery in the Maldives, and one of the largest livebait fisheries in the world. There is no regular monitoring of this fishery, or collection of statistics. Tagging trips provide an ideal opportunity for obtaining information about the livebait fishery. Information on the weight of livebait catches is particularly useful. This information is best obtained while the livebait is being caught. The procedure for weighing livebait catches is as follows:

- a. Tell the fishermen what is required, and ask their permission to weigh the bait.
- b. Put the weighing scales near the bait hold. Put a large plastic basin on the scales, with 5-10 litres (kg) of water in it. Note the weight (W1). It is important that enough water is included to prevent the livebait being squashed. For the same reason it is better to use a wide basin than a tall bucket.
- c. When a haul of livebait is made, have the fishermen tip it into the plastic basin.
- d. Note the new weight (W2) and empty the basin in to the bait hold. This must be done quickly to minimise damage to the livebait. The weight of the livebait in the haul (W3) is $W1 - W2$. Note this new weight, the species composition of the haul, and the approximate weight of any by-catch.
- e. Repeat for each haul. The total bait weight is the sum of all the haul weights ($\Sigma W3$).
- f. Occasionally, for very large hauls, it may be possible to weigh only a portion of the haul. Estimate the proportion, and multiply up to obtain the estimated total haul weight.
- g. Make a note if the fishermen consider the total livebait catch to be more or less than average.

5. TAG RETURNS

During the first tagging programme, fishermen or island officials were asked to supply tag recapture information in a letter. This proved less than ideal, and a standard tag recovery form was introduced for the second tagging programme.

For each tag recovered, a tag recovery form must be completed. Tag recovery forms should be printed and distributed to every island and to MIFCO and other parties (for every collector vessel, plus Felivaru cannery and all freezer plants) in good time before tagging starts.

Some tagged fish may be recaptured during the tagging trip itself. Take sufficient tag recovery forms and funds to pay rewards on each tagging trip.

When tag recovery forms are returned to MRC, check them for obvious errors against the tag release database. Note any discrepancies on the form using a distinctively coloured pen; sign and date any such notations; do not cross out or obliterate suspect information. Check immediately with the island where the tag was recovered to clarify any discrepancies. Arrange for the payment of the appropriate reward.

Some tags will be brought directly to MRC by fishermen. Be friendly and pay the appropriate reward immediately; remember that these fishermen are doing us a favour, not vice versa. Ensure that as much information as possible is recorded; mark the position of recapture on the map on the back of the tag recovery form.

Do not leave loose tag recovery forms lying around. They must be placed in the appropriate file immediately.

6. ANALYSIS AND REPORTING

Tag release and recovery data should be entered into an appropriate database as soon as possible. For the existing tag data from the first two tagging programmes, FOXPRO and EXCEL databases are used. The data should be checked as soon as they are entered, and the whole dataset should also be subject to additional periodic validation. Mistakes do happen, and it is vital that errors in the original data are kept to a minimum.

Keep back-up files of validated data. Make sure that old, non-updated files are kept distinct from updated files (or deleted). Copies of the 'final' tag release and tag recovery datasets should be sent to IOTC.

The types of analysis to be performed will depend entirely on the aims of the particular tagging experiment, so it is not possible to give an exhaustive list of procedures here. For simple analyses, follow the outlines of procedures used in the first two tagging programmes. For more detailed analysis and modelling, outside assistance may be required.

Reporting and result dissemination are in some ways the most important components of the whole programme. Final project reports must be written up on schedule. The full results of the programme should be reported in the scientific literature, either through IOTC or elsewhere.

Key findings should be disseminated within the Government of Maldives. Ensure also that there feedback of key results to the fishermen.

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APPENDIX 1. TAGGING PROGRAMME BUDGETS

A. First Tagging Programme Budget, 1990

External funding (US\$)

ITEM	AMOUNT
1. Consultants	\$ 7,250
2. Travel	
Vessel hire	\$ 7,500
Sea duty allowance	\$ 700
3. Payment for tagged fish (10,000)	\$ 30,000
4. Equipment	
10,000 tags	\$ 3,650
Applicators	\$ 1,650
Tagging cradles	\$ 200
Calipers	\$ 200
5. Publicity	
Posters	\$ 400
Rewards	\$ 3,000
6. Contingency	\$ 4,000
TOTAL	\$ 58,550

Maldivian Government funding (MRf) US\$ 1 = MRf 9.50 in 1990

ITEM	AMOUNT
1. Staff salaries	MRf 50,000
2. Travel	
Vessel hire	MRf 15,000
3. Rewards for recaptured fish	
T-shirts	MRf 45,000
Hooks	MRf 18,200
4. Publicity (radio)	MRf 1,000
5. Telex, fax, etc.	MRf 1,000
6. Contingency	MRf 2,000
TOTAL	MRf 132,200

B. Second Tagging Programme Budget, 1993-95

External funding (US\$)

ITEM	AMOUNT
1. Consultants	\$ 35,000
2. Travel	
Vessel hire	\$ 2,000
Sea duty allowance	\$ 7,500
3. Payment for tagged fish (7,000)	\$ 40,000
4. Equipment	
8,200 tags	\$ 3,190
Applicators	\$ 1,130
Tagging boards	\$ 1,000
OTC & injectors	\$ 850
Computer	\$ 9,840
5. Publicity and Rewards	
Publicity	\$ 2,000
Rewards	\$ 7,850
6. Training and workshops	
Staff training	\$ 3,150
Otolith work-up	\$ 20,000
Conferences	\$ 5,000
7. Contingency	\$ 9,500
TOTAL	\$ 147,170

Maldivian Government funding (MRf) US\$ 1 = MRf 11.50 in 1994

ITEM	AMOUNT
1. Staff salaries	MRf 72,000
2. Travel	
Vessel hire & airfares	MRf 35,000
4. Publicity	MRf 2,000
5. Radio messages, telex, fax, etc.	MRf 2,000
6. Contingency	MRf 4,000
TOTAL	MRf 115,000

APPENDIX 2. EQUIPMENT REQUIRED FOR TAGGING TRIPS

a. For Tagging

Icebox or other large container
 Tags
 Tag applicators
 Tagging 'apron'
 Jar for applicators
 Measuring boards
 Measuring tapes
 Spring balances
 Cotton gloves
 Forms: Tag release
 Daily trip
 Tag summary
 Tag returns
 Length frequency
 Yellowfin / Bigeye
 Length / weight
 Livebait weight
 Clipboards
 Waterproof covers for forms
 Pencils, pens, erasers
 Staplers
 Binoculars
 Walkie talkies plus batteries
 Torch plus batteries
 First aid kit
 Fish identification books
 Money for tag recoveries
 Receipt book
 Lockable case for money
 Charts

b. Tetracycline injection

Tetracycline
 Injectors
 Injector spare parts
 Castor oil

Needles
 Tubing

c. For Bait Fishing

Weighing balance (20 kg min)
 Plastic basin
 Forms
 Clipboards
 Pencils, pens, erasers
 Mask, fins, snorkel
 Collecting jars
 Formalin
 Fish identification books

d. Otolith Sampling

Hacksaw
 Forceps - coarse
 Forceps - fine
 Small collecting tubes
 Instructions
 Forms
 Clipboards
 Pencils, marker pens, erasers
 Magnifying glass or binocular microscope
 Bleach
 Petri dishes
 Fine brush

e. Personal Items

Hat
 Sun cream
 Protective footwear
 Raincoat
 Camera and film
 Notebook

APPENDIX 3. USEFUL ADDRESSES

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Hallprint
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