INDIAN OCEAN TUNA COMMISSION

TUNA TAGGING MANUAL IN TROPICAL TUNA FISHERIES

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TUNA TAGGING MANUAL IN TROPICAL FISHERIES

by

Jean-Pierre Hallier[1]

1 INTRODUCTION

Fish stock assessment models are the main research tools used to assess the importance of stocks and their productivity. Main data used in these models are statistics on catch and effort in other words the fishing mortality. Catch dived by effort or Catch Per Unit of Effort (CPUE) is generally used in models as indices of abundance. However to use it as such it is necessary to have a good knowledge on both factors: catch and effort. If the first one is generally quite easy to obtain, the second is often more difficult to calculate : lack of data, different gears involved that are difficult to add together, effort units not properly related to the real effort, increasing fishing power difficult to access in order to correct the effort…. In most fisheries, to overcome these difficulties, standardized fishing efforts have been developed and surveys by research vessels are conducted in order to obtain indices of abundance that are independent of the fisheries. For tropical tuna pelagic stocks the situation is very uneasy. If catch are more or less well known, efforts are quite elusive. Several different gears are exploiting different size ranges (i.e. purse seiners exploit the all size range of yellowfin tunas when longline are exploiting only adults), increasing efficiency (i.e. purse seiners are constantly improving their efficiency; longliners have done it also when deepening their longlines). Furthermore, it is impossible to obtain fishery-independent indices of abundance as the importance of areas and volumes of water to cover are beyond the reach of any research vessel effort. Others factors used by assessment models are natural mortality, growth rates and stock structure. This latter factor is essential to define on which fish stock the model is applied. There are several ways to obtain growth rates. But natural mortality is a difficult factor to assess with accuracy notably in tropical tuna stocks. A powerful tool to obtain reliable natural and fishing mortality, population turn-over rates, stock sizes, information on stock structure, growth rate, fisheries interactions is through tagging. Tagging is for tropical tuna stocks as necessary as regular surveys by research vessels are for coastal fish stocks. As such, data from tagging studies constitutes the essential baseline for research on tuna populations around the world even if they remain complementary to fishery statistics (Hunter et al., 1986).

Tagging large numbers of tunas is a complex procedure that can be divided in four main stages (Anderson et al., 2003): planning, tagging, recovery and analysis and reporting.

So far, the only tags available were ordinary plastic “dart” type tags but in recent years electronic tags (sonic, archival and pop-up) have been developed that can be used on most tunas. So far, these new tags have been mainly used to approach fish behaviour at small and large scale than to bring answers on stock related issues. The number and the types of tags to be used must be properly planned in advance but this will not be discussed in this paper. The main objectives of this manual are to give the field and office advises for the process of carrying tuna tagging and to present an overview of tuna tagging. This overview is not

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exhaustive but it serves to better understand why tagging operations must be conducted according to the instructions given below.

This document is based on my own experience and on several tagging manuals and other related documents that are referenced in the course of the text. The main contributions come from Kearney and Gillett (1982), Bayliff and Holland (1986), Hallier (1996), Hallier et al. (2001), Itano (2002, unpublished), Thorsteinsson (2002), Anderson et al. (2003) and Dagorn et al. (2004). This document also greatly benefits from the clever comments and numerous additions suggested by W. Bayliff and K. Schaefer from IATTC, J. Gunn from CSIRO, D. Itano from University of Hawaii, M. Lutcavage from the University of New Hampshire, L. Dagorn from IRD, M. Taquet from IFREMER, B. Leroy from SPC.

2 CONVENTIONAL TAGGING

When one speaks of conventional tagging, one means tagging with dart tag also called conventional tag. This type of tag is generally used by all large-scale tagging programmes on tropical tuna.

2.1 Tagging vessel

To obtain parameters at stock level, it is necessary to tag a large number of tunas, several ten thousands. Tropical tunas can be caught by various gears: troll line, handline, rods and reels, longline, pole-and-line, purse seine to mention the most employed tropical tuna fishing techniques. For tagging purpose, fish need to be in the best conditions as to obtain the best survival rate after tagging. This means that catch procedures need to be rapid and not harmful for the fish as well as able to give access to large numbers of fish.

Troll line involve some fighting time during which the fish becomes exhausted, stressed and more or less injured. There are some ways to decrease these drawbacks, however it will never be possible to catch tunas in large quantities when using this fishing technique. Handline, more than troll line, can catch medium to large size tunas in quite good conditions. As such it was used in different tagging programmes to catch large yellowfin and bigeye tunas (Holland and Braun, 2002; Schaefer and Fuller, 2004; Hallier et al., 2002; Wendling and Million, 2004). This gear can be used even from small fishing boats such as open artisanal boats (Figure 1) or from sport fishing boats (Figure 2). Fishing with Hawaian style handline gear and with rods and reels, both using heavy chrome jigs such as 8 oz diamond jigs, can be utilized to catch and tag thousands of tunas (Itano and Holland, 2000). IATTC has documented excellent survival rates from fish caught using those techniques with bigeye, yellowfin, and skipjack tunas. Those techniques were specifically used at night time when in association with a FAD and a large aggregation of tunas. This is also the method of capture for most all the tunas released with archival tags by IATTC (K. Schaefer, pers. com.).

Longline is a passive gear; consequently tunas will spend some time on the hook before they are brought on board to be tagged. The survival rate depends on several factors but it can be sufficient for certain species and a limited number of fish (Bach et al., 1999). This gear will give access to large tunas. Nonetheless, longline catch rates are generally quite low and do not permit large-scale tagging. Longliners' sizes goes from small local boats (Figure 3) to large industrial vessels (Figure 4).

Purse seine is catching tunas in very large numbers but at once and it takes time to get access to those fish once they are trapped into the net before you can tagged them. When fish have been concentrated into the net, lots of them are already stressed, exhausted and injured

when they are not already dead. The survival rate will then be quite low and all attempts have experienced low return rates. There could be some peculiar conditions where purse seine can be a mean to catch tunas for tagging this is the catch of bluefin tunas transferred into pens for ranching farms. In this case tunas are not cramped inside the net and remain in good conditions. Once in the pen and in the farm, they can be caught but pole-and-line, handline or another technique and then tagged and released.

The best way to tag large numbers of tunas in good conditions is with pole-and-line vessels or baitboats (Figure 5). Fish are pulled out of the sea as soon as they bite, they can be landed immediately onto a tagging platform where they are tagged and returned to the sea in a few seconds. However, there are some drawbacks and constraints: it will be difficult to catch medium size tunas (between 10 and 30 kg) and almost impossible to catch large tunas (greater than 30 kg) and finally live bait are most of the time obligatory. Anyway, almost all large-scale tuna tagging programmes successfully conducted so far have used baitbaots fishing with live baits and bamboo or fibreglass poles (Figure 5).

There are some exceptions to the exclusive use of live bait with pole-and-line. In some circumstances, a certain proportion of dead bait or only dead bait can be used. The Hawaii tuna tagging project was based on the use of thawed frozen dead anchovies imported to Hawaii and used by the local fisherman. The southern bluefin tuna tagging currently being conducted by the CCSBT utilizes dead bait on baitbaots for one-year-old fish but for fish older live bait are necessary (J. Gunn, pers. Com.). When large numbers of releases are not required such as for archival tagging, dead bait can be sufficient. In Japan, some artificial live bait are on sale since April 2004 by Nichimou Company. They are mainly used by purse fishing on yellowfin and albacore. But trials on baitboats fishing for skipjack were also good.

Pole-and-line technique has already been practiced by Japanese and Maldivians for several centuries (Figure 6) and it has not changed much since. It gives the possibility to catch mostly small tunas (less than 10 kg). It has been improved in some places such as Basque country in order to catch even large size bluefin tunas (up to 100 kg). For that, fishermen used 2 poles with one line and the top of the poles where they are joined is fit with a rope which is pulled through a pulley by a third person. The main constraint of pole-and-line fishing is the necessity to use live-bait as chum (Figure 7). This is why pole-and-line vessels are also called baitboats. The bait need to be caught and kept alive in tanks on board. In some places, baits are kept during several weeks or months (Long-range Japanese baitboats, Dakar-based baitboats, anchoveta of the Gulf of Panama, IATTC bigeye cruises - K. Schaefer, pers. com.).

2.2 Fishing gears

When large tunas are sought or only a small number of fish, Research Vessel can be used (Figures 8 & 9) and tunas are fished with troll lines, hand lines and vertical and horizontal small longlines. Handline for medium size tunas (10-30 kg) can be performed on small open boats as in Mayotte (Figure 1). The boat is generally either drifting if wind and current are low or anchored if the bottom is not too deep or attached to an anchored FAD[2].

There are many different types of hooks and lures used for trolling and handlining (Figure 10 & 11), that are more or less efficient according to areas, species and fish size. When baits (alive or dead) are used on troll lines (with or without rod and reel) or on handlines, it is better to use circle hooks as they are not going too deep inside the fish (Figure 12). A dehooking device can help to extract the hook quicker and with less damage (Prince et al., 2002). If the extraction is too difficult, the injury not too big and the hook not placed in a harmful position,

[2] All abbreviations are developed in appendix 1

Figure 1: Small open fibreglass boat used for tuna fishing (handline and troll line) in Mayotte (IOTC, Wendling and Million, 2004)

Figure 2: Sport fishing boat that can be chartered for tuna tagging

Figure 3: Small longline boat from Seychelles (IOTC, Itano, 2002)

Figure 4: Industrial longline boat in Seychelles (Photo, Fonteneau, IRD, 2002)

Figure 5: Baitboat from Dakar, Senegal

Figure 6: Pole-and-line fishing in Japan in the XVIII century

it can be either left in place and the leader is cut or the hook is cut in two leaving the hooking part in place and removing the other part with the leader.

2.3 Tagging platform

For large-scale tagging programs on board baitboat, the tagger will need to be in a very comfortable and suitable position in order to tag many fish during long periods of time. Therefore the tagger must stand up with a tagging cradle at his level. Most tagging cradle used on board baitboats are more or less similar to the SPC type illustrated by Figure 13 (Kearney and Gillett, 1982). The overall measures of this cradle are 160 cm in length, 108 cm width and 95 cm height. All detailed specifications are listed below. For tagging in Mayotte, this cradle was enlarged in order to tag tunas up to 150-160 cm Fork Length (FL): 190 cm in length and 120 cm in width. The cradle frame is made from steel tubes (galvanised steel is necessary, stainless is better as sea water is very corrosive) and the cover from tough but smooth vinyl material. The cover is set like a spout large and flat at the wider end and deep and narrow at the other end. This will create a sort of downward chute where the fish will glide by itself to reach the narrow end where it will be tagged. It is necessary to keep this surface wet to ease the sliding of the fish. It is necessary to cut near the end of the narrow side at its lowest point a drainage hole (1 x 1 cm) in the vinyl cover. Otherwise, accumulation of water at this end of the table will be very detrimental to tagging as tuna will tend to flap its tail vigorously if its head is in contact with water, splashing water all around. The end of the cradle, where the nose of the fish will rest, is also made of the same vinyl covering a flat piece of wood. This wood should not swell with water and be fixed on the frame with bolts; the fixation need to be very strong as the vinyl cover is then nailed on it. Bolts' heads should be drilled inside the wood to have a smooth surface on which the fish nose will rest. In order to protect the nose of the fish when it will slide down the cradle and reach its end, a small piece of foam is set between the wood and the vinyl. This foam does not need to be thick as not to interfere with accurate measurement readings. It should not soak up water. For this, cell foam is better. When fish are caught they are brought by fishermen on the wider end of the cradle where they are received by a tagger's assistant or fish handler. Generally, when the line is slacked, the hook drops by itself as most of the time barbless hooks are used. If the hook does not come by itself, the assistant will take it off with a simple swift of the line. If the hook is too deep, it might take too much time and/or too much injury to take it off; then the fish is rejected. The assistant can handle several fish together leaving them one by one sliding down towards the narrow end as soon as the tagging place is free. The fish is set on its left side, head first, for a right hand tagger. When used, the cradle has to be securely fastened to several points on the vessel. This is essential, as both the tagger and his assistant rely on the cradle for support in rough sea. The cover is stretched on the frame with a rope. In case of rough sea, the cover can be rolled up and attached at the narrow end. This cover need to be replaced every 3-4 months. The height and tilt of each cradle need to fit in each tagging location for maximum tagging efficiency. If cradles need to move between different locations, it might be better to build them with feet adjustable in height.

During the many tagging cruises conducted by IATTC, scientists have predominantly preferred to use solid V style cradle (Bayliff and Holland, 1986) where only one fish can be handled at a time. It is felt that the handling of more than one fish at a time, associated with the SPC tagging cradle, might lead to higher initial tagging mortality than other techniques particularly when dealing with skipjack tunas. The fishing rate of the fishermen should be synchronized with the speed of the handling and tagging. It is also possible that using solid V type aluminum cradles in which the tuna is upright rather than laying on its side is extremely beneficial: tunas are generally more quiet making easier for unhooking and measuring the fish. Then the fish can be quickly rolled over and tagged (K. Schaefer, pers. com.).

The pros and cons of these two techniques (SPC and IATTC style cradles) need to be well thought. But, so far, with the absence of simultaneous study on the use of these two cradles especially in term of initial mortality at tagging, it is difficult to make a choice.

It should be kept in mind that fishing periods by pole-and-line are generally quite short: most of them last less than 20 minutes and fishing is often better in the morning. Therefore rapidity is crucial not only to decrease fish stress periods but also to tag as many fish as possible. Every step should be taken in order to maximise the number of fish tagged. A good tagging cradle at a suitable position is essential. To maximize the number of tagged fish, it is also necessary to multiply the number of tagging platforms. On board baitboats, it is generally possible to have several cradles but this number is limited by the space available, the importance of the boat edge available to fishermen and the human resources (cf. § 2.7.). But, considering the high cost of running baitboats, the tagging capacities of a boat must be fully used. If quantity is essential, quality is also of paramount importance. **There is no point in tagging fish if these fish, once released, will soon die from fishing or tagging operations.** So, all measures should be taken to limit as much as possible fish mortality. Rules and approaches necessary to avoid fish mortality are detailed in the course of this document but some general comments are listed below. Taggers with experience are essential. This is only through intensive practice that taggers can attain an efficient tagging expertise. The same taggers should then be kept with the programme as much as possible to minimise negative tagger effect from inexperienced staff. A continuous change of taggers is very detrimental for tagging efficiency. New taggers must be trained on dead tunas before they start to operate on life ones. As tagger's time must be fully used, fishes must be supplied to the tagging cradle by several fishermen. It is also better to have somebody to receive and handle the fish: taking off the hook, if necessary, holding fish and passing them one by one to the tagger after their tagging viability has been checked. This tagging assistant can have an initial scrutiny of the fish and reject those with too much blood, eye, gills, fins or other body damages. The tagger will still have to check the conditions of the fish his assistant will pass on to him. And the tagger can still reject some fish as he is, at the end, responsible of the quality of the tagging. He is also the one that is throwing back tagged fish at sea; head first as much as possible. Therefore, his position and the one of the tagging cradle should permit an easy and safely return of the fish at sea.

When room on board and/or crew members are limited, the tagger has to work by himself to receive, unhook, measure, tag and release the fish and he will be served by a minimum of two fishermen (IATTC bigeye tagging program, K. Schaefer, pers. com.).

Overall, for a smooth running of tagging trips, all members of the tagging teams as well as captain and crew of the boat should be briefed thoroughly on what is expected from each member.

A SPC style tagging cradle fitted with adjustable feet can be set on different tagging boats even on small ones (Figure 14) as this is the case in Mayotte small-scale tagging (Hallier et al., 2002; Wendling and Million, 2004). But for small-scale or opportunistic tagging, often the size of the boat will not permit the use of such tagging cradle: lack of room on board and boat's motion too important for a stable tagger standing position. In large-scale tagging, if very large tunas are caught, it might be difficult to lift them on a cradle. Under these cases, it is necessary to use a tagging mattress or pad that can either be set on deck or on the cover of fish holds and the tagger will have to stand on his knees (Figure 15) or seated.

This mattress is made of vinyl material of the same type as the SPC style tagging cradle. The mattress used in Seychelles and Oman (Itano, 2002; Hallier, 2003) measured approximately 115 x 72 x 5 cm, it is filled with a foam pad and marked in whole cm for measurement purposes (Figure 15). The size of the mattress should be fitted to the tagging room available and to the size of the fish to be tagged. The mattress is constructed of tough

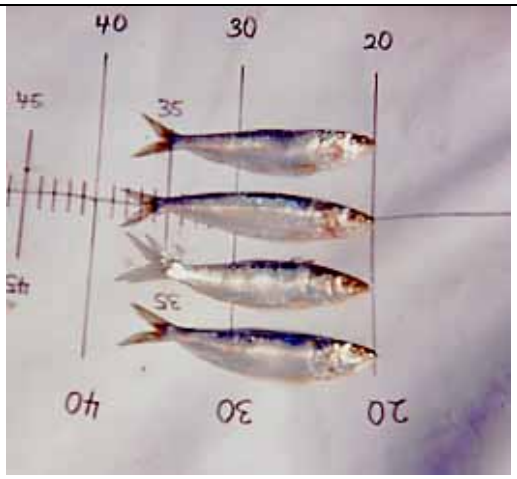

Figure 7: Sardines from Oman that can be used as live-bait for pole-and-line fishing (IOTC, Hallier, 2003)

Figure 8: Small catamaran from Mayotte used to tag tunas caught by troll lines or handlines (IOTC, Hallier et al., 2002)

Figure 9: R/V L'Amitié from SFA used for longline, handline and troll line fishing for tunas (IOTC, Itano, 2002)

Figure 10: Lures used for tuna troll line fishing (IOTC, Itano, 2002)

Figure 11: Lures used for tuna handline fishing (IOTC, Itano, 2002)

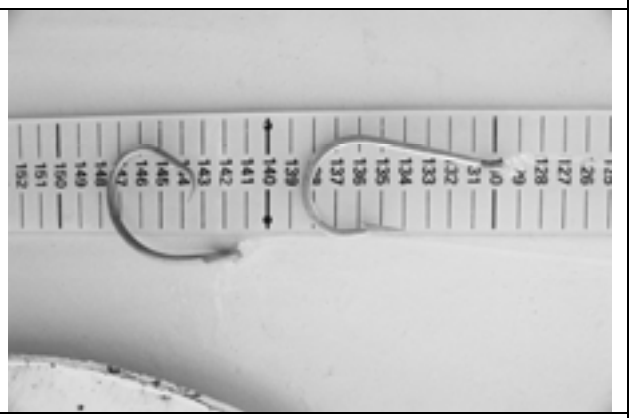

Figure 12: Circle hook (left) and straight hook (right) used on longlines and handlines for tuna fishing (IRD, Tagfad, Hallier et al., 2003)

but smooth vinyl material with a nylon zipper in one side to allow removal and cleaning of the foam pad. Six sturdy nylon straps are sewn into the corners and midway along the long axis to allow the unit to be easily secured to the vessel during heavy seas or to tie the unit up to drain and dry between uses. Ideally, close cell foam, which does not soak up blood or odours, is used inside but regular cushion foam can be used if the volume of tagging is not high. The mattress needs to be slippery by keeping it wet for the fish can slip easily on it. The mattress is easily stored and moved to various locations on the vessels and adequately cushioned the fish while allowing an easy surface upon which to measure the fish.

In order to measure tagged tunas, centimetre measurements are draw with permanent marker on the mattress or the cradle cover. The sizes of the fish need to be read very easily and quickly therefore measurements need to be redrawn every time they tend to fade out. Bars every 5 cm and 10 cm have to be longer than in-between cm and the lengths must be written in large numbers easily visible. A tape measure should be used periodically to check that the measurements on the mattress are correct, or if not, that proper correction factors are applied to release data.

Overall materials needed to build a tagging cradle are summarized:

- Galvanized or stainless steel pipes of 35 mm.
- Iron sheet (galvanized or stainless steel) 5-7 mm width to weld at the base of the cradle feet to protect the deck from the open ends of the pipes.
- A piece of wood 2-3 cm in width that will be set at the narrow end of the cradle; 10-12 cm in height and 16-18 cm width flat at the top and round at the bottom where the cover will be nailed.
- 5 bolts (3 to fix up the wood and 2 to hold the box that supports the wood tag magazine).
- Vinyl cover though but smooth on one side; its cutting form will be a trapezoidal rectangle 70 and 135 cm at both ends and 170 cm long for a small tuna cradle and 85, 145 and 200 cm for large tuna cradle. Except on the smaller end, the edge will be punctured with eyelets used to lace a rope to tight up the cover to the cradle's frame;
- A rope to tight up the cover onto the cradle's frame.
- Eyelets to set on the three largest sides of the vinyl cover to permit the lacing of the cover on the cradle with a rope.
- Small piece of foam to set between the wood end and the vinyl.
- A box made of marine plywood big enough to harbour the wood tag magazine, this box should have a few holes at its bottom for water drainage; it should also have some room where to set the gloves.
- Copper nails to fix the cover to the wood at the narrow end of the cradle;
- A hook to be fixed on the plywood box or the cradle's frames where to hang a bucket to receive the used applicators.

2.4 Tags

For large-scale tagging programmes, "dart" or conventional tag is the only usable tag. The conventional plastic dart tags used by IOTC are manufactured by Hallprint Pty. of Australia. The tags have a white vinyl single barb point joined to a 14 cm yellow streamer for a total length of 14.7 cm. The tag legend bore a sequential code made of letters and numbers written near the tag head and tag end with between the legend "IOTC VICTORIA SEYCHELLES – REWARD" in black lettering (Figure 16). For tunas of small size, it might be necessary to use smaller and thinner tags (cf. § 2.6.1.).

Floy tag from USA is the other manufacturer of dart tags. Both tag manufacturers have their advantages and inconveniences. One of the advantages of the Hallprint tags is that the lettering never becomes illegible because the yellow tubing is protected by a substantial fused-on layer of tough, clear polyethylene. On the other hand, the advantage of the Floy tags is that they are easier for fishermen, unloaders, and cannery workers to see because they don't have a coating of transparent plastic, so the diameter of the coloured portion of the tag is greater.

The Bigeye Tuna Year Program (BETYP) of ICCAT (1999-2003) has used tags originally designed for sport fishing tagging (Figure 16), i.e. designed to tag large fish at sea alongside the boat. But used for large-scale tagging, these tags are not very practical and they induce an extra tagging mortality (Hallier and Gaertner, 2002). However these tags remain the best type for in-water tagging of billfishes and large tunas (Foreman, 1987) and their performances were assessed as superior to the steel tags previously used for such tagging (Prince et al., 2002). They are also well-suited for tag seeding experiment (cf. § 2.6.3.).

To insert dart tag, the tag is introduced inside a stainless steel applicator with a sharp end similar to the end of a syringe (Figures 16). This metal tubing must be slightly longer and slightly larger in diameter than the tags. For a 13 cm streamer with a 2 mm diameter, the overall length will be 15.5 cm, the inside diameter 3.2 mm and 4.15 mm for the outside diameter. The sharp head can have an indentation to accommodate the barb of the tag. Tubing sizes and designs are made to store the tag in such a way that when set upside down for tagging the tag will not slip away by itself. If the tag falls out when attempting to tag, the head can be cut away. On the other end, tags in applicators must fit loosely; otherwise they may be partially or completely retracted from the fish when the applicator is withdrawn. It is then very important that the applicator is perfectly suitable to the tag type. This difficulty is generally avoided when tags and applicators are ordered from the same manufacturer. This point need to be well assessed as any discrepancies in that field can badly arm tagging efficiency. From time to time, the sharp head of the applicators may need to be sharpened.

Fast and large tagging requires a good tag storage design, this is also true for small-scale tagging as tags in their applicators need to be prepared and stored in advance. For large-scale tagging, tags in their applicator are stored in an upright position on hardwood blocks by one hundred (Figure 17). This block type was first designed by W. Bayliff at IATTC. This block should be compact and large: compact enough not to occupy too much room and large enough to grab easily each applicator. The advisable measures are about 38 cm in length, 12 cm in width and 7-10 cm in height (Kearney and Gillett, 1982) or 36.5 x 12 x 7 (Itano, unpublished). It should be made of a wood that will not swell with water. It is drilled by 4 rows of 25 holes of 1.5 cm deep. The top is painted with white paint and each hole is numbered from 0 to 24 for the first row and 25-49, 50-74 and 75-99 for the consecutive rows. This block is set in a wooden box fixed at the narrow end of the tagging cradle (Figure 18). Several blocks can be prepared in advance which is essential as fishing performances vary a lot from day to day. A sufficient number of tags must be ready to face any good tagging day and should be stored in a clean and safe place. During SPC tagging programmes, 1000 to 2000 tags a day were not so uncommon. These blocks with a hundred applicators in an upright position can be dangerous; their storage and manipulation on board need to be realized in safe conditions. During SPC tagging programme, blocks were stored by two in a plywood box open only on one side. These boxes were used to carry new blocks to tagging cradles. Each tagger must have one of these boxes, with spare blocks, at an easy reach from his cradle.

It is most preferable to have the fishermen that are providing fish to a cradle to stand on the large end side of the cradle. The objective is to avoid that fish or fishing lines interfere with the block of tags in their applicators.

For small-scale tagging, especially on small boat, but also for large-scale tagging, tags in their applicators are better stored in a flat vinyl tag magazines or aprons (Figure 19). These aprons that were first designed 30 years ago by IATTC are also used for large-scale tagging by IATTC. This storage is much safer than the block with its 100 applicators in upright position. They have been used by the Hawaii Tuna Tagging Project as they are well suited for use on small fishing vessels in cramped conditions. The tags are stored in paired vinyl magazines measuring 35 x 88 cm, each one having fifty slots for loading applicators in two rows. The first magazine is numbered 01 – 25 while the second is numbered 26 – 50. A second one will be numbered from 51 to 100. These vinyl tag magazines worked very well on small vessels to securely hold and organize tags and applicators ready for tagging in a safe, secure pouch. The magazines can be kept to the side during tagging and are not as dangerous as tag blocks where loaded applicators are exposed in an upright position. Also, the tag magazines can be secured to a vertical surface for rapid access.

2.5 Other equipments

- A piece of dark cloth (black or red are better – Figure 20).
- Cotton or rubber gloves, protective glasses, boots, helmet and other clothes for protection.
- A plastic bucket to collect used applicators.
- Bleach or phosphoric acid and detergent to clean the applicators after their use.
- Permanent marker to draw the measurements on the cradle vinyl or on mattress.
- Acetone or alcohol to clean the marks on the cradle.
- A measuring tape to check the measurements.
- A measuring board and spring balances (if weights are recorded) to collect sizes and weights of rejected tunas. For larger tunas, a calliper is better and First Dorsal Length (FDL) is measured instead of Fork Length (FL).
- If samples like muscles, otoliths, liver, stomachs, etc… are collected, the appropriate equipment is to be prepared (numbered plastic discs to identify fishes, plastic bags including some with seal closing, vials, containers, formalin or alcohol, tracing paper, pencils and fine markers, etc…according to the specific studies that are conducted simultaneously to tagging.
- If samples are collected, some might have to be stored in freezer on board.
- A maturity stage scale to define reproduction stages of fish.
- Books for the identifications of fish or other animals (turtles, mammals, birds) seen or caught at sea and eventually fish and other animals found in stomachs.
- Plastic data board (type used by divers) or a tape recorder to record tagging data on deck (Figure 21).
- Forms to record tagging and associated data.

Once a trip at sea has started, the availability of equipments on board should never force a vessel to come back to port. Therefore, equipments and spares need to be ordered in time and available on board.

A wet piece of cloth (Figure 20) can be used to calm down tunas by setting it onto its eye on the side up. It needs to be very smooth and clean (it has to be washed regularly) and should be just set on the head and never pressed against the eye. A dark colour (black, red or brown) is considered better! Shammy, leather or synthetic, is the best material. Bigeye is generally quite calm but yellowfin is more vigorous and the use of the wet cloth is often efficient in calming down the fish. Skipjack are extremely lively

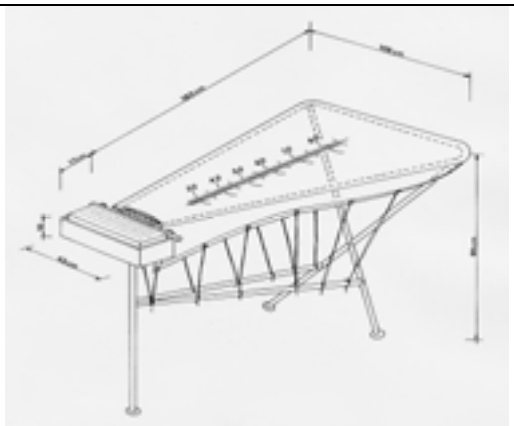

Figure 13: SPC type tagging cradle (SPC, Kearney and Gillett, 1982)

Figure 14: Fitting a large SPC style tagging cradle on a small catamaran (IOTC, Hallier et al., 2002)

Figure 15: Tagging mattress on the bridge of a purse seine supply vessel (IOTC, Itano, 2002)

Figure 16: Applicator for Betyp tag attached to a wood pole (top)
Betyp tag (second from top)
Dart tag (third from top)
Applicator for dart tag (fourth from top)
Measuring plastic rule as scale
(IRD, MAC, Hallier and Gaertner, 2002)

Figure 17: Holding block to store one hundred dart tags in their applicators (Photo Cayré, IRD)

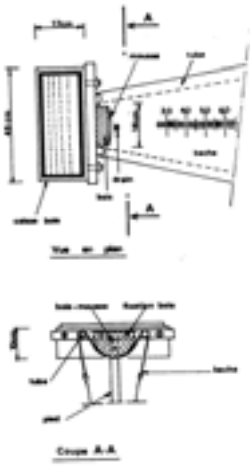

Figure 18: Setting of the dart tag holder magazine at the narrow end of the tagging cradle (SPC, Kearney and Gillett, 1982)

and the effect of the cloth is quite variable and rapidity is often the best way to tag properly this species. During large-scale tagging operations, tagging rate can be so fast that one should not bother with a too frantic tuna to use a wet cloth to try to calm it down, it is then rejected. If the rate is slower or during electronic tag use that takes time, the tagger can use the wet cloth or try to calm it down by putting his hand with his glove over the eye but without pressing on it.

Gloves are necessary for the tagger, first of all to avoid to be punctured by the round end of the applicator (this is especially true for larger fish with stronger skin), secondly to protect his hands from fish spines and hooks. The material needs to be smooth, easy to clean and the tagger should maintain his touch sense through the cotton or rubber. Gloves' cleaning is very important for hygienic purpose not only for the fish. If fish mucus remains on cotton gloves, it will attack the hands' skin and can cause skin infection. This can be avoided by the use of rubber gloves.

The tagger and his assistant should wear protective glasses to prevent fish and hooks to harm the eyes. However, for practical reasons, most of the time, it is not possible to wear these glasses. Therefore, everybody (tagger, assistant and fishermen) must be very cautious when tagging is taking place. Boots are also recommended to protect feet and legs of members of the tagging team and fishermen. To protect the head from hooks and knocks from poles or falling fish helmet is necessary. In the tropics, when at sea, at night and even during the day, it is sometimes necessary to wear oilskin suit or foul weather gear for protection against squall and rain. Caps and sun cream must also be part of the equipment necessary to tagging members. Because of all these hazards, first aid safety box must be available on board even during small-scale tagging.

A bucket should be attached at the head of the cradle under the box that holds the tag magazine where all used applicators will be thrown out. Once tagging is over, applicators should be cleaned in sea water and then drowned in a mixture of fresh water and bleach before to put them to dry. In Maldives (Anderson et al., 2003), applicators were sterilised by boiling in clean fresh water for at least 15 minutes. In IATTC (W. Bayliff pers. com.) when a cruise was completed, applicators were always cleaned with phosphoric acid, and sometimes this was done also in the middle of a cruise. Applicators were left a few hours in a bucket of phosphoric acid and then rinsed. K. Schaefer advises not to use bleach affecting the stainless applicators but to rinse them in salt water, then in fresh water, then soak in bucket with detergent, then rinse in fresh water and then completely dry before reloading.

Permanent marker is necessary to write measures on the cradle cover. However, whatever the quality, it fades out quite quickly therefore measures are to be rewritten regularly. They also should be checked regularly with a measuring tape to adjust or correct measurements if necessary.

2.6 Tagging

2.6.1 Single tagging

Tags should never be placed at the base of the first dorsal fin or directly into the dorsal muscle. The first dorsal fin is very sophisticated so related muscles and nerves should never be harmed in any way. Dart tags with their one-side barb will not remain well-attached if sets only in muscles. The only place where dart tags must be set is below or slightly posterior the second dorsal fin so that the tag head and barb passed transversely through the dorsal musculature to anchor securely behind the second dorsal fin pterygiophores (fin ray supports) (Figures 22 & 23). The tag should be placed at an angle lower than 45° with the body of the

fish (Figure 24) in order to minimize water resistance on the tag. The angle between the tag and the side of the fish must be well evaluated. If it is too big, the tag will offer too much resistance to the water flow; if it is too small, it will be necessary to insert the tag more deeply for the barb can reach the other side of the fin supporting rays. The tagging movement must be rapid and given with strength especially for larger fish as skin is quite though. Therefore, angle and depth are important for the proper placement of the dart tag as it is necessary that the barb reaches the other side of the fin ray supports. If it is too deep, the barb can go all the way through the fish and reach the other side of the skin. If it is too low, the tag will only be implanted into skin and muscle which might not be sufficient to hold it in place for lengthy periods.

The size of the tag versus the size of the fish is a controversial problem. The present IOTC tag is about 14.5 cm long and between 2 and 2.5 cm will go inside that still leave the fish with a 12-12.5 cm plastic tube on its side (Figure 25). SPC tags during the SSAP were 11.5 cm overall (Kearney and Gillett, 1982). Some experiments were conducted in Hawaii in collaboration with SPC on skipjack maintained in captivity in tanks and tagged with SPC tags. It was found that this size tag has a negative effect on the survival rate of skipjack less than 42-43 cm (unpublished data, Kearney, Pers. Com.). Therefore, when one tags a small skipjack (less than this size limit), it might be better to use smaller tags. During the RTTP of SPC, dart tags used had a 13 cm streamer (about 13.7 cm overall) with 2 mm diameter. For fish less than 35 cm FL, tags used were thinner and smaller (1.2 mm and 10.5 cm streamer - Itano, unpublished). For yellowfin and bigeye, the situation is more questionable as these fish can grow to large sizes. If the tag is small, it will sink deeper and deeper as the fish grows and it will eventually disappear inside the fish. At the best, the tag will be spotted in canneries but there is more probability that the tag won't be seen at all. Furthermore, there are some practical difficulties in using two tags of different sizes. Most of the time, sizes and species are mixed in the same school. Using different size tags means having two different tag magazines at hand at the time, choosing rapidly which size to use and to record properly which batch of tag is used. If one wants to do this properly, this will slow down a lot the tagging rate and will add more mistakes in data recording. Apart from some particular situation where almost all fish are undersized, it is not recommended to use at the same time two different sizes of tags. But when small fish that require smaller tags are mixed with larger ones, it is better to use smaller tags than bigger tags on both fish.

Here are listed several recommendations regarding fish handling during tagging operations:

- Tunas should never be handled by the tail especially when lifted as this is an essential swimming part of the body that need to remain unharmed. The best way to handle fish is horizontally and upside down. When held upside down most fish loose their equilibrium sense consequently they remain absolutely motionless at least for a short time. However, if this upside down position is very well suited for the implantation of archival or sonic tags in the abdominal cavity, fish need to be on the side to receive dart tags.
- Gills should never be touched with the fingers.
- When tunas are lifted onto the tagging cradle by a scoop, if it is possible, the scoop must be landed on the cradle or mattress together with the fish; the fish is tagged and returned to the sea with the scoop. However, when one wants to take the length of the fish, it is not possible to proceed this way as measurements on the cradle are difficult to read through the mesh of the scoop. Either, the round length is taken with a tape or the scoop must be removed from the cradle.
- When fish are caught with hand lines or troll lines, hooks used have barbs that even when filed a bit can still hold firmly in the fish mouth. First of all, if the hook is too deep in the

throat of the fish, this fish should not been tagged. If not, the hook must be removed with precaution as not to damage this delicate part of the body. Good pliers are often necessary. But if the hook does not come out it is then advised to cut it in half or to cut the line and leave the hook in place.

- Any sign of injury or important bleeding is to be searched, especially from the eyes, the gills or the jaw on both sides. If the hook has perforated the eye from inside (this is not so rare), some blood might be seen inside the eye but more evidently the surface of the eye will be depleted and rippled. These fish will be rejected as well as those with important bleeding from the mouth or gills.
- If there is any doubt on the quality of the fish, it must be rejected.
- On large cradle several fish can be handled at the same time by the tagger's assistant (two or three the most). However the assistant must be careful not to retain fish too long; after 15 seconds if the fish cannot be passed on to the tagger, it must be rejected.
- It should be kept in mind that small fish are weaker than larger ones and skipjack maybe more than yellowfin and bigeye.
- In some places, tuna can present round and perfect cleaned cuts mainly on the fish sides. They are made by a specialized little shark (*Isistius brasiliensis*). When the cut is made only in muscles, the fish can be tagged as many recovering tunas with these scars are observed. However, if fins or worst the abdominal cavity are cut, it is recommended not to tag these fish.
- When a cloth over the eye is used, it should be simply set onto the eye and the tagger must never lean his hand on it. In general, fish manipulations must be limited to the minimum as fish skin is covered with mucus that protects the fish. Important removal of mucus can kill the fish.

As already mentioned, rapidity is a key issue to large-scale tagging but this has to be done with good quality of both tagging and data recording. During SPC tagging, the maximum tagging rate reaches was 20 fish per minute (Kearney and Gillett, 1982).

During tagging cruises, the fish condition criteria would reject any fish for tagging that has hooking damage to the eye, gills, or showed significant arterial bleeding or significant jaw damage. The term "significant" is admittedly subjective so some means to better define these categories may be necessary. However, some tag releases are "better" than others, and the condition of fish on release should be noted and recorded in the database. A condition factor of "0" is assigned for a good/normal condition fish while a condition factor of "1" indicates some problem that is not so serious as to reject the fish for tagging but notes the fish is not perfect. In the rush concomitant to some large-scale tagging operations, some fish might be tagged and released before the tagger realized the bad fish condition. Then, the condition factor is 2 and indicates that this fish should not have been released. This should remain an exception. During SPC tagging, only 5.7 % of the fish were recorded for bad fish or tag conditions (Kearney and Gillett, 1982)

A properly placed conventional tag should feel very secure in place and should not be able to be pulled free without a great deal of force. Normally, a well-placed tag can support the weight of small tuna and will stretch or break before being pulled free from a larger fish.

Most importantly, standardized criteria for tag releases should be adopted throughout the tag release phase. There is no doubt that tuna can survive serious injury, but not all will and it is necessary to set some minimum criteria for fish condition. Each release should be as similar to the next as possible, although basic differences may be noted due to different capture gear types, tagger effects, etc.

2.6.2 Double tagging

Double tagging or placing two tags on the same fish is always part of large scale tagging programme to assess tag shedding rate. Tags can be badly placed or some inflammatory or rejection process can take place and the tag will be expelled from the fish. If this fish is recaptured, nobody will ever know that it previously bearded a tag. These uncounted recoveries will bias the tagging results. Double-tagging is performed to assess this shedding rate. Another advantage of double-tagging is to increase the return rates as the probability for a fish of losing both tags is much lower than losing one single tag.

Double tagging is accomplished by placing tags on different sides of the fish (Figure 26), one in front of the other so there is no danger of severing the first tag when the second applicator and tag is inserted. During the SSAP of SPC (the first large-scale tagging effort of SPC), double-tagging was performed by placing both tags on the same side of the fish. Either, tags were placed one after the other or they were placed at the same time by unifying two applicators with a piece of strong rubber band. During the RTTP of SPC, tags were placed on each side (Itano, unpublished).

It is generally advised to pair the tags so that the lower of the two numbers is an even number, i.e. A003200-A003201, A0039202-A003203, etc…In this way, double tags cannot belong to two different series such as A003299-A003300 and odd and even numbers are always on the same side of the fish. The idea is that subsequent analysis may wish to examine differential tag shedding by placement order or side of fish by tagger. Individual taggers should be required to release a minimum number of double-tagged fish by species and size range as determined by those conducting the tag recapture analysis to examine differential tag shedding effects.

2.6.3 Tag seeding

"Ideally, all tagged fish that are recaptured are identified and reported to the scientists conducting the experiment. In practice, this is almost never the case and some tags from recaptured fish never reached the collection points for a number of different reasons. During the analysis phase, failure to account for those unreported tags by incorporating an estimate of the reporting rate will directly bias estimates of various parameters, in particular estimates of the exploitation rate of the resource, the most important objective of the regional tagging programme.

Therefore, it is essential that independent estimates of reporting rate be obtained to adjust observed recovery rates. Among the various techniques to accomplish that, the most common are tag seeding experiments. In these studies, dead fish are tagged, shortly after they have been captured, but before they have an opportunity to be spotted by the 'recovery platform' that we are interested to assess.

This experiment cannot be done in all circumstances. For example in fisheries like the longline fishery, where each fish is handled individually at the moment of capture, it is likely that any tagged fish will be spotted by the longliner's crew first. Therefore, the information about reporting further down the line of processing is less relevant, as the reporting of tags will depend largely on the vessel's crew attitude. And the only existing method for estimating reporting rates from this gear requires observers on these vessels (IOTC, 2003).

In the case of the reporting from purse seine fleet, the number of reported tags and the quality of the information associated depends largely on where (and by whom) the tagged fish are expected to be recovered. Although some large tagged fish might be spotted by the crew when the catch is loaded in the purse seiner holds, most of the small fish might not be spotted on board" (Anganuzzi, 2004). Then, they will eventually be discovered at unloading or in canneries. But once spotted, there are many reasons for which the tag and the information will never be reported to the collection points.

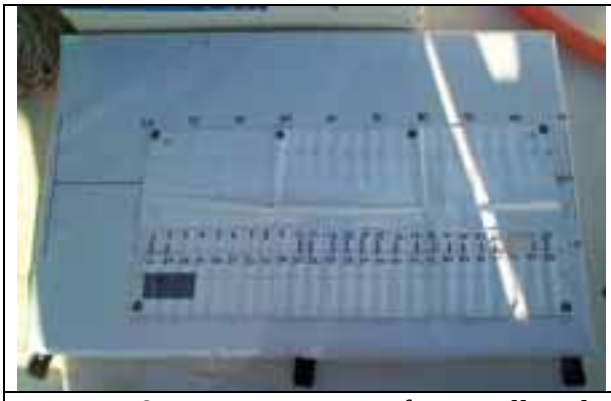

Figure 19: Tag magazine for small-scale tagging operations set above the tagging mattress (IOTC, Itano, 2002)

Figure 20: The use of a piece of cloth set on a yellowfin head to keep it quiet during tagging operation (IOTC, Itano, 2002)

Figure 21: Mini cassette recorder in plastic bag and neck strap ready for data recording. (IOTC, Itano, 2002)

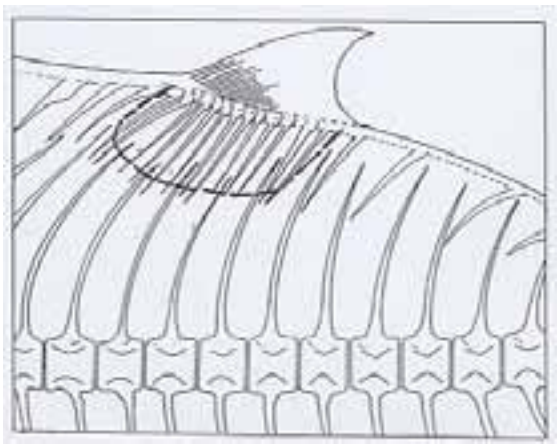

Figure 22: Drawing of fish bone area where to implant dart tags on tunas (SPC, Kearney and Gillett, 1982)

Figure 23: View of the place where to implant dart tag (IOTC, Wendling and Million, 2004)

Figure 24: Skipjack ordinary tagging (IOTC, Itano, 2002)

In order to assess the proportion of reported tags, it is necessary to conduct tag seeding experiments by placing a number of tags at sea immediately after the fish are caught and before they are placed in the wells of the purse seiners. As these tags are placed on dead fish that are going straight into fish holds, it is necessary to use tags with a tighter grip than dart tags. When a life fish is tagged, the only strength exerted on the tag at sea is the flow of water. After a few days in place there are often some tissues that develop around the tag and increase its implantation inside the fish. This is not the case for tag seeded dead fish. This is the reason why Betyp tag as illustrated in figure 16 or stainless steel dart tags as used for in-water tagging via jab stick are more suitable for tag seeding.

Generally, a few fish by size and species are tagged for each trip made by observers on board purse seiners. When discovered and reported, they are rewarded as normal tags. This seeding process must be an on-going tagging procedure during the all tagging programme.

To assess reporting rate, it is also possible to use some high value tags of unique colour. This is a kind of “gold” tag.

Tags can be discovered by fishermen, stevedores, or cannery workers. But tag seeding, as practised on purse seiners, is eliminating fishermen from the experiment. Stevedores and cannery workers have no incentive to discard the tags, but some fishermen do, or think that they do. Furthermore, fishermen earn far more than stevedores and cannery workers, so they have less financial incentive to return the tags. Conversely, fishermen are interested in the release data, whereas stevedores and cannery workers are not. Consequently, tag seeding experiments should permit to assess the proportion of tag returned by stevedores and cannery workers.

PIT tags can be an alternative to provide estimates of reporting and shedding rates from their ability to identify specific tuna double tagged with dart and PIT tags. These tiny electronic tags are commonly used in salmon research and management and have been tested on cage-cultured southern bluefin tuna. PIT tag detection device cannot be set at every unloading location but at some ports were large fractions of landing catches can be scanned (IOTC, 2003).

2.6.4 Otolith tagging

Growth study is one of the products expected from tagging as fish size increment between tagging and recapture is known when lengths are measured. This increment, together with time-at-liberty, gives the basic parameters to assess growth from the fish tagged. But dart tagging gives also the possibility to inject a chemical that will set a mark on fish hard parts such as otoliths, spines or vertebras (Foreman, 1987). During MAC programme in Senegal (Hallier et al., 2001), tuna tagged with OTC received one injection of 4 ml of OTC 5 from COOPHAVET ® for fish lower than 3 – 5 kg and 2 or 3 injections for larger fish according to their weight. In order to speed up injections, it is much better to use an auto-injector.

The injection of this antibiotic, oxy-tetra-cycline, leaves, the day the fish is tagged, a mark on the otoliths (Figure 27). This mark is visible in ultra-violet light under a microscope as tropical tuna otoliths are small. Then, the number of increments between the OTC marked ring and the last ring on the edge of the otolith when compared to the time-at-liberty will give the increment deposit rate. This rate for yellowfin and bigeye is one ring per day; for skipjack it is not regular especially after fish became mature. Ring counting, back from the OTC ring towards the center of the otolith will give the total ring count that can be converted to days to obtain the fish age. To properly identify those OTC injected fish as the fish must be returned to scientists, a different color dart tag is generally used. Often, higher rewards are also paid for those fish so they need to be quickly identified not only by scientists but also by tag inventors. There are color rules: ordinary tagging is done with yellow plastic tags; OTC

injected fish are tagged with orange or red plastic tags. Fish with an archival tag can receive a green or blue tag.

OTC is not the only marking chemical used for this purpose; strontium chloride and fluoro-chrome are also used. OTC and strontium used for bigeye tunas by CSIRO give better results with strontium (Clear et al., 2000a, 2000b).

2.6.5 Dummy tagging

In Maldives, it was felt that "during tagging when tunas are measured, their muscles are tensed. When they die their muscle 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'. Live tunas were tagged and measured as normal, but then thrown into the fish hold instead of at sea. Later, they were re-measured" (Anderson et al., 2003). Tunas were found a bit smaller by 0.41 cm when alive than when dead. This difference was respectively for skipjack, yellowfin and bigeye 0.88, 0.14 and 0.44 cm for bigeye.

2.7 Fishing for tagging

Large-scale tagging is almost always performed on baitboats or pole-and-line vessels notably for tropical tuna tagging (Figure 28). As fishing active periods are short, it is necessary to have as many cradles as possible. There are generally at least three cradles and sometimes more. During SSAP, most of the time three cradles were used but up to five were working in special situations when fishing was good and sufficient staff available. During standard SPC RTTP tagging operations, four tagging cradles were manned at port bow, starboard bow, starboard stern and port stern. A fifth cradle was sometimes set at the center of stern. During handline operations, tagging mattresses and a cradle were set up along the port mid-ships, low to the water, where handlining large tuna is easiest. A steel platform was also deployed off the centre stern, which provided a tagging station 40 cm above the sea surface. The platform was large enough for a tagging mattress, tagger and tagging assistant and used for handlining large tuna.

Weather conditions, seasonal tuna and baitfish abundances and scientific information sought from tagging are the primary considerations in planning tagging cruises. Baitfishing is made difficult or impossible in strong winds and even in moderate chop especially if boke-ami net is used and/or bait fragile. Baitfish resources are the main constraint in this regional tagging project as their abundance is not widespread contrary to the Western Pacific. Several baitfish surveys have been done in the past in some areas (Stequert and Poulain, 1973; Marchal et al., 1979; Anon., 1983; Conand, 2003) and a baitboat fishery existed in Madagascar from 1973-1975 (Stequert et al., 1975). Some experimental baitboat trials were made in Seychelles in the past (Ratcliffe, 1973; Cort, 1982, Nageon, 1982). All available data should be used even if they are scarce. Seasonal trade winds in some areas can hamper searching and fishing operations and attempts should be made to avoid regions where high winds are expected. Tuna abundance is seasonal but after twenty years of intensive purse seine tuna fishing this seasonality is well known. However, inter-annual tuna abundance is frequent therefore, close collaboration with purse seiners will be essential for the tagging baitboats. The tagging operations must compromise between a well planned tagging framework designed by modeling the tuna resources by species and sizes and the field conditions (weather, baitfish and tuna availability to the tagging vessels, and staff available on board) and vessel's constraints.

Yellowfin and bigeye are the primary targeted species of the IOTTP. But skipjack is the most abundant tropical tuna species in weight and especially in number. At the other end, bigeye is the least abundant species especially those at surface or sub-surface that are

accessible to baitboats. The ICCAT BETYP programme has recently experienced this difficulty in tagging a sufficient number of bigeye (Hallier, 2004). The picture coming out from recent bigeye tagging operations is that most successful bigeye tagging operations are limited to very specific areas such as Mauritania and Canary areas in the Eastern Atlantic Ocean (Hallier et al., 2001; Delgado de Molina et al., 2004), Coral sea in the Western-South Pacific Ocean (Hampton and Gunn, 1998), equatorial region of the Eastern Pacific Ocean (Schaefer and Fuller, 2004).

Tuna are widespread at ocean scale in a patchy way. Detection of tuna school concentrations is then a prerequisite for any tuna tagging. This can be attained through different ways: collect information from purse seiners, having access or possess radio beacon buoys attached to drifting FADs (Figure 29), using historical catch distribution, interpreting oceanographic satellite imagery (SST, chlorophyl, sea altimetry, etc…). Outside of the tuna concentrations and even more inside, the vessel need to be able to detect tuna schools. These detections are made by sight (birds, logs and FADS, tuna activities), by binoculars, by bird radars and by sonars. New sonars (with ranges of 3 – 4 km) are now widespread among the purse seine fisheries. They seem to play an important role for the detection of underwater or sub-surface schools that were mainly un-noticed before. Part of the very good catches of large yellowfin in the Western Indian Ocean since the beginning of 2003 is attributed to the use of these new sonars. At the same time, with the considerable use of FADs, fishermen recognize that free schools are less abundant. Therefore, it is necessary that the IOTTP baitboats need to be equipped with the most advanced detection apparatus. It is not advisable that the IOTTP baitboats tagged tunas among purse seine vessel's concentration. These boats should prefer to tag on the limits of these purse seine concentrations and even away from them. In this situation, they cannot always rely on purse seine information to find tunas and they will need to be equipped with very good detection systems in order to operate by themselves. They should also be able to seed their own FADs in the same manner as purse seiners. They will be stolen as the others but by participating to the general FAD seeding system, they will be part of it. When many fish associated to a FAD are tagged, the FAD should be removed before departure so a purse seiner does not set around it and catch the tagged fish within a few hours or days.

2.8 Fishing for bait

Bait is a prerequisite to pole-and-line fishing and bait fish need to be kept alive. This main constraint is lifted by using different fishing gears. Purse seine (Figure 30) is widespread for the catch of live-bait especially but not only in temperate and sub-tropical waters (Japan, Spain, France). Beach seines are also employed, but when baits are fragile, the best way and sometimes the only practical way is to fish with a bouke-ami. This net is managed from the side of the boat and its original design is Japanese. Baits can be caught during the day (purse seine, beach seine) or at night without light (purse seine) and with lights above water and underwater (purse seine, bouke-ami). The choice of net and method (during daytime, at night, with or without light) is related to the species targeted. Several baits do not respond to light, some can even run away from light; others are attracted to light. According to bait hardiness, they can be loaded dry or in bucket of water more or less crowded. They are dropped in tanks with sea water circulation and an underwater central light.

Most bait species belong to the following families: Engraulidae (anchovies), Clupeidae (sardines – figure 31, herrings), Dussumieriidae (sprats), Scombridae (mackerels), Carangidae (selar, decapturus, scads), Caesionidae, Atherinidae (hardyheads).

As mentioned previously, the use of dead baits mixed with live baits or not can be a way to catch tunas with pole-and-line fishing when live baits are scarce or missing.

Figure 25: A small tagged yellowfin ready to go back to sea (IOTC, Itano, 2002)

Figure 26: Bigeye double tagging; note staggering of tags to avoid cutting each other (IOTC, Itano, 2002)

Figure 27: Edge of a bigeye otolith showing the micro-increment where OTC is visible in ultraviolet light (LASAA, IRD, MAC, Hallier et al. 2003)

Figure 28: Pole-and-line fishing with bamboo poles on a baitbaot in the Eastern Atlantic Ocean (Photo Cayré, IRD, 1982)

Figure 29: Drifting wood Log or FAD with a radio beacon SERPE buoy (IRD, Tagfad, Hallier et al., 2003)

Figure 30: Bait fishing with purse seine in Senegal (Photo Barbaroux, IFREMER)

2.9 Measuring tagged fish

All fish tagged have to be measured as accurately as possible. This is why tagging cradle and mattress are always labelled in centimetres or half-centimeters.
As vinyl covers are soft, fish cannot be measured with a precision lower than ½ cm or 1 cm. The general procedure is to measure to the nearest inferior ½ cm ou cm (Figure 32).

2.10 Recording data

Large-scale tagging will generate large numbers of data. The collection of these data is the second step of the tagging procedure and it is of paramount importance that they are collected in the best conditions. The value of a tagged fish is directly related to the collection of related data. Generally, for practical and financial reasons, it is not possible to have staff specially dedicated to tagging data collection. Tagging data will have to be collected directly from and by the tagger. It is then necessary to use tape-recorders or tape desks to collect these data. Recent tagging programs have adopted the use of mini-cassette tape recorders to record tag release data, such as the one shown in figure 21. For maximum efficiency and to minimize the chances of data loss, the following criteria should be followed. Tape recorders should be simple “one touch recording” type and as sturdy as possible, lacking added features such as integrated AM/FM radios, voice activated recording systems or other extraneous features that may interfere with voice recording. Units with large, clear front windows that allow the viewing of the tape in motion during recording and a clearly visible tape counter are preferred. Pause buttons should be deactivated with vinyl tape so the unit can not be paused accidentally and the volume control should be taped to maximum. Tapes should be pre-recorded with music or some sound other than tag data which will alert the tagger if his unit accidentally switches from the “Record” mode to “Play” mode. Audio tapes should be normal bias, 90 minute tapes clearly labelled with an “A” side and “B” side and an individual identifying number.

Each tagger should have two tape recorder units with fresh AA alkaline batteries ready for use in Ziploc plastic bags taped shut and rigged for wearing around the neck. Sound will easily pass through the plastic bag while protecting the unit from water damage. A third unit should be available as a backup and all three recorders clearly marked with the tagger name and in some way to differentiate one unit from the other, ie KNB #1, KNB #2, KNB #3.

When tagging is over, data collected on tapes are registered at the end of each day on log sheets before being entered on laptop. This is the first step of verification before entering into the computer. The tapes are not always clear, lots of distracting noises, lots of other factors. Also, if one goes simply from tape to computer, there is no way to verify (repeat) the process for verification, as it all happened inside your head, and this after a long day in the hot sun on a bouncing sea. Each run would be an independent variable.

Standard practice with SPC was to transcribe taped data to data sheets. It is extremely important that everyone have good quality headsets so the listener can concentrate on his voice recording without distracting others.

The general procedure is :

- Transcribe data same day
- Enter in computer
- Print out what has been entered in computer
- Verify computer printout with the transcribed hard copy, one by one
- Backup computer file
- File hard copy data (theoretically, hard copy data can be verified or checked against computer data later at the home office, but it is important that the tagger performs the first data entry and check)

- Recharge batteries, prepare tape recorders for more fish

Ideally, all this should be done before the day is finished.

For small-scale tagging, it is possible to record data manually by writing them on a plastic data board (Plexiglas's type board used by divers) with pencil (2B is better). Once data have been transcribed on proper data sheets and entered in computer, the board can be erased with a rubber or better washed with cleaning powder to be re-used for the next tagging operation.

2.11 Data collection

Of course tagging data is the main focus of such programme; however other types of data are needed or are complementary. It is necessary, for instance, to have some ideas on the daily routine of the vessel, on baitfish and tuna catches; sightings are essential in the search for tuna schools and FADS; often some biological data and samples are collected. Consequently, different forms are needed. As example, forms used by the RTTP of SPC are presented below.

2.11.1 Daily Log form (Appendix 2, form 1)

The Daily Log form summarizes what was done during the day: running time; searching & fishing time; amount of bait carried, used and dead; the number of fish tagged (single or double) by species and the cumulative number; biological data collected (by species, by type of data: length, weight, sex, gonad, otolith, stomach, morphometry, etc…). In this form, few oceanographic data (Wind, Sea state, sea and air temperatures, cloud cover) are recorded three times per day (6:00, 12:00 and 18:00).

2.11.2 School Sighting Form (Appendix 2, form 2)

This form is to record all sightings encountered by the vessel during its searching and fishing activities: time, position and several characteristics. In particular school type should be recorded as typically purse seine fisheries are broken down by set type in stock assessments. So if the tag-recapture data are to be integrated in the assessment, then it is desirable to have recoveries by set type.

2.11.3 Baitfish Form (Appendix 2, form 3)

All baitfish catches are recorded in this form: for each haul, the time, position, depth, bottom type, lunar day, cloud coverage, current, catches (weighted, loaded and discarded). The main different species are identified to the species level with their average size, their size range and the proportion into the catch. As baitfish resources are not widely distributed in the Western Indian Ocean as it is the case in the Western-South Pacific, it is necessary to maintain the best records of bait resources to help to document bait availability and seasonality.

2.11.4 Biological Samples Form (Appendix 2, form 4)

All biological data and samples are registered on this form: school N°, sample N°, species, FL, Weight, Sex, gonad stage, gonad Wt, otolith, stomach contents (volume, main items).

2.11.5 Tag Release Form (Appendix 2, form 5)

Data recorded during tagging include the date/time, tag number, species, fork length to the nearest cm or ½ cm, position in latitude and longitude, tagger's name and cradle's position, fish and tag conditions. During tagging operations, the entire tag number is noted periodically,

but only the last two digits need be recorded most of the time to allow faster operations. The convention in database recording used by the South Pacific Commission was to designate each tagger by three initials, ie Kevin N. Bailey = KNB. For practical reasons, tagging and recapture data are collected on two different forms (Form 5 and 8 of appendix 2). However the final file should contain both data on the same line. The school sighting form will contain all the school data information related to each school from which tagging is performed.

2.11.6 Daily Tag Release Form (Appendix 2, form 6)

This a daily summary of the fish tagged by school fished and by cradle. The objective is to know where on the boat and by whom fish were released.

2.11.7 Tags Used Form (Appendix 2, form 7)

This form records the tag series used from each cradle with the starting and finishing dates. This helps to follow the tag utilization.

2.11.8 Tag Return Form (Appendix 2, form 8)

On this form, return information are listed: species, tag N°, length, weight, finder, reward paid, fishing date if recovered at sea with vessel, position, fishing gear, school type; if found after capture (date found, vessel, location, port, finder).

2.11.9 Log and FAD Record Form (Appendix 2, form 9)

As logs and FADs are playing an important role in the purse seine fisheries, a special form is designed to record data on these items: date/time, position, sea conditions (SST, wind, sea state, current, cloud coverage), description of the FAD (type, radio buoy, previous records, etc… Catches and tagging results on the FAD with reference to the log pages and school N° are reported on the form. Some data on the associated fauna and flora can also be noted.

2.12 Daily routine

This account describes the main facts occurring while tagging on board a baiboat:

- While captain and crews are searching for schools or FADs, the scientists are recording in the daily form any sightings and few data regarding the boat and environment situations.
- When a school is spotted and approached, all scientists get ready for action; when tunas start to bite, it is too late to get ready. “Large numbers of fish are often tagged in short periods of time aboard baitboats, so it is imperative that everything be well organized at all times. An adequate number of tags in their applicators should have been loaded into the tag magazine the preceding evening” (Bayliff and Holland, 1986). Biting is more frequent and successful early morning. The cruise leader writes down data on the daily form and the school form especially the school number and position. Each tagger checks his tape recorders and the following data are recorded:
  - the date and time,
  - the position or number of the school,
  - the cradle number,
  - the first full tag number,
- The tagger and his assistant put theirs gloves on.
- Water is spread on the cradle and the gloves.
- When the school is responding to chumming, tagging is starting.

- The assistant receives the first fish, unhooks it if necessary and rapidly check its condition. If unsatisfactory the fish is thrown on the deck.
- The tagger grabs the first tag.
- The fish is passed on to the tagger by letting it to glide down the cradle on its left side up and head first.
- The tagger assesses its condition and tags it if satisfactory. The empty applicator is dropped in a bucket hanged at the tagging cradle.
- He records the species, the size and any information on the tag and fish conditions.
- The fish is dropped over the side head first if possible.
- The next fish is passed on by the assistant.
- The tagger records the last two numbers of the tag, the species, the size and conditions.
- Etc…
- From time to time when tagging is slacking down the tagger verifies his tape recorder, records the full number of the tag and the time. When there is a break, tape recorders are set on pause; this is to avoid listening to too many tapes when records will be reported on spread sheets.
- When fishing is over the tagger records the time and the number of applicators that have been dropped inside the bucket.
- Applicators with tags or tags that fell on the deck during tagging or were accidentally cut off by the applicators or rejected for other reasons were placed into the bucket; their numbers are recorded. At the end of the day, after checking their numbers, and when necessary the tags are destroyed.
- Applicators are collected at each cradle, rinsed in sea water and dropped in fresh water with 10 % household bleach for at least 20 minutes and then rinsed in fresh water.
- Gloves need to be well cleaned.
- Data on the end of fishing/tagging is recorded in the daily book and schools forms.
- Tape recorders are checked. If there is not much tape left on one side, the tape must be turned out or changed.
- New blocks of tags in theirs applicators are prepared when crew resume his search for other schools and FADs.
- A masking tape with the full numbers of the tag series is stuck to the end of each block; this helps to choose the block in following series.
- When another school is fished, the processes described above are repeated.
- When fishing is over for the day, daily forms, schools forms are collected as some of their data will be copied on the tagging forms by each tagger. If some data were recorded on plastic forms their data are copied on paper forms.
- Each tagger listens to his tape(s) and writes down the information on the tagging forms. For security reasons, the tagging books have carbon copies (the copies are kept on board while originals are sent regularly to the main office). The verification process is described in the previous page.
- Tapes are rewound and recorders are checked and prepared for the next day. Batteries have to be changed regularly to avoid any failure during tagging. Tapes becoming less audible are rejected.
- If time is sufficient, tagging form data are entered in laptop files and a backup copy is made regularly. Backup files are regularly sent to the main office.
- New blocks are prepared for the next day.
- If necessary, measurements on cradles are checked and the errors are eventually recorded for later corrections. If necessary, measures are cleaned and re-written.

Tagging success relies on well organized procedures. And considering the complexity of large-scale tagging, the expected performances and the costs involved (money and human efforts), there should be no room for amateurism; just the best professionalism is needed.

3 ELECTRONIC TAGGING

Apart from conventional tagging with dart tags, several electronic tags have been developed during the past 30 years:

- Sonic tag (Figure 33) that will emit a frequency (sound) that will be registered by an hydrophone connected to a recorder to identify the emission; this tag can also transmit data on some physiological aspects of the fish, depth and its environment;
- Archival tags (Figure 34) that will record several parameters in a memory;
- Pop-up tags (Figure 35) that are similar to archival tags but the memory part will detach itself from the fish at a chosen time to transmit its data via a satellite.

3.1 Tagging vessel

Electronic tags are always implanted on a limited number of fish. Each fish will have to be dealt separately. In these conditions, even a small vessel is sufficient to realise these tagging operations: it can be a small research vessel or a chartered sport fishing vessels (Figures 2, 3 & 8). But, the size of the vessel is also related with the distance to the fishing grounds. If targeted tunas are large, some special measures have to be taken (use of special fishing gears, a lowered fishing and tagging platform set on the outside of the boat for not having to lift tunas too high, a lifting device).

3.2 Lifting device

When tunas are big, it might be necessary to use a device to bring them on board especially if the vessel is high above sea level. The simplest devices are scoops of different sizes. The scoop presented on Figure 36 has a diameter of 1 meter and can be used for fish with length up to 1 meter. It can be improved by giving an oval shape. At IATTC, scoops are used for tunas up to 150 cm FL. The scoop is handled by two persons: one is holding the 5 m long handle, the second is holding the rope attached at two places on the round edge of the scoop. This rope is kept loose until the fish is inside the scoop; then it is pulled up together with the handle. For fish larger, it is necessary to use a stretcher as illustrated by figure 37. The length is 2 meters therefore all large tunas can be lifted with this apparatus. Because of its size, its weight and the weight of large fish, the stretcher can only be managed with a crane that will slow down the in-take and release of the fish. Therefore, as they are not as versatile as scoops, their use should be limited to the biggest tunas. All nets used for these lifting devices should be knotless. Mesh size must be small enough to avoid that tuna's fins get caught into the net especially pectoral fins.

SPC has designed another type of device to lift up large tunas as illustrated in figure 38. The plain material shown on this picture has since been replaced by trampoline material to decrease water resistance. This is manageable by two persons and can replace the scoop. This type has been adapted by IOTC using knotless net.

Figure 31: Sardines (Clupeidae) on a fish market in Mayotte (IOTC, Wendling and Million, 2004)

Figure 32: Setting a bigeye on a tagging mattress for measurement (IOTC, Itano, 2002)

Figure 33: Two types of Vemco sonic tags (FADIO, Dagorn, 2003)

Figure 34: Wildlife MK9 archival tag (IRD, Tagfad, Hallier et al., 2003)

Figure 35: Archival Pop-up tag of Wildlife used by CSIRO, Australia (Photo Thor Carter, 2004)

Figure 36: Scoop net for small and medium size tunas (IOTC, Wendling and Million, 2004)

3.3 Tagging cradle

For archival or sonic tags that need to be implanted into the abdominal cavity of the fish, it is better to use a V-shaped cradle made of hard material as fibreglass as illustrated in figure 39 (IATTC design). A padding covered with vinyl can be added to protect the fish.

Generally a stainless steel measuring board is attached to the cover (Figure 39) or centimetre measurements are drawn with permanent marker on the vinyl cover in order to obtain accurate lengths. The different equipments needed (cf § 3.7.) have to be easily accessible.

3.4 Tag attachment

Sonic tags when attached on the back of the fish are generally secured with two attaches: one at the top of the tag passing through the front handle of the tag and a second one compassing the body of the tag (Figure 40). The tag can also be simply tied-up with a nylon rope with a stainless steel harpoon like end (the type uses for in-water tagging of large tunas and billfishes especially in sport-fishing) or a two-barb vinyl hook. This last type of attachment is also used for Betyp tag (Figure 16) and for pop-up archival tags (Figure 35). The hook at the end can be in plastic or in titanium; sleeves are in aluminium or in stainless steel. For archival tags and also for sonic tags, implantation of the tag inside the fish is also practised. The tag can either be inserted inside muscles or into the abdominal cavity (Figure 41). Intra-muscular insertion is often responsible of a high rejection level as the tag is expelled from the flesh and lost. Consequently, insertion in the body cavity is preferred (cf. § 3.6.).

3.5 Tags

Most of these tags are under-going research efforts to improve their reliability and performance. Therefore they are in constant evolution. Manufacturers are few, some are given for information: for sonic tags (Vemco, Sonotronics, Hydroacoustic Technology Inc.), for archival tags (Wildlife Computers – WLC - and Lotek Wireless - Figure 34) and for pop-up tags (WLC and Microwaves Telemetry). These tags cost much more than ordinary tags; in fact they cost 300 to 600 times more for sonic tags, and 1000 times to 3000 times more for archival and pop-up tags. But, they also collect much more information. Dart tags in the best conditions will give the date, position and size of the fish at tagging and at recapture. While archival tags will give the same data plus several parameters that will be recorded several times per day such as pressure, body and sea water temperature and light intensity. Pop-up tags will give similar information as archival tags but their data are recovered in total independence from fisheries while dart and archival tags need to be recaptured by a fishing gear. The all history of the fish from tagging to recapture dates can be known from archival and pop-up tags.

3.5.1 Sonic tags

Sonic tags belong to two main groups: the continuous transmitting tags and the coded tags or pingers. The first type is made for tracking where a boat will follow the tagged fish (or several fish if they remain in the same school), while the second type is used to detect tagged fish when they come close to a listening station. Sonic tags have different dimensions (Figure 33) in direct relation with the frequencies they emit (Arnold et Dewar, 2001). They can be either implanted inside the fish (inserted inside the stomach or inside the abdominal cavity as for archival tags) or externally as illustrated on figure 40, where two nylon “tie-wrap” sutures

are passed through the muscle and pterygiophores after the second dorsal fin. The implantation choice is mainly directed by the data recording duration. For tracking, which generally lasts only a few days or for pingers that are used during a limited time, the tag is generally set externally as it is faster to tag. But tags set this way get detached quite rapidly. Forcing tags inside the stomach of the fish that one wants to tag or inside a prey fish that will be eaten by the targeted fish (Taquet, pers. com.) is also used for short time tagging as the tag retention is also limited (a few days to several weeks). When one wants to record data on more than a few days or weeks, the internal implantation by surgical means is preferred. As mentioned, insertion inside the abdominal cavity is preferred to muscle insertion for a better retention rate.

3.5.2 Archival tags

Archival tags were first developed and tried by CSIRO (Gunn et al., 1994). Some synthesis on the methods and results that can be achieved with these tags can be found in Gunn and Block (2001) and in Arnold and Dewar (2001). The archival tag is internally implanted in dorsal muscle or more often inside the abdominal cavity by surgical means. An antenna with light and temperature sensors comes out below the fish belly. The recorded parameters are pressure, body and water temperature, light intensity, battery level, etc… To recover all data stored inside the memory at a chosen time rate, it is necessary to get the tag back; the fish need to be fished again. To better identify fishes bearing these tags and insure a better return, an ordinary tag is also set on the fish back. In ICCAT bluefin tuna tagging programme, a two-ton coloration dart tag is implanted on the back of the fish. On the white portion of the streamer of the tag it says “electronic tag inside cavity” and on the green side it says “big $$$ reward”. There are many types of archival tags whose weights range from 5 g to 15 g. Tag weight and volume are limiting factor for their use. WLC archival tags such as MK9 have been implanted in tunas as small as 50 cm (about 2.5 kg) (Hallier et al., 2003).

3.5.3 Pop-up tags

Pop-up tags (Pop-up Archival Transmitting – PAT – tags) are archival tags that detach themselves from the fish at a chosen time and transmit their data that are received via a satellite (Figure 34) (Lutcavage et al., 2000; Arnold and Dewar, 2001). The recapture of the tagged fish is not necessary; this makes these tags completely independent of the fisheries. Of course, they need to be implanted externally. This is done by using a harpoon. This technique, which is widely used to tag large fish such as billfishes, bluefin tunas, sharks directly at sea with conventional tags, is also employed to fix pop-up tags. These tags still present several difficulties: attachment failure when the tag gets detached too early, data transmitting problems. Their quite large size and the related dragged force through water still limit their use to large fish or cetaceans. WLC and MT advise them for animals 40 kg and over. Weight of pop-up tag is around 70 g.

3.6 Tagging with implanted sonic and archival tags

The procedure to internally tag tunas with sonic and archival tags is as follows:

- Fishing master lead fish to the 1 m scoop net.
- Small fish can be lifted directly by the fishing line onto the cradle; this depends on the weight of the fish and the size of the line and hook. But it is recommended to ease the fish by holding it with hands.
- If the scoop is used, it is lifted by two persons; one holds the handle, the second pulls on the rope.

- Either the scoop with the fish is landed on the deck and the person who will perform the conventional tagging brings the fish on the tagging cradle.
- Or the scoop can be placed directly on the tagging cradle together with the fish. It will be then more difficult to read the length or the round length must be taken using a measuring tape. It should be recalled that accurate measurements are only needed if growth study is part of the sonic or archival tagging experiments. Often, this is not the case.
- Fish handling must be as limited as possible and fish mucus that covers the skin must be preserved at best.
- The conventional tagger, with bare hands or wearing cotton or rubber gloves, must hold the fish steady with ventral surface up.
- He removes the hook from the fish as gently as possible. If it is necessary the hook itself or the leader is cut; the remaining being left with the fish.
- The fish must be inspected to assess its condition and any damage.
- If fish is acceptable, a pipe with running water is installed inside the mouth of the fish; the water flow must be limited.
- Archival tagger wearing surgical gloves (they should be changed for each new fish) :
- To ease the archival tagger job, the different instruments he needs can be passed on to him by the conventional tagger.
- Scalpel is used first (blades have to be changed for each new fish).
- Makes incision posterior to pelvic fins or on the side but not through to the stomach cavity (the peritoneum membrane should not be cut). The cut must be 2.5-3 cm long depending on the size of the tag. More you cut, more stitches will be necessary.
- Breaks peritoneum with finger.
- Injects 2.5/3 ml antibiotic from a syringe but without the needle on.
- Slowly and carefully inserts archival tag.
- Inspects for signs of blood which may indicate damaged internal organs.
- Seals wound with 1 or 2 stitches quite away from the cut with needle holder and needle.
- All this should last around 1 ¼ mn ~ 1 ¾ mn
- Conventional tagger :
- Measures fish to the nearest inferior ½ cm
- Single tags fish.
- Returns it gently to waters.
- Scribe records: species, conventional/archival tag numbers, location, time, duration of operation, arrival/departure behaviour, taggers names etc…
- Total tagging time should be < 2 mn.
- Several antibiotic syringes are prepared in advance.
- Archival tags are kept in Betadine

This procedure is employed by CSIRO for bluefin tagging and was employed during the first TAGFAD cruise (Hallier et al., 2003). Several differences exist with other archival tagging operations. Kurt Schaefer and Richard Brill do not used any running water pipe to provide water to the fish. The only antibiotic used by Schaefer and Fuller (2002, 2004) is an intra-muscular injection of oxy-tetracycline that will serve as a wide-spectrum antibiotic and will set a mark on otoliths that can be used for growth studies. Instead of changing gloves for every fish, bare hands can be used but fingers are dropped in betadine before each fish. CSIRO that is tagging mainly bluefin tunas prefers to put the archival tag just posterior to the pelvic fin. By doing so, the tag is pressed between the plate of the pelvic fins and the top half

Figure 37: Stretcher for large size tunas (IOTC, Itano, 2002)

Figure 38: SPC designed lift for large tunas (SPC, Oceanic Programme, 2003)

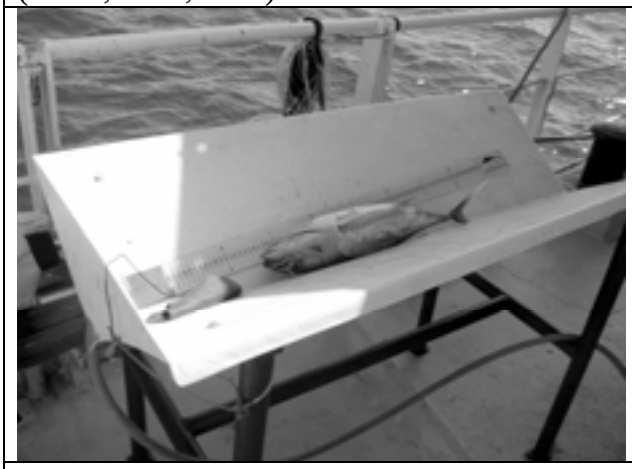

Figure 39: Tagging cradle used by FADIO & TAGFAD programmes in the Indian Ocean for sonic and archival tagging (IRD, Tagfad, Hallier et al., 2003)

Figure 40: Sonic tag attached on the back of a bigeye tuna (Photo Bertrand, IRD, ECOTAP, 1997)

Figure 41: Stitching an archival tag in the abdominal cavity of a yellowfin tuna (IRD, Tagfad, Hallier et al., 2003)

part of the stomach or even the entrance part of the stomach. Bluefin tunas are generally swimming in temperate waters and their body temperature is several °C and even up to 10°C higher than the sea temperature. Their preys are at sea temperature. Consequently, when they will swallow a large quantity of preys, the local temperature of their stomach will drop and this can be recorded by the archival tag. However, in case of tropical tunas especially small and medium yellowfin and bigeye, preys and tuna body are at the same temperature; therefore food in-take cannot be detected this way. Furthermore, for small yellowfin and bigeye, the area posterior to the pelvic fins is irrigated by important blood vessels that can be cut during surgery. Finally, when set next to the stomach Kurt Schaefer reports that there is evidence in some specimens of invagination of the tag into the stomach or the intestine from where it could eventually be voided. Therefore, it is better to implant archival tags a bit further away and slightly on the side. Kurt Schaefer recommends 10 cm (4 inches) from the anus and 2.5 cm (one inch) on the side.

Archival tags are also attached externally but it was found that consistently the retention of the tag by bigeye and yellowfin is less than for internal implantation (Holland and Braun, 2002).

3.7 Equipment needed when implanting sonic and archival tags

Equipments needed are standard among the different laboratories that have already set archival tags on tunas. However, there are several feeling about the use of disinfectants and antibiotics:

- Ordinary dart tags (it is better to choose another colour than the yellow colour which is standard for ordinary tagging or the orange or red colour reserved for OTC tagging).
- Applicators for dart tags.
- Archival tagging with the laptop and the device to connect, to program and to initialize the tags, silicon grease to seal the tag connexion.
- A tagging cradle or a mattress as for conventional tagging and a way to measure tunas.
- Sterile surgical gloves for the archival tagger in natural rubber latex; Kurt Schaefer (pers. com.) prefers Nitrile blue gloves, a material different from latex.
- Cotton or rubber gloves for the conventional tagger; but some recommend bare hands.
- Scalpel n°2 with blades that need to be changed for each new fish or cartilage knife with raspatory 55 mm that needs to be sterilized after each fish.
- Needle holder Hegar-Olson ® (BM128R), Mayo-Hegar ® 14 cm or from another manufacturer but with a cutting part; this will avoid having to change instrument once the stitch is done for cutting the thread.
- Needles: several types are available according to needle's length, shape, section's shape, length and quality of the thread; needles can also be ready set with the thread on or not. Some examples are given here:

- Needle DS35 from Silkam ®: length of the needle 35 mm with a curvature of 3/8, a triangular section and 75 cm non-absorbable suture in twined silk, to be used for small tunas (below 3 kg).
- Needle DS48 from Safil ®: length of the needle 48 mm with a curvature of 3/8, a triangular section and 70 cm absorbable suture in polyglycolic acid, to be used for medium tunas (between 3 and 10 kg).
- Needle XLH from Ethicon ®: length of the needle 70 mm with a curvature of 1/2, a circular section and a 1 m absorbable suture in polyglactin 910, to be used for large tunas (above 10 kg).

- Needle PDS II from Ethicon ®: length of the needle 36 mm (CP1) or 48 mm (CPX) depending on the size of the fish with a curvature of ½ and 70 or 90 cm code “0” size violet absorbable suture.
- Syringe to inject antibiotic in abdominal cavity: 3cc/ml or 5 ml depending on the size of the fish.
- Scissors.
- PVC or another plastic board to record data on deck or tape recorder.
- Disinfectants (Kurt Schaefer (K.S.) and Richard Brill (R.B.) are not using any antibiotic as preventive measures; K. S. uses OTC for growth study that serves too as an antibiotic):
- Antibiotic amoxicillin to inject with syringe in the abdominal cavity.
- Sulfadoxin + trimethoprime at 24 % (1 ml/15 kg) to inject with syringe and needle in fish muscles.
- Oxytetracyclin 5 from Coophavet ® to inject with syringe and needle in fish muscles that will mark the hard parts (otoliths, vertebras, spines); 4 ml for a 3-5 kg fish and 2 or 3 injections for larger tunas.
- Betadine solution (Povidone-iodine) at 10 %
- Chlorhexidine gluconate at 4 % for surgical handwash.
- A 1.5 – 2 cm section pipe with running seawater; the water pressure must remain low (K. S. and R. B. are not using any pipe but the all tagging procedure must not last more than 3 minutes).

The suture thread to be used need to have a sufficiently large diameter (code “0”) as tuna flesh is quite soft and a too thin thread might cut the flesh especially if the suture is a bit too tight. As for the other equipments, tagging operations are sufficiently complex and expensive to organize for not being short of supplies when at sea. Therefore sufficient spare parts need to be order in advance and available on board.

3.8 Tagging with pop-up satellite tag

As fish to be tagged are large, it is necessary to tag the fish in-water with a harpoon or to bring it on board with a lifting device (cf. § 3.2). Even for in-water tagging, it can be more convenient to use a scoop to prevent too much movements from the fish. When the fish is brought on board, it remains inside the scoop during the all process before it is returned at sea; this is to restrict the fish manipulation to its minimum. When fish is brought on board, the use of a running water pipe in the fish mouth is necessary if the all process lasts more than 1-2 mn. A small cut in the fish’s skin will help to insert the tag’s hook as large tuna skin is quite tough. The leader or the hook itself is to be cut prior to release.

3.9 Data to record

Data that are sought with these tags are recorded by the tag itself. Anyway, several data will need to be recorded at tagging and recapture. When the fish is tagged, the following data have to be recorded:

- Species,
- A-tag and dart tag numbers,
- Tagger’s names,
- Tagging duration,
- Types of data recorded (body and sea temperatures, pressure, light level, etc..),
- Data recording frequency,

- Length (FL or FDL or RL),
- States of the fish and of the tag implantation,
- Cruise N° and operation N°,
- Fishing gear,
- Date,
- Position as precise as possible,
- Type of school in which the fish was caught (free, FAD, whale-shark, current line, etc…),
- Any relevant comments.

When the fish is recaptured the following information are required:

- Date,
- Position,
- Inventor's name and address,
- Length, weight,
- State of the fish and the tags (electronic and dart),
- Sex and maturity stage,
- Photos and description of the

It might be of interest to collect more samples from such fish:

- the otoliths or the otolith brain part (this last sample must be preserved in deep freezer to be used for micro-chemistry of the otolith),
- Muscle sample for carbon and nitrogen isotopes analysis,
- Liver (for condition factor),
- Stomach for diet studies.

4 PUBLICITY AND REWARDS

4.1 Publicity

There is no point on tagging fish if every mean are not deployed to insure the best return for recaptured fish. To achieve this goal, publicity is indispensable and must be developed in the best way and as widely as possible. This point will not be developed here but it is nonetheless important to recall that publicity is an essential part of each tagging programme. The publicity campaign should start at the same time as the tagging programme or even a little before as most recoveries will be made in a short time after tagging. It should cover all landing ports and fisheries that are supposed to catch fish tagged and it should be revived regularly taking any opportunity to advertise the programme achievements through all media channels. These channels have to be well identified according to countries and targeted people. It should employed posters (appendix 3), newspapers, radios and TV announcements or interviews. Any peculiar news releases regarding tagging achievements should be made available to the different channels. Rewards in T-shirts, caps, etc…should be attractive as to serve as well as advertising devices. Attractive posters should be widely distributed. Photos and videos from the tagging operations should well explain the programme and its objectives.

It is essential to have dedicated staff or liaison officers in all ports and locations where tagged tunas can be found. Publicity materials must inform that these technicians and liaison

officers will accept the tags, measure the fish, record the data on their recapture and pay the rewards, etc…

Furthermore, the technicians must have summaries of the tagging cruises from which tags are likely to be returned. This will help to ascertain recovery information from the finder and eventually to challenge these data if they don't fit with the expected ones. This also makes it clear to the finder that the organization is anxious to get accurate data, rather than just any data.

4.2 Rewards

Rewards will be the determining point for good tag return rate; to achieve this goal, rewards must be:

- Attractive as to insure that the largest numbers of recovered tags are returned to the collecting points.
- Tag inventors should have the choice between rewards in cash or in items such as T-shirt, cap, flag, insulated drink holder, etc…. Because rewards can take several forms, it is not possible and advisable to print a reward amount on the tag itself or even on publicity materials. It is always possible that the level of reward will be adjusted during the course of a tagging programme.
- It is essential that rewards are paid as soon as possible. In ports where many tags are expected, a dedicated person must be appointed and it is essential that this person must be in a position to pay rewards immediately when he collects tags.
- Data collected on returned tags should answer to the questions where, when and how the fish was caught, should give the fish length or weight as precisely as possible, the name and address of the inventor, the name of the person that collects the tag and the information.
- Reward is to be paid whatever the amount of information tied up to the tag. Firstly, because it is difficult to decide if the amount of data collected with the tag is sufficient or not to merit the full reward, secondly it is necessary to avoid that reasonable-sounding information are made up to insure a full reward.
- The reward in cash needs to be modulated according to countries costs of living. When costs of living are quite similar, the amount of the reward can be the same whatever the country. But in places where costs of living are very different, it is necessary to adapt the reward in cash (Bayliff and Holland, 1986). In Senegal MAC tagging programme (Hallier et al., 2001), the ordinary reward (€ 3.1) was calculated as the price of an 8 kg tuna on the local market or 3 % of the minimum wage. In IOTC Mayotte tagging programme, tags returned receive a €15 reward which corresponds to a 6 kg tuna at market price or 2.8 % of the monthly minimum wage or a day pay. While in Seychelles, the ordinary tag receives a €10 reward; this represents 3 % of the minimum wage. In Maldives, the rewards vary from US$ 2 for a tag without full recovery information to US$ 4.4 with full information (Anderson et al., 2003). But in a particular port, the amount of reward paid should be the same for all tags of an experiment.
- Each tag of a double tagging experiment when returned, must each receive the reward; this seems to be the case in all tagging programmes.
- For tagging experiments where the fish must be returned with the tag, the tag inventor must receive a bigger reward. For OTC tagged fish, it is necessary to collect hard parts (vertebrates, spines or otoliths). For archival tags, it is better if a well trained person can extract the archival tag in the best conditions. Furthermore, data collected by archival tag are much more complete than those of an ordinary tag and the tag cost

about 1000 times the price of an ordinary tag. In these situations, the reward should be higher than the price of the fish on the market, even if the fish is returned to the inventor. In MAC programme (Hallier *et al.*, 2001), red tags were set on OTC tagged fish. If the red tag was returned without the fish, the reward paid was the same as for yellow ordinary tag. But if the tag was returned with the fish, the reward was 2 ½ times higher. In Maldives, the OTC tunas when returned received a US$ 17.40 which is four times the rewards paid for an ordinary tag with full information. In IATTC, archival tags when returned receive a US$500 reward instead of $5 for an ordinary tag. In IOTC, archival tag reward is set at €250 instead of €10 for ordinary tag. In ICCAT tagging programme with archival tags on Bluefin tunas in the Mediterranean, a US$1000 reward is paid. To achieve a better tag return for these very valuable tags, it might be good to have the high reward amount printed on the dart tag together with the information that the all fish with its tags is wanted.

- Lotteries are also often used by tagging organizations to promote the tag return. ICCAT organizes an annual lottery with two US$500 prices, one for tropical tunas, one for temperate tunas. For the Bigeye Year Programme, a special lottery with a US$1000 price is organized by ICCAT for bigeye recaptures. In Maldives (Anderson et al., 2003), two "lucky dip" (or lotteries) were held during which ten tag numbers were drawn, each receiving a cash price of US$85.
- Incentives need also to be set at the tagging level: captain and crew of chartered tagging vessel must have all or a large part of their salary in proportion to the number of fish tagged. The charter cost that is paid to the boat owner must also include a certain percentage related to the number of fish tagged. During IOTC Mayotte small-scale tagging programme, tunas to be tagged are caught by local fishermen and paid at 3.1 € per kg while they are sold on the local market at 2.5-3 € per kg. It is also envisaged to set a special bonus of €150 for the fisherman who will have caught the biggest number of tuna for tagging (Wendling and Million, 2004). In Maldives, tunas were paid about three times the market price and staff participating to tagging trips received an extra allowance (Anderson et al., 2003)

5 CONCLUSIONS

There is no doubt that large-scale tagging is an indispensable tool for tropical tuna management. However, this is a costly and complex operation that needs money, manpower, fishing vessel, baits and a well planned tagging scheme with fully dedicated staff working in close collaboration with the scientists involved. Equipment is no doubt important but staff involved from the tagging team to the captain and his crew all have their share in the success of such operation…let us hope baitfishing and tuna fishing will be at the rendez-vous.

This document tries to give as much as possible all technical procedures for sound and efficient large-scale tagging for those who will performed tagging and also those who will use its results.

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APPENDIX 1

DEVELOPMENT OF THE ABBREVIATIONS USED IN THIS DOCUMENT

BETYP: Bigeye Year Programme
CCSBT : Commission for the Conservation of Southern Bluefin Tuna
CNROP : Centre National de Recherches Océanographiques et des Pêches, Mauritania
CRODT : Centre de Recherches Océanographiques de Dakar-Thiaroye, Senegal.
CSIRO : Commonwealth Scientific and Industrial Research Organisation (Australia)
FAD : Fishing Aggregating Device. Some sort of raft that can be anchored (generally used by artisanal coastal fisheries) or let drifting (used by industrial purse seiners in all tropical oceans).
FL : Fork length
FDL : First Dorsal Length
HTTP : Hawaii Tuna Tagging Program
IATTC: Inter-American Tropical Tuna Commission
ICCAT : International Commission for the Conservation of Atlantic Tunas
IFREMER: Institut Français de Recherche pour l'exploitation de la mer
IOTC : Indian Ocean Tuna Commission
IOTTP : Indian Ocean Tuna Tagging Programme
IRD : Institut de Recherche pour le Développement
MAC : "Mattes associees aux Canneurs" research programme of IRD, CRODT and CNROP on the permanent association of tuna to Dakar-based baitboats.
MT : Microwaves telemetry
RTTP : Regional Tuna Tagging Project of SPC
SPC : Previously the South Pacific Commission, now the South Pacific Community
SSAP : Skipjack Survey and Assessment Programme of SPC
TAGFAD: Tagging tuna associated to FADs
TP : Thorax Perimeter
WLC : Wildlife Computers

APPENDIX 2

SPC FORMS USED DURING THE RTTP

1. Daily Form
2. School Sighting Form
3. Baitfish Form
4. Biological Samples Form
5. Tag Release Form
6. Daily Tag Release Form
7. Tags Used Form
8. Tag Return Form
9. Log and FAD Record Form

1 - DAILY LOG (RTTP)

Page No.:____

DD MM YY

DATE:___/___/___ **AREA:**_____**Cruise No.:**_____

Time	Latitude (° ' N/S)	Longitude (° ' E/W)	Activity	Wind (°/kts)	Sea Cond	S.S.T. (°C)	Air T (°C)	Cloud (%)
0600								
1200								
1800								

ACTIVITY:_____

RUNNING TIMES:_____-_____, _____-_____, _____-_____, Total hrs:_____

SEARCHING & FISHING TIMES:_____-_____, _____-_____, _____-_____, Total hrs:_____

BAIT: Bkts carried:_____Spp. comp.:_____
Bkts used:_____ Mortality: _____

TAG RELEASES	Daily totals			Cruise cumulative			**Daily**	
	Single	Double	Total	Single	Double	Total	**YF**	
Yellowfin							**SJ**	
Skipjack							**BE**	
Bigeye							**Oth**	
Other							**TOTAL**	

BIOLOGICALS	Length	Weight	Sex	Gonad	Otolith	Stomach	Morph	Other
Yellowfin								
Bigeye								
Skipjack								

REMARKS:

2 - SCHOOL SIGHTING / FISHING LOG (RTTP) Page

No:_____

DD MM YY

DATE: ____/____/____ **COUNTRY:** _____ **AREA:** _____ **RECORDER:** _____ **Cruise No:** _____

TIME	SCH	RT #	LAT (N/S)	LONG (E/W)	SZ	TYP	ASS	DET	CH	RS	SP	TAG	POL	OTH	TOTL	SST	COMMENTS

3 - BAITFISH LOG (RTTP) Page No.:____

DD MM YY

Date:___/___/___ **Country:**_____ **Cruise No.:**_____

Area:_____ **Recorder:**_____

Haul No.	Time	Lat.N/S	Long.E/W	Depth Bottom (m)	Lunar type	Cloud day (%)	Curent	Bucket		
								Wgt	Load	Disc
1										
2										
3										

	Haul 1			**Haul 2**			**Haul 3**		
Family/Genus Species	%	Mean	Range	%	Mean	Range	%	Mean	Range

Comments:_____

_____

_____

_____

_____

4 - BIOLOGICAL SAMPLES LOG (RTTP) Page No.:_____

DD MM YY

DATE:___/___/___ AREA:_____ SCHOOL No.:_____ CRUISE No.:_____ RECORDER:_____

Sch No.	Sam No.	SP	FL (cm)	WT (gm)	Sex (MFI)	Gnd St (1-7)	Gnd Wt (gm)	Oto (Y/N)	Stomach Contents		Other
									Vol	Items	

5 - TAG RELEASE LOG (RTTP) Page No.:__

MM DD YY

DATE:___/___/___ **AREA:**_____**Cruise No.:**__

Tag Series: _____ **Comments:** _____

Tag #	SP	FL	Gr	Tag #	SP	FL	Gr	Tag #	SP	FL	Gr	Tag #	SP	FL	Gr
01				26				51				76			
02				27				52				77			
03				28				53				78			
04				29				54				79			
05				30				55				80			
06				31				56				81			
07				32				57				82			
08				33				58				83			
09				34				59				84			
10				35				60				85			
11				36				61				86			
12				37				62				87			
13				38				63				88			
14				39				64				89			
15				40				65				90			
16				41				66				91			
17				42				67				92			
18				43				68				93			
19				44				69				94			
20				45				70				95			
21				46				71				96			
22				47				72				97			
23				48				73				98			
24				49				74				99			

6 - DAILY TAG RELEASES (RTTP)

Page No.:_____

DD MM YY
Date:____/____/____ Cruise:________ Country:______________
Area:____

School No.:________

Cradle	YFN single	SKJ single	BIG single	UNKN single	**Total singles**	YFN double	SKJ double	BIG double	UNK double	**Total doubles**	**Cradle totals**
Port Bow											
Star Bow											
Port Stern											
Star Stern											
Total											

School No.:________

Cradle	YFN single	SKJ single	BIG single	UNKN single	**Total singles**	YFN double	SKJ double	BIG double	UNK double	**Total doubles**	**Cradle totals**
Port Bow											
Star Bow											
Port Stern											
Star Stern											
Total											

School No.:________

Cradle	YFN single	SKJ single	BIG single	UNKN single	**Total singles**	YFN double	SKJ double	BIG double	UNK double	**Total doubles**	**Cradle totals**
Port Bow											
Star Bow											
Port Stern											
Star Stern											
Total											

School No.:________

Cradle	YFN single	SKJ single	BIG single	UNKN single	**Total singles**	YFN double	SKJ double	BIG double	UNK double	**Total doubles**	**Cradle totals**
Port Bow											
Star Bow											
Port Stern											
Star Stern											
Total											

TOTAL TAGGED

	YFN single	SKJ single	BIG single	UNKN single	**Total Singles**	YFN double	SKJ double	BIG double	UNKN double	**Total Doubles**	**Cradle Totals**
Total											

7 - TAGS USED (RTTP)

Page No.:____

Cradle	Port Bow	Port Stern	Starboard Bow	Starboard Stern
Block series	Date Start - Finish	Date Start - Finish	Date Start - Finish	Date Start - Finish
001 - 100				
101 - 200				
201 - 300				
301 - 400				
401 - 500				
501 - 600				
601 - 700				
701 - 800				
801 - 900				
901 - 000				
001 - 100				
101 - 200				
201 - 300				
301 - 400				
401 - 500				
501 - 600				
601 - 700				
701 - 800				
801 - 900				
901 - 000				
001 - 100				
101 - 200				
201 - 300				
301 - 400				
401 - 500				
501 - 600				
601 - 700				
701 - 800				
801 - 900				
901 - 000				

8 - TAG RETURNS

Page No.:_____

Use one sheet for each tagged tuna or tag you find or are given. Please try to fill in as much of this sheet as possible

Tag information

Species: Skipjack / Yellowfin / Other:_____

Tag Number: _____ Fork length: _____ cm / inches

Measuring tool: Measuring board / Ruler / Tape measure / String / By eye / Other _____

How measured: Fish laid on flat surface / Along curve of body

Weight: _____ kg / lb

Weighing tool: Beam balance / Spring balance / Estimated by eye / Other _____

Finders name; and address: _____

_____

Reward: Not Given / Cash / Shirt / Cap Handled by:_____

Recovery information

If recovered while fishing:

Date of catch: DD MM YY ____/____/____ Vessel name: _____

Position of catch: Latitude: _____ Degrees _____ Minutes N / S
Longitude: _____ Degrees _____ Minutes E / W

Or describe: Fishing area:_____

How position obtained: SATNAV / Radar / Estimated by Captain / Estimated by Finder/ Other:_____

Fishing method: Pole & line / Purse-seine / Longline / Troll / Handline / Other:_____

School type: FAD / Log / Free school / Other:_____ If FAD, what number:_____

If found after capture (sorting, transshipping, unloading, processing):

Date found: DD MM YY ____/____/____ Port/Vessel/Location:_____

Process when found: Transfer catch / Unloading ship / Weighing / Thawing / Butchering room
Other:_____

If possible, obtain as much infomation on the actual date, position and method of catch as possible.

Additional comments:

_____

_____

ATTACH TAG HERE WITH STAPLER. MAKE SURE IT IS FIRMLY ATTACHED

9 - LOG & FAD RECORD (RTTP) Page No.:_____

Date:___/___/___ Cruise No.:_____ Time found:_____ Recorder:_____

Position:____°____'N/S, ____°____'E/W Area:_____

SST:____°C Wind:___°T ___kt Sea:C/S/M/R Current:___°T ___kt Cloud:___%

DESCRIPTION SPC FAD Tag No.:_____ Radio buoy call sign:_____

Previous records (Page No.):____,____,____,____,____,____,____,____,____,____

Last recorded position:____°____'N/S, ____°____'E/W Drift:____°T ____kt

Type:_____ Shape:_____ Material:_____ Colour:_____

Orientation:_____ Length:_____m Width:_____m Depth:_____m

Describe:_____
(Also draw top and side views of FAD on reverse side of page, including dimensions, area covered with attached fauna, and area underwater.)

% underwater:____ Time in water:Short/Med./Long Poss. source:_____

Other FADs in area:Y/N Type:_____ Distance from last FAD:_____nm

Signs of previous fishing on FAD: net, radio buoys, corks, known sets by boats _____

CATCH & TAGGING Tag Release Log pages _____ to _____ School No.:____

Fishing method:_____ Time start/end:_____/_____

	No. caught	No. tagged	Est. tonnes	FL range (cm)
Yellowfin				
Skipjack				
Bigeye				

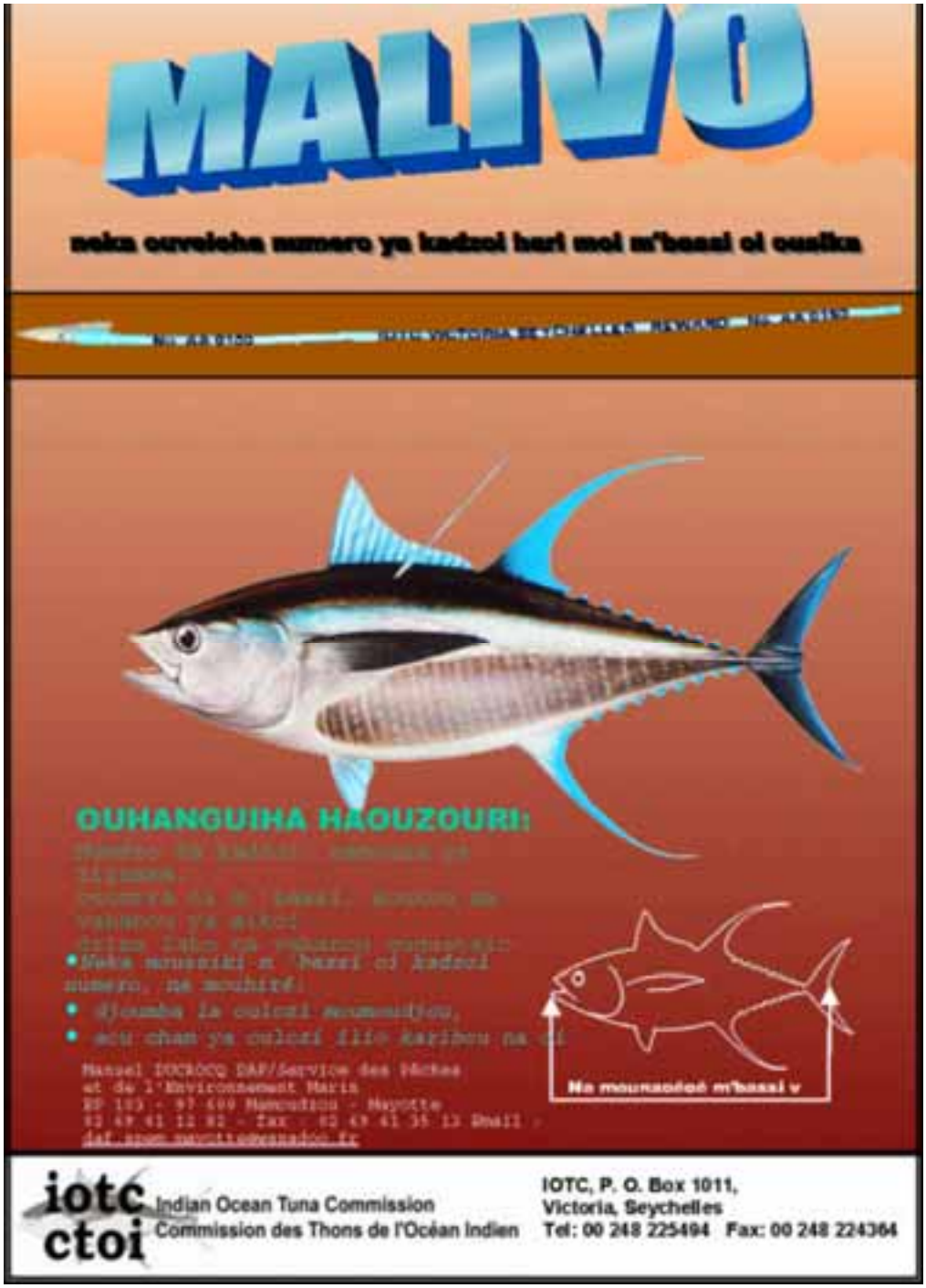
ASSOCIATED FAUNA & FLORA

(a) Under FAD		**(b) Attached to FAD**		**(c) Birds**	
Species	Est. No.	Species	Est. No.	Species	Est. No.

% FAD covered _____

APPENDIX 3

EXAMPLE OF POSTER FOR ADVERTISSEMENT OF THE IOTTP



List of figures titles