4.6 Tagging

Tunas and billfishes are currently being tagged by many different organisations in all parts of the world where they occur, and fishermen and fish handlers of many nations have the opportunity of encountering tagged fish. ICCAT has developed an international cooperative tagging program in the Atlantic Ocean and its adjacent seas. A number of member countries are now participating in the program and releasing many tunas, billfishes and tuna-like fishes tagged with either “conventional” tags, or electronic tags of various types (acoustic transmitters, archival tags, pop-up archival tags (section 4.7)). Tunas and billfishes are tagged to obtain information about their movements, migrations, stock structure, growth, population size, mortality, schooling behaviour, and physiology and to investigate the effects of various patterns of fishing on the fish and the fisheries.

Tagging these large, active fish is not easy, and workers who have had relatively little experience with this type of work can profit from the experiences of those who have.

To make this program successful, it is essential to secure the cooperation of both fishermen and industry in recovering these tags. There may be substantial rewards associated with the recovery of a tagged fish, especially if the tag is an electronic one. These rewards are paid by the research agency involved in the tagging campaign. In addition, to promote recovery of tags, ICCAT holds annual lotteries (see 4.6.4 below). Many of the tags that have been returned have been accompanied by incomplete data, or no data at all, so obviously there is a need for better systems for collection of the required information for the tagged fish that are recaptured.

This section of the Field Manual is a summary of the methods used to tag tunas and billfishes and to secure the return of the tags from those that are recaptured, along with the required information.

4.6.1 Tagging experiments in tuna stock assessment and management in the ICCAT area

Tuna are highly prized by both commercial and recreational fishers. But, their size power and swimming speed have made it a challenge to study their behaviour and biology, especially in the wild. Their thermoregulatory physiology and size enable them to migrate between polar seas and warm temperate or tropical waters over periods of week or months. However, comparatively little is known about the lifetime patterns of movement of tuna, where they breed, or how their populations are structured. This lack of knowledge has accompanied the recent demise of some tuna stocks (e.g. Atlantic bluefin). The US National Research Council (NRC, 1994) committee report on the status of Atlantic bluefin tuna noted that current research on the biology of this species was insufficient to address major biological questions relevant to the management of the fishery. A specific recommendation of the report was to use new tools, such as electronic tags, as a means for resolving stock structure.

ICCAT presently manages northwest Atlantic and northeast Atlantic-Mediterranean Sea bluefin tuna resources as two separate management units. One stock is recognised in the eastern Atlantic with a breeding area within the Mediterranean Sea and a second stock is presumed to exist in the western Atlantic with a breeding ground in the Gulf of Mexico (Metcalfe *et al*., 2002). The NRC review recommended that the two-stock hypothesis be re-examined (NRC, 1994). The greatest uncertainty identified in the report was the extent of bluefin movement within and between the eastern and western Atlantic, spawning site fidelity and the results such lifetime trans-oceanic movements have on the choice of management strategy.

To understand the life history of bluefin and other tuna species and to develop effective management strategies, the temporal and spatial patterns of movement in the oceans needs to be identified and quantified. Resolution of the stock structure questions for Atlantic bluefin tuna is critical to the management of the species. Data on dispersal patterns of pelagic fishes with large geographical ranges are difficult to obtain because of the limited resolution the analytical tools available for studying such animals in the wild.

Results from conventional tagging studies demonstrate that all size classes of bluefin have the propensity to make trans-Atlantic crossings (NRC, 1994). Currently, technologies are needed that can augment conventional tagging data sets to improve the definition of the geographical boundaries of the stocks. A fundamental tuna management problem in relation to spawning site fidelity is to determine, for those individuals that move across the Atlantic, whether tuna breed only in one area (e.g. the Gulf of Mexico or the Mediterranean) or in both places. Recent research using electronic tags to study the movements and population structure of Atlantic bluefin tuna supports the two-stock hypothesis and provides evidence for distinct spawning areas that overlap on North Atlantic foraging grounds. Results also reveal hot spots for spawning bluefin tuna in the northern slope waters of the Gulf of Mexico (Block *et al*., 2005).

4.6.2 Tagging Programs

Many research organisations carry out tagging programs aimed at collecting data on different tuna and tuna-like species in different regions of the Atlantic. A list of recent or on-going tagging programs can be found at: www.iccat.int/tagging.htm

ICCAT maintains inventories of the tags that are released. Scientists who carry out tagging campaigns should report the relevant information (tag type, number, area, gear, date, species, size, etc.) to ICCAT so that the inventory can be maintained up to date.

4.6.3 Opportunistic or directed tagging experiments?

Which particular approach is taken to catch and tag tuna is dependent on the aim of the tagging programme.

If the aim is to engage fishers in tagging activities as a means of increasing awareness and responsibility for fish conservation (e.g. by encouraging sport fishers to release the fish alive rather than kill them), then opportunistic tagging has a role, but chances of getting useful scientific data are often diminished. This applies not only to where and how many fish are tagged in a population (since no targets are set against scientific objectives) but it may also result in poor tag recovery rates, either because fish are not handled as carefully as is required to ensure long-term post-tagging survival or, more likely, because there has been insufficient attention paid to a good tag recovery programme, lacking sufficient or suitable publicity about releases and/or with no structured system for returning recapture details to taggers and paying rewards. Key to the success of any tagging programme is good recovery of tagged fish and accurate recapture data.

This consideration indicates that tagging programmes should be carefully planned with clearly defined objectives (e.g. population abundance estimation; estimation of mortality rates; identification of stocks/migration routes; evaluation of who is exploiting a particular stock; etc.).

In planning a tagging programme it is important to have an idea about the size the "stock", the extent of its geographical distribution, and what tag recovery rates are likely to be. These factors are important in estimating how many fish need to be tagged, where and when, in order to achieve a statistically robust result. It is also important to understand who is likely to catch the fish; can they be used for tagging, or is experimental fishing necessary to get sufficient fish tagged in the appropriate location(s)?

4.6.4 Tag recovery, publicity and rewards

Tagging experiments are usually costly exercises requiring vessel time, experienced staff and, if using electronic tags, involving the deployment of expensive devices. It is therefore paramount that an appropriate amount of resource is deployed to encourage fishers to return tags together with accurate tag recapture details and, when appropriate, the fish carcass. These considerations are likely to be particularly important in the case of tuna where the commercial value of the fish is high. It is often the case, particularly in opportunistic tagging, that tagging programmes fail to achieve the potential because insufficient resources are allocated to publicity and rewards to ensure maximum tag recovery.

Publicity and rewards

The number of tags recovered will improve considerably with good publicity and reward systems in association with a good catch/stock scanning programme (see below). Tag recovery programmes should therefore include:

- an investigation of the likely geographic area where tags will be recovered
- advertising the tagging programme in the appropriate geographical area and in the local language(s)
- adequate tag scanning programmes and sufficient sample sizes
- clear instructions to fishermen
- an incentive to declare tags and information.

Investigation of the likely geographic area of recovery

Tagging programmes should take into account the probability of recapture of the tagged fish. In marine fisheries, the area of encounter is potentially vast but can be reduced significantly with backup information from catch data or earlier tagging studies. For electronic tagging programmes, pre-tagging surveys with conventional tags should be carried out to provide a rough estimate of where the electronic tags will be recovered and what the target fisheries are likely to be. Subsequently, standard fishing techniques can be applied to recover tags or catches can be scanned in a similar manner to conventional tags.

Advertising the tagging programme

Initially, the objectives, tag type, secondary tag type (if used) and the rewards (if any) should be clearly advertised. Prospective individuals who are likely to recover tags or be aware of recovered tags (fishermen, fish processors, sport anglers etc.) should be informed that tags of different types may be present in the fish they handle. It is important to emphasise the scientific value of the tagging programme, and the value of the data recovered from electronic tags (if used) as well as the overall benefits of the data for protecting and possibly enhancing stock assessment and management.

Publicity can include:

Advertisements in international, national and local newspapers – if the tagging programme is locally based, it is probably best to advertise only in local papers to emphasise the probable recovery location of the tagged fish.

Posters – these should show the features that will identify a tagged fish (presence of an external tag, fin-clip, mark etc) and a clearly identified contact for return of the fish or the tag. Posters have been used extensively in conventional and electronic studies and placed prominently in fish processing facilities and at fishing ports. The language in which the poster is printed should be customized for anticipated regions of tag recovery.

Public presentations – Experience has shown that direct interactions between scientists and commercial fishermen or the public improve the rate of recovery of tags and provide a more lasting impression of the objectives of the programme. Public presentations should be directed at fishermen and fishing organisations, processors, local representative groups and all users of the resource being studied. Direct contact with fishermen or other local contacts through local interviews allows any queries to be dealt with expediently and creates a valuable dialogue between scientists and the public.

Subsequent reinforcement - reinforcing both the original message and the initial contacts has been shown to be effective in obtaining tags which might otherwise not be recovered, especially if tags may be recovered in more than one fishing season.

Tag scanning programmes and sample size

Even if the general area of encounter has been identified, there is still the problem of tag retrieval. For marine fisheries, where shoal sizes may be large relative to the number of tagged fish, large numbers of fish may need to be captured to ensure recovery of a single tag. In general then, marine tagging programmes are usually associated with commercial fisheries where large numbers of fish are available for examination. Ideally, the entire catch should be examined for tags. If this is not feasible then a sufficient proportion of the catch should be examined. Numbers will depend on the estimated size of shoals, their temporal and geographic distribution and the number of tagged fish released initially. Significant improvements could be made if entire catches were routinely scanned for tags on board fishing vessels or in processing plants. This might be performed by scientific personnel at port, by scientific observers on board vessels, or by key appropriately trained fishermen.

Clear instructions to fishermen and processors

Instructions on removing the tags and the procedures to be followed for recording relevant information, or retaining the fish, should be issued well in advance of the tagging period, and then reinforced while the fishery is taking place. For some research programmes, it may be important to recover the carcass of the fish to investigate growth and condition, or determine whether spawning has taken place. During intensive commercial fishing operations and in busy fish processing plants, retrieval of tags should not interfere substantially with routine processing, or interfere with commercial operations. If tag removal is simple, then more co-operation can be enlisted from fishermen or fish processors who are most likely to come into contact with tagged fish. This can be done on a contract basis or by organising a fee for tags recovered. In some instances, the time available to fishermen or processors to retrieve tags may be short, and it may be better to rely on trained technical personnel to scan landings and remove tagged fish.

Incentive to declare tags

Tagging data is valuable, particularly if it involves the used of electronic tags since the data recorded by even a single archival tag can be significant. There should therefore be a good incentive to return tags, particularly if tag recovery is dependent on commercial fishermen or processors. The following incentives have been used extensively in conventional tag recovery programme with varying degrees of success.

(a) Monetary rewards
This is a time honoured standard, although it is often difficult to decide on an adequate monetary reward. If the intention is to retrieve transmitting tags for re-use, the reward should be less than the cost of a replacement tag. For data storage tags the value must be decided in relation to the cost of the tagging programme, the value of the data and the effort needed to obtain tag recoveries, although this may be difficult to estimate in terms of direct cost benefit. ICCAT offers a reward of $1000 (U.S.) for the return of each implantable archival tag and $500 (U.S.) for each external popup satellite archival tag from its Atlantic bluefin and billfish tagging programmes (Prince & Cort, 1997).

(b) Gifts
Gifts are often preferred as they are easier to administer and are often more acceptable, particularly if they have a high 'popularity' value. In many parts of the world institutes are moving towards offering T-shirts, sweatshirts, badges and peaked caps, all of which have a collectable appeal.

(c) Information
Often, the incentive to return tags can be increased if there is a corresponding return of information back to the individual recovering the tag, particularly if he/she is working within the fishing industry. Generally, the information would be in the form of an information leaflet outlining the objectives of the tagging study, information on the tagged fish that was recovered and information on the overall results of the programme.

(d) Recognition
Publication of a list of individuals who have recovered tags in an institute or fishing newsletter is often useful to advertise the tag programme and encourage tag recovery.

(e) Competitions and lotteries
As a general incentive, a lottery scheme can be a useful method to improve return rates for tagged fish. ICCAT holds annual lotteries. Three draws are held, one each for billfish, temperate tunas and tropical tunas, with a US$500 prize for each winner. The ICCAT tagging lottery takes place annually during the SCRS meeting.

4.6.5 Methods of fish capture

There are many methods for catching live tuna that can be appropriate for tag and release programmes with either conventional or electronic tags, these include line fishing, netting and trapping. Fish may be tagged within a few seconds or minutes of capture and in the same sequence that they are caught (baitboat, trolling, or sport-fishing gear), or there may be a longer period of time between capture and tagging with the fish not being tagged in the same sequence in which they were caught (purse seines, traps, gill nets, or longlines). Much more success is realised from experiments in which the fish are tagged a few seconds to a few minutes after they were caught. The return rates for tagged purse seine-caught tunas are lower than those for tagged baitboat-caught tunas, and the return rates decrease as the times of confinement in the net prior to tagging and release increase (Bayliff, 1973). In some cases at least, large portions of the fish tagged and released from traps are recaptured by the same traps within a few days.

Special methods have been developed for capturing and tagging large pelagic species such as sharks, tunas, marlins and sailfish, which are difficult to handle and sedate on board a boat because of their size and strength. Pole and line fishing from vessels using lures with special barbless hooks is the main method of capture. The fish are handled rapidly without anaesthesia and care is taken not to cause skin damage by using soft plastic covered tagging or measuring cradles (Williams, 1992).

4.6.6 Fish handling

Once caught, fish must be handled gently. They should be tagged and returned to the water or released as quickly as possible, provided they appear capable of maintaining forward movement through the water. Alternatively, if fish appear to be exhausted or show signs of stress (i.e. coloration or obvious injuries) that would inhibit them from swimming away after release, every effort should be made to resuscitate (see Prince *et al*. 2002 for resuscitation methods for tuna and billfish). Fish should not be dropped on the deck or allowed to strike the side of the boat or the bulkhead. When picked up they should be held horizontally and the gills should not be touched with the fingers. Only fish in good condition should be tagged and released. This is not only important from a fish welfare point of view, but also because electronic tags (if used) are expensive so long-term survival of the fish is critically important.

In field experiments, the ideal conditions for handling fish cannot always be met. Setting up facilities for anaesthesia and recovery may be difficult because of spatial restrictions or poor weather at sea. The experimenter must then evaluate the relative difficulties of applying anaesthesia against possible trauma and damage caused by handling unanesthetized fish, although legal considerations may be paramount. When tags can be attached rapidly and non-intrusively, anaesthesia has often been replaced by simpler methods of keeping the fish quiet during tagging such as blindfolding. Anaesthesia has in general not been applied when tagging tuna or billfish. The capture process is likely to be much more stressful and time consuming than attaching the tag, even when electronic tags are being used, which generally only requires a minor surgery. Instead, covering the eyes usually quietens the fish. Special devices to ease the process and minimise handling time have been developed. (See below and Block *et al*. (1991a, 1991b, 1998a), Carey & Robison (1981), Holland *et al*. (1990a; 1990b) and Williams 1992; Prince *et al*., 2002).

Block *et al*. (1998a) developed a successful method of capturing and handling Atlantic bluefin tuna (*Thunnus thynnus*) for use in archival tagging and acoustic tracking studies. The fish are caught by heavy tackle using circle hooks and bait presented in a chum stick ("chunk fishing"), a technique that allows chasing down the fish in order to minimize fight times. The fish are taken on-board the tagging vessel by lip hooking the tuna through the tip of the lower jaw with a small gaff through and pulling the fish through a "tuna door" in the stern onto the deck on a wet mat. The eyes of the fish are immediately covered with a soft wet cloth and the gills are then aerated with a saltwater wash-down hose while the tag is implanted inside the body cavity. The method is suitable also for handling large individuals (up to 250 kg) with low risk of damaging the fish. A similar approach has been used with southern bluefin tuna (Gunn *et al*. 1994)

Various methods for handling tuna and tuna-like fishes have been described in the FAO Fisheries Technical Paper "Materials and methods for tagging tuna and billfishes, recovering the tags and handling the recapture data" (Bayliff and Holland, 1986) and these are described below. In addition, more recent guidance on tagging methods for stock assessment and research in fisheries has been published as a report of a Concerted Action FAIR project (CATAG) (Thorsteinsson, 2002).

In-the-water method

This method is employed by commercial and recreational fishers, as well as scientists, using conventional or popup satellite archival tags for fish that are generally too large or dangerous to be brought aboard the vessel (Prince *et al*., 2002; Ortiz *et al*. 2003; Prince and Goodyear, 2006). The fish are brought along side the boat and tagging is accomplished while the vessel moves slowly ahead. but only after the fish is "played down" to a point where it is subdued and easier to handle. This approach has, in the past, sometimes been considered less advantageous than other methods since there is often a general lack of control of the fish in the water and some fish are in poor condition due to having struggled for some time during capture. Also, it is not always possible to measure fish accurately when handled in this manner. However, new fish handling devices and techniques have been developed to control the fish at boat-side and position the fish in the water to insure accurate and safe tag placement (Prince and Goodyear, 2006; **Figure 4.6.1**). In addition, innovative methods have also been developed for resuscitation of both tuna and billfish using this method and these procedures greatly increase the survival of tag released fish (Prince *et al*. 2002). Moreover, efforts to resuscitate tagged fish are increasingly being considered as critical to the post release survival (Prince and Goodyear 2006). In other words, in-water tagging methods have evolved over time from a relatively primitive approach, to one with increasingly more sophistication. Historically, this approach has proved valuable, especially for tagging rare event species, such as istiophorid billfish, where commercial methods of capture are often impractical. In other cases, the in-water method is useful when no alternative method has been found to handle very large fish safely and returns from fish tagged in this manner have added considerably to our understanding of the biology of large tunas and billfishes (Ortiz *et al*. 2003). A large portion of the ICCAT tagging data base for large pelagic species consists of data using this method, particularly from constituent-based tagging programs.

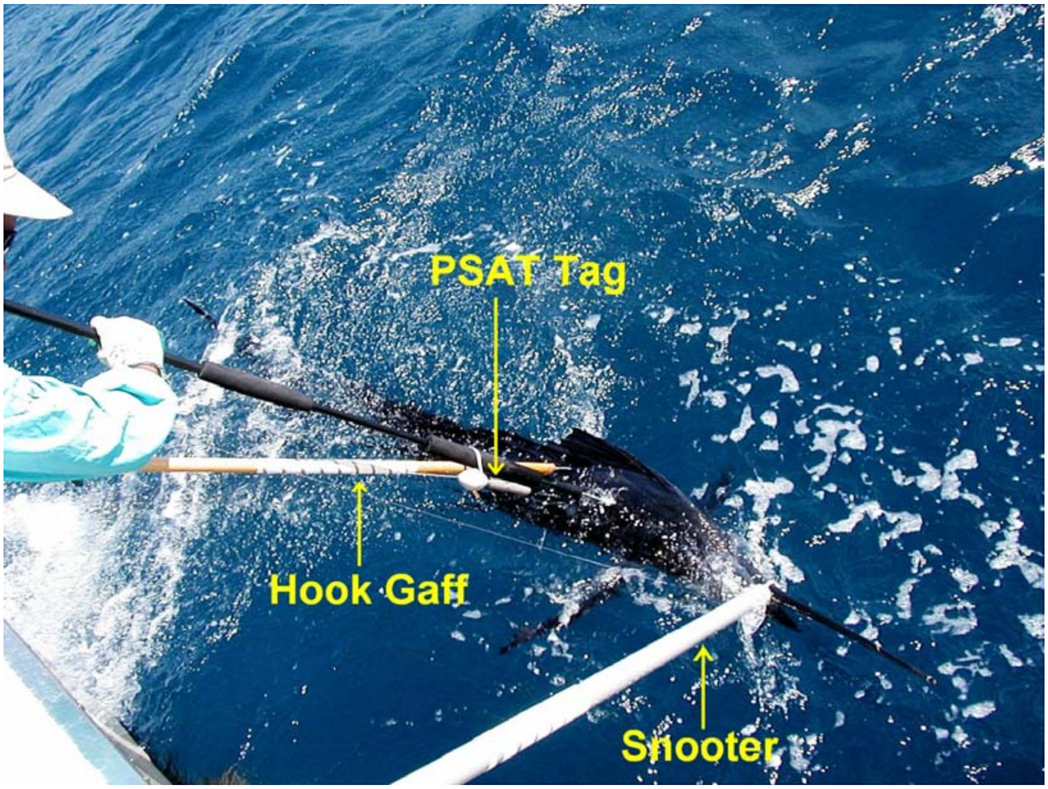

Figure 4.6.1. A snooter (pvc pipe and wire snare) and small hook gaff (wooden pole) are being used in tandem to control this Atlantic sailfish to insure safe and precise placement of a PSAT tag. Reprinted from Fisheries Oceanography with permission.

Winging

This method has been used from time to time with skipjack (*Katsuwonus pelamis*, Yamashita & Waldron, 1958) and albacore (*Thunnus alalunga* (Laurs, *et al*., 1976). In the fishing operation, the fish are hooked, swung up, caught under the left arm and unhooked. The tagger stands about 50 cm behind the fisher (usually there is one tagger for two fishers). While the hook is being removed the tagging needle is inserted, usually from the right side.

In general, this method is inferior to the cradle method (see below) because a significant amount of skill is required and it is difficult to measure and weigh the fish accurately. In addition, it probably results in more damage to the fish than does the cradle method. However, under appropriate conditions and when only a few fish have to be tagged, this method may be suitable.

Deck method

This method has been used mostly with large tunas. Its use was first reported by Fink & Bayliff (1970), for large yellowfin, *Thunnus albacares*, on a baitboat. Improvements for this method are described by IATTC/CIAT, 1981:26.

In this method, the entire stern deck of the vessel and the sides of the bait tanks adjacent to the deck are heavily padded with energy-absorbing (closed cell) plastic foam covered with Herculite, a smooth plastic material. This makes it possible to slide the fish into position with relative ease and without removing excessive amounts of mucus from them. Fishing takes place only at the port stern corner of the boat, and fish are tagged at the starboard stern corner and on the port side about 4 meters forward of the stern. The horizontal padding is raised slightly with extra padding at the port stern corner so approximately equal portions of the fish slide toward the two tagging stations. The fish are slid onto flat cradles with nose blocks so that they can be measured accurately. After being tagged and measured, the ones at the starboard stern corner are slid overboard through a small door cut in the starboard bulwark of the boat, and those on the port side are slid up a slight incline over the rail.

The deck method has also been employed for purse-seine caught fish and for baitboat-caught fish that are too large to be lifted into and out of cradles such as those described below. While it is the best method for tagging purse-seine caught tunas, confinement in the net is harmful to the fish, and the return rates are usually low.

Cradle method

More tunas have been tagged by the cradle method than by any other method. There are two basic types of cradles, those that hold only one fish and those that hold more than one fish. These will henceforth be called small and large cradles, respectively.

The small cradle (Wilson, 1953; Fink, 1965) is essentially a V-shaped trough, usually made of aluminium, closed at one or both ends (**Figure 4.6.2**). It is covered with padding, which is usually covered with smooth plastic fabric. The fish is placed in the cradle, the hook is removed, and the fish is tagged and released. The tags are usually stored further from the cradle to prevent them from being hit by the struggling fish. The sides of the cradle hold the fish in position, and also seem to reduce its struggles somewhat. It is important that the padding be covered with smooth fabric, as Bayliff (1973) showed that the return rates were higher for fish tagged in covered cradles than for those tagged in uncovered cradles. In some cases small cradles are fastened securely to some part of the boat, usually one of the rails, and in other cases they are not fastened down, and moved out of the way when they are not in use.

Large cradles (Kearney *et al*., 1972; Kearney and Gillett, 1982) are better than the small ones because it is easier to transfer the fish from the hook to the cradle without dropping them on the deck. Fish can also be stored momentarily at the large end of the cradle when, for brief periods, fish are being caught more quickly than the tagger can tag them. However, large cradles require more deck space and they cannot be moved out of the way as easily as small cradles when fish are not being caught. In general, small cradles are useful when there is limited working space and the numbers of fish to be tagged are relatively small, but for large-scale experiments large cradles are preferable.

Figure 4.6.2 The small cradle method in use on the stern of a live-bait pole-and-line vessel during IATTC bigeye tuna tagging charters (courtesy of Kurt Schaefer)

Chute method

Scientists of the U. S. National Marine Fisheries Service, La Jolla, California, U. S. A., have modified small cradles for tagging albacore as follows.

A chute about 90 cm long is attached to the nose end of the cradle at its base with a hinge, and the nose block of the cradle is attached to the rest of the cradle with a single pivot so it can be lifted up to permit the fish to slide from the cradle to the chute. After a fish is tagged, instead of lifting it up and dropping it overboard, the nose block is lifted and the fish slides overboard through the chute, which is angled downward. This increases the speed of the tagging operation, decreases the amount of handling to which the fish are subjected, and eliminates the dropping of tagged fish on the deck, which sometimes occurred when the cradles without chutes were used. Most importantly, the fish enter the water head first and pointed toward the bow of the boat. Before the modified cradle came into use, when the fish were dropped overboard they entered the water at the stern of the boat in the middle of the school, and tended to scare the fish away, especially if they failed to enter head first (Bayliff, 1979).

A more elaborate chute system was constructed by the IATTC. With this system the fishers catching the fish deposit them into troughs constructed from a strong smooth fabric (e.g. Shelterite) on pipe frames. The troughs slope towards the cradles so that the fish slid in that direction. Assistants at the cradles unhook the fish if necessary and push them head first and one at a time into the cradles. The fish are tagged by the taggers and then put overboard (**Figure 4.6.3**). The principal advantages of this method are:

1. The fishers have a large target in which to deposit the fish;
2. the tagging process can be better controlled;
3. tagging location is well removed from the fishing position which means fish can be released away from where the fish are being caught;

The pads, cradles and chutes are marked at 1 cm intervals so that the fish can easily be measured while they are being tagged. Because these marks fade or ware quickly, they need to be renewed frequently at sea.

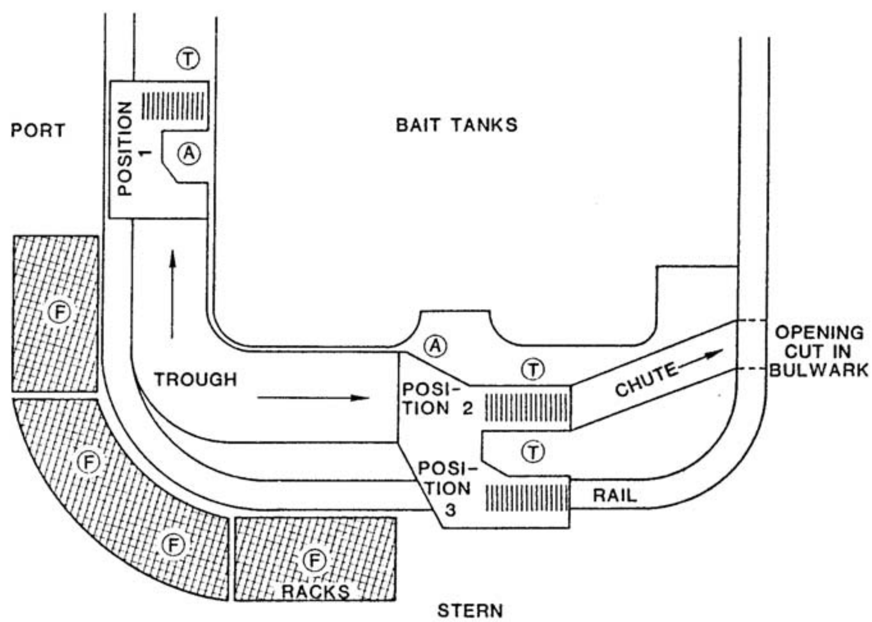

Figure 4.6.3 The chute system used by IATTC. The circles marked F, A and T indicate the position of fishers, assistants and taggers respectively (From Bayliff and Holland, 1986).

4.6.7 Conventional tags

Conventional tags are simple, uniquely numbered, tags. They usually consist of a plastic tube attached to a plastic surgical grade nylon, or metal dart anchor. (**Figure 4.6.4 and Figure 4.6.5**) The tags usually carry the address to which the tag (and fish) should be returned. They may also indicate a reward and what additional fish recapture information is required. Most nylon tag heads are manufactured or supplied either by **Floy Tag Manufacturing Inc.** (www.floytag.com, or: 4616 Union Bay Place NE, Seattle, WA 98105, USA. Phone: 206-524-2700 Fax: 206-524-8260 Email: floytag@halcyon.com) or Hallprint (www.hallprint.com or by **Hallprint Pty Ltd**., 15 Crozier Rd. Victor Harbor, South Australia 5211. Phone (International) +61 8 8552 3149, Facsimile (International) + 61 8552 2874; Email: davidhall@hallprint.com.au.

Tags, applicators and holders

During the 1950s and early 1960s tuna and billfishes were tagged with loop tags, but these have now been replaced by dart tags. The most common type has a nylon or head with a single barb. Tags are usually about 15 cm long and 2.5 mm in diameter but shorter tags (7-8 cm) have been used on small skipjack tuna. Larger dart tags with nylon or stainless steel heads are used to tag billfishes and larger tuna on sport-fishing vessels. Most of the tags are made from low-temperature vinyl tubing that is attached to the nylon head. This tubing tends to become brittle at temperatures close to freezing (below about 4°C). Since some fishing vessels freeze their catch, these tags are likely to break off and be lost. To overcome this problem, tags made of polyethylene tubing bonded to nylon heads have been introduced (Anon., 1986). Polyethylene is resistant to breakage at low temperatures and less springy than vinyl. The latter characteristic may be an advantage, as the tag may retain the configuration that causes the least resistance to the water when the fish is swimming in a straight line at its normal speed.

Most tags are yellow, but other colours have been used from time to time. Data presented by Broadhead (1959) and Blunt and Messersmith (1960) indicate that yellow tags are easier to see than red, blue, white, or clear ones. Fish that were injected with tetracycline (see below) have been tagged with yellow tags with the tips painted red or with red or international orange tags to let the persons who recover them know that the fish were of special interest. Tags should have the name of the organization to which they should be returned and the codes on them. The codes should be printed on both ends of the tags so that the information is less likely to be lost if the tag is broken or mutilated when it is returned. Tags are most often coded with five digits (100,000 possible combinations), a letter and four digits (260,000 possible combinations for the English alphabet), or two letters and four digits (6,760,000 possible combinations for the English alphabet). They usually arrive from the manufacturer sorted into groups of 100, and they are almost always allocated to the various taggers at sea in those same groups. It is less confusing and more convenient for computerized analyses if these groups contain, for example, A0000-A0099, A0100-A0199. etc., rather than A0001-A0100, A0101-A0200. etc. (Kearney and Gillett, 1982).

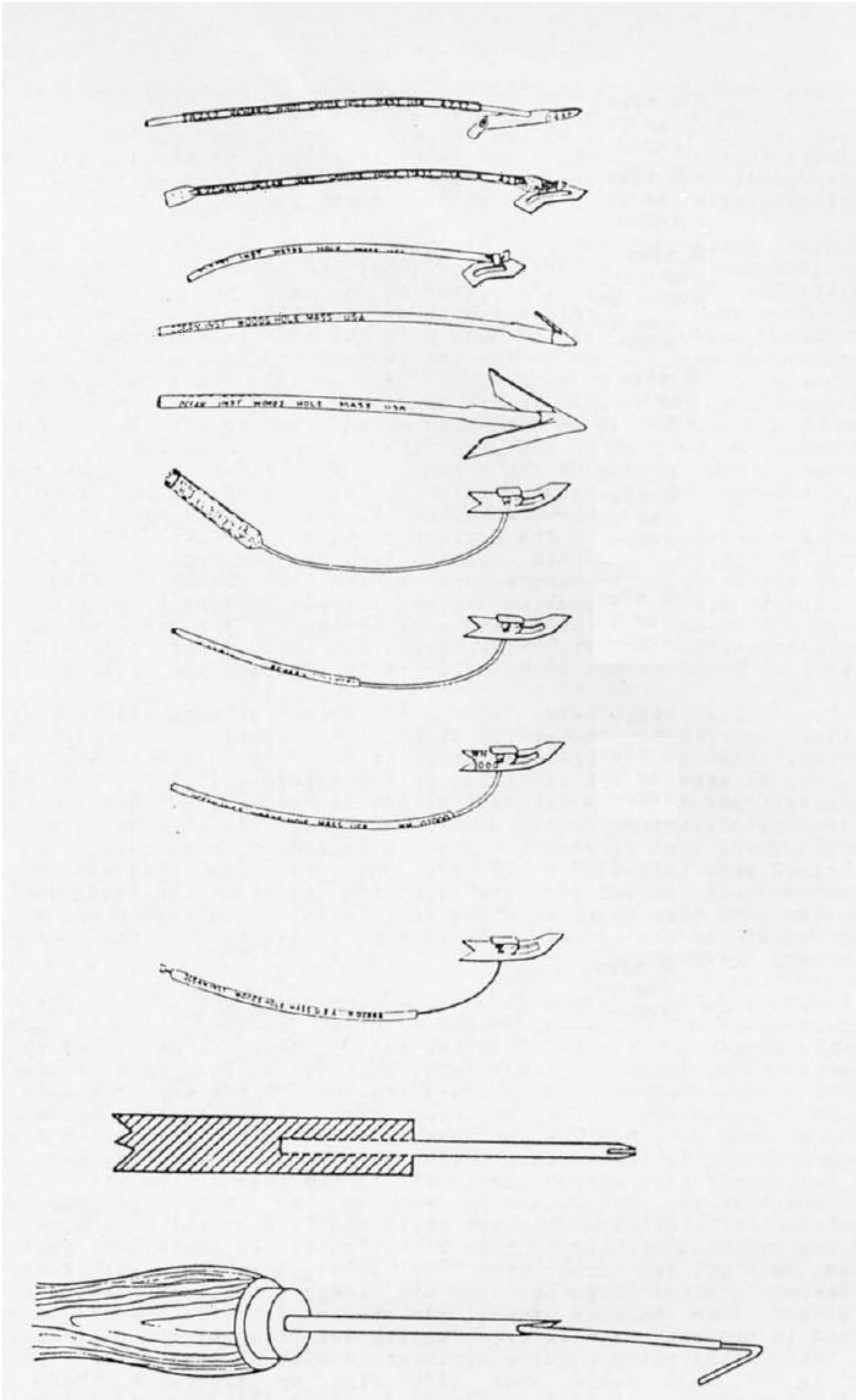

Figure 4.6.4. Various types of conventional tags and tag applicator used to tag tuna and tuna like fishes (from Bayliff and Holland, 1986. Reproduced with permission from FAO).

Figure 4.6.5. Stainless steel dart tag, Tag A (top) and hydroscopic nylon double-barb dart tag, Tag B (bottom) used in the double-tagging study to evaluate retention of the two tag types on billfishes (1990–1999). Reprinted from Prince *et al.* (2002) with permission of the authors.

According to Mather *et al*. (1974), metal heads are superior to nylon heads when the in-the-water tagging method is employed. However, Prince *et. al*. (2002) recommend using nylon double-barb dart tags on large fish because these result in higher tag retention rates. Ortiz *et al*. (2003) who reviewed tagging results of the world's 5 primary constituent-based billfish tagging programs found that tag retention of the medical grade nylon anchor had superior retention qualities when compared to the stainless steel dart tag. (Gaertner *et al*, 2004). Nevertheless, this type of tag is, in spite of everything, less adapted for the massive tagging operations carried out on tropical tunas and causes additional mortality just after the tagging.

Dart tags of the type shown in **Figure 4.6.4 and Figure 4.6.5** are attached to the fish with applicators that consist of pieces of steel (tubing or solid) slightly longer and/or slightly larger in diameter than the tags. As shown in the figure, these are sharpened at one end, as shown in the figure. Commercially-made heads often have an indentation in the sharpened end to accommodate the barb of the tag, but this does not seem to be necessary. It is important that the applicators be longer than the tags, otherwise the tags will not go all the way into them when they are stored in the holders before use, and the head will be cut off when attempting to attach the tags to the fish. It is also important that the applicators be neither too large nor too small in diameter. If they are much too small the tags cannot be slipped entirely into the applicators, and if they are slightly too small the tags may be pulled out of the fish when the applicators are withdrawn. If the applicators are too large the tags are likely to fall out when attempting to attach them to the fish. However, in the latter case they can be crimped to prevent the tags from falling out (Kearney and Gillett, 1982). It is suggested that an organisation which is planning to tag tunas or billfishes for the first time order its tags and applicators from the same manufacturer so as to be sure that the tags will fit the applicators.

Prince *et al*. (2002), recommend using a dual applicator tagging stick (**Figure 4.6.6**) for in-water tagging because these applicators increase the flexibility of the angle of tag entry when the fish may turn sideways.

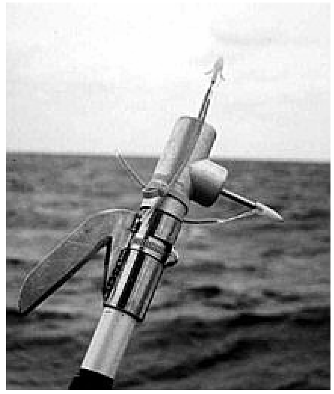

Figure 4.6.6. Dual applicator tagging pole (Courtesy of Eric Prince, NOAA).

4.6.8 Tagging procedure

To minimise tag loss, each tag should be inserted into the dorsal musculature sufficiently deep so that the barbed heads passes between the pterygiophores below the base of the second dorsal fin on tunas; and in the hump behind the head or near the base of the first dorsal on billfishes (**Figure 4.6.7**). Ideally, the tag should be positioned at an angle of 45º, or less, to the axis of the fish to minimise water resistance. The tag should not go so deep as to cause unnecessary damage to underlying tissue. Once the tag has been inserted, only the tube or capsule should be visible. With experience, the tagger should be able to feel when the barb has passed between the pterygiophores. The rates of shedding of tags differ among taggers (Bayliff, 1973; Prince *et al*., 2002), indicating the importance of careful placement of the tags and suitable training of taggers (also see below on double-tagging).

Prior to use, tags should be inserted into the applicators. In situations where many fish will need to be tagged over a short period of time, applicators with tags can be stored in groups of 100 in holders made of fabric (Wilson. 1953) or wood (Fink, 1965; Bayliff, 1973; Kearney and Gillett, 1982). The compartments or holes in the holders are numbered from 00 to 99, and the tags are matched with these numbers. Fabric holders are suitable for small-scale tagging, as on a troller or sport-fishing vessel, but wooden holders are better for large-scale tagging. Up to about 30 holders are loaded with tags prior to fishing. Since the sharpened points of the applicators are exposed, all of the holders but the first ones to be used are stored in wooden boxes (open on one side, but not at the top) from which they can be easily removed.

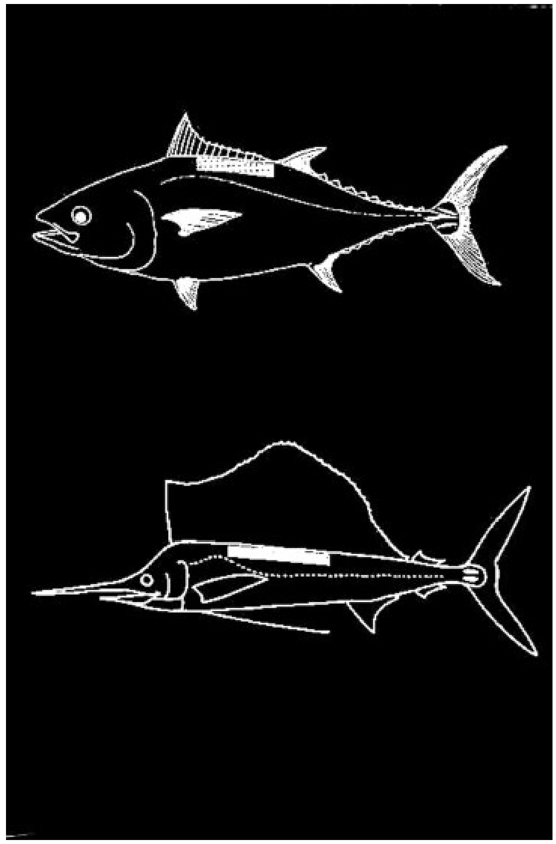

Figure 4.6.7. Target area (rectangles) for tagging tuna (top) and billfish (bottom) recommended by the Southeast Fisheries Science Center's Cooperative Tagging Center. Tags should be placed above the lateral line, away from the head and other vital organs along the dorsal musculature. Reprinted with permission of the authors (Prince *et al.* 2002).

Recording equipment and materials

The data corresponding to each tag which is used (location, date, species, length, remarks concerning the condition of the fish, etc.) must be recorded. A list of the data that are commonly recorded is given below. In some situations large numbers of fish are tagged in short periods of time aboard baitboats (and also purse seiners), so it is imperative that everything be well organised at all times. Tagging is usually much slower aboard other types of vessels, so less organisation is required. An adequate number of tags and applicators should have been loaded into the holders before tagging starts. A piece of masking tape with the tag series written on it can be stuck to the end of each holder so the tagger can quickly choose the series with the lowest codes and record which series he/she is using without pulling one of the tags out of its applicator. The holders should be placed in boxes near each tagging cradle or position. Each tagger, if he/she is using a tape recorder, should ensure that it is working properly and has enough tape for recording. Each tagger should record the location, date, time, cradle or position, etc. Cotton or wool gloves should usually be worn by taggers and assistants during tagging to protect them from cuts and enable them to get a better grip on the fish. When large numbers of fish are tagged the hands of the persons who handle them sometimes develop a rash and blisters; this can be prevented by wearing thin rubber gloves beneath the cotton or wool gloves. Water should be sprayed or poured over the cradles or chutes and the gloves should be thoroughly wetted just before tagging commences.

Data that could be included in a release-recapture record for a tagged fish.

Release data

- Cruise number
- Tag code Tag type Species Location
- Country in which released and gear used
- Date
- Time of day
- Length
- Sea-surface temperature
- Tagger
- Position or cradle
- Injected or not injected with tetracycline
- Condition of fish

Recovery data

When a tag is recovered, the following information needs to be reported:

- The species
- The number(s) in the tag
- The date and place where you caught it and the fishing gear used
- The size (length) and/or weight of the fish, including the type of measurement
- If possible, the sex and information on the type of fishing (ex free school, FAD, shark-whale, etc.

Tag returns can be sent to the ICCAT Secretariat or to ICCAT tagging correspondents (see www.iccat.int/tagging.htm).

NOTE: To remove an archival tag, a 15 cm incision should be made in the belly cavity, in front of the area where the sensor enters into the fish. The silver or white archival tag (with light sensor attached) should then be removed by hand. DO NOT REMOVE THE ARCHIVAL TAG BY PULLING ON THE LIGHT SENSOR. Wash the tag with water and store it at room temperature.

Additional data that might usefully be recorded at recapture include:

- Sex
- Condition when measured (fresh, frozen, thawed after having been frozen, etc.)
- Vessel
- Process in which recovered (fishing, unloading fishing vessel, unloading freezer ship, butchering. etc.)
- Port returned
- Regulation status
- Person handling the return data

It is more common to record fish lengths in whole centimetres; the IATTC records them to the nearest centimetre and the organisations that participate in the tagging program of the ICCAT record them to the next lowest centimetre (i.e. lengths from 60.0 to 60.9 cm are recorded as 60 cm).

Double tagging

Fish are double tagged for at least three reasons. First, information about the effects of tagging on the mortality and growth can be obtained by comparing the return rates and growth rates of single- and double-tagged fish, e.g. if the return rates or growth rates for the double-tagged fish are lower than those for the single-tagged fish the tags are probably detrimental (I-ATTC/CIAT, 1984:31-32). Second, comparison of the return rates of single-tagged fish and of double-tagged fish with one or two tags retained makes it possible to estimate the rates of shedding of the tags (Bayliff and Mobrand, 1972; Laurs *et al*., 1976; Baglin *et al*., 1980; Kirkwood, 1981; Wetherall, 1982; Xiao, 1996; Adam and Kirkwood, 2001; Prince *et al*. 2002). It should be noted that the independent estimation of tag shedding rates from double tagging experiments is an integral part of a well-designed tagging experiment. Third, greater return rates, especially for fish at liberty long periods of time, are often realized when the fish are double tagged (Hynd, 1969; Bayliff, 1973). The Southeast Fisheries Center's Cooperative Tagging Center, in conjunction with the Billfish Foundation Tagging Program, double-tagged Istiophorid billfish and swordfish to test retention of two tag types (Prince *et al*. 2002). This program recommended inserting a tag on both sides of the fish to promote increased visibility. However, this was not always possible, as illustrated in **Figure 4.6.8.**

Figure 4.6.8. A hydroscopic nylon double-barb dart tag (left) and a stainless steel dart tag (right) used to double tag billfish, such as this blue marlin, to assess the relative retention of the two tag types. Reprinted with permission of the authors (Prince *et al*. 2002).

The IATTC has double-tagged large numbers of yellowfin and lesser numbers of skipjack and northern bluefin. The tags are placed on opposite sides of the fish, one about 1 cm anterior to the other. The taggers do not try to insert the two tags simultaneously, as this can result in one or both of them being too shallow or too deep. They are instructed to pair the tags so that the lower of the two numbers is an even number. i.e. A3900-A3901, A3902-A3903, etc., rather than A3901-A3902, A3903-A3904, etc. The holders and the plastic and paper forms for recording the data have the numbers paired in the manner just described. This helps prevent the tagger from getting the numbers mixed up when he/she is tagging. The South Pacific Commission (SPC, 1981) has double-tagged skipjack, inserting both tags on the same side of the fish. These are inserted either individually or both at the same time.

4.6 9. Further reading

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