



Using passive integrated transponder (PIT) technology to improve performance of CCSBT's conventional tagging programme.

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1 Abstract

The Commission for the Conservation of Southern Bluefin Tuna's conventional tagging programme, initiated through the Scientific Research Programme, had the potential to provide powerful information on the status and other important characteristics of the SBT stock. However, the use of external dart tags led to a reliance on voluntary reporting by fishers for tag return information. The full potential of the tagging programme has not been reached due to low returns and difficulty in reliably estimating tag reporting rates.

This problem led the CCSBT-SC to consider whether Passive Integrated Transponder (PIT) tags could be used in place of the external dart tags. PIT tags are around 11-22 mm in length and are surgically implanted into the host fish. They contain no power source, but the unique identifier stored within the tag can be 'retrieved' by a tag reader sending a signal to the tag which provides the tag with sufficient power to transmit its code back to the reader. Historically the tags have been encased in glass, but recently they have become available encased in surgical-grade plastic.

We describe some of the important considerations in using this technology and describe some initial field research undertaken by CSIRO in conjunction with Australian farming operators, to address some of these issues.

We show that this technology has the potential to overcome the problem of voluntary tag returns and increase the quality of release and recapture data, particularly if initiated in conjunction with individual fish marking under a Catch Documentation Scheme. The use of PIT tags will also eliminate the need for tag rewards which are estimated to have cost around AUD\$105,000 each in 2006 and 2007.

There are two major obstacles that need to be overcome before it will be feasible to use this technology: 1) food safety concerns relating to the unintentional ingestion of PIT tags by consumers; and 2) the development of tag readers that can achieve a high rate of tag detection at reasonable distances.

It is also possible to combine this technique with gene tagging which is described in detail in CCSBT-ESC/0809/13.

2 Introduction

In 2001 the Scientific Research Program (SRP) of the CCSBT was established with the conventional tagging programme as a core component (Davies et al. 2007).

This programme had the potential to improve our understanding of fishing mortality rates (and through this the relative strength of incoming cohorts) and also growth, movement, mixing, and interactions among fisheries.

Prior to becoming part of the SRP, there were three previous large-scale SBT conventional tagging programmes in Australia with the first starting in 1959. Within the SRP, conventional tagging has taken place between 2001 and 2007 (Polacheck and Eveson 2007; Eveson and Polacheck 2008).

For conventional tagging studies to be effective there needs to be some level of reporting that is both reasonable and able to be estimated. Indeed, conventional tagging under the SRP program was suspended in 2007 in part due to concerns over reporting rates (Anon. 2007). Of concern was the inability to accurately estimate reporting rates from some of the major longline fisheries (due to insufficient levels of observer coverage and an inability to

experimentally determine reporting rates) and the decline in reporting rates from the surface fishery (as estimated from tag seeding experiments (Hearn et al. 2007, Hearn et al. 2008)). In addition to the decline in reporting rate, the spatial distribution of tag releases has been less than expected due to low numbers of tags being deployed outside of the Great Australian Bight (Davies 2007).

2.1 Outline of paper

In September 2007 the CCSBT-SC recommended that the release phase of the tagging programme be suspended while new approaches were examined to improve the quality of results from the programme (Anon. 2007). New Zealand offered to develop a proposal for continuing the conventional tagging programme using Passive Integrated Transponder (PIT) tags for consideration at CCSBT-SC13. This report describes some of the issues that must be considered in using PIT tag technology in the CCSBT tagging programme and describes several field and laboratory experiments that have been undertaken by Australian researchers to address some of these issues. Another potential technique is genetic (DNA fingerprint) tagging and this is described in CCSBT-ESC/0809/13.

The intention of this paper is not to review the use of PIT tags, but to provide a point of discussion for the use of PIT tags in a large-scale tagging program. For a recent review of the use of PIT tags please see Gibbons and Andrews (2004)

3 PIT tagging technology

3.1 Overview of the technology

The use of Radio-Frequency Identification (RFID) technology and Passive Integrated Transponder (PIT) tags, by allowing for autonomous detection of tagged fish, may also overcome the current limitations in the 'conventional' SPR tagging program. PIT tags have no internal power supply; a minute electrical current induced in the PIT antenna by the incoming radio frequency signal provides just enough power for the tag to transmit a response (in this case a unique identification number). Because PIT tags do not require an internal power source their lifespan is indefinite.

The first true ancestor to the modern RFID (radio frequency identification) tag was patented in 1973 by Mario Cardullo (US Patent 3,713,148). Since then RFID tags have greatly decreased in both size and cost, thus increasing their usefulness in areas such as animal tracking and supply chain logistics. Passive integrated transponders, or PIT, tags have been widely used in animal studies; arguably the most well known use being to track salmon stocks in North America. The advantage of PIT tags over other passive tags is the ability to uniquely identify an animal and to detect the tag without having to sacrifice the animal.

At the most basic level all PIT tags work in the same fashion. Data (e.g. an identification number) is stored on the tag's microchip. The tag's antenna receives electromagnetic energy from an RFID reader's antenna. Using the electromagnetic energy the tag reflects radio signals back to the reader. The reader then interprets the reflected frequencies as meaningful data (e.g. the unique identification number).

Because PIT tags have no internal power source they are entirely reliant on the RFID reader as their power source. On the other hand, because PIT tags have no internal power source their life expectancy is indefinite.

3.2 Types of PIT tags

RFID tags come in three general varieties: passive, active, or semi-passive. For the current exercise we are only interested in the passive variety (PIT). Until recently PIT tags were only available in a biocompatible glass capsule. However, PIT tags are now available and are made from FDA-approved surgical grade acrylic plastic (<http://www.hallprint.com/1399/2923.html>). In the experiments that follow, we have only used the food-safe PIT tags.

There are two main types of PIT technologies: half duplex (HDX) and full duplex (FDX). The FDX tags can transmit and receive signals at the same time and can be made much smaller (8 mm) than HDX tags. Their main downside is their reduced detection range. Conversely the HDX tags sequentially transmit and receive signals and have larger detection distances, but currently are not available smaller than 22 mm in length.

For application with SBT, the fish are quite large (compared to fish down to 100 mm tagged with PIT tags elsewhere in the world) and detection range is likely to be an issue, so HDX PIT tags are likely to be the preferred technology.

3.3 Review of current uses in fisheries

RFID technology is currently in wide use in supply chain logistics as well as animal identification (e.g. the Canadian Cattle Identification Agency: <http://canadaid.ca/index.shtml>). PIT tags are also common in some fisheries applications (e.g. Columbia River); however their use has generally been restricted to the freshwater environment. Two notable exceptions are the use of PIT tags in the Australian Toothfish industry (Australian Antarctic Division), and their use in the snapper fishery of New Zealand (McKenzie et al. 2006). The limited uptake of RFID/PIT tag technology in the marine environment is due to problems associated with the detection range of tags. Adams et al. (2006) were able to detect PIT tags within 30 cm of the antennae within an estuarine system (salinities up to 30 ppt). Further developmental work by Warren Leach (Oregon RFID, per comm.) has resulted in detection ranges in saltwater of about 30 cm for 23 mm tags and 45 cm for 32 mm tags. Detection distance was further enhanced through a novel antenna design. The technology is improving to the point where it may be suitable for working in the marine environment. In the toothfish fishery for example, PIT tags are detected by a reader in the shoot/supply line of the onboard processing factory.

Literally millions of PIT tags are implanted each year to fish and other animals. They have been used in tagging programmes for New Zealand snapper, Pacific halibut, various North American salmon species, rockfish, a variety of Australian freshwater fish found in the Murray River catchment.

4 Tag deployment

4.1 Tag type

As noted above the most appropriate PIT tagging to use for SBT would be the so-called 'food safe' plastic encapsulated PIT tags from ENSID. Currently this group is the world leader in food safe PIT tag technology. Given the need for larger detection distances, the 22 mm HDX tag would be the first choice.

4.2 Tag location

A key issue with PIT tags is the location for implanting them. Factors to be considered when determining the best location:

- Animal welfare: will it interfere with the health and wellbeing of the fish
- Retention / migration: will the tag stay within the fish or move from the implant location
- Processing: is it in a place that will remain after processing (can be overcome by searching for tags prior to processing)
- Consumption: is it in a part of the fish (or can it migrate to a part of the fish) that is eaten by consumers.

Given previous research on tagging fish with PIT tags, and the size of SBT, the first two issues are not of major concern. However, the last two issues are very relevant with non-visible tags such as these. For the NZ snapper tagging, tags were placed in the abdominal cavity as the fish were landed whole and the contents of the gut cavity were not eaten. In a black rockfish tagging programme the tags were implanted in the neck/head region as the fish were filleted.

For SBT, there is at-sea processing, the level of which varies between fleets. All fleets remove the abdominal cavity contents and gills, but there is variation in the amount of gill plate removed and cuts to the head of the fish associated with the capture (e.g. gaff) and killing process. Further, in Japanese culture (at least) the entire head of the SBT is often cooked / consumed, often for important cultural events (Figure 1). Under a PIT tagging programme it is not expected that all fish will be scanned for tags and they will be no visible identifier of a tag implantable fish.

Based on processing practices alone, the preferred tagging location would be either in the 'nose; or 'cheek' of the fish, but based on the information made available to the authors, there are no obvious tagging locations that would survive processing, and then not potentially be eaten. This issue is discussed further under the Food Safety section.

4.3 Data capture

One large advantage of tags that can be read automatically is the ability to accurately record release data. Poor data quality is a major problem with tagging programmes and can lead to the loss of important (and expensive) information.

When the PIT tag is inserted into a fish, a scanner attached to a computer can be used to record the tag details avoiding the need to write down multi-digit numbers. Further gains can be made by using electronic measuring boards that allow the full electronic recording of all release data. This approach was used in the NZ snapper tagging programme. Such is the advantage that one of the major dart tag producers (Hallprint) produces dart tags that also contain a PIT tag inside them.

5 Tag recovery

The main difference between using dart (or spaghetti) tags and PIT tags is the nature of the recapture event. With (visible) dart tags you assume that all fish are 'examined' for tags, but that only a proportion of the fish that originally had tags in them will be reported as recaptures. This 'loss' is due, in part, to the effects of tag shedding and non-reporting. These losses can be quite high and are difficult to estimate reliably (Hearn et al. 2008). This uncertainty carries through into the subsequent estimates of population parameters of interest.

With PIT tags, tag shedding has been shown to be very low (none was found in several studies) and there is no reliance on fishers or processors to report tags. There is still a factor analogous to non-reporting which is related to tag failure and tag detection, but both of these factors can be easily tested and estimated under trial conditions. Some experiments to consider these issues are described in this report. Rather than assume that all fish are examined for tags, only the number of fish examined for tags needs to be known. The analogous scaling parameters for PIT tagging programmes (e.g. tag failure and detection rates) are typically smaller and easier to estimate than those of dart tagging experiments (e.g. tag shedding and reporting rates) and should lead to better information. In particular, the very low tag shedding rates would significantly reduce the uncertainty associated with tagger effects relative to conventional tags (Hearn et al 2008).

Two general approaches have been used to detect PIT tags: 1) hand held or mounted scanner arrays, and 2) aerials / antenna. The former are often used to detect tags in processed fish, while the latter are commonly used in small streams or in facilities associated with hydro dams and involve the fish swimming through an aerial. There are options for both in the two fisheries.

5.1 Surface fishery recoveries

There are two approaches for detecting PIT tags in the surface fishery: attempting to ‘scan’ fish while in the pens, or scanning fish at the time of harvest. If it was possible to accurately detect fish prior to processing, then it would be possible to implant the tags into parts of the fish that would be removed during processing and therefore eliminate any potential risks to consumers of encountering tags. While you would not necessarily get the biological data associated with a recapture (e.g. fish size) this is not particularly useful for fish that are being on-grown.

Potential mechanisms for in situ sampling include:

- Suspending a floating antenna in a fattening pen for a period of time recording tag recaptures as tagged fish swim by the antenna; or
- Creating an antenna in a frame used when transferring fish from towing to farm cages, i.e. you scan for tags while you count the fish.

The challenge for both approaches is the current relatively low detection range of these tags, particularly in salt water. For the floating antenna, considerable field work would be required to determine the detection rate and whether it varied with any other factors (e.g. fish size, any size-related behavioural differences, environmental conditions).

Most processing vessels have well set out work stations so it could be possible to setup a scanner or array of scanners to detect fish while being processed or alternatively an observer could scan for tags while monitoring processing activities.

5.2 Longline recoveries

Given the larger number of vessels and diverse fleets, sampling of the longline captures is more complicated. It is possible that observers could be provided with a handheld scanner and scan for tags. In theory this should allow a minimum of 10% of the longline catch to be scanned. A more sophisticated solution would be to have a scanner array setup on the haul door of a longline vessel to detect tags as the fish were brought aboard. Both of these options would allow the placement of tags in a part of the fish that is removed during processing.

After processing, it could be possible to have an array near the freezer or a measuring board or scales (that might be needed to collect the necessary information for a CDS). The recent

changes in the Japanese fishing rules for SBT have reduced the number of ports where SBT can be landed and involve increased monitoring of unloads. During this monitoring, it would be possible to scan for tags. The level of coverage of this monitoring is not known at present. One potential issue with scanning for tags in landed SBT is the freezer processing used to store these fish. They can be stored at -60 C for several months. Several experiments later in the report examine the performance of tags exposed to these sorts of conditions.

6 Health and safety issues

The safety of the product to consumers is of fundamental importance to any tagging programme and has historically been a concern with PIT tags. Until recently, the only PIT tags available were encased in glass, but recent developments have involved the use of virtually indestructible surgical grade plastic. These advances were specifically made to address concerns about food safety, however, in the application to NZ snapper, the tags were still inserted in part of the fish that was not eaten.

The authors are grateful to Japan for the open dialogue that they have had regarding concerns over the use of PIT tags. In an email dated 25 April 2008 Mr Takaaki Sakamoto indicated that *“My staff member had a meeting with officials of the Ministry of Health, Labour and Welfare (MHLW). The officials of MHLW told my staff that the MHLW would like the FAJ to strongly ask foreign countries not to use PIT tags for tunas, which have high potential to be imported to Japan”*. Further to this, Japan provided a copy of the Japanese Food Hygiene Law which has been translated by the Secretariat and is attached as Attachment 1.

The simplest way to overcome these issues is to be able to scan for tags prior to processing of the fish. If possible to a sufficient level, then this would allow tags to be implanted in parts of the fish that are removed during processing. If this cannot be done, then the best course of action is to continue to refine the food safe nature of these tags and determine the parts *least likely* to be eaten. While it could be argued that there is minimal risk to any consumer that might ingest a PIT tag, this is clearly an important issue for Governments to consider.

7 Trials and other experimental work

7.1 Testing tag insertion locations, tag rejection/migration/infection

Tag insertion locations are highly constrained by the end consumer of the product. Historically PIT tags have not been used in SBT because they were constructed of glass. Therefore they were not considered food safe. Recently ENSID Technologies (New Zealand) has developed and produced food-safe PIT tags constructed of food grade surgical resin. Despite the availability of food-safe PIT tags there is still a need/desire to ensure PIT tags are not placed in tissue that is commonly used for consumption.

Due to the factors concerning tag placement, for the initial trial using food-safe PIT tags the cheek region was chosen. However, this proved to be an unsuitable location for a number of reasons: a) current food-safe PIT tags are relatively large in relation to the depth of cheek muscle; b) the current applicator was unsuitable for the task; c) the ability to tag effectively, efficiently and quickly would be compromised in this region. Further experimentation was performed by placing food-safe PIT tags into the dorsal musculature immediately behind the leading edge of the second dorsal fin (i.e. the same location as current conventional tags).

Experimental procedure.

- 20 x Ensid 22 mm HDX food safe PIT tags
- 20 x Ensid 11 mm FDX-B food safe PIT tags

Following the standard procedure developed for the 40 fish sample we aimed to randomly tag 40 SBT with a single PIT tag and an orange conventional tag (for later visual identification). There were no control fish as the fish used for this experiment were already under stress from other experimental work.

Fish were removed from the experimental farm using a barbless hook on a short length of rope. They were landed into a cradle, checked for existing tags, measured, then injected with a PIT tag and an orange tag applied. Fish were re-released into the experimental fish farm. The typical time out of water was under 2 minutes.

Following release back into the experimental fish farm the fish were fed daily at the rate of about 1 kg per fish per day. Further experiments on physiology were conducted on fish in the experimental fish farm on approximately a weekly basis; all orange tagged fish (PIT tagged fish) that were subsequently caught during these experiments were returned to the fish farm and not used for further experiments.

Orange tagged fish that died prior to the harvest of the majority were scanned for a PIT tag and the tag removed. As of July 1, 2008 harvesting of the experimental farm had not begun. The full experimental results from this experiment will be reported at a later date.

Experimental results.

The proposed number of PIT tags to be used in the live fish trial (20 each of 11 and 22 mm length) was not reached. Of the 22 mm HDX food-safe PIT tags only seven were deployed; 20 of the 11 mm FDX-B food-safe PIT tags were deployed. The cheek region turned out to be too tough for the design of the commercial PIT tag applicator. This resulted in the needle being pulled out of the applicator on several occasions. Furthermore, one needle became jammed with a PIT tag and could not be cleared.

Problems with the equipment were compounded with the location chosen for the PIT tag. The cheek muscle was too thin to accommodate the 22 mm HDX PIT tags resulting in tags being pushed through into the buccal cavity. Because of the concerns and problems listed above, the majority of the PIT tags were placed in the dorsal surface of the fish close to the leading edge of the second dorsal fin. This position was chosen because it has historically been the location where conventional tags have been placed. It is noted that this would not be a suitable location for any future tagging programme, but was used as a basis for testing other aspects of tag performance (see below).

7.2 Tag performance under low temperatures

ENSID Technologies food-safe PIT tags have been rated to perform at temperatures as low as -60 C. However, the ability to read tags that have been frozen inside the cheek or muscle of SBT has not been tested. This test was designed to simply demonstrate the ability to read tags while embedded in the cheek and having been frozen to at least -60 C.

Experiment 1:

The heads from two 104 cm SBT were used. A 22 mm HDX PIT tag was inserted into the cheek of one head; an 11 mm FDX-B PIT tag into the other. The heads were then placed into a -60 C freezer and left undisturbed for several months. After this period the heads will be

scanned with an Allflex RFID compact reader (RS200-1). The results of this experiment are not yet available as the experiment is ongoing.

Experiment 2:

Ultra low temperature (-80 C) tests were conducted on both 11 mm FDX-B and 22 mm HDX tags inserted into 4 cm³ chunks of yellowfin tuna muscle. The muscle samples were placed into individual bags marked with the PIT tag number. After nine days the muscle samples were removed from the freezer and immediately scanned for the PIT tags. The muscle samples were then replaced into the -80 C freezer. A second reading of the frozen muscle samples was taken 11 days after freezing. The samples were then placed in a fridge for three days to thaw, after which a third reading was obtained. The results are reported in Table 1.

Table 1: Maximum detection distance for 11 mm and 22 mm PIT tags embedded in 4 cm³ chunks of yellowfin tuna muscle and frozen to -80 C.

PIT tag No	Size (mm)	Maximum read distance (mm)		
		9 days @ -80 C	11 days @ -80 C	Thawed
50840	11	20	25	45
50958	11	20	25	50
50990	11	20	25	50
50995	11	25	30	55
102355	22	no read	no read	100
102363	22	no read	no read	120
102364	22	no read	no read	100
102366	22	no read	no read *	115
102367	22	no read	no read #	100

* reading obtained using a RealTrace RT100 9V reader at max distance of 25 mm

reading obtained using a RealTrace RT100 9V reader at max distance of 30 mm

Both the 11 mm FDX-B and the 22 mm HDX PIT tags have been tested by the manufacturer to -60 C. These tests were done with tags that were not embedded in tissue of any kind. Based on the results of Table 1 we were unsure if the inability to read 22 mm HDX tags frozen in tissue to -80 C was the result of damage to the tag itself or an operational error due to the low temperature. An additional four 22 mm HDX PIT tags were frozen (without being embedded in tissue) to -80 C. After 48 hours at -80 C these tags were removed from the freezer and immediately read. All four tags were detected with the handheld Allflex RFID reader.

Experiment 3:

As a result of the ultra low temperature tests another experiment was conducted to examine read distances of 22 mm HDX PIT tags embedded in yellowfin tuna muscle before freezing, after freezing to -20 C, and then further freezing to -40 C. The experimental procedure was the same as for the ultra low temperature test with the PIT tag being embedded 15 mm below the surface of the skin in a 4 cm³ chunk of yellowfin tuna. The results are reported in Table 2.

Table 2: Maximum detection distances for 22 mm HDX PIT tags embedded in yellowfin tuna muscle. Readings were taken from fresh (un-frozen) muscle tissue, tissue frozen to -20 C, and tissue frozen to -40 C. The PIT tag reader was an Allflex RFID Compact Reader – RS200-1.

	Maximum read distance (mm)							
	in Air		in fresh tissue		frozen to -20 C		frozen to -40 C	
Tag No	* parallel	# right angle	parallel	right angle	parallel	right angle	parallel	right angle
102368	162	38	120	33	95	30	!no read	!no read
102370	155	58	108	38	25	!no read	!no read	!no read
102371	158	37	114	41	60	35	!no read	!no read
102374	155	41	105	40	75	5	!no read	!no read
102375	150	55	120	80	95	25	!no read	!no read

* denotes the axis of antenna of the tag reader was parallel to the long axis of the PIT tag.

denotes the axis of the antenna of the tag reader was at right angles to the long axis of the PIT tag.

! tag detected using RealTrace RT100 9V handheld reader.

Conclusions from freezing experiments.

Ensid 11 mm FDX-B and Ensid 22 mm HDX PIT tags are able to withstand freezing to at least -80 C. Embedding tags in tissue may reduce the detection envelope by about 73% that of non-embedded tags. The detection envelope is further reduced by freezing the tags in tissue. The detection envelope for Ensid 22 mm tags frozen to -20 C was approximately 49% that of non-embedded tags at ambient room temperature (~20 C).

The Allflex RFID compact reader (RS200-1) was unable to detect the Ensid 22 mm HDX tags embedded in tissue that was frozen to -80 C. However, a RealTrace RT100 9V handheld reader was able to detect two of the 22 mm HDX PIT tags. This suggested the inability to detect the 22 mm HDX tags was a combination of ultra low temperatures and reader configuration.

Although freezing does appear to affect the detection envelope of PIT tags, it does not preclude the use of PIT tags in a large-scale tagging programme.

7.3 In-situ tag detection

For a tagging program to be effective tagged fish need to be detected. Ideally the detection of tags would occur at the earliest stage of processing. Detecting tags reliably and consistently while the fish are alive and in water would satisfy this criterion. However, historically PIT tags have not performed well in salt water due to attenuation of the signal leading to poor detection distances. In partnership with EDiT iD, CSIRO initiated a trial to compare detection distances in salt water and open air with an un-tuned antennae system.

Experimental procedure.

These trials occurred before the food-safe tags were available. However, ENSID Technologies (provider of food-safe tags) were able to supply two 22 mm HDX glass PIT tags that were representative of the food-safe tags to be supplied for the insertion experiments reported above.

The test procedure involved securing a single tag at a fixed distance from a 600 x 400 mm antennae linked to a standard EDiT iD 134.2 KHz dual HDX/FDX ISO 11784/11785 compatible RFID reader Control Unit interfaced with a TruTest XR3000 indicator. Power was then supplied to the unit and the read rate in open air determined by the XR3000 indicator. This procedure was repeated at varying distances from the antennae. The entire procedure was then repeated in salt water at a depth of 1.5 m. In all tests the minimum read distance from the antennae was 400 mm; the maximum distance was 600 mm.

Experimental results.

At 600 mm from the antennae the RCU failed to detect the tags in either open air or salt water. Based on the tag/antenna configuration used in this trial, the furthest distance that would provide a read rate in both open air and salt water was 540 mm (Table 3).

Table 3: Read rate per minute for 22 mm glass PIT tags at varying distances from a 600 x 400 mm antenna.

Distance from antenna (mm)	Read rate/minute	
	Open Air	Salt water
400	706	639
500	293	300
540	23	19
600	0	0

Conclusions.

Based on the above configuration there is no difference in read distance between open air and in salt water when using the 134.2 KHz RFID tag and EDiT iD Reader. The manufacturer believes greater read distances could be achieved by tuning the system to the specific model of PIT tag. Greater read distances would be required should the system be used to detect tagged fish in saltwater enclosures.

8 Comparison between dart/spaghetti and PIT tags

This report has described a proposal to modify the current CCSBT conventional tagging programme by replacing the current dart or spaghetti tags with PIT tags. Here we briefly summarise some of the key differences between the use of the different tag types including some issues relating to cost differences.

By using implantable PIT tags you overcome the need for voluntary returns from fishers and the need to estimate / assume reporting rates. The advantages of this include improved estimates of population parameters of interest and reduced costs as you no longer need to pay for tag rewards, annual tag shedding experiments, or promotional / publicity material for fishers and processors¹. These savings will be offset in part by the higher cost of the tags and the system setup to scan catches for tags.

¹ It is recognised that these activities may need to continue for some time due to the large number of dart tags still deployed in fish and the valuable information that can still be obtained from tag returns.

Based on figures provided by the Secretariat, the cost of tag rewards and publicity has been approximately AUD\$210,000 over the past two years of the CCSBT programme. These costs would steadily decline until conventional tags are no longer recovered from the fishery (although a small amount may be necessary for 'legacy' tags for quite some years). Based on 20,000 tag releases the additional cost of the tags will be approximately AUD\$70,000 over that of conventional tags.

9 Recommendations

PIT tagging technology appears to have great potential for improving the quality of information from the CCSBT tagging programme. It is premature to initiate full-scale tagging with PIT tags for the 2008/09 year, but there are three streams of work that should be completed to fully inform the consideration of this at CCSBT-SC14.

9.1 Additional experimental work

1. Develop PIT tag applicators that are robust and more ergonomically designed
2. Development of a system for supplying PIT tags to the applicator in a quick and efficient manner (both 1 & 2 are required if PIT tagging is used in large scale applications). This should also include a tagging cradle design incorporating a measure and PIT tag reader could be developed.
3. Experimentation with the application of PIT tags at right angles to the long axis of the fish. Detection distances are a function of tag orientation; thus tags inserted at right angles to the spine may increase the detection distance depending on the orientation of the antenna.
4. Further experimental work with PIT tags in the cheek region if a suitable applicator can be developed/sourced.
5. In water detection of PIT tags in fish for potential farm applications
6. Development of an antenna system suitable for freezer boats and for longliners (this would include further experimental work to develop a highly tuned antenna system to increase the detection envelope of tags which have been frozen).

9.2 Additional policy work

Members should examine their own relevant domestic legislation to determine what, if any implications there are for implanting PIT tags in SBT.

9.3 Statistical design of a tagging programme using PIT tags

Experience in the design of New Zealand PIT tagging programmes has found that the number of tags released and number of fish scanned for tags are the two critical determinates of programme performance (e.g. precision of estimates of population parameters). A formal design analysis should be undertaken to assess this, while also incorporating the cost associated with release and recovery operations.

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Figure 1: Examples of the cooking / consumption of tuna heads.

Attachment 1: Translation of Japans Food Sanitation Law

食品衛生法

Food Sanitation Law

第六条

次に掲げる食品又は添加物は、これを販売し(不特定又は多数の者に授与する販売以外の場合を含む。以下同じ。)、又は販売の用に供するために、採取し、製造し、輸入し、加工し、使用し、調理し、貯蔵し、若しくは陳列してはならない。

Article 6. No person shall sell (hereinafter in this Law, the term "sell" includes supplying for purposes other than sale to the public or a large number of persons), or handle, manufacture, import, process, use, prepare, store, or display with intent to sell any food or food additive given below:

一

腐敗し、若しくは変敗したもの又は未熟であるもの。ただし、一般に人の健康を損なうおそれがなく飲食に適すると認められているものは、この限りでない。

(1) Those which are rotten, decomposed, or immature; provided, however, that this Subparagraph does not apply to articles that are generally deemed not to be injurious to human health and are deemed to be fit for human consumption.

二

有毒な、若しくは有害な物質が含まれ、若しくは付着し、又はこれらの疑いがあるもの。ただし、人の健康を損なうおそれがない場合として厚生労働大臣が定める場合においては、この限りでない。

(2) Those which contain or bear toxic or injurious substances or which are suspected to contain or bear these substances; provided, however, that this provision does not apply to the cases which are prescribed by the Minister of Health, Labour and Welfare as not injurious to human health.

三

病原微生物により汚染され、又はその疑いがあり、人の健康を損なうおそれがあるもの。

(3) Those which are either contaminated with or suspected to be contaminated with pathogenic micro-organisms and which may injure human health.

四

不潔、異物の混入又は添加その他の事由により、人の健康を損なうおそれがあるもの。

(4) Those which may injure human health due to uncleanliness, the admixture or addition of extraneous substances, or any other causes.