Update on Tag Seeding Activities and Preliminary estimates of reporting rate from the Australian surface fishery based on tag seeding experiments

Tom Polacheck
Clive Stanley

Prepared for the CCSBT 5th Meeting of the Stock Assessment Group (SAG5) and the 9th Meeting of the Scientific Committee (SC9)
6-11 and 13-16 September 2004, Seogwipo KAL Hotel in Jeju, Korea

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Abstract

A pilot tag seeding project was conducted in 2003 on purse caught fish when they were transferred from tow cages to grow out cages in the Australian southern bluefin tuna fishery. Further tag seeding was conducted during the 2003/2004 fishing season. The primary purpose of the tag seeding is to obtain estimates of tag reporting rates from this component of the global SBT fishery. This paper presents initial analysis of the results obtained in the 2002/2003 tag seeding experiment and a report on the seeding conducted during the 2003/2004 surface fishing season. In 2003/2004, tag seeding occurred in fish from 22 out of a total of 36 tow cages (an increase from 6 cages in the previous year). Harvesting operations are still under way and as such the total number of returns is unknown at this point. As in 2002/2003, there have been no reports of any of the tag seeded fish dying prematurely or other negative impacts on fish from the tag seeding. Preliminary analyses of the results from the 2002/2003 tag seeding yielded an estimate of a mean reporting rate across cages of 0.66 (s.e. = 0.092) taking into account tag shedding (estimated to be ~0.024 for the probability of shedding both tags). There are a number of statistical estimation issues that need to be further explored including the estimator for tag shedding rates, potential biases including the representativeness of the cages tagged and the development of an appropriate error model for the tag shedding and reporting rates estimates. The preliminary estimates of reporting rates presented are low based on past expectations. It is suggested that a reduction in direct and personal interactions between industry and the tagging program may be having a negative effect on the subsequent reporting rates.

Introduction

The CCSBT has embarked on a large scale juvenile tagging program as part of its collaborative Scientific Research Programme (SRP). The aim of the tagging component is to provide direct estimates of fishing and natural mortality rates (see Anon 2001). Estimates of tag reporting rates are essential for the SRP tagging program to meet its principle objective. In the design of the tagging program, it was anticipated that for most of the main fisheries components (i.e. the various longline fisheries), reporting rates would be estimated from observer data collected under the scientific observer component of the SRP. However, for the Australian purse seine surface fishery, which catches fish for tuna farming, observers can not provide useful data for estimating reporting rates since fish are not removed from the water at the time of capture. Thus, it is impossible to observe the number of fish with tags at the time of capture. As such, alternative approaches are required to estimate the reporting rate from this important component of the global SBT fishery. As part of its commitment to the SRP, Australia undertook a commitment to explore and develop an approach for estimating reporting rates from the SBT farm sector.

After consideration of alternative approach, tag seeding was assessed to be the most (perhaps only) viable approach that would allow for direct estimation of reporting rates. In this approach, tags are inserted in a sample of fish within tuna farms. Since the number of seeded tags released into the farms is known exactly, reporting rates can be directly estimated from the number of tags subsequently returned taking into account any tag shedding. A pilot tag seeding program was conducted in 2003 to assess whether in fact tag seeding could be implemented to provide reliable reporting rates. The project was a pilot one in that it aimed to demonstrate (1) the viability of tagging fish in the farms without inducing mortality, (2) to determine if sufficient industry support could be gained to allow the tag seeding to go ahead in the future and (3) to provide data that would determine the level of tag seeding required to obtain reporting rate estimates with reasonable levels of precision. This paper provides an initial analysis of the results obtained in the 2002/2003 tag seeding experiment and a report on the seeding conducted during the 2003/2004 surface fishing season.

Methods

Seeding operations

Stanley and Polacheck (2003) document the details of the approach taken for tag seeding. The approach developed was based on extensive discussions with industry and was designed to address three major concerns that were raised:

1. Potential for tag induced mortality and thus loss of fish and income;
2. Potential stress and reduction in growth within the farm from handling of fish for tagging;
3. Potential for the confidentiality and proprietary information on growth achieved by individual farmer to be compromised.

The protocol developed was to require that all tagging was to be undertaken by experienced taggers. In addition, to minimize stress and increased handling of fish, all fish that would be tagged would be taken from the 40 fish sampled for weight and length at the time fish are transferred from the towing cages to fish pens. This means that tag seeding would not require any additional fish to be taken from the water and physically handled. Moreover, tagging would thus entail a minimal of additional time that a fish sampled for weight and length would be out of the water. In order, to ensure that the confidentiality and proprietary nature of any potential information on growth was maintained, it was agreed that no data on the length or weight of fish at the time of harvesting would be retained in the scientific tagging data base. Such data would not contribute to the interpretation of the results and thus their non-retention would not compromise the reason for conducting tag seeding experiments.

Given the above, a target was set of tagging 10 fish from the 40 fish that are sampled for weight and length from as many tow cages as possible. In all cases, tagging was at the discretion of the company that owned the fish. (If a farmer desired to have more than 10 fish tagged, then up to 40 fish would be tagged.). All fish were to be doubled tagged so that tag shedding (which may be higher for fish tagged in cages) could be accounted for in the estimation of reporting rates. Standard conventional tags labelled with return to CSIRO were used in 2002/2003 pilot experiment

Based on the success of the 2002/2003 experiment in terms of no reported negative concerns having been reported by industry relative to mortality and growth of seeded tagged fish, the same approach was used in 2003/2004. The only substantive difference between tagging in 2003/2004 from that in 2002/2003 was that CCSBT labelled tags were used. This should help to ensure the intended "double blind" nature of the seeding experiments (i.e. that seeded and un-seeded tags are indistinguishable) since almost all recent SBT tagging has been done with CCSBT labelled tags.

Estimation Model for Reporting Rates

For the preliminary results present here, reporting rates were estimated as

$$\lambda = \left(\sum_{i}^{n} \frac{R_{i,j}}{(1-\gamma_j) N_{i,j}} \right) \Big/ n \qquad (1)$$

where

λ = the estimated reporting rate;

γ_j = the estimated tag shedding rate for the j^{th} tagger;

$N_{i,j}$ = the number of tags seeded into the i^{th} tow cage tagged by j^{th} tagger;
$R_{i,j}$ = the number of recovered seeded tags from the i^{th} tow cage tagged by j^{th} tagger;
n = the number of tow cages with seeded tags.

Note that the shedding rate is defined as the number of seeded tagged fish which have shed both tags prior to have been recaptured. The tagger specific shedding rate is estimated by

$$\gamma_j = \left(\frac{S_j}{R_{.j}} \right)^2 \qquad (2)$$

where

γ_j = the estimated tag shedding rate for the j^{th} tagger;
$S_{.j}$ = the number of fish which tags were recovered with only one tag from seeded fish tagged by the j^{th} tagger;
$R_{.j}$ = the total number of recovered seeded tags tagged by the j^{th} tagger.

Note that this estimate of the shedding rate (γ_j) assumes that the probability of losing one of the two double tags is independent.

Results

2003/2004 Tag Seeding

In 2003/2004 out of a total of 36 tow cages, tags were seeded into 22 of them at the time of transfer. All seeded tagged fish were double tagged and the target of 10 fish per tow cage was achieved or exceed in all cases. A total of 224 tag seeded fish were released into farm cages. A list of tag numbers and tow cage numbers has been sent to CCSBT and the release data have been incorporated into their data base. As of August 9, 2004, the CCSBT had received and entered return data for 39 of thw 2003/2004 tag seeded releases. This number of returns should not be taken as indicative of the level of tag reporting. Harvesting operations are still under way and substantially more returns are anticipated. As in 2002/2003, there have been no reports of any of the tag seeded fish dying prematurely or any other negative effects on the fish from as the result of tagging.

Tag shedding from the 2002/2003 experiments

Table 1 provides estimates of the number of tag seeded fish from which tags were returned by each tagger, the number of these for which two tags were returned and estimates of the shedding rate by tagger. The mean for the fraction of fish for which only a single tag was returned was 0.14. However, there was considerable variation among taggers (i.e. 0.06 to 0.20). Nevertheless, the overall estimated shedding rate (i.e. the probability of fish shedding both seeded tags) is relatively small in all cases (a maximum of 0.04).

Preliminary Reporting rates from the 2002/2003 experiments

Table 2 lists the number of tagged seeded fish that were released and the number that were recovered by tow cage. Also given is the percentage returned from each cage, which is an

estimate of the reporting rate for that cage uncorrected for tag shedding. Correcting these reporting rates for tag shedding using the individual tagger estimates in Table 1 and excluding the one cage for which only single tagging took place yields an estimate of the mean reporting rate among cages of 0.66 (s.e. = 0.092). This compares to an uncorrected mean rate among cages of 0.64 (s.e. = 0.099). Note that the standard error for the reporting rate corrected for tag shedding does not take into account the uncertainty associated with the tag shedding rate estimates.

Discussion

The estimated reporting rates presented here are preliminary as there are a number of statistical estimation issues that should be explored further. Thus, the tag shedding rates are assumed to be a function only of the tagger, when in fact there is probably also a component due to the farm in which the seeded tagged fish resided in. In previous tag seeding experiments in 1997 and 1998, tag shedding rates were substantially higher (mean across cages of 0.060 and 0.11 respectively) and there was considerable variation among cages ranging from 0 to 0.56. This was in spite of the fact that all tagging was by a single individual in these years. Thus, differences among cages could arise from differences in stock densities and other aspects of fish management while in the grow-out cages. The considerably lower shedding rate observed in 2003 may be the results of improvements in farming techniques since 1998, but further data would be needed to evaluate this. In addition, the estimates of the shedding rates do not take into account the time between release and recovery (shedding rates would expected to increase with time at liberty). However, the range of recovery times was relatively narrow (on the order of a few months). As such, the differential times in the farms is probably not a large source of variation in the shedding rates, but this should be confirmed when more data are available. Nevertheless, the low estimated shedding rates in 2003 indicate that the overall estimates of reporting rates from these shedding experiments will be relatively robust to the development of a more detailed model for the shedding process.

In addition to these issues, there is a need to develop appropriate error models for the overall shedding rate estimates that take into account the large variation among cages/farm operations. While such models are unlikely to have effect on the estimated expected value for the reporting rates, the development of such models is critical for being able to estimate the degree of confidence that should be given to overall estimates of mortality rates and population abundance estimates from tagging analyses that use these reporting rate estimates. The development of appropriate error models is also important in determining the relative weights that would be given to tagging data from the overall SRP in an integrated SBT assessment context.

Finally with respect to statistical issues, the question of the representativeness of the estimates (i.e. bias) needs to be considered. There are two potential concerns (1) the selection of the tow cages that were seeded and (2) the effect that seeding itself can have on reporting rates. For two of the six cages in 2003 in which seeding occurred, the farm operator has in the past and was going to undertake tagging irrespective of tagging seeding as part of monitoring of fish growth in the cages. As such, in this case, there was very high awareness and motivation to recover tags. The two highest reporting rates were obtained from these two cages (75 and 100%). If the other cages are considered more representative of the “average” farm, the reporting rate would have been 55%. The other issue is that seeding itself may change the reporting rate for a farm both as a result of the increased awareness knowing that seeded tags have been placed in your cages. In addition, the finding of one tag, may stimulate

increased attentiveness and propensity to look for and return tags. Ideally, all cages (or very high proportion) of cages should be seeded to avoid these types of potential bias.

It should also be noted that one seeded tag was returned from a recreational fisherman fishing outside the cages in Port Lincoln. This presumably represents an escapee from one of the farms. While the expectation is that such escapes are rare, they could potentially slightly confound the interpretation of the seeding results – i.e. some (small) fraction of the non-reported seeded tags could represent escapees from the farm. In terms of the analyses of the overall tagging data, the question would be whether such escapees essentially die in the Port Lincoln area as a result of been caught and placed in the farm (e.g. because of having developed a dependency on the farms for feeding) or whether they return to the wild stock. In the former case, it would be appropriate to include escapee as part of the non-reported returns, in the latter they should be counted as non-captured tagged fish.

The preliminary estimated reporting rates presented here are low based on past expectations from the 1990's Recruitment Monitoring tagging program. Based on returns rates per thousand fish caught in the surface and Australian longline fishery, reporting rates were generally estimated to have been on the order of 100% or greater (Polacheck, et al 1998). Additionally, some preliminary analyses of tag seeding experiments conducted in 1997 and 1998 suggest reporting rates of 86 and 76%, respectively, although there is a large amount of uncertainty about these estimates because of the high shedding rates observed for some cages (Polacheck, personal communication). The apparently lower reporting rates from the surface fishery in the current CCSBT SRP tagging program are of concern for the levels of precision that may be achieved in population and mortality rate estimates derived from the program. During the 1990's, there was a much higher degree of direct, personal interaction between the industry and the tagging program, including a liaison officer with a large fraction of his time dedicated to tag return related activities. Although difficult to determine, it is our impression that such direct and personal interactions have a large effect on the subsequent reporting rates.

Literature Cited

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Acknowledgements

We wish to acknowledge the cooperation of those tuna farm operators that allowed tagging seeding to be undertaken within their cages. Without such cooperation, these tag seeding experiments would not be possible. We also wish to thank Protec Marine for their assistance with the tag seeding and tag return operations. The Australian Government Department of Agriculture, Fisheries and Forestry (DAFF) provided funding support for this project.

Table 1: summary of tag shedding results and rates by tagger for tag seeded fish from the 2002/2003 tag seeding experiment.

Tagger	No. Tagged fish recovered	No. With two tags	Fraction with only one tag	Shedding rate
1	35	33	0.06	0.003
2	6	5	0.17	0.028
3	15	12	0.20	0.040
total	56	50	0.11	0.011
			(mean 0.14)	(mean 0.024)

Table 2: Summary of tag returns by tow cage from the 2002/2003 tag seeding experiments.

Cage	Tagger	No. Tagged	No. Returned	% Returned
1	1	20	20	100
2	1	20	15	75
3	2	10	6	60
4	3	10	5	50
5	3	11	7	64
6	3	10	3	30
7*	4	38	20	53

* The tagger in this case mistakenly only single tagged the fish