Tag seeding activities in 2004/2005 and preliminary estimates of reporting rate from the Australian surface fishery based on previous tag seeding experiments

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Table of Contents

Abstract

A pilot tag seeding project was conducted in 2002/2003 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 and 2004/2005 fishing seasons. 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 a report on the seeding conducted during the 2004/2005 surface fishing season. In addition, initial analysis of the results obtained in the 2003/2004 tag seeding experiment are reported and compared with results from the 2002/2003 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), and overall tags from 49.1% of the fish were recovered. In 2004/2005 tag seeding took place for 34 of the 36 tow cages. Harvesting operations for 2004/2005 are still under way and as such the total number of returns is unknown at this point. For all years 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 2003/2004 tag seeding experiment and a report on the seeding conducted during the 2003/2004 and 2004/2005 surface fishing seasons.

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, and thereafter CCSBT labelled tags.

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 and 2004/2005. The only substantive difference between tagging from that in the 2002/2003 pilot experiment and subsequent tag seeding 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. In 2003/2004 , some of the taggers preforming the tagging in the seeding experiments were inexperienced because of unanticipated need for Protec Marine, the company that undertakes the 40 fish sampling, to engage extra staff. It became apparent when the results of the 2003/2004 seeding experiments were available, that high shedding rates were high for some taggers (see results below). Consequently, a preseason tag training workshop was conducted prior to the 2004/2005 tag seeding and only personnel that had been trained conducted tag seeding in 2004/2005 in order to reduce shedding rates. The workshop covered the rationale of tag seeding and instructed the taggers in tag insertion techniques.

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

2004/2005 Tag Seeding

Fish were tagged and seeded into farms from 34 of the 36 tow cages (94%) in 2004/2005. This was an increase from the 61% of cages that were seeded the year before. To date, few seeded tags have been returned to CCSBT. Nevertheless, tag shedding rates appear to have been reduced considerably over 2003/2004 (Table 1). However, harvesting operations are still under way and substantially more returns are anticipated. As such, the data in Table 1 are only indicative of the likely final shedding rates.

Tag shedding

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 for each fishing season. In 2003/2004, the mean for the fraction of fish for which only a single tag was returned is 0.46. However, there was considerable

variation among taggers (i.e. 0.23 to 0.71). This results in estimates of shedding rates (i.e. γ_j - the probability of losing both tags) ranging from 0.05 to 0.51. The rates are considerably higher then those observed in 2002/2003 in which the average fraction of fish for which only a single tag was returned was 0.14 (range 0.06-0.20) and the maximum estimate of γ_j was 0.04 among taggers in this season.

Reporting Rates

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. For 2003/2004, 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 0.63 (s.e. = 0.076). This compares to an uncorrected mean rate among cages of 0.51 (s.e. = 0.070). 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. Also, for five cages, the tag-shedding corrected reporting rates were over one and were truncated at 1.00 in estimating the overall mean. There appears to be little relationship between taggers shedding rate and the resulting estimates of cage specific reporting rates (Figure 1). Also, there is substantial variation among the reporting rates from individual tow cages for a company (Figure 2).

The tag-shedding corrected reporting rates for 2003/2004 were similar to those obtained in 2002/2003. Thus, in 2002/2003, the comparable mean reporting rate among cages when corrected for tag shedding was 0.66 (s.e. = 0.092).

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. The tag shedding rates in 2003/2004 were substantial higher then in 2002/2003 (i.e. the average probability of fish losing both tags was 0.24 compared to only 0.02 and there was substantial variability among taggers (0.05 – 0.51). The higher rates and large variation most likely reflects the inexperience of some of the taggers more then variation among farming techniques among companies. Both high and low shedding rates were observed among cages from the same farm. Nevertheless, there may also be a cage effect. Thus, in previous tag seeding experiments in 1997 and 1998, the variation among cages ranged from 0 to 0.56in spite of the fact that all tagging was by a single individual in these years.

It should be noted that 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. While this is unlikely to affect the estimates substantially, it does point to the need to develop a more detailed shedding model, particular when shedding rates are high. .

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 an effect on the estimated expected value for the reporting rates, the development of such models is important for being able to provide robust estimates of 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.

It should also be noted that one seeded tag from the 2003/2004 seeding was returned from a recreational fisherman fishing outside the cages in Port Lincoln, and similarly 2 from the 2004/2005 seeding. These presumably represent escapees from 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 for both 2002/2003 and 2003/2004 are consistent in magnitude and suggest that only ~2/3rd of the tags are returned. They are lower then 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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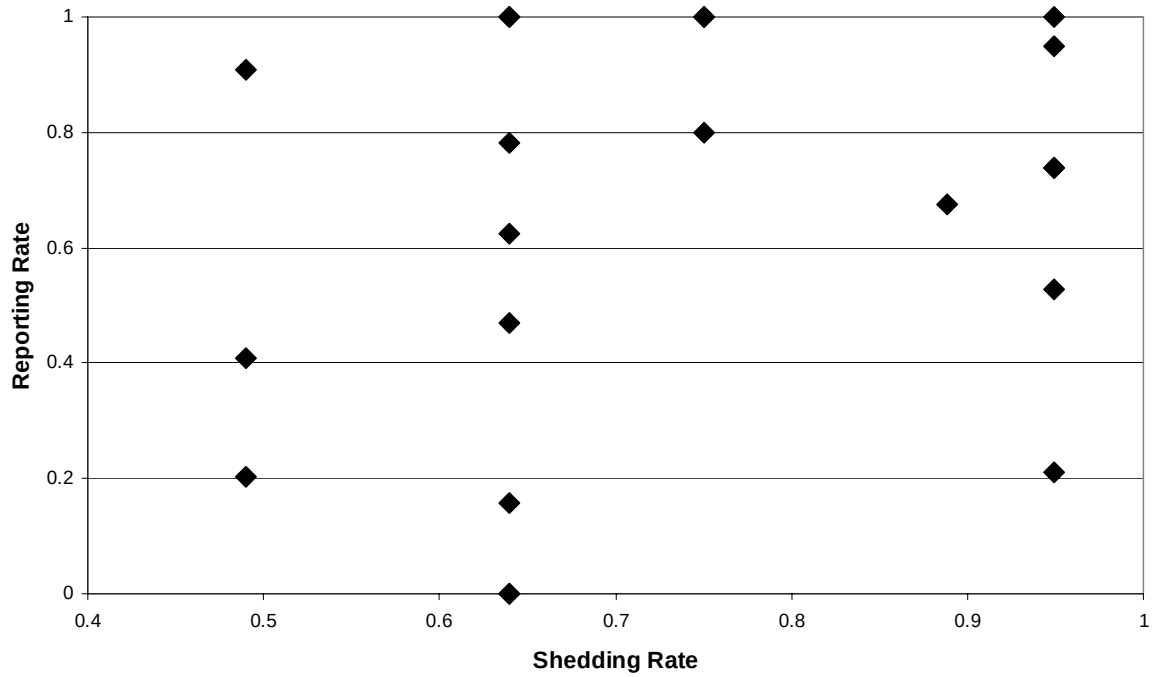

Figure 1: The reporting rate from individual cages versus shedding rates from the 2003/2004 tag seeding experiments. Each vertical row of points represents the results from an individual tagger.

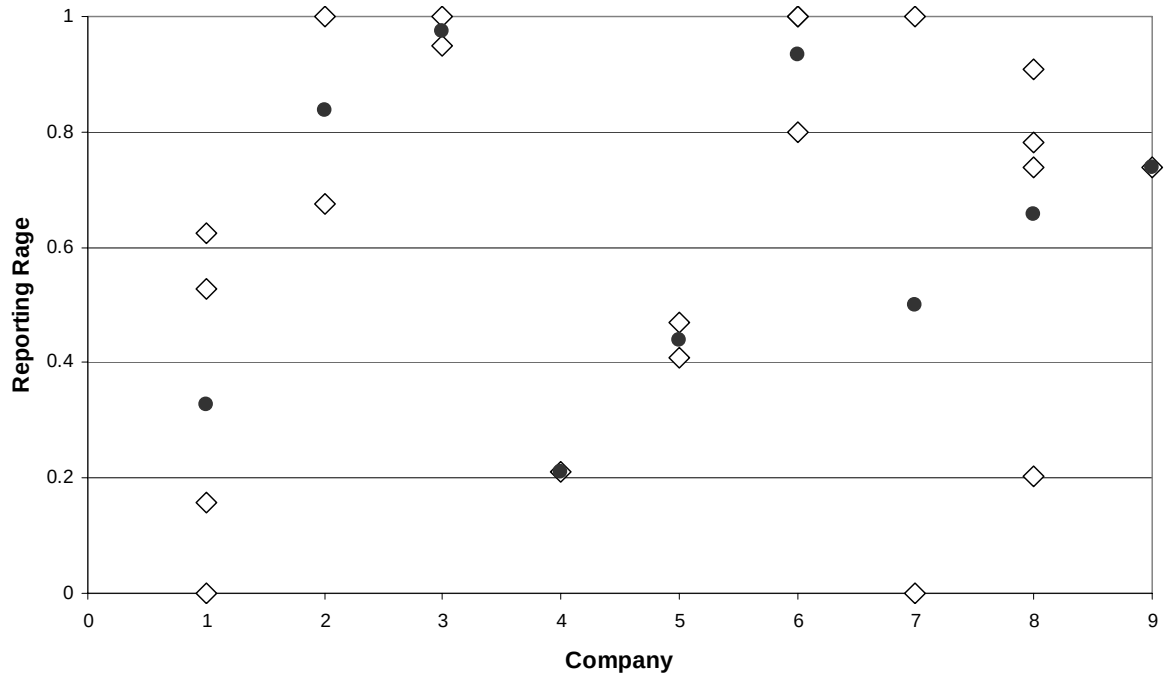

Figure 2: Reporting rates for different companies based on the 20032004 tag seeding experiments. The open diamonds represent the estimate for individual cages and the solid circle in the mean rate for that company.

Table 1: summary of tag shedding results and rates by tagger for tag seeded fish from the tag seeding experiments.

Tagger and year	No. Tagged fish recovered	No. With two tags	Fraction with only one tag	Shedding rate
2002/2003				
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)
2003/2004				
3	24	11	0.54	0.293
4	40	31	0.23	0.051
5	30	15	0.50	0.250
6	7	2	0.71	0.510
7	6	4	0.33	0.111
			(mean 0.46)	(mean 0.243)
2004/2005				
3	2	1	0.50	0.250
4	18	16	0.11	0.012
5	7	5	0.29	0.082
6	1	1	0.00	0.000
			(mean 0.23)	(mean 0.086)

Table 2: Summary of tag returns by tow cage from the 2002/2004 tag seeding experiments.

Cage	Tagger	No. Tagged	No. Returned	% Returned
2002/2003				
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
2003/2004				
1	4	10	7	70
2	5	10	5	50
3	4	10	7	70
4	6	10	1	10
5	6	9	3	44
6	5	10	0	0
7	5	10	8	80
8	3	10	8	80
9	3	10	8	80
10	3	10	6	60
11	6	10	2	20
12	5	10	3	30
13	4	10	2	20
14*	8	16	5	31
15	4	10	10	100
16	4	10	9	90
17	5	9	9	100
18	7	10	6	60
19	5	10	1	10
20	5	10	0	0
21	5	10	4	4
22	4	10	5	50

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