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Review of Methods for Estimating Tag Reporting Rates and Their Applicability to SBT Longline Fisheries

Tom Polacheck
J. Paige Eveson
Geoff M. Laslett

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Abstract

This paper reviews alternative approaches to the use of observers for estimating tag reporting rates and discusses their applicability for obtaining estimates from the SBT longline fisheries. Five basic approaches were identified and reviewed. Of these, only the use of high reward tags appears to have any potential to provide robust and direct estimates. However, the logistic and reward issues associated with this approach would appear to make its realization problematical and also quite expensive. However, developing technologies may make approaches based on automatic detection systems more feasible in the future and, as such, might warrant further investigation if tagging is to be used as a long term monitoring strategy for SBT.

Introduction

As part of its Scientific Research Program, the CCSBT is undertaking a large-scale tagging program of juvenile SBT in order to obtain improved estimates of natural mortality and timely, reliable estimates of current juvenile fishing mortality rates (Anon. 2001). A critical component in the analyses of the data from such a tagging program is the ability to estimate reporting rates (i.e. the proportion of tagged fish, captured by fishermen, actually returned to the CCSBT). The 2003 CCSBT Scientific Committee concluded that the current levels of observer coverage in the Japanese, Korean and Taiwanese longline fleets are not high enough to provide useful estimates of reporting rates from these fleets and thus fishing mortality rates in these fleets (Anon. 2003). The overall implications of this conclusion for the ability of the SRP tagging program to meet its primary objectives were not certain and the Scientific Committee agreed to convene a Technical Group Meeting in conjunction with its next meeting to evaluate this question. One of the terms of reference for this working group was to "consider alternative methods, other than increasing observer coverage, for improving the estimates of reporting rates" (Anon. 2003). The current paper reviews approaches for estimating tag reporting rates and discusses their applicability for obtaining estimates from the SBT longline fisheries. Based on a review of the tagging literature, five basic approaches were identified and are reviewed here:

1. High reward tags
2. Tag seeding
3. Automatic tag detection systems
4. Extrapolation from estimates from the surface fishery
5. Model-based approaches

High reward tags

One approach to estimating reporting rates that has been used in tagging studies is to have a high reward associated with a relatively small fraction of the tags being released (Pollock et al. 2001). Those tags carrying a high reward must be clearly identifiable by a tag finder (e.g. different colours) and carry a sufficiently high reward that 100% of these tags will be returned by all tag finders. The ratio of the return rate (i.e. the number of tags returned divided by the number of releases) of "regular" tags compared to that of high reward tags provides a direct estimate of the reporting rate. Fishery-specific reporting rates can be estimated using this approach by considering within-fishery return rates.

For this approach to be viable, a sufficient number of high reward tags must be caught within each of the fishery components so that a viable reporting rate can be obtained, taking into account overdispersion in the recapture probabilities and potential incomplete mixing. This might require that a relatively high number of high reward tags are released given the differential age-specific mortality rates between fishery components (e.g. a large number of high reward tags would be vulnerable to capture in the surface fishery at ages 2 and 3, prior to the ages of where fish are being captured in reasonable numbers by longline vessels). High reward tagging also requires that there is sufficient publicity that the fishermen on all vessels in each of the fishery components are aware of the existence of these high reward tags and the rewards they carry. There also must be well developed procedures in place to ensure that these high rewards actually are paid to those finding the tags. In addition, as already stated, the magnitude of the reward must be large enough that 100% of the high reward tags are returned. It is these latter two requirements that would appear to be the most difficult to meet within the SBT longline fisheries.

Past experience has shown that it can often be difficult to ensure that the tag finder is the person who actually receives the reward for a returned tag. This is due to the long time lags between tag finding and actual tag returns as a result of long fishing trips, logistic problems with contacting and getting returns back to individual crewmen, and problems with determining who to actually reward (e.g. the fishing master will often collect tags with the identity of the actual tag finder being lost, and thus removing the incentive to return tags from those actually responsible for finding them).

More problematical is determining a reward that would provide sufficient incentive to ensure a high degree of certainty that 100% of the recaptured high reward tags would be returned. Experience with the provision of rewards for archival tags indicates that a reward with a value on the order of $250A has not been sufficient to ensure near 100% reporting rates (i.e. return rates for archival tags with a $250 reward and conventional tags from longline vessels have been similar and low). The problem of suitable rewards is also compounded by the fact that in some fleets cash rewards are considered unacceptable and the incentive for any particular “in kind” reward is hard to assess.

In summary, high reward tagging does have the potential to provide estimates of the reporting rates from longline vessels. However, the logistic and reward issues would appear to make realization of this potential problematical and also potentially quite expensive.

Tag seeding

Tag seeding is a common approach that is used to estimate tag reporting rates in some commercial fisheries and is being used in the current SRP tagging program to provide estimates of reporting rates from the Australian surface fishery. The basis of tag seeding experiments is to plant tags into fish after they have been captured but before those handling and/or processing them have had a chance to actually recover the tags (e.g. prior to unloading of the catch for processing in a cannery). The proportion of planted tags recovered then provides a direct estimate of the reporting rate. It is critical that the tag seeding is done blind in the sense that the tag finders are unaware of the tag seeding and that tag seeded fish are indistinguishable from wild tagged fish. In the case of pelagic tuna longline fisheries, each fish is individually hauled on board and processed at the time of landing. As such, longlining provides no opportunity for tags to be seeded without the fishermen being aware of the tags being planted in the harvested fish. As such, tag seeding does not provide a viable alternative for estimating reporting rates for the SBT longline fisheries.

Automatic tag detection systems

Automatic tag detection systems (e.g. PIT tags) provide one approach for either eliminating the need to estimate reporting rates altogether or for estimating reporting rates. In the former case, it is essential that systems are in place that would ensure that all tuna landed pass through the detection system and the reliance on fishermen for tags is eliminated. Given the complex array of landings, transhipment and markets that are involved with SBT, a practical and acceptable system that was intended to detect all tags post-landing would be extremely difficult to implement, particularly within the timeframe of the current SRP, and would likely be expensive (both financially and in terms of labour) to operate and maintain. Alternatively, an automatic detection system could conceivably be developed for detecting tagged fish at the point of landing on a longline vessel. Such a system would need to be coupled with a system that ensured (or at least monitored) whether all fish were in fact passed by the automatic detection apparatus (e.g. video monitoring of the landing area?). Development and employment of such systems would require a strong level of commitment and appreciation for their need by industry. The initial cost of such a system would be expensive, but once deployed might be relatively cost effective compared to on-board observers, particularly if tagging was to be used as a long term monitoring approach.

Alternatively, automatic tag detection systems could be used in conjunction with conventional tagging to estimate reporting rates. In this case, a certain fraction of the fish tagged with a conventional tag would be also be tagged with an automatically detectable tag. Then, a proportion of the catch would be scanned for the automatically detectable tags at the time of landing. In this case, the automatically detectable tags would need to be cryptic with respect to the fishermen, which is the case for PIT and coded wire tags. The proportion of conventional tags that were retrieved from fish that were detected with an automatically detectable tag would then provide an estimate of the reporting rate.

This approach requires that both a representative and substantial fraction of the landed catch be scanned for automatically detectable tags. Current technology for automatically detectable tags requires that fish are individually scanned with a detection device or that fish come within a few meters or less of the detection device. This, combined with the large range and variety of landing and marketing options for SBT, would make obtaining representative, large scale samples post-harvesting extremely difficult. Thus, to obtain large scale representative sampling would require a large number of on-the-ground technicians to do the scanning with ability to obtain relevant information on the detected scanned fish (i.e. location and time of capture) and access to the different landing/marketing venues.

It should be noted that technologies are evolving. The potential exists for automatic tag detection systems with much greater detection ranges that require less human involvement and still have high probabilities of detection without direct human monitoring. In this case, the use of automatically detectable tags might be a feasible and cost effective alternative in the future.

Finally, industry has expressed concern about potential consumer issues with past proposals to use automatically detectable tags (e.g. PIT tags). This relates to the placement of the tag and the potential for the tag to go undetected prior to being sold and/or consumed. Placing the tags within the body cavity is not viable if detection is to take place after the fish have been landed since fish are gutted at this point. Previous proposals have suggested placing PIT tags in the head; however, the heads of SBT are sold and eaten. Industry objected to placing such tags within the head because of possible liability if a tag were eaten, plus the potential for associated negative publicity. Developing acceptable tag placement arrangements which overcome such concerns would also be required prior to any large scale use of automatically detectable tags.

Extrapolation from estimates from the surface fishery

Tag reporting rates can be extrapolated from the surface fishery assuming complete mixing and that reliable estimates of reporting rates are available for the surface fishery (Hearn et al. 2003). This can be done by comparing, for each age class, the ratio of the number of tagged fish returned to the total number of fish caught in the longline fishery to the ratio of the number of tagged fish returned (after correcting for the estimated reporting rate) to the total number of fish caught in the surface fishery. The age-specific reporting rates can then be combined to provide an overall estimate of the reporting rate for a fishery within a year, assuming that reporting rates within a fishery are independent of age of the recaptured fish.

Extrapolations from the surface fishery require that reliable estimates of the catch at age data are available for both the surface fishery and the longline fishing components for which reporting rates are to be estimated. The precision of extrapolated reporting rate estimates for a longline component will be dependent upon the precision of the catch at age estimates for both the surface and longline components. A poorly estimated catch at age distribution in either component will translate into poorly estimated reporting rates.

If the assumption of complete mixing is violated and not accounted for, then biases will be introduced in tag-based estimates of mortality rates and population size, and these biases will be compounded by biases in reporting rate estimates when extrapolation methods are used to estimate them. This is because in the extrapolated reporting rate estimates, low return rates will be taken to signify low reporting rates. Thus, the estimated actual number of returns will be inflated. However, if the low return rate is due to incomplete mixing of tagged fish into areas of longline vulnerability, the actual number of returns should not be inflated (and this would be the case if an independent estimate of the reporting rate was available for the longline component). In addition to the compounding of biases, the reliance on extrapolated reporting rates can preclude the use of diagnostic tests for non-mixing (e.g. it is not possible to separate non-reporting in an area/time strata from lack of tagged fish being in that area/time strata). Moreover, the use of extrapolated reporting rates would prevent the application of more spatially explicit tag recovery models to account for heterogeneity in recapture probabilities as a result of non-mixing.

Model-based approaches

Within a Brownie estimation framework, it is theoretically possible to estimate tag reporting rates from the tagging data alone if reporting rates and natural mortality rates are constant over time[1]. However, except within specific special circumstances, the estimates are extremely imprecise (Hoenig et al. 1998; Pollock et al. 2001). Constancy in the reporting rate for the CCSBT SRP tagging program seems unlikely because of the evolving nature of the return promotional activities combined with the differential and changing age-specific catches within the various fishery components (since overall reporting rates for any age class in a given year are a weighted average of the reporting rates within each fishery component weighted by the catch in that component). Moreover, such model-based estimates of

[1] Some relaxation of these constancy assumptions may be possible if multiple cohorts as well as multiple years of tagging of the same cohorts are done.

reporting rates would preclude the use of diagnostic tests for non-mixing or the application of spatially explicit models to account for it.

Discussion

Substantial problems appear to exist with all five approaches identified and reviewed as alternatives to the use of observers for estimating tag reporting rates in the context of SBT longline fisheries. Two of the approaches, namely extrapolation and model-based approaches, are indirect (i.e. they use no direct observational data on the actual reporting rates). The model-based approach provides highly imprecise estimates in most cases and requires restrictive assumptions about constancy in reporting rates and natural mortality rates. Extrapolation from the surface fishery requires accurate and precise estimates of the reporting rates in the surface fishery and of the size/age composition of the catch from all fleets. More importantly, the estimated reporting rates for the longline fisheries are dependent upon the assumption of complete mixing. Violation of this assumption will introduce biases in extrapolated reporting rate estimates, which can compound biases that already exist in tagging estimates of mortality rates and population size when non-mixing is not accounted for. Moreover, extrapolation methods preclude diagnostic testing for non-mixing as well as the use of spatially explicit tag recovery models.

Two of the three approaches that provide direct estimates of reporting rates are logistically infeasible, at least at the current time (i.e. automatic detection systems and tag seeding). However, developing technologies may make automatic detection systems more feasible in the future and might warrant further investigation if tagging is to be used as a long term monitoring strategy. The third direct method, high reward tagging could potentially provide a way to estimate reporting rates. However, it is not clear what would serve as a sufficiently attractive, yet still affordable, award to ensure 100% reporting of such tags, and there are also substantial logistical problems with its implementation. It should be noted that it would be possible to combine the high reward tagging and the observer approaches for estimating reporting rates. The combined data would provide an improvement over data from a single approach (Pollock et al. 2002). However, the relative trade-off and improvements is not straightforward to determine and would depend upon a large number of relatively unknown factors. It is also possible to use high reward tags in just one component of the longline fishery to estimate reporting rates for that component, and then use these estimates along with the extrapolation method to estimate reporting rates in the other longline components; however, all of the assumptions and potential problems associated with the extrapolation method would still apply.

In summary, of the alternative approaches to the use of observers for providing estimates of tag reporting rates from longline vessels, only the use of high reward tags appears to have any potential to provide robust and direct estimates. However, logistic and reward issues make realization of this potential problematical and also potentially quite expensive.

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