Short communication

Combining passive integrated transponder tags with conventional T-bar tags to improve tag reporting rates in a rock lobster trap fishery

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Abstract Tag reporting rate is an important parameter required for estimating fishing and natural mortality in fished populations. It is an extremely difficult parameter to estimate and can vary both during the fishing season and between fishing years. Improving tag reporting rates has been identified as a cost-effective way of improving precision in fishing and natural mortality estimates derived from tagging data. In this study we evaluated the use of passive integrated transponder (PIT) tags to improve tag reporting rates in a lobster (Jasus edwardsii) trap fishery. To minimise the risk of PIT tag ingestion by consumers, we tested insertion of the PIT tag into the base of the antennae, the base of the walking leg, and the base of the telson. The base of the antennae proved to be the best option for lobster health although impacts were observed at all tag insertion sites. We further developed and tested a hybrid tag that combined a conventional external T-bar tag with a PIT tag embedded within the shaft. PIT tag scanners were positioned in bottlenecks in the capture process so that all lobsters retained on board the vessel were passed through a scanner. Thus, the tag reporting rate was expected to be 100% for the subsample of the fleet fitted with scanners when scanners were operational. Scanner malfunction was a major issue and further engineering solutions are required to ensure that scanners are reliable when working in harsh marine conditions such as on-board fishing vessels. Advantages of the hybrid tag are: the ability to be detected by both automatic detectors and fishers; known tag-induced mortality and tag loss rates from previous research; and PIT tagging without risk of human ingestion.

Keywords lobsters; mortality rates; Jasus edwardsii; hybrid tag; tag location

INTRODUCTION

Over the last two decades, there has been increased attention directed towards the development and use of mark recapture analysis to determine exploitation rate and natural mortality in fisheries (Hoenig et al. 1998; Hearn et al. 1998; Frusher & Hoenig 2001a, 2003). To separate total mortality rate into fishing and natural mortality rate, an estimate of tag reporting rate is required (Pollock et al. 2002). Tag reporting rate is normally included as an average of the entire fishing fleet and estimated as a single parameter that is held constant over the fishing season and between fishing years (Frusher & Hoenig 2001a). However, tag reporting rates could vary significantly between participants within the fishing season, and between fishing years. For example, adverse
weather may make it difficult to record tags, new deckhands may have different levels of motivation to check and report tags, and enthusiasm to report tags may change between fishing years. Improving tag reporting rate to take account of temporal variation has been identified as one of the most effective ways of improving the accuracy and precision of fishing and natural mortality estimates from multi-period mark-recapture studies (Frusher & Hoenig 2001b; Burch 2002).

Multi-period mark recapture models incorporate a tag reporting rate parameter that captures three terms: the actual tag reporting rate, tag loss, and tag induced mortality (Hoenig et al. 1998). It is now possible to separate these components for the southern rock lobster Jasus edwardsii (Hutton, 1875) with the recent development of methods for the quantification of tag loss and tag-induced mortality from T-bar tagging data (S. D. Frusher unpubl. data). Similar information is not available for passive integrated transponder (PIT) tags in this species although the same analytical methods could be applied.

The T-bar tag (Hallprint Pty Ltd, Australia) is the most commonly used tag in lobster fisheries (Claverie & Smith 2007). It is attached dorsally between the carapace and the first abdominal segment or ventrally in the first abdominal segment. As these tags have an external component, they can be detected by fishers without specialised equipment. PIT tags are a more recent development and have been tested in several fisheries (see Gibbons & Andrews 2004) with most studies focused on estimating survival rather than fishing and natural mortality.

An important benefit of PIT tags is that they can be detected automatically—an attribute we exploited in this research. PIT tags emit short-range radio frequency signals after being “energised” by an electromagnetic field created by a dual coil radio frequency tag exciter-scanner. As the tags require no internal power source they are small enough to insert into animals such as lobsters. Automatic scanners can be used to detect PIT-tagged animals along “bottlenecks” in the capture or survey process whereby the fish, or a subsample of the fish, are passed by the scanner. However, their detection distance decreases with reduction in the size of the tag and the power of the scanner, with detection distances often less than 20 cm (Gibbons & Andrews 2004). In this paper we describe a new hybrid tag that combines the conventional T-bar tag with a PIT tag to enable reporting by both automated scanners and fishers. The external placement of the tag was also anticipated to improve tag detection by scanners.

Previous research with PIT tags has involved injecting the tag within the abdominal tissue thereby introducing risk to human consumers, which is especially problematic where the coating of PIT tags is glass. A “food-safe” PIT tag was developed by ENSID Technologies Ltd (Victor Harbor, Australia) in conjunction with National Institute of Water & Atmospheric Research (NIWA, New Zealand) by coating the tag with United States Food and Drug Authority (US FDA)-approved surgical plastics. These tags can withstand extreme temperature (–84°C to 100°C), pressure (up to 900 bar) and shock (IEC 68-2-29 & IEC 68-2-26), and are compatible with most PIT tag scanners (ENSID Technologies Ltd, New Zealand; www.ensid.com). The plastic coating resulted in the tag being slightly larger in outside diameter (OD) than standard glass PIT tags (2.86 mm OD cf. 2.12 mm OD). Although the coating has enabled the use of PIT tags to meet US FDA standards, there remain concerns about the ingestion of the tag by consumers. We examined methods to reduce this risk, first by testing tag insertion locations that minimise the potential for ingestion, then through the use of the hybrid T-bar PIT tag.

**MATERIALS AND METHODS**

**Internal tag insertion trials**

PIT tags (ISO 11784/11785, frequency 134.2 kHz FDX-B; Hallprint Pty Ltd, Australia) were coated in a food-grade plastic and inserted into southern rock lobster using a single shot applicator to one of three positions. These positions contained sufficient muscle tissue to hold the tags, yet were in locations that would reduce the potential for the tag to be ingested by humans. The three tagging locations were muscle tissue at the base of the left antennal horn, the base of the third walking leg, and within the base of the telson. For each tagging location, 6 lobsters of each sex were PIT tagged. All lobsters were randomly selected and after tagging were placed in the same tank. Six untagged lobsters of each sex were also held in the same tank as a control. Lobsters from different treatments were fixed with different coloured antennal tags to allow identification.

The lobsters were then checked using a handheld scanner to read and confirm the tag identification number, and maintained in a tank with a flow-through system and fed a diet of mussels, squid and pellets every 2–3 days ad libitum. The lobsters were checked daily for 40 days to monitor mortality
and moulting. The tank was drained weekly and all lobsters checked for damage and tag retention. Notes were made when obvious damage and/or colour change occurred around the tag insertion point.

Adult southern rock lobster undertake an annual moult with female and male lobsters primarily moulting from May to June and from September to October in Tasmania, Australia, respectively (Ziegler et al. 2003). To ensure that there was no effect on tag retention by sex, we ran experiments before both moulting periods. One trial began in April 2004 to evaluate the impact of tagging of females in pre-moult, tag retention during the female moult, and the impact of tagging males during intermoult. Another trial began in early August 2004 to evaluate the impact of tagging males in pre-moult, tag retention during the male moult, and the impact of tagging females in intermoult.

To determine the probability of recapturing PIT-tagged lobsters, both tag loss and mortality were combined across all treatments and compared with that of control lobsters using a 2 × 2 contingency test (Sheskin 2007). To determine if any of the three PIT-tag insertion locations provided significantly improved detection rates, tag loss and mortality were combined for each treatment and compared between treatments using a 2 × 3 contingency test. Owing to the low numbers in each cell of the contingency tables, Fisher’s exact test statistic ($P < 0.05$) was used (Sheskin 2007).

**Hybrid T-bar PIT tag**

We developed and tested a hybrid tag that incorporated the glass PIT tag within the external flexible section of the conventional T-bar tag (Fig. 1). As the PIT component was carried externally, it did not require a food-safe plastic coating, which reduced the outside diameter of the PIT tag from 2.86 mm to 2.12 mm so that it was more easily moulded into the plastic T-bar tag.

We adopted the same tagging protocol used for conventional T-bar tags (Frusher & Hoenig 2001), so that tag loss and tag-induced mortality would be equivalent to estimates for the conventional T-bar tag (S.D. Frusher unpubl. data). Tag loss can also occur with PIT tags (up to 12% in sharks; Feldheim et al. 2002; 4.8% in the red king crab *Paralithodes camtschaticus*; Watson et al. 1991) but has not been quantified in *J. edwardsii*.

A total of 1162 hybrid T-bar PIT tags were inserted ventrally into the muscle tissue of the first abdominal segment in legal-sized lobsters during October 2004, before the start of the 2004/05 fishing season in early November. One hybrid T-bar PIT tag was inserted in each lobster and only healthy lobsters with no signs of damage were selected for tagging. Tag-induced mortality for this area and time of the year has been estimated at 37% (S.D. Frusher unpubl. data) resulting in effectively 732 hybrid T-bar PIT tags available for capture.

We examined the automated PIT-tag recaptures using scanners located at bottlenecks in the capture process aboard commercial vessels.

Scanners were fitted to the vessels of 12 fishers who had significant previous catch histories from our release site.

Twelve vessels were fitted with modified panel scanners (Allflex Australia Pty Ltd, Australia; ISO 11784/85; 400 mm × 600 mm × 30 mm) similar to those used in cattle and sheep stockyards. The antenna coil was sealed within laminated plastic and the electronic assembly was enclosed in a separate compartment with a gasket cover to meet IP67 specifications of being dust tight and immersible in water to 1 m. The data/power cable exited the scanner compartment through a watertight strain relief, then connected by waterproof connectors (sealed to IP67) to a data logger within a plastic housing (130 mm × 80 mm × 60 mm). The data logger had memory to record up to 5000 recaptures.
and an inbuilt clock to record event time. The unit had a switch-mode AC-DC converter that enabled use with either 12 or 24-volt power supply, which is essential as power supplies vary between vessels.

Scanners were modified by cutting various sized holes in the plastic between the antennal coil to enable lobsters to be scanned as they passed through the electromagnetic field. They were fitted to either the vessel’s wet well or to holding bins adjacent to the area where fishers removed the lobsters from their traps. Thus, all retained lobsters passed a scanner as they were placed in either the wet well or the holding bins. Lobsters fitted with the hybrid PIT tags were passed through all regions of the wet well or holding bins during installation trials to ensure that there were no “dead” regions where the PIT tag could not be detected. The data logger was mounted adjacent to the scanner and connected to the boat’s power source.

The data loggers were downloaded routinely and the scanners were checked when the vessels were in port throughout the fishing season.

**RESULTS**

There was no significant difference in the potential of detecting a tagged lobster (i.e., the lobster had neither lost its tag nor died) for either sex from either monthly trial (Table 1). Although not significantly different, the sex that was preparing to moult (i.e., females in April and males in September) had relatively fewer lobsters that were alive with the tag retained compared with the other sex.

A significant difference in the combined tag loss and mortality between tag insertion locations was only observed for male lobsters in September, which is just before the moult (Table 2). It is noteworthy that probability estimates for tag loss from males in the April trial were also low at 0.074. The only tag insertion position that resulted in the tag either being lost or the lobster dying in both sexes and both trials was at the base of the telson. In six out of eight of these lobsters the tag was lost.

During the field trials, the scanners suffered from water damage and failed to function at various

### Table 1

<table>
<thead>
<tr>
<th>Month</th>
<th>Sex</th>
<th>% survival with tag intact</th>
<th>P value</th>
</tr>
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<tr>
<td>April</td>
<td>Male</td>
<td>77.8</td>
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<tr>
<td></td>
<td>Female</td>
<td>55.6</td>
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<tr>
<td>September</td>
<td>Male</td>
<td>13.3</td>
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<td>Female</td>
<td>94.5</td>
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### Table 2

<table>
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<th>Insertion location</th>
<th>% survival with tag intact</th>
<th>P value</th>
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<tbody>
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<td>100</td>
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<td>Telson</td>
<td>67</td>
<td></td>
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<tr>
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<td>Female</td>
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<td>0.100</td>
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<tr>
<td></td>
<td></td>
<td>Leg</td>
<td>50</td>
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<td>Telson</td>
<td>67</td>
<td></td>
</tr>
<tr>
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<td>0.025</td>
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<td></td>
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<td>Leg</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Telson</td>
<td>83</td>
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</table>
times throughout the season. This problem mostly arose from the plastic laminated layers separating where the panels were cut to make an opening for passing the lobster through. Water was also found to enter through poor seals on the panel’s electronic compartment, resulting in most of the units being non-operational for several months of the season.

When functioning, the scanners detected 21 recaptures during the 2004/05 season, representing 2.9% of the total number of tags released after accounting for tag-induced mortality.

The combined effort for vessels with scanners was 31 911 trap lifts for the survey area. However, as the scanners were not fully functioning for the entire season, effort for the season when the scanners were considered to be operational was estimated at 20 234 trap lifts. The 20 234 trap lifts equate to the effort expended up to the time the scanners were found to be inoperable during the routine inspections when the vessel was in port. As the scanner only recorded information when a tag was detected, the absolute time when the scanner failed between port inspections is unknown (i.e., if no tags were recorded the scanner could have failed any time during the trip away from port). The 20 234 trap lifts are therefore considered a maximum amount of effort.

The estimate of effort for vessels fishing in the tag release area when their scanners were considered to be operational represents 6.7% of the total effort for all fishers (303 094 trap lifts) during the season. The exploitation rate estimate from these tags was approximately 45% assuming 100% tag detection by the scanners.

Tag recapture records of the fishers who had scanners fitted did not record any hybrid T-bar PIT tags that were not found by the scanner, although three of the tags recorded by the scanners were not reported by the fisher.

**DISCUSSION**

**Internal tag insertion trials**

Our results suggest that internal PIT tagging of lobsters before molting is likely to result in greater tag loss or mortalities. Similar results have been found for sphyrion tags (Moriyasu et al. 1995) and streamer tags (Comeau & Mallet 2003). In contrast, 100% PIT tag retention rate was recorded in 6 female red king crab that had moulted (Pengilly & Watson 1992).

Pengilly & Watson (1992) also found no signs of tissue necrosis or mortality in 12 red king crab that were tagged internally with PIT tags at the base of the rear walking leg. In a separate trial, tag retention was estimated at 95.2% of 145 internally PIT-tagged red king crab (Watson et al. 1991). The prevalence of tissue necrosis in tagging at the base of the leg and telson and tag morality in all treatments in our study suggested that insertion of a tag of this size in *J. edwardsii* is likely to be highly stressful and tag retention could not be guaranteed.

Although further trials with larger sample sizes are required, our initial results indicate that the base of the antennae resulted in 100% tag retention and survival in three of the four treatments (two sexes at two time periods) and is worthy of further investigation.

**Hybrid T-bar PIT tag trials**

Collecting the tag number during the fishing operation has many advantages: the fisher is known so the tag can be traced back to specific fishing grids; the exact date of capture is known; and it allows for other ancillary data to be incorporated such as global positioning system (GPS) location and depth. Disadvantages include the need to adapt the scanner to a number of different vessel configurations and the need to cover a specified portion of the fishing fleet, both of which can be expensive (see Burch et al. 2008, this issue).

Other studies have placed scanners where bottlenecks occur including processing facilities (Pengilly & Watson 1994) and dam bypass systems (Skalski et al. 1998). As there are far fewer processors, the costs would be reduced as fewer scanners would be required. Disadvantages of the processor-based scanner is the loss of information regarding the exact date of capture, the location of capture and any ancillary data associated with the capture. Processors of lobsters in Tasmania grade the lobsters according to size, colour and condition and then distribute the different grades to different holding tanks, hence multiple scanners being required for each processor. Processors prefer to minimise the time that the lobsters are out of the water and would be reluctant to pass lobsters through the openings in the scanners because of the increased time required, particularly during periods of warm weather when lobster mortalities are higher.

The successful recording of the PIT tags when the scanners were operational on vessels, and the realistic estimate of exploitation rate demonstrates the “proof of concept” that these tags are a viable alternative to conventional T-bar only tags. Importantly, the exact date and time of recapture is available, and the
assumption of 100% tag reporting rate with minimal fisher participation appears to be met. Gibbons & Andrews (2004) found over a range of studies that PIT tag detection was reliable (95 to 100%) and reading accuracy approximately 100%. As the hybrid tag is external, tag reporting from fishers without scanners increases the tag reporting rate. Models that include tag reporting rates for different fleets (fleets with and without scanners) have been developed (P. Burch unpubl. data) and are similar to models developed for fleets with and without observers present (Hearn et al. 1999; Pollock et al. 2002).

Further engineering is required to ensure that the scanners can withstand the rigours of the combined marine environment and fishing activity. Although 100% reliability of the scanners may not be guaranteed, a clock associated with the date logger, so that the exact time of malfunction can be recorded, should be standard with each scanner.

The incorporation of scanners within the normal fishing operation provides an example whereby data can be collected with minimal interference to fishing activities. Tagging remains one of the most used methods for identifying individuals and this method opens new opportunities to linking recaptures with auxiliary information. Links to the vessel’s GPS and depth sounder or incorporating GPS technology in the data recorders would enable tag returns to be linked to precise capture locations and depths, thus improving the recorded information with each tag recovered. Data could also be downloaded automatically via satellite, thus reducing the costs associated with visiting the vessels to download the data, and the identification of system failures earlier.

PIT tags and scanners are considerably more expensive than conventional tags, but the improvement in tag reporting rate, exact knowledge of tag reporting rate (i.e., no difference in spatial and temporal reporting rates within and between fishing seasons) and the possibility of fewer tags makes this option viable (Burch et al. 2008).

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