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Non-lethal aging of tropical catch-and-release sport fishery species

Ronald Baker[a,b,c,*], Michael Bradley[a,b], Stefano Freddi[b], Katya Abrantes[a,b], Adam Barnett[b], Marcus Sheaves[a,b]

[a] TropWATER, James Cook University, Townsville, Queensland, Australia
[b] Marine Biology and Aquaculture Unit, College of Science and Engineering, James Cook University, Townsville, Queensland, Australia
[c] University of South Alabama, Dauphin Island Sea Lab, Dauphin Island, Alabama, USA

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ABSTRACT

Non-lethal methods for deriving age estimates from species of conservation significance or those supporting catch-and-release sport fisheries can assist in their sustainable management. In this study we tested if dorsal spines provide equivalent age estimates to otoliths for two species of large tropical snappers (*Lutjanus goldiei* and *L. fuscescens,* Lutjanidae) that support a catch-and-release sport fishery in remote parts of Papua New Guinea. Comparison of putative age estimates from sections taken at the base, mid and tip of the dorsal spine revealed that the base sections provided the most similar ages to otoliths, while mid and tip sections underestimated otolith age, especially for older individuals. Dorsal spine base-sections provided equivalent age estimates to otoliths for both species across the full range of ages examined (up to 17 for *L. goldiei*, and 14 for *L. fuscescens*). Like other lutjanids, these species show a wide range in length-at-age. This means that small fish are not necessarily young fish, and recruitment could potentially fail for more than a decade before anglers or guides notice a lack of smaller fish in their captures, by which time the opportunity to identify and reverse the cause of recruitment failure may have passed. Dorsal spines provide an effective and minimally-harmful means of monitoring population age structure to ensure ongoing recruitment to the fishery, and offer the opportunity for engagement of anglers, guides, and community members in the sustainable management of this fishery.

1. Introduction

Information on the age distribution of a fished population is critical for many aspects of fishery management (Beverton and Holt, 1957). Fish otoliths provide robust age estimates for many species (Campana, 2001), but collecting them is a lethal procedure. For species of conservation concern, or those supporting catch-and-release sport fisheries, non-lethal approaches for aging can help to balance the conflicting needs of acquiring accurate biological data to monitor population recovery or sustainability, and the protection of vulnerable stocks (Metcalf and Swearer, 2005; Murie et al., 2009).

Otoliths are widely used to age fish (Secor et al., 1995; Campana and Thorrold, 2001), however other structures such as scales, fin rays, and spines have a long history in fish aging studies (Jackson, 2007). Two key advantages of otoliths over other structures for aging fish are that otoliths grow continuously throughout a fish's life, and they are not subject to resorption that can modify the formation or persistence of increments (Campana and Neilson, 1985; Campana and Thorrold, 2001). Scales or spines may under-estimate the age of fish, especially older individuals (Barbour and Einarsson, 1987; Braaten et al., 1999), due to the resorption of tissue during periods of low growth (Campana and Thorrold, 2001), or the crowding of annuli in the outer margins of the structure (Chilton and Beamish, 1982). Scales are subject to replacement during the life of a fish, which can also lead to the underestimation of fish age (Ilies et al., 2014). Spines and fin rays may also be subject to occlusion, whereby calcified material in the centre of the structure is gradually replaced by vascular tissue, leading to the loss of inner growth increments (Drew et al., 2006). However, despite these potential issues, spines and scales can be sampled non-lethally (Hobbs et al., 2014; Ilies et al., 2014), and they have been shown to provide accurate age estimates for fish from a variety of environments (Cass and Beamish, 1983; Drew et al., 2006; Ilies et al., 2014). Among tropical species, Hobbs et al. (2014) found dorsal spines to provide reliable age estimates for the grouper *Plectropomus leopardus*. Similarly, *Lutjanus argentimaculatus* dorsal spines provide accurate estimates of age, while scales from the same fish are less reliable (Freddi et al. unpubl. data).

The objective of the present study was to determine if it is possible to obtain non-lethal age estimates for two large tropical snappers, the Papuan black bass *Lutjanus goldiei* (Macleay, 1882), and the spot-tail snapper *Lutjanus fuscescens* (Valenciennes, 1830). Virtually nothing is

* Corresponding author at: Dauphin Island Sea Lab, 101 Bienville Blvd, Dauphin Island, Alabama, 36528, USA.
E-mail address: Ronald.baker@jcu.edu.au (R. Baker).

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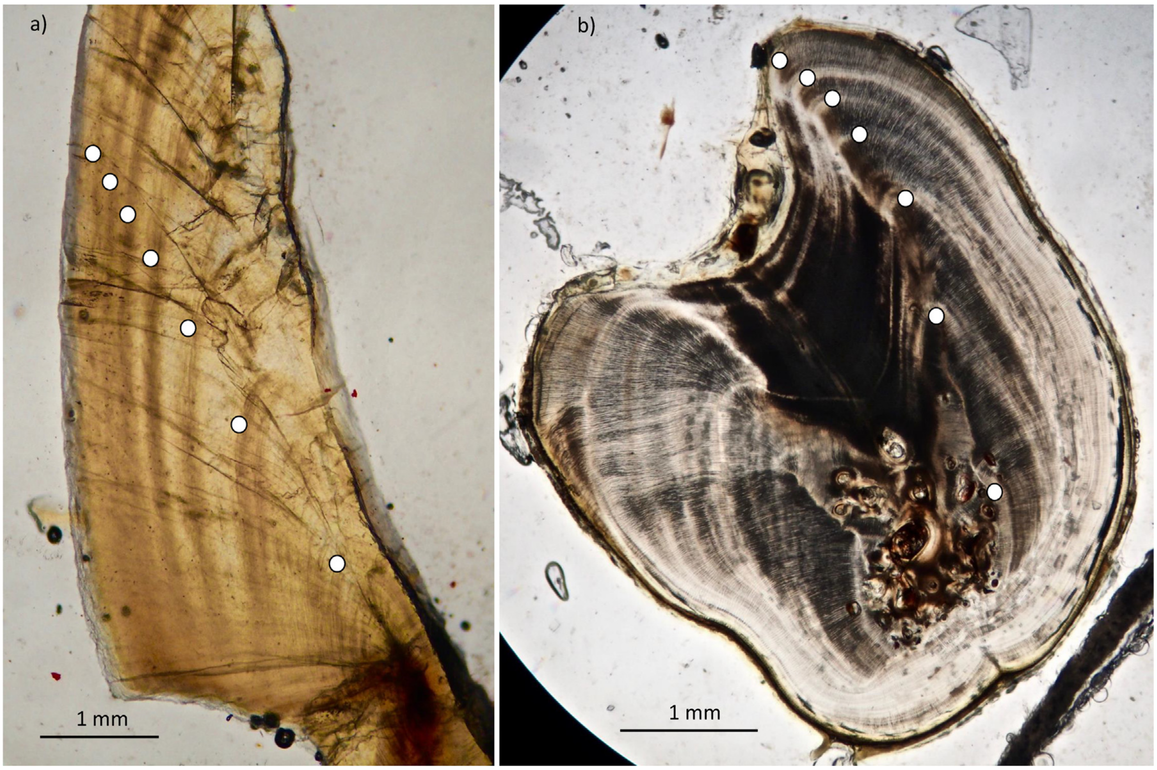

Fig. 1. Images of sections of a) otolith, and b) base of second dorsal spine of a 640 mm TL *Lutjanus goldiei*, with 7 annuli visible in each structure as indicated by white dots. The first increment in the spine section is almost obscured by occlusion and vascular tissue. Note that most age readings required manipulation of focus, magnification, field of view, and light intensity to identify annuli.

known of the biology or ecology of these species (Sheaves et al., 2016; Froese and Pauly, 2017). They grow to large sizes (> 20 kg) and form the basis of a wilderness-style catch-and-release sport fishery in remote parts of Papua New Guinea (Wood et al., 2013). The fishery has the potential to provide significant environmental and economic benefits to remote communities if it is managed sustainably (Barnett et al., 2016). A key element of management is to monitor the age structure of the fished populations. Our specific aim was to determine if dorsal spine sections provide equivalent age estimates to otoliths for these two species.

2. Materials and methods

2.1. Sample collection and preparation

Samples were taken from fish retained to provide a range of biological samples as part of a larger project examining the fishery ecology of *L. goldiei* and *L. fuscescens*. A total of 73 *L. goldiei*, and 78 *L. fuscescens* were sampled for this aging study on multiple dry-season (Apr-Nov) trips between May 2013 and April 2017. Fish were collected from the Pandi-Open Bay region (4°50′S, 151°30′E) of West New Britain, Papua New Guinea (PNG). Fish were measured (total length (TL) to nearest mm). Both sagittal otoliths were removed, rinsed, and blotted dry, and one randomly selected for aging. The second dorsal spine was removed from a subsample of *L. goldiei* (n = 46) and *L. fuscescens* (n = 30), by clipping with wire-cutters at the point of insertion. Other structures were considered for aging these fish. However, in a separate study scales were found to be unreliable for the close relative *L. argentimaculatus* and an initial small sample of *L. goldiei* (Freddi et al. unpubl. data), and spines have proven more reliable than fin rays in some species (Brusher and Schull, 2009), so these other structures were not considered further in the present study. To satisfy biosecurity requirements for importing samples from PNG to Australia, all samples were dried at 60 °C for 48 h before transport.

Otoliths were sectioned transversely through the core by either grinding and polishing on a Gemmasta Faceting Machine (Model GF4) using 1500 and 3000 grit grinding discs (small otoliths) or embedding in epoxy resin and cutting with a Buehler Isomet low speed saw (larger otoliths) before mounting and polishing the sawn sections as per small otoliths. Dorsal spines were embedded in epoxy resin, sectioned with the saw, and polished with 3000 grit grinding disks. All sections were regularly examined during polishing. Polishing ceased once growth increments were clearly visible rather than polishing to a consistent thickness, and final sections were all less than ca. 1 mm thick. Increments tended to be more visible in thicker sections of spines than of otoliths.

2.2. General aging procedure

All aging was completed by one person, with each structure aged three times with a minimum of 7 days between readings, and blind, i.e. with no knowledge of the identity of the fish or the previous age estimates. The median of the three age estimates was used as the final estimate. If the three age estimates spanned more than 3 years (i.e. $age_{max} - age_{min} > 2$; n = 8 of 151 otoliths and 22 of 112 spine sections), a fourth reading was conducted following the protocols above, and the median of the three estimates within a 3-year span was used as the final estimate. If after a 4th reading ages still did not converge to provide three estimates within a 3-year span (n = 1 otolith, 2 spine mid-sections and 2 spine base sections), the structure was excluded from further analyses. Many studies discard otoliths or other structures when consistent age estimates cannot be derived from the initial planned readings. However, because of the limited opportunities to collect samples of these species of conservation significance from remote locations, we chose to conduct a 4th reading and acknowledge the potential uncertainty around those age estimates (Piddocke et al., 2015b). The mean coefficient of variation (CV) was calculated to assess the relative precision of age estimates from each structure (Campana,