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The age estimation of an extremely old Silver Drummer *Kyphosus sydneyanus* (Günther 1886) from southern Western Australia

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ABSTRACT

Kyphosids are conspicuous members of temperate and tropical reef fish communities. Some species contribute to commercial and recreational fisheries but are vulnerable to capture in large numbers due to their schooling behaviour and site fidelity. Previous ageing studies of kyphosids have determined that some species are long-lived, with maximum ages >40 years, which is a trait often associated with low natural mortality rates. *Kyphosus sydneyanus* is one of the largest kyphosids and has historically been caught in large numbers as a bycatch species in the demersal gillnet fishery in southern Western Australia. A large *K. sydneyanus* specimen was collected from that fishery in March 2021. A count of the growth (opaque) zones in the sectioned otoliths were used to determine that the age of this individual was 93 years, more than double the previous maximum age of a *Kyphosus* species and the longest-lived coastal species in southern Australia.

Keywords: bycatch, Kyphosinae, longevity, mortality, otoliths, rocky reef, teleost, temperate.

Introduction

The Kyphosidae consists of four subfamilies, 14 genera and 53 species. The Kyphosinae (drummers, sea chubbs, rudderfishes) is comprised by three genera, with the *Kyphosus* genus contributing 15 of the 17 species in this subfamily (Nelson *et al.* 2016). In Australian waters, *Kyphosus* species are conspicuous members of rocky and coral reef fish communities in temperate and tropical waters, respectively, forming large schools (Shepherd and Edgar 2013; Pillans *et al.* 2017). These species are primarily herbivorous and are important in regulating the algal abundance on reef systems (Clements and Choat 1997; Downie *et al.* 2013). *Kyphosus sydneyanus* (Silver Drummer or Buff Bream) is a large-bodied species that attains total lengths and weights of at least 860 mm and 12 kg, respectively, and is found across southern Australia, including around Tasmania, as well as New Zealand (Gomon *et al.* 2008; Bray 2021). The biological characteristics, such as age, growth and reproduction, of this species are currently unknown.

Much of the biological information for kyphosids, including age, has only been obtained for those few commercially and recreationally important species. Those studies that have validated the periodicity of growth zone formation in otoliths, have demonstrated that *Labracoglossa argentiventris*, *Girella tricuspidata*, *Scorpis lineolatus* and *Scorpis aequipinnis*, attain maximum ages of 8, 24, 54 and 68 years, espectively (Stewart and Hughes 2005; Watari *et al.* 2005; Gray *et al.* 2010; Coulson *et al.* 2012). Other studies of *Girella* species, in which ages have not been validated, indicate maximum ages of 10–41 years (Ferrell 2005; Bredvik *et al.* 2011). The only study of a *Kyphosus* species demonstrated that the opaque zones in the otoliths of *Kyphosus bigibbus*, from coastal waters in Japan, are formed annually and that this species is long-lived, attaining a maximum age 46 years (Ogino *et al.* 2020).

The longevity of some kyphosids, along with other traits such as schooling behaviour and site fidelity (Kingsford 1989; Stewart and Hughes 2005; Gomon *et al.* 2008), is suggested to

contribute to the vulnerability of these species to over-exploitation (Stewart and Hughes 2005; Gray *et al.* 2010; Coulson *et al.* 2012). For example, despite attaining a maximum age of at least 24 years, the ages of *G. tricuspidata* in commercial gillnet and beach-seine catches in New South Wales are highly truncated, with few fish >8 years (Gray *et al.* 2010). In addition, concentrated fishing effort was proposed to have led to declining commercial catches of *S. lineolatus* in the mid-1990s and also to the high fishing mortality estimates for *S. aequipinnis*, despite catches of this latter species being miniscule in comparison to other kyphosids (Stewart and Hughes 2005; Coulson *et al.* 2012). Although not retained, *K. sydneyanus* and *Kyphosus cornelii*, referred to collectively as *K. cornelii*, historically constituted the largest component, by weight, of the scalefish catch in the Temperate Demersal and Gillnet and Demersal Long-line Fishery (TDGDLF) off south-western Australia (McAuley and Simpfendorfer 2003). More recently, total annual catch from the TDGDLF has declined due to management decisions and the consequent declining effort (Watt *et al.* 2021), with *K. sydneyanus* and *K. cornelii* now estimated to constitute a negligible proportion of the catch in comparison to retained scalefish and elasmobranchs (Braccini *et al.* 2022).

The known biological characteristics, in particular their extended lifespans, of kyphosids, in conjunction with behavioural traits, may lend these species to being over-fished. Longevity estimates in fish populations are fundamental to understanding this vulnerability, thus providing valuable information for management. As *K. sydneyanus* is a dominant fish species on temperate reefs throughout southern Australia, increasing our understanding of the biology of such species will permit wholistic management of these systems and their inhabitants.

Materials and methods

A *K. sydneyanus* specimen was captured on 19 March 2021 by a commercial gillnet fisher (mesh range = 165–178 mm) at a depth of ~50 m in the close proximity of Windy Harbour (34.8°S, 116.0°E) on the south coast of Western Australia. The whole fish was transported on ice to the Western Australia Fisheries and Marine Laboratories, Hillarys, Western Australia. The total length (TL) and fork length (FL) was measured to the nearest mm and whole weight recorded to the nearest g. The sex and developmental stage of the gonad was determined by macroscopic examination, as defined by Coulson *et al.* (2010), and the gonads weighed to the nearest 0.01 g. Both sagittal otoliths were removed, cleaned, dried and stored in a seed envelope.

The right and left otoliths were embedded separately in epoxy resin and thin transverse sections (~250 μm) taken through the primordium perpendicular to the sulcus acusticus, from the dorsal apex to the ventral apex, using a Buehler Isomet low-speed saw with a diamond-tipped wafering blade (Jenke 2002). The sections were mounted on microscope slides with a coverslip using casting resin. Using transmitted light and a Nikon eclipse 80i compound microscope with a Nikon DS-Ri2 (16.25 MP) digital camera, multiple images of the sectioned otoliths were taken at 5×, 10× and 20× magnifications. Images captured at 5× and 10× magnification were stitched together using the 'stitch' function in Leica Application Suite (v. 4.3) to form a composite image of the entire otolith section (Fig. 1*a*, *b*) and ventral side of the sulcus (Fig. 1*c*, *d*), respectively. Both the 5× and 10× composite images were used to confirm the number of opaque zones, that were marked and counted using LAS (v. 4.3). The 20× magnification image (Fig. 1*e*, *f*) was used to assign the otolith an otolith edge category based on proportional state of completion the translucent and opaque zones (i.e. narrow translucent, wide translucent, opaque; Wakefield *et al.* 2010).

Results

The *K. sydneyanus* specimen measured 694 mm TL, 626 mm FL and weighed 7048 g. The fish was female and the ovaries, weighing 287.61 g, were mature and in pre-spawning condition [Stage V – Ovaries large, occupying ~2/3 of body cavity, yellow in colour with extensive capillaries visible on ovarian wall].

The whole otoliths of the *K. sydneyanus* individual were very thick, and entirely opaque, which immediately prohibited the use of the whole otoliths to age this individual. The primordium of the sectioned otoliths possessed a central opaque region that became progressively more diffuse towards the first narrow, discrete opaque (growth) zone (Fig. 1*a*, *b*). On the ventral edge of the sulcus of both the left and right otoliths, the growth zones were discrete and easily discerned from each other, with the distance between successive zones being relatively small, but consistent (Fig. 1*c*, *d*). There were a few features on both sections that enable corresponding zones to be identified. (1) The 4th and 6th opaque zones can be followed into the sulcus region on both sections, (2) The 9th, 10th and 11th opaque zones appear to bundle together forming a wider darker region, (3) the 21st to 24th zones also collectively form a wider darker region, (4) the region in the sulcus around the 65th zone is darker, and (5) the region around the 74th zone is lighter than the otolith material either side of this zone.

The number of growth (opaque) zones counted on both the left and right otoliths was 93. In the same region where the last growth zone was counted, on both otolith sections, there is a wide translucent zone between the outer margin of the last opaque zone and the edge of the otolith (Fig. 1*e*, *f*). Taking into consideration the date of capture, the number of opaque zones in the otolith, the otolith margin type and when this species spawns, (i.e. autumn and winter months; P. Coulson unpubl. data), and assuming that the first opaque

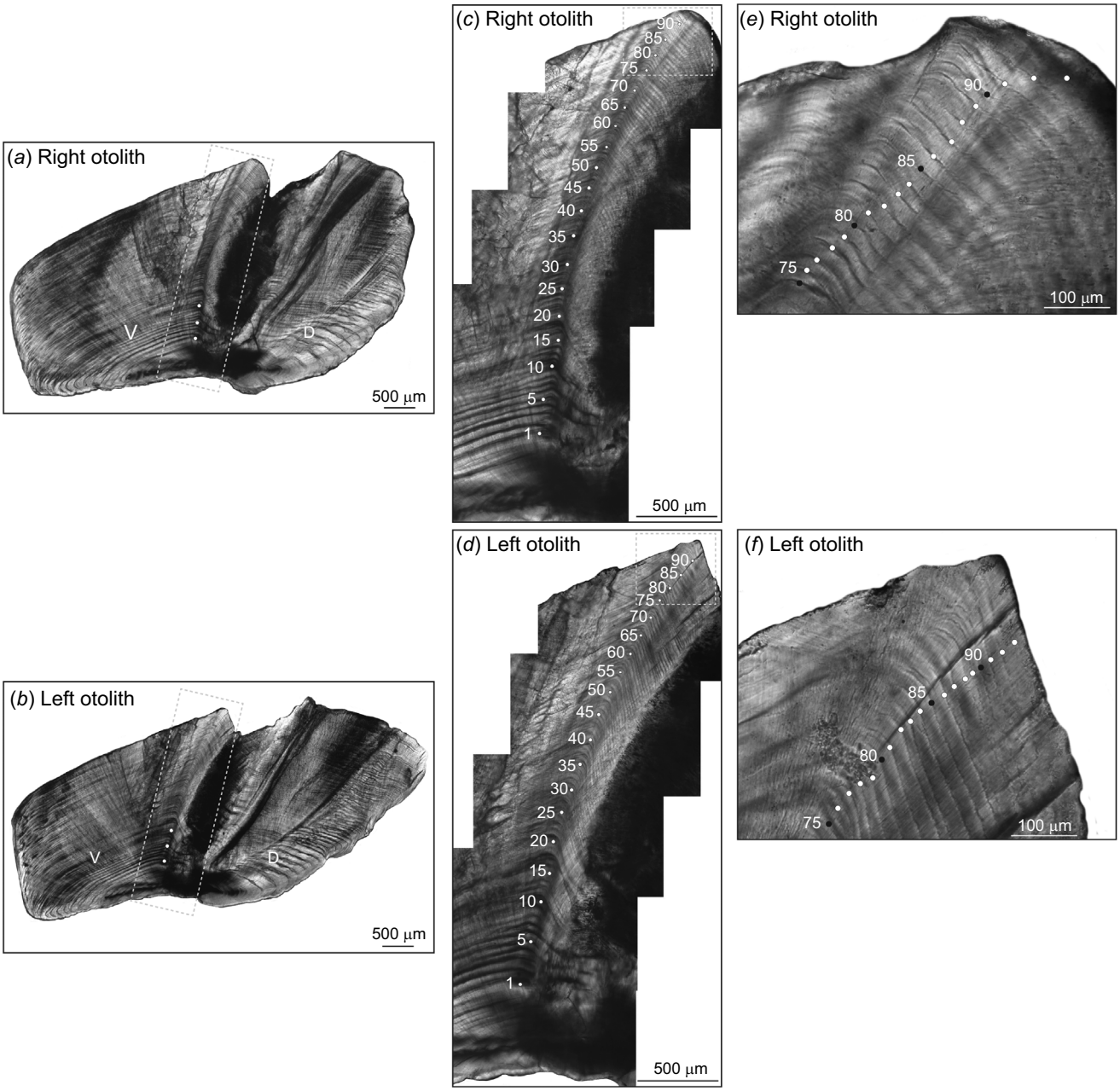

Fig. 1. Images of the entire transverse section of the (*a*) right and (*b*) left otoliths (5×), the ventral side, along the sulcus, of the (*c*) right and (*d*) left otoliths (10×) and the outer edge of the ventral side, along the sulcus of the (e) right and (*f*) left otoliths (20×). In (*a*) and (*b*), the position of the 1st, 5th and 10th zones are marked with a white dot. In (*c*) and (*d*), the first and every fifth zones are marked with a white dot. In (*e*) and (*f*) every fifth number zone is marked with a black dot and all other zones marked with a white dot. V, ventral; D, dorsal. Scale bars shown.

zone is formed at the end of the first winter of life, the decimal age of this *K. sydneyanus* individual is estimated to be 93.1 years.

Discussion

The estimated age of 93 years for this specimen of *K. sydneyanus* is more than double the maximum age of 46 years for *K. bigibbus* (Ogino *et al.* 2020), the only other *Kyphosus* species that has been aged. As seen in the sections of the otoliths, the opaque zones become highly compressed towards the periphery of the otolith. These zones would not have been able to be differentiated in the whole otoliths, thus requiring the otoliths to be sectioned, as is the case when ageing many long-lived species (e.g. Coulson *et al.* 2009; Friess and Sedberry 2011). Ogino *et al.* (2020)

proposed an alternate way to prepare sections of the otoliths of the congener *K. bigibbus*, by initially taking a very thick section (~1–2 mm) and grinding each side using waterproof sandpaper of successively smaller grit size, while constantly making micro adjustments to the angle of grinding with frequent observations under the microscope, to achieve a final section in which opaque zones were exactly perpendicular to the sectioning surface. The methods used to prepare the otolith section of this *K. sydneyanus* followed those outlined in Jenke (2002) and are identical to those used in the ageing studies of a number of other long-lived species in south-western Australia (e.g. Coulson *et al.* 2009). In this method, the sulcus is aligned perpendicular to the cutting angle providing a transverse section. The initial cut through the otolith is made just to the side of the primordium, with one of the following two ~250 μm sections passing directly through the primordium, providing a clear view of the alternating translucent and opaque growth zones. The same methods were used to section the otoliths of two other kyphosids, *Scorpis aequippinis* and *S. lineolatus* which were both found to attain ages of 68 and 52 years, respectively (Stewart and Hughes 2005; Coulson *et al.* 2012). This method is relatively quick and able to prepare sections of sufficient quality for age estimation.

The extreme longevity of the *K. sydneyanus* estimated in this study parallels the high maximum ages of other kyphosids, particularly the 68 years recorded for *S. aequipinnis*, which were also collected from the south coast of Western Australia (Coulson *et al.* 2012). The longevity of a number of teleost species in waters off southern Western Australia (e.g. Coulson *et al.* 2009, 2012) has been proposed to reflect the oligotrophic nature of marine waters that are, in part, a result of the warm, poleward flowing Leeuwin Current largely suppressing any upwelling (Koslow *et al.* 2008; Molony *et al.* 2011). Longevity enables fish species to encounter conditions favourable for spawning, egg and larval survival and juvenile recruitment at least a few times during their extended adult lives, as demonstrated by the highly variable recruitment of species in southern Western Australia (e.g. Coulson *et al.* 2009; Wakefield *et al.* 2017).

While *K. sydneyanus* is not targeted by commercial or recreational fishers and the numbers of individuals caught as bycatch in the commercial gillnet fishery off southern Western Australia is now considered to be negligible (Braccini *et al.* 2022), they have historically been taken in large quantities in this fishery (McAuley and Simpfendorfer 2003). Attributes such as schooling behaviour and high site fidelity of kyphosids (Ferguson *et al.* 2013; Pillans *et al.* 2017) lend these species, when caught, to be caught in large numbers, as is demonstrated by the very high catches of *G. tricuspidata* in New South Wales (Gray *et al.* 2010). This is corroborated by the fact that, although annual commercial catches of the confamiliar *S. aequipinnis* in south-western Australia are very small (~3 t; Newman *et al.* 2021), fishing mortality rates for this species are high, suggested to be the result of commercial fishers repeatedly targeting the same reefs (Coulson *et al.* 2012). A similar situation was proposed to be the case with *S. lineolatus* in NSW waters (Stewart and Hughes 2005). In addition, the age structure of the commercial catch of *G. tricuspidata* in New South Wales became highly truncated after a period of high catches in the late 1980s (Gray *et al.* 2010). The results of these studies demonstrate that such species are vulnerable to fishing activities.

While this study details the age of a single individual, it has highlighted the fact that *K. sydneyanus* is very long-lived and is indeed one of the longest-lived fishes recorded in coastal waters of Australia, not just Western Australia. This study highlights the potential susceptibility of some non-target species in commercial fisheries and demonstrates that such species may be as vulnerable, if not more, to fishing than the target species.

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Data availability. The data that support this study are available in the article.

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