

Age, Growth and Mortality of *Gymnocranius audleyi* (Pisces: Lethrinidae)

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Abstract

Age, growth and mortality of *Gymnocranius audleyi* (Pisces: Lethrinidae) from the central Great Barrier Reef (GBR), Australia were investigated. Age was determined by analyzing annuli in whole and sectioned otoliths (sagittae). Rings have not yet been validated as annuli for this species but for other lethrinids, as well as lutjanids and seranids on the GBR they were. The oldest fish in the sample ($n = 107$) was estimated to be 13 years of age. A high variability in size at age was observed. Both whole and sectioned otoliths and left and right otoliths were found to provide similar age estimates. Age estimates correlated with otolith weights better than with fork-length (FL), standard-length (SL) or total fish weight (TW). Fitted von Bertalanffy growth functions (VBGF) gave growth (FL) parameter estimates ($\pm$ S.E.) of $L_{inf} = 282 \pm 9$ mm; $K = 0.557 \pm 0.100$; and $t_0 = -0.651 \pm 0.388$. The growth performance index was $\phi' = 4.648 \pm 0.388$ (S.E.) (for FL). Although all growth estimates were within ranges published for other lethrinids, *G. audleyi* appears to be a relatively fast-growing species. The total instantaneous rate of mortality (Z) was estimated as 0.583 ± 0.390 (S.E.). This study provides a basis for future management of the exploitation of this species on the GBR.

Introduction

Gymnocranius audleyi Ogilby (1916), (F. Lethrinidae) is found along the east coast of Queensland, Australia (Carpenter and Allen 1989). Lethrinids are important in the commercial and recreational fisheries of the Great Barrier Reef (GBR). They are good-eating and are a popular target of recreational anglers (Randall et al. 1990). Because they are perceived to be slow-growing and relatively long-lived, they may be particularly susceptible to over-exploitation. Thus, management practices (such as bag limits, size restrictions, seasonal closures and closed reserves) are needed to preserve the stocks (Dalzell et al. 1987; Williams and Russ 1994).

Throughout their Indo-pacific range, lethrinids are important for commercial, artisanal and recreational fisheries (Carpenter and Allen 1989). Between

1980 and 1987, FAO statistics show the world catch of lethrinids increased from 26987 to 56710 tonnes (Carpenter and Allen 1989). These statistics do not represent all countries that fish for lethrinids, as well as under-report catches of municipal fisheries where many lethrinids are caught.

The GBR fishery for lethrinids is restricted by legislation to the use of handlines (Williams and Russ 1994). *Lethrinus miniatus* and *L. nebulosus* are the most important in terms of catch, with *L. miniatus* comprising 24% of the total linefish landings on the GBR in 1987. Two-thirds of these were caught by amateur and charter boat fishers. The total line catch (all fish groups) on the GBR was 2791 t in 1990 (Trainor 1991; Williams and Russ 1994).

Population dynamics, potential yield estimates, responses to fishing pressure and proper fisheries management require estimates of growth and mortality of the species involved (Beverton and Holt 1957; Williams and Russ 1994). Good estimates of growth and mortality generally require the determination of age and age-structures. Although many studies were able to derive age indirectly from length-frequency data and mark-release-recapture (MRR) techniques, the use of hard-parts of fish is generally regarded as the best method for determining the age of a fish. Otoliths are reliable age estimators because they are not subject to resorption, remodelling or regeneration (Secor et al. 1995).

Annuli in otoliths can be validated through marginal increment analysis, by counting increments (e.g. daily) between annuli, by matching ages derived from otoliths with the progression of length modes in length-frequency analysis, and by using known-age (e.g. held in ponds) or MRR fish (Geffen 1995). A more recent approach is tetracycline "double-banding", involving the recapture of previously injected fish, re-injecting them and keeping them in aquaria. Generally, it has been demonstrated clearly using this method that annuli occur on the hard-parts of fish on the GBR (e.g. Ferreira and Russ 1992, 1994; Fowler and Doherty 1992).

Otoliths have been prepared for study by a variety of methods, including whole, broken, sectioned and burnt (e.g. Loubens 1978; Christensen 1964). McPherson et al. (1988) considered that whole otoliths may underestimate the age of larger fish. Ferreira and Russ (1994) considered it useful to know the limit of readability of whole otoliths because they require less preparation than sectioned otoliths and appear to give more precise readings for smaller fish.

A non-subjective, cost-effective method for age determination may be the use of otolith weights as suggested by Boehlert (1985) and used by Worthington et al. (1995) for *Pomacentrus moluccensis* and *P. wardi* on the GBR. Otoliths are acellular and do not grow by ossification but in a manner similar to the formation of mollusk shells (Secor et al. 1995). Otolith length and width appear to be linear to a certain size or age, thereafter the otolith thickens along the sulcus region of the interior proximal surface (Beamish and McFarlane 1987).

The growth rates of fish have been described by a variety of mathematical expressions including various growth curves (e.g. Moreau 1987; Kauffman 1981; Schnute 1981) and polynomial functions (Chen et al. 1992). However, growth rates of fish are usually described by using the von Bertalanffy Growth Formula (VBGF). This formula has been used extensively to make comparisons in the growth rates of different species in different areas (e.g.

Munro and Williams 1985; Williams and Russ 1994; Dalzell et al. 1987). Williams and Russ (1994) provides estimates for growth rates (K) of 15 species of lethrinid. K values ranged from 0.056 to 0.87, while average maximum sizes (L_{inf}) ranged from 106.5 cm (Fork Length-FL) to 14.0 cm (Standard Length-SL).

There appears to be some variations in estimates of mortality rates, both within and between fish taxa. Rates of mortality are shown to be age-dependent and decrease rapidly after metamorphosis (Doherty and Sale 1985). Estimates of mortality rates can be extracted from the age of the oldest animal in the catch, mean size of animals in the catch, length frequency data, MRR data, and age frequency data (Pauly 1984). Estimates of total mortality (Z) can be obtained using the age-based catch curve of Beverton and Holt (1957). However, one needs to account for age-specific vulnerability to the gear, the representativeness of the sample, migration, and recruitment variability (Brothers 1995).

Williams and Russ (1994) gave 42 estimates of natural mortality rate (M) for 17 species of lethrinids, ranging from 0.32 to 1.87. Many of these may well be overestimates, derived mostly from the empirical formula of Pauly (1980). This formula was derived directly from growth parameter values and mean water temperatures. A need exists for empirical estimates of natural mortality rates of lethrinids in unfished populations. One of the few places in the world where this may be possible is in the GBR Marine Park.

Loubens (1980), in New Caledonia, recorded that the mean, maximum age of the larger carnivorous species of reef fish (e.g. lethrinids) is typically around 20 years, with growth cessation at about 11 years of age. However, there was a large variation in the maximum observed age among species. Among smaller coral reef fish species, longevity of 3 to 5 years is probably common although annual species also exist (Sale 1982).

Growth and mortality parameters for *G. audleyi* have not been recorded previously in literature. However, Loubens (1980) recorded growth and mortality parameters for *G. rivulatus*, *G. japonicus* and *G. lethrinoides* in New Caledonia. L_{inf} ranged from 35.1 to 46.4 cm SL. K values ranged from 0.22 to 0.28, while natural mortality (M) ranged from 0.57 to 0.69.

A need exists for further empirical studies of the age, growth and mortality rates of lethrinids to ensure appropriate biological data on which to base fisheries management decisions. The aims of this study were fourfold, to: 1) determine the age of *G. audleyi*, 2) obtain a growth curve for *G. audleyi*, 3) estimate the mortality rate of *G. audleyi*, and 4) examine the relationships between otolith variates (length, width and weight) and fish variates (age, length and weight).

Materials and Methods

Overall sample

Gymnocranius audleyi (n=107) were caught using modified O-traps with a 40 mm mesh-size at John Brewer, Davies, Rib, Lodestone and Trunk Reefs off

Townsville on the Central GBR (18°-19°S, 146°30'-147°30'E), Australia (Newman 1995). The fish were caught in both day and night soaks between May 93 and March 94 at a depth of 10 to 40 m.

Fork length (FL, mm), standard length (SL, mm) and total weight (TW, g) were recorded.

Otoliths

Sagittae, the largest of the 3 pairs of otoliths, were used for age determination. After removal from the animal they were cleaned and stored dry. A majority ($n = 86$) were weighed using a Mettler AE 200 scale (to .0001 g) while length and width were measured using the Amiga software program V-TRACE 2.2 (to .001 mm). Both sagittae (left and right) were measured. Otoliths were read, whole (left and right) and sectioned (generally right only).

Whole otoliths were placed concave side up in a black container filled with immersion oil and read with a dissecting microscope under reflected light at 16X magnification. Only opaque rings with well defined intervening spaces were counted. Protocol required two independent readings by two experienced readers. If the two readings did not agree, the otoliths were again examined independently by the same readers who would afterwards hold a consultation. If an agreed count could still not be reached, these otoliths were not included in the studies. Counts of annuli on the left and right otoliths were taken independently and found to be in agreement in all cases. Two readers took independent readings, with 91% agreement. Further independent readings resulted in 100% agreement.

Right otoliths were generally used for sectioning. Where these were not available (due to loss or breakage), left otoliths were used ($n = 15$). These were embedded in epoxy resin (Spurr, 1969) and left for 24 hours. Subsequently, otoliths were sectioned transversely through the core to a width of 700 μm using a Buehler Isomet low-speed saw, mounted on glass slides with Crystal Bond 509 adhesive, ground on 600- and 1200- grade sand paper and polished with 0.3 mm alumina micropolish. Sections were examined under a dissecting microscope at 40X magnification. Annuli in the sulcus region were counted and cross-checked under reflected and transmitted light. Two counts of sectioned otoliths were taken independently, resulting in 83% agreement. Further independent readings resulted in total agreement. Counts of annuli in sectioned otoliths were considered more reliable because annuli were more distinct and it was possible to compare readings from transmitted and reflected light.

Data analysis

A Pearson correlation matrix among all the variates measured was computed to indicate possible trends. The relationship between SL and FL, otolith weight and age, otolith length and age, otolith weight and FL, otolith weight and TW, and otolith length and FL, were described using simple linear regressions of the form $y = a + b \cdot x$. Power functions of the form $y = a \cdot x^b$ were used to describe relationships between TW and FL,

and otolith weight and otolith length. Right otolith measurements were used for all regressions.

FL-at-age was fitted (non-linear fitting procedure) to a von Bertalanffy growth formula (VBGF) to determine the growth parameters (L_{inf} , K and t_0). The VBGF used for length was $L_t = L_{\text{inf}}(1 - e^{-K(t-t_0)})$, where L_t = length at time t , L_{inf} = average maximum length, K = growth constant and t_0 = theoretical age at which fish length = 0. The relationship between K and L_{inf} was described using a growth performance index $\phi' = \log_{10}K + 2 \log_{10}L_{\text{inf}}$ (Pauly, 1980).

Estimates of total instantaneous mortality rate Z were obtained using the age-based catch curve method of Beverton and Holt (1957). A linear regression of the natural logarithm ($\ln$) of fish numbers in each age class against their age gives a descending slope, b , which gives an estimate of Z . Annual survivorship S was calculated as $S = e^{-Z}$.

Results

Overall sample

The total sample consisted of 107 *G. audleyi*. Numbers per size class in the sample displayed a bimodal distribution with a preponderance of fish between 146-180 mm FL and between 232-267 mm FL. The numbers per age class did not show a bimodal distribution. There was a preponderance of 1, 2 and 3 year-olds with a decreasing number of older fish, apart from one 11 year-old and two 13 year-olds.

Length of the fish averaged at 214.89 ± 4.37 (S.E.) (mm, FL). The longest fish in the sample was a 7 year-old which measured 319 mm (FL). The smallest fish was a 1 year-old measuring 146 mm (FL). Average weight (TW) in the sample was 254.89 ± 14.49 g (S.E.). The heaviest fish was a 6 year-old that weighed 750.6 g, the lightest was a 1 year-old weighing 68.0 g.

The average age was 2.55 ± 0.21 (S.E.) years. The oldest fish ($n = 2$) were 13 years, the youngest ($n = 39$) were 1 year.

Regressions were used to describe the relationships between FL and SL, and FL and TW. The relationship between FL (mm) and SL (mm) was described using the linear regression: $SL = -2.780 + 0.86438 \cdot FL$ ($r^2 = 0.996$). The relationship between FL (mm) and TW (g) was best described using a power function (Fig. 1): $TW = (3.04 \cdot 10^{-5}) \cdot FL^{2.95}$ ($r^2 = 0.992$).

Otoliths

Sagittae were found to have a distinct pattern of alternating opaque (annuli) and translucent bands (Fig. 2). Within these bands smaller rings could be seen. These smaller rings may be monthly or daily growth bands. Annuli were wider and more distinct than these smaller rings. Under reflected light annuli appeared lighter than the surrounding areas, while under transmitted light annuli were in the form of definite brown rings. The first annulus was

usually very broad and diffuse, with bands becoming progressively thinner towards the edge of the otolith.

Differences in readings between whole and sectioned otoliths did not appear to be significantly biased towards any age class. There were no differences in counts for the first age class, despite this being the most abundant age class in the sample ($n = 39$). Simple linear regression indicated that there was a tendency for a greater difference in readings for older fish (with sectioned otoliths giving a higher reading), although this was not significant ($r^2 = 0.1867$, $p = 0.1605$).

The Pearson correlation between age (whole) and age (sectioned) was 0.96. The correlation between sectioned age and otolith weight was 0.89 while the correlation between age and the dimensions of the otoliths (length, width) was 0.72 and 0.70 respectively. Between length (FL and SL) and age, the correlation was 0.72; between total weight (TW) and age it was 0.71. Otolith weights were always correlated with otolith dimensions to a value greater than 0.9. Otolith dimensions themselves were all correlated to a value in excess of 0.93. Comparisons between left and right otoliths showed high correlations: 0.999 for weight, 0.970 for length, and 0.975 for width.

It should be noted that the low number of old fish may have had an unduly large influence on any regression analysis. As a result, values for the 11 and 13 year-olds were not used in the following regressions.

The relationship between age (years) (as determined from sectioned otoliths) and otolith weight (OW) (g) (Fig. 3) was: $\text{age} = -0.9643 + 62.433 \cdot \text{OW}$ ($r^2 = 0.835$). The relationship between age (years) and otolith length (OL, mm) was: $\text{age} = -8.3435 + 1.42209 \cdot \text{age}$ ($r^2 = 0.750$). That between OW (g) and FL (mm) was: $\text{OW} = -0.0366 + 0.00042 \cdot \text{FL}$ ($r^2 = 0.945$). Also, $\text{OW} = 0.02041 + 0.00013 \cdot \text{TW}$ ($r^2 = 0.945$); $\text{OL} = 2.5907 + 0.02328 \cdot \text{FL}$ ($r^2 = 0.937$); and $\text{OW} = (1.136 \cdot 10^{-4}) \cdot \text{OL}^3$ ($r^2 = 0.913$).

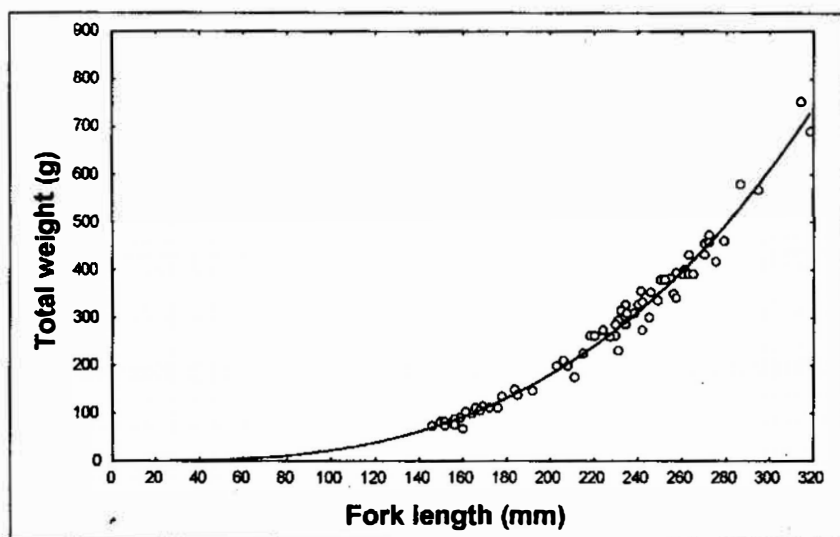


Fig. 1. Power curve of total weight against fork length for *Gymnocranius audeleyi*.

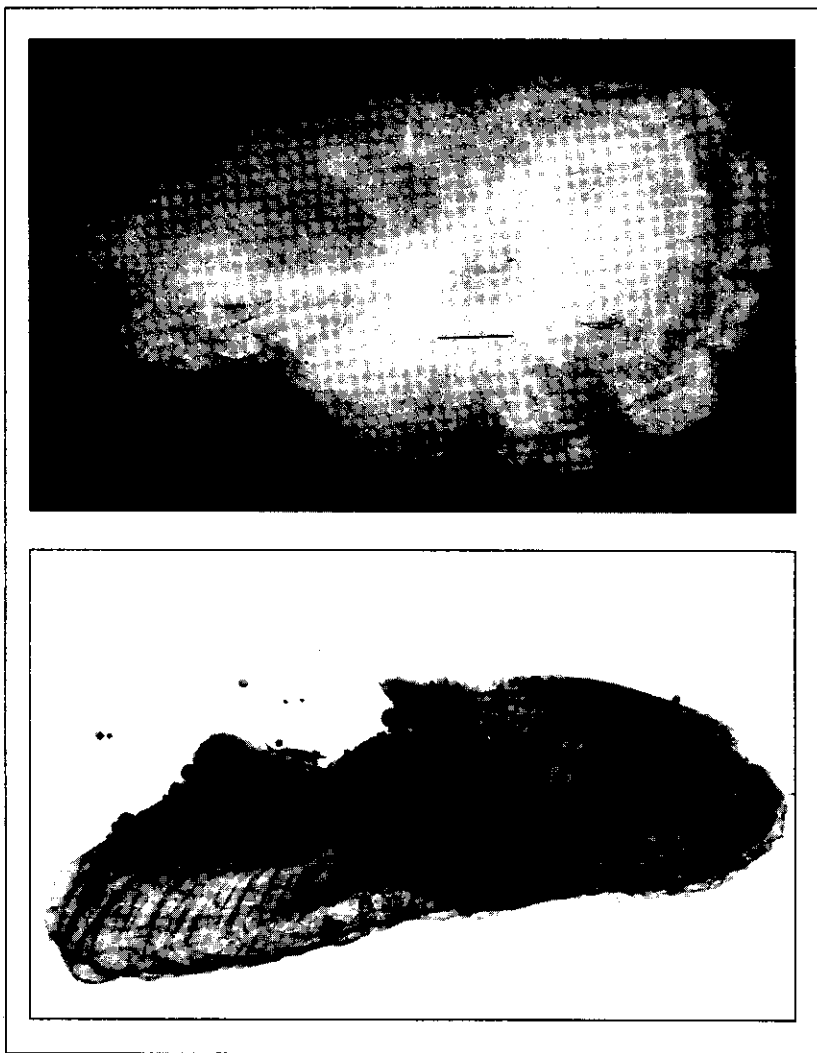


Fig. 2. Photographs showing the same 7 year-old otolith whole (above) and sectioned (below). Scale bar indicates 1 mm. (whole otolith viewed under reflected light, sectioned otolith under transmitted light with a bright field; $\times 10$ magnification, $\times 2.5$ photo eyepiece)

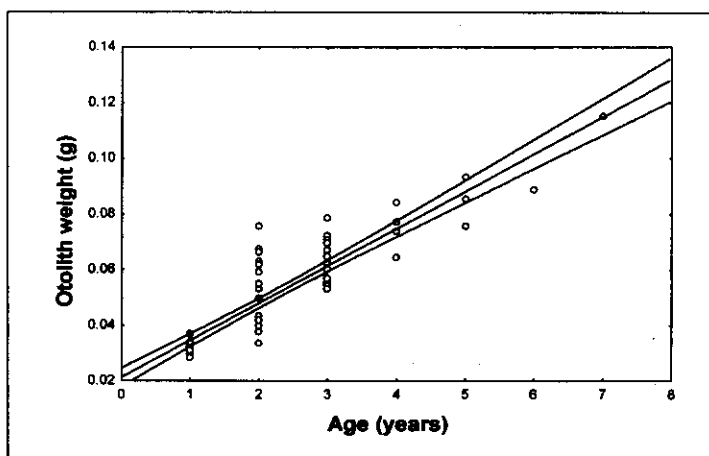


Fig. 3. Regression of otolith weight against age for *Gymnocranius audleyi*. Dashed lines represent 95% confidence.

The growth parameters ($\pm$ S.E.) for FL (mm) (Fig. 4) were: $L_{\infty} = 282.445 \pm 9.306$, $K = 0.557 \pm 0.100$, $t_0 = -0.651 \pm 0.388$, $\phi' = 4.648 \pm 0.388$ ($r^2 = 0.719$).

Mortality

The total mortality rate (Z), using all the age data, was found to be 0.303 ± 0.885 (S.E.) ($r^2 = 0.719$) using Beverton and Holt's (1957) catch curve method, which represents an annual survivorship of approximately 73.85%. It was possible to get a better fit for the mortality curve by ignoring the 11 and 13 year-olds (Fig. 5), whereby Z was calculated as 0.583 ± 0.390 (S.E.) ($r^2 = 0.940$), representing a survivorship of approximately 55.81% per annum.

Longevity

The oldest fish in the sample, and thus maximum longevity estimated by this study, was 13 years. There appears to be a substantial slowing of growth after 7 years with virtual growth cessation at around 10 years.

Discussion

Gymnocranius audleyi appears to be fast-growing compared to other *Gymnocranius* spp., and with lethrinids in general. Two points need to be acknowledged. First, the annuli have not been validated for this species. Second, the sample size is small and the older fish (11 and 13 year-olds) in this study appear as outliers in the various regressions.

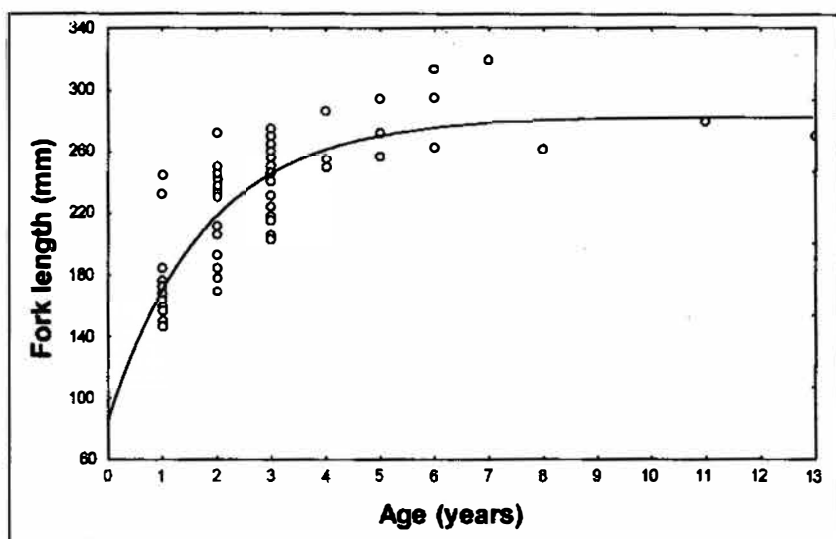


Fig. 4. Fitted von Bertalanffy growth curve of *Gymnocranius audleyi* using fork length-at-age.

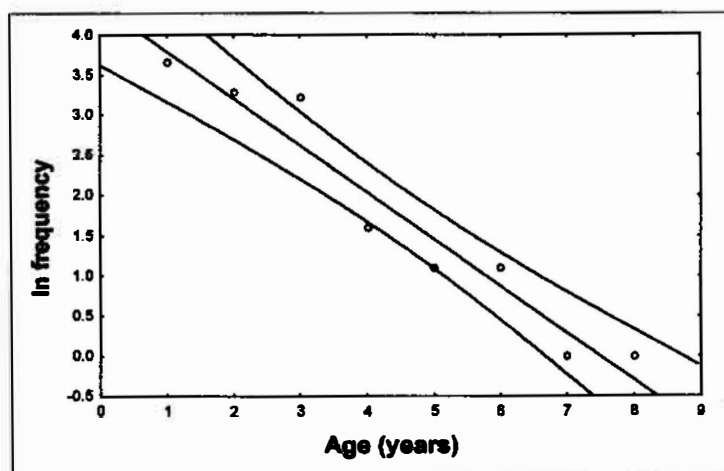


Fig. 5. Mortality regression of $\ln$ frequency against age for *Gymnocranius audleyi*. Dashed lines represent 95% confidence.

A large amount of literature has largely confirmed the hypothesis of daily growth increments and annuli in otoliths in both temperate and tropical waters (eg. Secor et al. 1995, Pitcher and Hart 1982). No studies have clearly disproved that the rings of the type seen in Fig. 2 are not annuli. It has been clearly demonstrated that annuli occur on the hard parts of reef fish on the Great Barrier Reef (GBR) (eg. Ferreira and Russ 1994, Fowler and Doherty 1992). In particular, Ferreira (*in* Williams and Russ 1994) has validated annuli on the otoliths of a lethrinid (*Lethrinus nebulosus*) on the GBR by using tetracycline "double-banding". Hilomen (1997) has also validated annuli on the otoliths of the lethrinids *Lethrinus harak* and *L. lentjan* on the GBR using tetracycline banding. The bands considered as annuli in the present study appear identical to those reported as annuli in these three species of lethrinid. The method of tetracycline banding has also been used to validate annuli in serranids (Ferreira and Russ 1992, 1994), lutjanids (Newman et al. 1996a, b), pomacentrids (Doherty and Fowler 1994), scarids (Lou 1996; Choat et al. 1997), and acanthurids (Hart and Russ 1996; Choat and Axe 1996) on the GBR. Validation of annuli for *G. audleyi* in the present study was hampered by the lack of recaptured individuals that had been injected with tetracycline (Newman 1995).

The small representation of 11 and 13 year-olds in the sample could be due to larger fish migrating to locations different from where trap catches were made (e.g. to breed and/or feed) or due to trap selectivity. Trap selectivity can result in small individuals escaping and larger individuals being unable to enter the trap. On the GBR, Newman and Williams (1995) considered that trap selectivity was not a function of a given mesh aperture to retain individuals of a certain body depth, rather the behaviour of fish to the trap and its occupants was of most importance. Using modified O-traps (the same that were used in this study) of four mesh sizes (12.5, 30, 40, 50 mm), Newman and Williams (1995) found that mesh size had no significant effect on the total catch rates of lutjanids and lethrinids. However, the 12.5 mm mesh size failed

to catch larger fish while the 50 mm mesh did not retain smaller individuals. The selection curve for other mesh sizes showed a relatively normal distribution. Newman and Williams (1995) decided on a 40 mm mesh size (used for this study) because it tended to catch a wider size range than the 50 mm mesh while the catch rate was higher than the 30 mm mesh. Therefore, although trap selectivity may account for the apparent poor representation of 11 and 13 year-olds by selecting against larger fish, it is also possible that the sample ($n = 107$) was too small to be fully representative. For example, the maximum size reported for *G. audleyi* is approximately 400 mm (Randall et al. 1989), while the largest fish in this sample was 319 mm (FL) and the average maximum size (L_{inf}) calculated was 282 ± 9 mm (FL).

No systematic difference in increment counts between left and right sagittae has been reported (Campana and Neilson 1982, Geffen 1982, Neilson and Geen 1982). Age determination readings between left and right otoliths in this study indicated that either can be used. This similarity in counts between left and right otoliths extended to their weights, lengths and widths. Readings of whole otoliths were very close to those obtained by sectioning. Differences were probably due to rings being close together and confusion due to the presence of smaller rings that were not in fact annuli. However, it appears that in most cases whole readings are also accurate for this species. This includes older fish although these readings do become more difficult in whole otoliths due to crowding of the annuli at the otolith edge (Ferreira and Russ 1994).

Correlations and regressions in this study indicate that otolith weight was a good age indicator, explaining more variations in age than fish size. It should be noted, however, that otolith weight also had a high correlation with fish length and total weight. This may indicate that somatic growth has some effects on otolith growth. FL, SL, and TW had higher correlations with otolith weight and otolith dimensions (length, width) than with age. Otolith dimensions appear to correspond to fish sizes (FL, SL, and TW), and to have a smaller correspondence with age, as compared to otolith weight. This may indicate that otolith length and width are primarily influenced by somatic growth while otolith weight is secondarily influenced by age. This corresponds with other published results. For example, Anderson et al. (1992a) found a linear relationship between otolith weight and fish age for the Murray cod *Maccullochella peelii*. Otolith thickness continued to increase throughout the life of the fish and contributed most to the increase in otolith weight. Otolith length and width reached a maximum when fish length also approached its maximum. Anderson et al. (1992b) found a similar relationship for the golden perch *Macquaria ambigua*. Gooley (1992) found a linear relationship between otolith length and fish length for *Maccullochella peelii*. Francis (1992) found otolith weight to be a better age estimator than otolith radius for the snapper *Pagrus auratus*.

G. audleyi ages are better determined by otolith weights than by fish lengths. The high variability of fish lengths within one age-class and the lack of correspondence between length-data and age-data suggests that any attempt to estimate age-classes from length-frequency data alone could result in misleading and possibly erroneous conclusions. Ideally, one would section otoliths

for age determination, although this is time consuming. The next best option is to read otoliths whole but if time is extremely limiting, it would appear that weighing otoliths (after drying) would be the next best option (Worthington et al. 1995; Fletcher 1991, Russ *et al* in prep.). The fact that such a good relationship was obtained between age and otolith weight (Fig. 3) further supports the suggestion that the bands reported in this study are annuli.

Growth rates ($K = 0.557 \pm 0.100$; $L_{\text{inf}} = 282 \pm 9$ mm) indicate that *G. audleyi* is a relatively fast growing species, with L_{inf} approached by some fish in the 2nd or 3rd year. Although there is a paucity of fish 7 years and older in this sample, it appears that growth decreases substantially after the 7th year. It should be noted that some 2 year-old fish were larger than the 13 year-old fish, indicating that there was large variation in individual size-at-age and thus individual growth rates. Williams and Russ (1994) provide estimates for growth rates (K) of 15 species of *Lethrinus*. K values range from 0.056 for female *L. miniatus* (Church 1989) to 0.87 for male *L. genivittatus* (Loubens 1980). Munro and Williams (1985) gave 28 estimates of K for 17 lethrinids, K values ranging from 0.87 (as above) to 0.061 for *L. miniatus* (Aldonov and Druzhinin 1979). Average maximum sizes (L_{inf}) obtained by lethrinids range from 106.5 cm (Fork Length-FL) for *L. olivaceus* (Aldonov and Druzhinin 1979) to 14.0 cm (Standard Length-SL) for female *L. genivittatus* (Loubens 1980) (from Williams and Russ 1994). Growth parameters for *G. audleyi* have not been previously recorded in the literature. Compared to growth parameters recorded for other *Gymnocranius* spp. in Munro and Williams (1985), the values recorded here give a lower L_{inf} (eg. *G. rivulatus* = 464 mm SL) and a higher K (eg. *G. japonicus* = 0.22). However, the values fall well within the values recorded for lethrinids as a whole (Dalzell et al. 1987, Williams and Russ 1994, Munro and Williams 1985).

Mortality rates ($Z = 0.583 \pm 0.390$) are within the range of other published results for lethrinids (Munro and Williams 1985). The exclusion of the three oldest fish (11 and 13 year-olds) is justified on the basis that the sample may not represent the true relative abundance of these older age-classes. Williams and Russ (1994) gave 42 estimates of M for 17 species of *Lethrinus*, ranging from 0.32 for *L. nebulosus* to 1.87 for *L. genivittatus*. Carpenter and Allen (1989) gave ranges for *Lethrinus* spp. from 0.5 to 1.9. Many of these may well be overestimates because they were derived mostly from the Pauly (1980) formula which was directly derived from growth parameter values and mean water temperatures. A need exists for empirical estimates of natural mortality rates of lethrinids in unfished populations. One of the few places in the world where this may be possible is in the GBR Marine Park. Russ *et al* (1998) have recently sampled reefs closed to fishing in the GBR Marine Park to produce an empirical estimate of natural mortality of coral trout (*Plectropomus leopardus*).

The longevity of *G. audleyi* is within the range reported for lethrinids by other authors, being at least 13 years with virtual growth cessation at about 10 years. Walker (1975) aged *L. miniatus* to 7-8 years on the GBR, although Williams (1997), also working on the GBR, aged the species to 21 years. In New Caledonia, Loubens (1980) aged *L. miniatus* to 14-22 years and Church

(1989) in Norfolk Island, aged it to 15-18 years, indicating that longevity estimates may be subject to methods used for aging. Williams and Russ (1994), in a list of known maximum longevities of *Lethrinus* spp. gave a range from 5 years for *L. lentjan* in India (Toor 1964) to 27 years for female *L. nebulosus* in New Caledonia (Loubens 1980). Loubens (1980) gave maximum observed age for Lethrinidae at a range of 7-27 with a mean of 17 years ($n = 12$). Growth cessation ranged from 4-17 years with a mean of 11 years ($n = 9$).

The main conclusions of this study were that left and right otoliths were of equal value for the age determination of *G. audleyi*. Whole otoliths appeared to be reliable age estimators. Otolith growth may be primarily somatic with additional growth (otolith thickness) being a factor of age. *G. audleyi* appears to be a fast growing species, with a high K value and a low L_{inf} although this may be influenced by the low number of old fish in the sample. There was a high variability in individual growth rates. Mortality rates and apparent longevity were also very close to other published results. It is suggested that a larger sample size (200+) be taken in future studies of this species.

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