Age composition and growth rates of selected fish species in Western Australia

Submitted by

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I declare that this thesis is my own account of my research and contains as its main content work that has not previously been submitted for a degree at any tertiary education institution

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Abstract

Growth typically varies considerably amongst the individuals in a population and between individuals in different populations of the same species, especially when those populations are found in environments in which the characteristics differ markedly. Although the annuli in hard structures are often used to age fish, such growth zones are not always clearly defined in these structures. Thus, in these cases, it is necessary to use alternative methods for ageing, such as analysis of modal progressions in length-frequency data. However, these types of techniques can usually only identify distinct size classes that correspond to an age class. They thus only enable an individual fish to be aged when it is a member of a discrete size cohort. Such a situation generally only applies to the younger age classes. This thesis reports the results of studies on a species that can be aged using the annuli in one of its hard parts (asteriscus otoliths), *i.e*. *Cnidoglanis macrocephalus*, and four species (*Amniataba caudavitatta*, *Apogon rueppellii*, *Pseudogobius olorum* and *Favionigobius lateralis*) for which it was necessary to use a method such as length-frequency analysis for ageing.

Cnidoglanis macrocephalus is an important recreational and commercial species caught in coastal marine and estuarine environments in south-western Australia. However, all previous detailed studies on the age and growth on this species have focused on estuarine populations. This thesis reports the results of a study of the biology of *C. macrocephalus* in Princess Royal Harbour, a marine embayment on the south coast of Western Australia. Samples of *C. macrocephalus* were collected from amongst the macroalgae that were removed from this highly eutrophic embayment by mechanical harvesters. Analysis of the reproductive and size composition data derived

from these catches showed that spawning occurs between October and December and that fecundity ranged from 75 in a 384 mm fish to 465 in a 443 mm fish. Small fish (<200 mm) were rarely caught, reflecting the fact that the young of this species are difficult to capture.

Analysis of the trends exhibited by the marginal increments on otoliths showed that the number of annuli on this hard structure could be used to age *C. macrocephalus*. The samples of *C. macrocephalus* collected from Princess Royal Harbour contained female and male fish that had lived for up to 10 and 9 years in age and reached maximum lengths and weights of 523 mm and 745.3 g and 557 mm and 735.8 g, respectively. To overcome the paucity of small fish, von Bertalanffy growth curves were constructed using back-calculated lengths and employing the scale proportional hypothesis and body proportional hypothesis (see Francis 1990). The growth rates of females and males were slower than those in a nearby seasonally closed estuary (Wilson Inlet) and in a permanently open estuary on the lower west coast of Australia (Swan River Estuary). Yield per recruit analyses were conducted in order to ascertain what minimum legal lengths were appropriate for the capture of *C. macrocephalus* in Princess Royal Harbour, the Swan River Estuary and Wilson Inlet in order to sustain the stocks in those water bodies.

The age and growth of *Amniataba caudavittata* and *Apogon rueppellii* in the Swan River Estuary were determined by analysing the trends exhibited by modes in sequential monthly length-frequency data. This was achieved by employing MULTIFAN, which constrained the means of the lengths of the cohorts in successive monthly samples to a seasonal form of the von Bertalanffy growth curve. The resulting growth parameters derived by MULTIFAN were similar to those derived from the

growth curves fitted to the means of the cohorts determined independently for each monthly sample by MIX.

The discreteness of the distributions and modes of size classes in length-frequency data for *A. caudavittata* and *A. rueppellii* enabled sound growth curves to be constructed for both of these species. The growth curves of these two sexes of both species were significantly different, with K being lower and L_∞ being higher for females. The trends exhibited by these growth curves emphasised that the growth of both species is highly seasonal, with little or no increase in length occurring during the cooler part of the year. The seasonal von Bertalanffy growth equations implied that "negative growth" occurred in winter, but this is an artefact produced by size-related differences in offshore movements that occur at that time of the year.

The age and growth of two further species from the Swan River Estuary, *Pseudogobius olorum* and *Favonigobius lateralis*, were also studied. Since *P. olorum* and *F. lateralis* both spawn at different times of the year and these times (spring and autumn) are not regularly spaced during the year, they produce new 0+ recruits at two irregularly-spaced times of the year. Consequently, MUTLIFAN cannot be used to analyse the size-distribution data for these two gobiid species. Thus, MIX was used to identify the size classes present in sequential samples and to provide means for the length distributions of those size classes. von Bertalanffy growth equations were then fitted to the mean lengths at the inferred age of the males and females of each size class of each species. It was found appropriate to use the traditional von Bertalanffy growth curve for describing the growth of the product of the spring-spawning group of both species and a seasonal von Bertalanffy growth curve for that of the product of the autumn-spawning groups of both species.

The growth curves, when considered in conjunction with the trends exhibited by reproductive variables, demonstrate that female *F. lateralis* attains sexual maturity more rapidly and at a larger size than *P. olorum*. The majority of the female and male progeny of the summer and autumn-spawning groups of *F. lateralis* reach maturity when they are approximately 3½ and 8½ months old, respectively, compared with five and seven months old, respectively, for *P. olorum*.

Models, incorporating data on water temperature and salinity and the growth and reproduction characteristics of *P. olorum* and *F. lateralis*, were used to postulate how environmental factors might be regulating when these two gobiid species spawn. The results of these models support the conclusion that the bimodal timing of spawning of *P. olorum* in the upper estuary was regulated by water temperature, with spawning occurring between 20 and 25^{o}C but inhibited by temperatures greater than 25^{o}C. They also showed that, although water temperature also influenced the timing of spawning of *F. lateralis* in the lower estuary, the onset of spawning by this species only occurred when salinities had reached $30^{0}/_{00}$.

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Publications

The publications listed below form the basis for the parts of this thesis.

Gill, H.S., Wise, B.S., Potter, I.C. and Chaplin, J.A. (1996). Dual spawning periods and resultant divergent patterns of growth in the estuarine goby *Pseudogobius olorum*. Temperature induced? Marine Biology 125:453-466.

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