Biology of two species of sparid on the west coast of Australia

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

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Abstract

Various aspects of the biology of the tarwhine *Rhabdosargus sarba* and western yellowfin bream *Acanthopagrus latus* were studied. The studies on *R. sarba* have focused on populations in temperate coastal marine waters at *ca* 32^{o}S and the lower reaches of an estuary (Swan River Estuary) located at the same latitude and in a subtropical embayment (Shark Bay) at *ca* 26^{o}S, while those on *A. latus* were conducted on the population in the latter embayment.

A combination of a macroscopic and histological examination of the gonads demonstrated that *R. sarba* is typically a rudimentary hermaphrodite in Western Australian waters, *i.e.* the juveniles develop into either a male or female in which the ovarian and testicular zones of the gonads, respectively, are macroscopically undetectable. This contrasts with the situation in the waters off Hong Kong and South Africa, in which *R. sarba* is reported to be a protandrous hermaphrodite. However, it is possible that a few of the fish that are above the size at first maturity and possess, during the spawning period, ovotestes with relatively substantial amounts of both mature testicular and immature ovarian tissue, could function as males early in adult life and then change to females. Although *R. sarba* spawns at some time between late winter and late spring in Western Australia, spawning peaks later in the Swan River Estuary than in coastal, marine waters at the same latitude and Shark Bay, in which salinities are always close to or above that of full strength sea water, *i.e.* 35 ‰ . While the males and females attain sexual maturity at very similar lengths in the Swan River Estuary and Shark Bay, *i.e.* L_{50}s all between 170 and 177 mm, they typically reach maturity at an earlier age in the former environment, *i.e.* 2 vs 3 years old. Thus, length and consequently growth rate influence the timing of maturity rather than age. During the spawning period, only 9 % of the fish caught between 180 and 260 mm in nearshore, shallow marine waters had become mature, whereas 91 % of those in this length range over reefs were mature, indicating that *R. sarba* tends to move offshore only when it has become “physiologically ready” to mature. The L_{50}s at first maturity indicate that the current minimum legal length in Western Australia (230 mm) is appropriate for managing this species.

Oocyte diameter frequency distributions, stages in oocyte development, duration of oocyte hydration and time of formation of post-ovulatory follicles in

mature ovaries of *Rhabdosargus sarba* in the lower Swan River Estuary (32^{o} 03'S, 115^{o} 44'E) were used, in conjunction with data on tidal cycles, to elucidate specific aspects of the reproductive biology of this sparid in an estuarine environment. The results demonstrated the following. (i) *Rhabdosargus sarba* has indeterminate fecundity *sensu* Hunter *et al.* (1985). (ii) Oocyte hydration commences at about dusk (18:30 h) and is completed by *ca* 01:30-04:30 h, at which time ovulation, as revealed by the presence of hydrated oocytes in the ovarian duct and appearance of newly-formed post-ovulatory follicles, commences. (iii) The prevalence of spawning was positively correlated with tidal strength and was greatest on days when the tide changed from flood to ebb at *ca* 06:00 h, *i.e.* approximately when spawning ceases. Spawning just prior to strong ebb tides would lead to the transport of eggs out of the estuary and thus into salinities that remain at *ca* 35 ‰ . The likelihood of eggs being transported downstream is further enhanced by *R. sarba* spawning in deeper waters in the estuary, where the flow is greatest. (iv) Although mature ovaries were found in *R. sarba* in the estuary between early July and December, the prevalence of atretic oocytes was high until September, when salinities started rising markedly from their winter minima. Batch fecundities ranged from 2,416 for a 188 mm fish to 53,707 for a 266 mm fish. The average daily prevalence of spawning amongst mature females during the spawning period of *R. sarba* caught in the lower estuary, *i.e.* July to end of October, was 36.5 %. Thus, individual female *R. sarba* spawned, on average, at intervals of *ca* 2.7 days in each spawning season. Female *R. sarba* with total lengths of 200, 250 and 300 mm were estimated to have a batch fecundity of 7,400, 20,100 and 54,800 eggs, respectively and annual fecundities of 332,000, 903,000 and 2,461,000 eggs, respectively.

Rhabdosargus sarba is shown to undergo size-related movements in each of the three very different environments in which it was studied. In temperate coastal waters, *R. sarba* settles in unvegetated nearshore areas and then moves progressively firstly to nearby seagrass beds and then to exposed unvegetated nearshore areas and finally to areas around reefs where spawning occurs. Although *R. sarba* spawns in the lower Swan River Estuary, relatively few of its early 0+ recruits remain in the estuary and substantial numbers of this species do not start reappearing in the estuary until they are *ca* 140 mm. In Shark Bay, *R. sarba* uses nearshore mangroves as a nursery area and later moves into areas around reefs. The maximum ages recorded for *R. sarba* in coastal marine waters (11 years) and Shark Bay (13 years) were far greater than in the lower Swan River Estuary (6 years). However, the maximum lengths recorded in these three environments were all *ca* 350 mm. Due to the production by size-related movements of differences amongst the lengths of *R. sarba* at given ages in different habitats in coastal marine waters, the composite suite of lengths at age was not fully representative of the population of this species as a whole in this environment. A von Bertalanffy growth curve, which was adjusted to take into account size-related changes in habitat type, significantly improved the fit to the lengths at age of individuals in the composite samples for the population beyond that provided by the unadjusted von Bertalanffy growth curve. This resulted in the maximum difference between the estimates of length at age from the two growth curves, relative to the L_∞ derived from the unadjusted von Bertalanffy curve, reaching a value equivalent to 8 %. However, the maximum differences for the corresponding curves for populations in the lower Swan River Estuary and Shark Bay were far less, *i.e.* 1.7 and 3.2 %, respectively, and thus not considered biologically significant. *Rhabdosargus sarba* grew slightly faster in the lower Swan River Estuary than in either coastal marine waters or Shark Bay, possibly reflecting the greater productivity of estuarine environments.

Acanthopagrus latus is a protandrous hermaphrodite. Detailed macroscopic and histological examination of the gonads of a wide size range of fish, together with a quantification of how the prevalences of the different categories of gonad change with size and age and during the year, were used to elucidate the sequence of changes that occur in the ovotestes of *A. latus* during life. The scheme proposed in the present study for the protandrous changes in *A. latus* differed from those proposed for this species elsewhere, but was similar to that of Pollock (1985) for the congeneric *Acanthopagrus australis*. The ovotestes of functional males develop from gonads which, as in older juveniles, contain substantial amounts of testicular and ovarian tissue. Such ovotestes, and particularly their testicular component, regress markedly after spawning and then, during the next spawning season, either again become ovotestes in which the testicular zone predominates and contains spermatids and spermatozoa (functional males), or become ovotestes in which the ovarian zone predominates and contains vitellogenic oocytes (functional females). Once a fish has become a functional female, it remains a female throughout the rest of its life. The trends exhibited during the year by reproductive variables demonstrate that *A. latus* in

Shark Bay typically spawns on a very limited number of occasions during a short period in August and September and has determinate fecundity. The potential annual fecundities of 24 *A. latus* ranged from 764,000 in a 600 g fish to 7,910,000 in a 2,050 g fish and produced a mean ±1SE of 1,935,000 ± 281,000. The total length at which 50 % of *A. latus* become identifiable as males (245 mm) is very similar to the current minimum legal length (MLL) of 250 mm, which corresponds to an age of 2.5 years less than the age at which 50 % of males become females. Current spawning potential ratios calculated over a range of alternative values for natural mortality (*M*) for *A. latus* in Shark Bay suggests that the present fishing pressure is sustainable, but that the current MLL should be reviewed if recreational fishing pressure continues to increase.

The age composition and von Bertalanffy growth parameters for *Acanthopagrus latus* have been determined. The relevant parameters were inserted into the empirical equations of Pauly (1980) and Ralston (1987) for estimating natural mortality (*M*). Total mortality (*Z*) was calculated using Hoenig's (1983) equations, relative abundance analysis and a simulation based on maximum age and sample size. The two point estimates for *M* for *A. latus*, which were both 0.70 year^{-1}, greatly exceeded all estimates for *Z* (range 0.18 to 0.30 year^{-1}), which is clearly an erroneous result. To resolve this problem of inconsistent estimates, a Bayesian approach was developed, which, through combining the likelihood distributions of the various mortality estimates, produced integrated estimates for *M* and *Z* that are more consistent and precise than those produced for these two variables using the above methods individually. This approach now yielded lower values for *M* than *Z* and a measure of fishing mortality that appears to be consistent with the current status of the fishery. This approach is equally applicable to other fish species.

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