The biology of four tuskfish species (*Choerodon*: Labridae) in Western Australia

By

David Fairclough

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DECLARATION

I declare that the information contained in this thesis

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David Fairclough

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Abstract

The biology of four species of *Choerodon* (Labridae), the blue tuskfish *C. cyanodus*, the bluespotted tuskfish *C. cauteroma*, the baldchin groper *C. rubescens* and the blackspot tuskfish *C. schoenleinii* was studied in Shark Bay in Western Australia. These species are fished commercially and/or recreationally in this large subtropical marine embayment, which is a world heritage area. The biology of *C. rubescens* was also studied in the Abrolhos Islands, which are located ~ 300 km to the south of Shark Bay, where this labrid is an important commercial and recreational fish species. The broad aims of this project were to determine the following for the above four *Choerodon* species in Shark Bay. (1) Whether they are protogynous hermaphrodites, as is the case with many labrids. (2) The biological variables required for developing management plans for these species, such as the timing of spawning, the lengths and ages at both maturity and sex change, size and age compositions and growth parameters, and (3) the habitat types occupied during their life cycles and also of the purple tuskfish *Choerodon cephalotes*. Finally, comparisons are made between the age and size compositions, growth and reproductive biology of *C. rubescens* in Shark Bay and the Abrolhos Islands. Where relevant, the underlying hypotheses for the individual studies conducted during this PhD are included in the following chapters.

A macroscopic and histological examination of the gonads of the full size range of *C. cyanodus*, *C. cauteroma*, *C. rubescens* and *C. schoenleinii*, together with an analysis of the length and age compositions of female, transitional (individuals changing sex) and male individuals, demonstrated that each of these species is a protogynous hermaphrodite, *i.e.* individuals change sex from female to male during their life cycle. The gonads of all small (< *ca* 100 mm) and young (< *ca* 1 year old) individuals of each species comprised solely ovarian tissue and thus the individuals of each species began life as a female. All individuals subsequently become sexually mature as females and then later in life some will change to males. Since this was found to be the only method of sex change in these species, they are termed monandric. Individuals that were changing sex contained “undelimited type 2” gonads *sensu* Sadovy and Shapiro (1987). These gonads contained both ovarian and testicular tissue that was intermixed and not separated by connective tissue. The males of each species possessed secondary testes, which retained structures of the ovary they had replaced, such as a membrane-lined ovarian lumen, lamellae and ovary wall. Furthermore, histological sections indicated that sperm were transported towards the outer walls of the testes, where the multiple

sperm sinuses present in that region were presumably responsible for transporting sperm to the cloaca, rather than to a singular sperm duct as is the case with gonochoristic species.

The typically large size and different colour of the males of *C. rubescens*, *C. schoenleinii* and *C. cauteroma* and the bias in the sex ratios of their adults towards females suggests that the males of each of these species are either haremic, *i.e.* permanently territorial, or form leks, *i.e.* are temporarily territorial during their spawning seasons. In these three species, the presence of ripe testes that are far smaller than ripe ovaries and the release by females of eggs in batches are consistent with a single male spawning with an individual female, as commonly occurs in haremic/lekking species. In contrast to the above species, *C. cyanodus* was not sexually dichromatic, the sex ratio was not biased towards either sex and the weight of ripe testes remained relatively constant as body weight increased. The latter implies that the relative investment of energy by males into testicular development during the spawning season declines with increasing fish size. Thus, the males of *C. cyanodus* may be opportunistic spawners when small, possibly spawning in groups, and may tend towards a haremic or lek mode of life when larger.

The respective lengths and ages at which 50% of the females of *C. cyanodus* *C. cauteroma* and *C. schoenleinii* attained sexual maturity (L_{50m}, A_{50m}) in Shark Bay were *ca* 129, 196 and 253 mm and 2.3, 2.0 and 3.5 years of age. The corresponding L_{50m} and A_{50m} for *C. rubescens* in Shark Bay and the Abrolhos Islands were *ca* 274 and 279 mm, respectively, and 2.7 and 4.1 years of age, respectively. The respective lengths and ages at which 50% of the females of *C. cyanodus*, *C. cauteroma* and *C. schoenleinii* changed to males (L_{50c}, A_{50c}) in Shark Bay were 221, 310 and 556 mm and 4.1, 6.4 and 10.4 years of age. The length at which *C. rubescens* changed sex (L_{50c}) was significantly greater in Shark Bay (545 mm) than in the Abrolhos Islands (479 mm), whereas the reverse pertained with respect to the age at sex change (A_{50c}), *i.e.* 10.5 *vs* 11.9 years of age. Since some females were found in the oldest age classes of each species in Shark Bay and in the population of *C. rubescens* in the Abrolhos Islands, some of the females of each species do not apparently change sex.

The trends exhibited by the gonadosomatic indices of females and males and the stages of ovarian development in sequential months demonstrated that the spawning periods of each species varied. Thus, *C. rubescens* (in both Shark Bay and the Abrolhos Islands) and *C. cauteroma* spawn predominantly in spring, whereas spawning occurs in late spring/early summer in *C. schoenleinii* and in summer in *C. cyanodus*. As

C. schoenleinii, *C. cyanodus* and *C. cauteroma* occur predominantly within the inner gulfs of Shark Bay, the offset in the timing of their spawning periods would be likely to reduce any potential for competition between the larvae of those three species for resources.

The trends exhibited by the mean monthly marginal increments in sectioned otoliths with differing numbers of opaque zones demonstrated that, in each species, those opaque zones were laid down annually. Thus, the numbers of opaque zones in the sectioned otoliths of individuals of each species could be used, in conjunction with the birth date and time of year when those zones are delineated, to determine their approximate ages at capture. The maximum ages recorded for the four *Choerodon* species in Shark Bay ranged only from 12 to 16 years. However, in that environment, the maximum lengths of *C. rubescens* (649 mm) and *C. schoenleinii* (805 mm) were far greater than those of *C. cauteroma* (424 mm) and *C. cyanodus* (382 mm). In contrast to the situation with *C. rubescens* in Shark Bay, this species reached a substantially older maximum age (22 years), but slightly shorter length (629 mm), and grew at a slower rate in the Abrolhos Islands, possibly reflecting the influence of greater productivity in Shark Bay and/or greater densities of this species in the Abrolhos Islands.

Although a few *C. rubescens* and *C. schoenleinii* reach large sizes in Shark Bay, most of the individuals of these species were less than 400 mm, their minimum legal length (MLL) for capture. This raises the possibility that these two sought after species, *i.e.* the seventh and ninth most abundant species in the recreational fishery in Shark Bay, are subjected to substantial fishing pressure. Sampling for *C. cyanodus* was considered representative of the sites that this species occupies in Shark Bay and the sampling methods would have been likely to have captured the full size range of this tuskfish. Thus, the failure to catch any *C. cyanodus* greater than 400 mm indicates that, in Shark Bay, this species does not grow to the far greater lengths of about 600 mm reported for this species as a maximum by Allen (1999). Furthermore, the 400 mm MLL for this species in Western Australia precludes the retention by fishers of this species in this environment. *Choerodon cauteroma* was caught at lengths up to 424 mm, which is greater than the maximum of 360 mm reported for this species (Allen, 1999). Although there is no MLL for *C. cauteroma*, recreational fishers are restricted to a bag limit of four fish per person per day, as is the case with all other tuskfish species.

Since fishers target large fish preferentially and the largest size classes of each of the species of tuskfish are dominated by males, heavy fishing pressure has the potential to remove a large proportion of the males of the *Choerodon* species that are fished in Shark Bay, *i.e. C. rubescens*, *C. schoenleinii* and *C. cauteroma*, and also of *C. rubescens* in the Abrolhos Islands. Since the ratio of females to males in catches of *C. rubescens* taken by the commercial fishery in the Abrolhos Islands are *ca* 1:1 and yet the typical adult sex ratio is heavily biased towards females (*ca* 14:1), that fishery is removing a substantial proportion of the males from the population. Protogynous hermaphroditic species are apparently able to respond to such pressure on the males by initiating a change in sex by the larger females. However, there is evidence from studies of other protogynous species that heavy size-selective fishing can lead to a reduction in the size and age at which a species changes sex and ultimately to a collapse in the stock.

The results of visual surveys, when taken in conjunction with the locations of the catches of each of the five *Choerodon* species, demonstrated that *C. rubescens* lives on reefs in "oceanic" waters along the western boundary of Shark Bay, whereas *C. schoenleinii*, *C. cyanodus*, *C. cauteroma* and *C. cephalotes* are found predominantly in the two inner gulfs of this large embayment. *Choerodon cephalotes* lives almost exclusively in seagrass beds, while *C. schoenleinii* and *C. cyanodus* occupy predominantly inner gulf reefs and rocky shorelines and *C. cauteroma* occurs in all of those three habitats. *Choerodon cauteroma* was the only species that underwent an obvious size-related shift during its life cycle, moving from seagrass to hard substrates, such as inner gulf reefs and rocky shorelines, as it reached adulthood.

The biological and habitat data produced during this thesis will provide fisheries and environmental managers with the types of information that will enable them to develop management plans for conserving tuskfish species and their habitats in Shark Bay. The biological data for *C. rubescens* in the Abrolhos Islands will be able likewise to be used to develop plans for conserving the stock of this species in waters in which it is heavily fished.

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