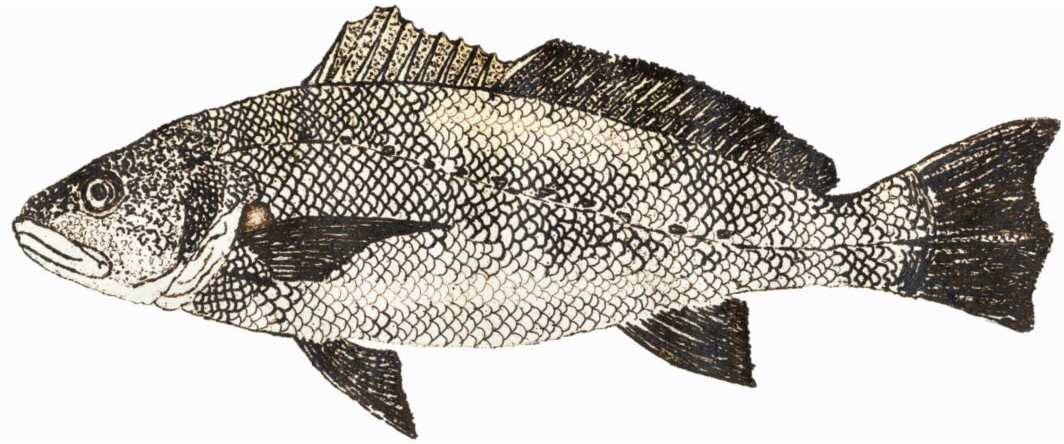
Comparisons of the biological and genetic characteristics of the Mulloway *Argyrosomus japonicus* (Sciaenidae) in different regions of Western Australia



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Submitted by
Bryn Morgan Farmer
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Declaration

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 unless otherwise stated

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Bryn Morgan Farmer

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Abstract

The research conducted for this thesis has produced quantitative data on the biology and population genetics of the Mulloway *Argyrosomus japonicus* in Western Australia, where this sciaenid is recreationally and commercially fished. These data were used 1) to test various hypotheses regarding the relationship between key biological characteristics of *A. japonicus* and both latitude and environmental variables, 2) to investigate the population structure and genetic characteristics of populations of *A. japonicus* on the west and south coasts of Western Australia and to assess the relationships between these populations and those of *A. japonicus* in eastern Australia and South Africa and 3) to consider the implications of the biological and genetic results for management.

Argyrosomus japonicus was collected by angling and gill netting at intervals along the *ca* 1400 km of coastline between Carnarvon (24°53´S, 113°39´E) and Albany (35°01´S, 117°53´E). For the analyses, the distribution of this species was considered to comprise three main regions, 1) the upper west coast, *i.e.* Carnarvon to Kalbarri (27°42´S, 114°10´E), 2) the lower west coast, *i.e.* Kalbarri to Black Head (34°46´S, 115°57´E) and 3) the south coast, *i.e.* east of Black Head. All fish from the upper and lower west coasts, apart from those collected from the Swan River Estuary (32°04´S, 115°44´E), were obtained from nearshore and offshore marine waters, while those from the south coast were caught in an estuary, *i.e.* Oyster Harbour (34°58´S, 117°57´E). Fish were aged employing the number of opaque zones in sectioned otoliths, and population genetic structure was explored using nucleotide sequence variation in the control region of mitochondrial DNA.

Sampling of marine waters on the upper and lower west coasts yielded all stages of *A. japonicus* from small juveniles to large and old mature adults. The maximum total lengths and ages recorded for *A. japonicus* in marine waters on both the upper west coast (1293 mm and 25 years) and lower west coast (1437 mm and 32 years) were far greater than those recorded in the estuarine environment of Oyster Harbour on the south coast (813 mm and 10 years). It was not possible to obtain samples from marine waters on the south coast, where anglers encounter *A. japonicus* far less frequently than on the west coast, and consequently it was not possible to ascertain whether older fish were present in these waters.

The growth curves of female *A. japonicus* from the upper west and lower west coasts were not significantly different from each other and the same was also true for

the males from these locations ($p > 0.05$). The lengths at age of the females and the males on the whole of the west coast were thus pooled. Although the growth of females and males on the west coast were significantly different ($p < 0.05$), these differences were minor, as is illustrated by the small differences in their L_∞s, *i.e.* 1228 and 1189 mm, respectively, and k, *i.e.* 0.242 and 0.249 year $^{-1}$, respectively. Growth on the west coast was very rapid, with *ca* 80% of their asymptotic lengths being attained by females and males by only six years of life, at which age the majority of fish had already attained maturity. As the majority of fish on the south coast were ≤ 4 years old, comparisons between the growth on the west and south coasts were confined to those derived from the lengths at age of fish up to four years old. By age four, the fish on the west coast had attained *ca* 805 mm, whereas the females and males on the south coast had only reached *ca* 640 and 565 mm, respectively. Furthermore, at a given length, the fish on the west coast were relatively heavier than those on the south coast.

Argyrosomus japonicus spawned on the lower west coast between November and April, when the mean monthly water temperatures exceeded 19°C. On the other hand, spawning occurred throughout much or all of the year on the upper west coast, where the mean monthly water temperatures did not fall below 19°C. Although sampling was more restricted on the south coast, it provided evidence that spawning occurred at a similar time to that on the lower west coast. The collection in late spring/early summer of substantial numbers of the preflexion larvae of *A. japonicus* in plankton trawls in nearshore marine waters at 32°S on the west coast and the absence of the eggs/larvae of *A. japonicus* in catches obtained during extensive sampling for ichthyoplankton further offshore at a similar latitude, strongly indicate that this sciaenid spawns in nearshore waters.

Although *A. japonicus* typically spawns in nearshore coastal marine waters on the west coast, the following data collected for an assemblage in Mosman Bay in the lower reaches of the Swan River Estuary demonstrated that spawning also occurred in these estuarine waters: 1) *A. japonicus* was only caught and detected acoustically in Mosman Bay during the spawning period, *i.e.* late October to April. 2) All *A. japonicus* caught in Mosman Bay exceeded the L_{50} at first maturity and several of the females possessed stage VI ovaries, *i.e.* contained hydrated oocytes and/or post-ovulatory follicles. As Mosman Bay is essentially marine during late spring and summer, it provides environmental conditions analogous to those in protected coastal waters in which this species typically spawns. Since all females with stage VI ovaries were caught between 21:00 and 23:30 h, spawning must occur at night. Furthermore, as all of the female fish with ovaries containing hydrated oocytes were caught immediately prior to the peak of high tide, there is a strong probability that the fertilised eggs would be transported downstream and out of the estuary on the ebb tide.

As the ovaries of mature females caught during the spawning period contained previtellogenic, cortical alveolar and yolk granule oocytes, and occasionally hydrated oocytes and/or post-ovulatory follicles, *A. japonicus* is an indeterminate spawner, *i.e.* fecundity is not determined prior to the onset of spawning.

The L_{50}s at first maturity of females on the lower and upper west coasts were not significantly different and the same was true for their males. The L_{50}s of females and males on the west coast were 903 and 880 mm, respectively, and far greater than the corresponding L_{50}s of 493 and 419 mm on the south coast. Furthermore, maturity was typically attained by females and males at an older age on the west coast, *i.e.* $\geq$ 5 years, than in Oyster Harbour on the south coast, *i.e.* $\leq$ 3 years.

On the west coast, juveniles, *i.e.* with lengths < L_{50} at first maturity, were caught almost exclusively in nearshore waters < 10 m deep, whereas adults were caught in both those nearshore waters and in offshore waters, where depths ranged from 20 to 200 m. The small juveniles were found mainly in protected embayments and along low-energy beaches on the west coast and were abundant in the estuarine environment of Oyster Harbour on the south coast. The greater use of nearshore coastal waters as nursery habitats by *A. japonicus* on the west coast of Australia than is the case in eastern Australia and southern Africa is presumably related to a paucity of permanently-open estuaries and the presence of the protection provided to nearshore coastal waters by the chain of barrier reefs and islands that are found along this coast.

The spawning of *A. japonicus* over a far more protracted period on the upper west than lower west coast parallels the situation typically found in conspecific teleost populations at lower *vs* higher latitudes. However, the similarities in growth and length at maturity of *A. japonicus* on these two coasts contrasts with the differences frequently found between these variables in assemblages of the same species at different latitudes.

On the basis of the compositions of the mtDNA haplotypes of *A. japonicus*, it is concluded that the assemblages from Carnarvon on the upper west coast are genetically distinct from those of both Geraldton and Perth on the lower west coast, which are similar. However, the genetic composition of *A. japonicus* from the west coast overall differs markedly from that of this species in Oyster Harbour on the south coast. Thus, the assemblages of *A. japonicus* on the upper and lower west coasts represent different populations (biological stocks) and these both differ, more markedly, from that found in Oyster Harbour on the south coast.

The genetic differences between the west coast and Oyster Harbour assemblages resided not only in haplotype composition but also in genetic diversity, with 11 to 14 haplotypes being detected in each of the three west coast locations compared with only one in that of Oyster Harbour. This indication that the latter assemblage has undergone substantial inbreeding is consistent with a substantial number of their individuals possessing deformities in their nasal olfactory openings and, to a lesser extent, their lower jaw, otoliths and operculum. As deformities were most common in 0+ and 1+ fish, those individuals may be particularly susceptible to mortality during the earliest years of life.

The mtDNA data for *A. japonicus* on the west coast of Australia were compared with corresponding but restricted data for populations in New South Wales and South Africa. These comparisons indicated that, while the genetic composition of *A. japonicus* on the west and east coasts of Australia were significantly different, the populations on those coasts had diverged relatively recently, and that the populations of *A. japonicus* in Australia and South Africa have been isolated for a much longer period and could potentially represent different species.

As the current minimum legal length for the retention of *A. japonicus* (MLL) in Western Australian waters is only 500 mm and thus well below the L_{50}s at first maturity of both the females (903 mm) and males (880 mm) of this species on the west coast, many fish on this coast will be caught and retained before they have had the opportunity to spawn. On the west coast, it would thus appear appropriate to consider a substantial increase in the MLL for this species, which is heavily fished in some of the nearshore waters typically occupied by the juveniles. As the spawning aggregations of *A. japonicus* in the lower reaches of the Swan River Estuary are targeted by the many recreational anglers that fish in this part of the estuary, managers may also need to provide this species with particular protection during the spawning period of this sciaenid in this estuarine region. Since the L_{50}s of female and male *A. japonicus* in Oyster Harbour were 493 and 419 mm, respectively, and thus below the current MLL of 500 mm, the majority of fish in this population would potentially have the opportunity to spawn at least once prior to being retained.

Table of Contents

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