



# Mulloway Aquaculture in South Australia

*Aquaculture SA*

## General Information

<b>Scientific name</b>	<i>Argyrosomus japonicus</i> (previously <i>Argyrosomus hololepidotus</i> )
<b>Common names</b>	Mulloway, jewfish
<b>Age at maturity (years)</b>	6
<b>Size at maturity (cm)</b>	75 TL
<b>Spawning period</b>	Spring-Summer
<b>Maximum age (years)</b>	30
<b>Maximum size (cm)</b>	200 TL
<b>Maximum weight (kg)</b>	43
<b>Habitat</b>	Estuarine, neritic, reefs
<b>Depth range (m)</b>	0 – 150
<b>Australian distribution</b>	Qld, WA, SA, NSW, Vic, inland and coastal waters
<b>Distribution outside Australia</b>	Southern Africa and Madagascar
<b>Resource status</b>	Unknown
<b>Type of fishery</b>	Aquaculture, commercial and recreational
<b>Fishing method</b>	Lines and traps

Mulloway, *Argyrosomus japonicus* (previously called *A. hololepidotus*), inhabit central and southern mainland Australian waters from Bundaberg and the Burnett River in Queensland to North West Cape in Western Australia. Although these fish are common in western Victoria, they are much less abundant between Melbourne and southern New South Wales and have rarely been reported from Bass Strait. Mulloway are also found in South Africa, Namibia, Madagascar, Mauritius and India.

Mulloway live in coastal environments, including the lower reaches of rivers, estuaries, rocky reefs, ocean beaches, embayments and the continental shelf to a depth of 150 metres. Adults are generally found close to the estuary floor or around shallow coastal reefs or rocky shores. Mulloway are more prevalent in and around the mouths of larger rivers and embayments eg. the Coorong at the Murray River mouth in South Australia, especially after periods of high summer rainfall ('freshes'). Juveniles, at least, have a wide salinity tolerance. Juveniles occur in estuaries, embayments and nearshore coastal environments, however little is known of their spatial distribution in estuaries. Studies in NSW have shown that two distinct juvenile cohorts recruited to the estuary each year; the first in February – March and the second in May. Mulloway are presumed to spawn in inshore waters, with larvae and juveniles using nearshore areas and estuaries as nursery areas. Surveys have shown that no Mulloway were caught at sites that were permanently fresh water and few were caught at the marine dominated sites closest to the mouth of the estuary.



## Life History

In South Australia, spawning Mulloway shoal in coastal marine waters adjacent to the surf zone between late October and February. These fish leave the Coorong during Autumn and return to the adjacent coastal beaches in the following Summer. Juvenile Mulloway grow rapidly especially from January to March. Fish 2 to 3 years old average 46 cm in total length and 1.5 kg in weight; for 5 to 6 year old fish the corresponding sizes are 80 cm and 8 kg. Mulloway can live for 30 years or more and may grow to 2 m in length. The largest mulloway recorded in Australia weighed 43 kg, although fish up to 71 kg have been caught in South Africa. Mulloway mature at about 6 years of age and are approximately 75 cm long.

Mulloway feed throughout the water column. Adults eat a variety of fish including yellow-eye mullet, leatherjackets, garfish, blue mackerel, bony bream, tommy ruff, pilchards and yellowtail. They also consume sand crabs, prawns and worms. Adult Mulloway also feed on juvenile Mulloway.

The reduction in flow from the Murray River has affected the spawning potential of Mulloway in South Australia, with some evidence of a decline in catches.

## Aquaculture Potential

There has been a good deal of interest in growing Mulloway in both the offshore and land environment. The use of sea cages for the grow out of finfish is reasonably well known in Australia, and may therefore be the preferred culture method for this species. However, as marine areas become fully utilised, site availability will become a major problem. This can be overcome by using sites which are further offshore or looking at land based alternatives. Mulloway can withstand reasonably low salinities, and as such are good candidates for inland saline aquaculture in ponds and tanks.

Mulloway are a good candidate species for commercial culture because it is widely distributed, has a good domestic market profile, is highly fecund, and euryhaline (can tolerate a wide range of salinities). Mulloway also has a suitable biology for aquaculture, with fast growth rates and good food conversion ratios. An interesting result of grow out trials in both ponds and tanks has been discovering the wide range of salinities and water temperatures these fish will tolerate. Grow out can be in salinity of 5 ppt up to 35 ppt. In that salinity range Mulloway can grow up to 1mm per day, which means that 1.0 kg fish may be possible to produce in 14 – 15 months. Another advantage is that Mulloway show good growth rates at a range of temperatures from 15 – 30°C, with grow out successful in sea cages, coastal earthen ponds, and recirculating aquaculture systems. There is also good prospects in local markets for substitution of declining wild catch.

There is a large degree of interest in spawning adult Mulloway not only for aquaculture purposes ie growing juveniles either in sea cages or on land, but also restocking natural areas for the recreational and commercial sectors in order to restock a depleted natural fishery.

Currently there are commercial operations utilising sea cages in New South Wales at Botany Bay, South Australia at Port Lincoln and other areas of Australia. On land trials are occurring in the south east of South Australia and other places in Australia.

## Spawning

Broodstock can be conducted to spawn 'spontaneously' in tanks after injection with hormones (particularly human chorionic gonadotropin) and pellet implants, meaning eggs are released naturally by females in the water and fertilised by males. Hand stripping after hormone induction is another suitable method.

Spawning will occur at approximately 30 to 35 ppt. A mature 10kg female can release approximately one million eggs in a single spawning event. Eggs are approximately 1.0 mm in diameter.

## **Juvenile rearing**

Mulloway larvae need a salinity of 5 – 35 ppt, and temperatures of 18 – 25°C, although will tolerate up to 30°C. The optimum salinity for growth in juvenile rearing of Mulloway is approximately 5 – 12 ppt. Mulloway prefer water with some marine influence, but are able to survive in fresh water for at least short periods. Disease problems have been found to be lowest at lower salinities ie 5 ppt.

Larvae are approximately 2.3 mm (total length) at hatch and begin to feed and inflate their swim bladder at three days after hatching. Metamorphosis begins when larvae reach approximately 12 mm at 23 days of age, and is completed by day 34 when larvae are 15 – 26 mm. Larvae with functional swim bladders grow faster than those without. Cannibalism occurs from day 18, and generally occurs to those without swim bladders. Enriched rotifers can be fed to larvae from day 3 to 15. Enriched brine shrimp can be fed to larvae from day 12 to 40 at densities of 0.2 – 0.6 per mL. Juveniles can be fed a variety of foods from day 33 onwards, and can consist of adult brine shrimp from day 38 to 68, finely chopped pilchards from day 38, a weaning diet from day 39 and a 50% protein 3 mm pellet from day 80. From day 106 to 180 fish can be fed solely on pellets. Juveniles can grow to a mean weight of 21 g and a mean length of 121 mm in 180 days.

Survival rates of larvae to weaning are around 15 – 20 per cent. There has been few disease or parasite problems, however brood stock in recirculation tanks are susceptible to fluke problems and juveniles have been susceptible to ectoparasitic protozoans.

Larval rearing can be undertaken in a range of culture systems including intensive clearwater systems, green water tanks and extensive fertilised ponds.

Growth rates through the larval and juvenile stages are relatively rapid with the fish growing 0.3 – 0.5 mm a day (intensive) and 1.0 – 1.7 mm a day (extensive). With the successful development of hatchery techniques, fish ready for transfer to grow out facilities can be produced in 30 – 40 days.

A study has shown that the growth and survival of larvae to juvenile fish is generally lower in intensive tanks than in extensive ponds. Cannibalism was a problem in intensive tanks, despite regular size grading, and may have accounted for the high mortality rates experienced. Cannibalistic behaviour becomes less of a problem when fish are around 80 mm total length. Survival of larvae in extensive ponds generally increased when older larvae were stocked into ponds. The best strategy to maximise survival and sustainable production of juvenile mulloway may be a combination of initial larval rearing in intensive tanks, followed by on growing in fertilised ponds.

## **Grow out**

Mulloway can be stocked into grow out operations at about 40 mm, approximately 30 – 40 days old.

At this stage the upper culture limit for Mulloway stocking densities are unknown. To date only about 15 kg per m<sup>3</sup> have been trialed. However Mulloway are gregarious suggesting they will tolerate high stocking densities. Observations of Mulloway in sea cages showed they were mostly bunched together in the corners of square nets.

Mulloway have good attributes for grow out in cages such as their preference for forming schools and ability to adjust to captivity, which makes inspection for diseases relatively easy. Mulloway tend to spend long periods of time 'hovering' rather than swimming. The energy saved by this behaviour may result in faster growth.

Mulloway grown in sea cages in the Sydney area reached legal size of 45 cm and approximately 1.1 kg within 26 months.

## **Inland aquaculture**

Inland Australia has huge quantities of saline ground water. Evaporation ponds are currently used to evaporate saline ground water which has been pumped to the surface from shallow water tables. This is done to prevent the saline water table from rising into the root zone of irrigated agricultural crops. In this way, growing fish on land can bring about a two fold benefit for traditional farmers by rehabilitating salt degraded land and adding a lucrative sideline to their business. This represents one of many excellent opportunities to utilise saline water resources.

Researchers in several states have identified a number of fish species suitable for farming in ponds filled with extracted saline ground water and underground aquifers. Mulloway appear to have good potential to utilise these reserves.

Recent trials in South Australia and New South Wales have shown that Mulloway grow well in a range of salinities (a euryhaline species) and water temperatures in ponds, tanks and recirculating systems, providing a range of opportunities for farmers with brackish water.

Purpose built earthen ponds have several advantages over intensive systems, for example the ease of expansion and the decreased capital costs compared to recirculating systems. A major disadvantage with pond culture is that Mulloway will require reasonably high dissolved oxygen levels to survive and grow. This will inhibit high stocking densities and as such may dictate that the economics of such a venture will not be feasible or not in the order of return required by the investor.

Pond trials have shown that 1g fingerlings could be grown to an average of 760 grams in 16 months with a temperature range of 9 – 30°C. Pellet feeds displayed a good FCR of 1.13:1.

In recirculating systems stocking densities have been trialed up to 25 kg/ m<sup>3</sup>, although higher rates are expected. A FCR of 1.1:1 has been achieved using pellet diets.

In recirculating systems, Mulloway have taken 10 months to reach greater than market size of 500 grams, and have reached 1 kg in 16 months, and up to 1.2 kg average in about 2 years.

## **Disease**

Epidemic diseases caused by organisms such as ciliated protozoan and monogenean trematodes, have killed juvenile and adult Mulloway. The behaviour of heavily infested fish often changes rapidly and may include loss of appetite, 'flashing' or rubbing their bodies on tank surfaces, slow swimming and rapid or laboured gill movements. Control measures exist for protozoans and trematodes and can be achieved either through prophylactic treatment or treatment as required.

The full extent of the diseases that Mulloway may be susceptible to have yet to be verified. This is the case especially with fish grown in sea cages where they are in constant contact with the surrounding marine environment.

## **Marketing**

Unlike snapper, large Mulloway (more than 2.5 kg) currently fetch the best price. Wild caught smaller Mulloway have poorer consumer acceptance, however informal taste tests of 1 kg Mulloway grown in sea cages were very favourable and pond rearing trials have also produced a high quality product. Little is known of the export potential of Mulloway.

In all southern mainland States, Mulloway are sold on local markets as fresh, gutted fish. In 1991 – 1992, the average price for 'jewfish' at the Sydney Fish Market was \$5.85, and the average monthly prices at the Melbourne Wholesale Fish Market ranged from \$4.07 to \$6.90. Currently however Mulloway can generally be sold for between \$10 – 15 per kilogram.

In sea cages Mulloway have been grown to market size, 700 g to greater than 1.0 kg, and have been sold live to Sydney's Chinatown market for greater than \$14/ kg.

Mulloway have been grown in ponds designed for prawns, with excellent market acceptance.

Only Mulloway from the pond trials have been marketed in any quantity. Cultured Mulloway obtained good acceptance with chilled whole/ gilled – gutted fish with prices around \$10/ kg. The fish were found to be moist, tender with a white flesh free of off-flavours and low in fat. Fillet recovery was high at 52 per cent with the rib cage removed. With most Australian consumers preferring white fleshed fish with few bones and a mild flavour, cultured Mulloway can meet these consumer preferences, indicating that a substantial market should exist for this product.

## **Economic outlook**

The profitability of Mulloway culture in Australia is unknown; however other members of the family Sciaenidae, such as red drum, have been successfully cultured elsewhere. The optimum culture and production infrastructure is unknown but likely to be compatible with other eurythermal and euryhaline species.

The commercial culture of this species appears imminent; however, the establishment of the fish as an aquaculture candidate in South Australia will probably depend on its market value.

Reseeding or enhancement of wild marine fish is not widely practised in Australia, but is common in some other countries, and is receiving increasing consideration as a means of increasing fisheries world wide. Experiments in NSW have demonstrated that large numbers of juvenile Mulloway can be reared in hatcheries, and that stock enhancement of intermittently opening lagoons is feasible.

## **Business Assistance**

Prospective applicants are encouraged to contact their nearest Regional Development Board (RDB) if they require assistance in business planning, financial returns and other business related matters. New applicants can also approach the Boards for general aquaculture advice. Aquaculture SA, PIRSA, has an established partnership with the Boards providing technical support to them on aquaculture issues. The Board has several aquaculture tools to assist people such as a financial planner for finfish culture, aquaculture handbooks for sale and have access to an array of general and technical information.

## **Aquaculture Development Regulations**

To obtain a marine farming licence, a number of application forms must be completed in sequence. These can be obtained from the PIRSA website or by calling Aquaculture Licensing on 8226 0770. If tenure is available, Aquaculture SA will assess the applications and forward it to the Development Assessment Commission to assess the application for planning issues. Marine licences are renewed annually, and must meet all licence conditions and have fees paid in full in order for renewal.

To undertake landbased farming a fish farming registration must be obtained. An application form can be obtained from the PIRSA website or by calling Fisheries Licensing on 8226 2313.

## Further Information

### **South Australian Marine Finfish Farmers Association**

Executive Officer – Mark Cody  
PO Box 2099  
Port Adelaide SA 5015  
Telephone: (08) 8303 2754

### **Aquaculture SA, PIRSA**

PO BOX 1625  
Adelaide SA 5001  
Telephone: (08) 8226 0314  
PIRSA website: [www.pir.sa.gov.au/aquaculture](http://www.pir.sa.gov.au/aquaculture)

## Bibliography

- Anon (1999). Inland aquaculture solution for water salinity. *Austasia Aquaculture* **13 (2)**, p 57.
- Battaglione, S. C. and Talbot, R. B. (1994). Hormone induction and larval rearing of Mulloway, *Argyrosomus hololepidotus* (Pisces: Sciaenidae). *Aquaculture* **126**, 73 – 81.
- Fielder, S. (1999). Mulloway tamed. *Fisheries NSW* **2 (4)**, pg 21.
- Fielder, D. S. and Bardsley, W. (1999). A preliminary study on the effects of salinity on growth and survival of Mulloway *Argyrosomus japonicus* larvae and juveniles. *Journal of the World Aquaculture Society* **30 (3)**, 380 – 387.
- Fielder, D. S., Bardsley, W. J. and Allan, G. L. (1999). Enhancement of Mulloway (*Argyrosomus japonicus*) in intermittently opening lagoons. NSW Fisheries Final Report Series No 14.
- Fisheries NSW website (2001). Aquaculture prospects for marine fish in New South Wales.
- Gray, C. A. and McDonall, V. C. (1993). Distribution and growth of juvenile Mulloway, *Argyrosomus hololepidotus* (Pisces: Sciaenidae), in the Hawkesbury River, south – eastern Australia. *Australian Journal of Marine and Freshwater Research* **44**, 401 – 409.
- Hall, D. A. (1986). An Assessment of the Mulloway (*Argyrosomus hololepidotus*) Fishery in South Australia with particular reference to the Coorong lagoon. Department of Fisheries, South Australia.
- Jenkins, G. (1998). Potential for inland saline aquaculture of fishes. *ACIAR Proceedings Series* No 83, pg 42 – 46.
- Kailola, P. J., Williams, M. J., Stewart, P. C., Reichelt, R. E., McNee, A. and Grieve, C. (1993). Australian Fisheries Resources. Pg 318 – 320.
- Nel, S (2001). SA Aquaculture Handbook
- O'Sullivan, D. and Ryan, M. (2001). Mulloway trials suggest opportunities for brackish water ponds. *Austasia Aquaculture* **15 (2)**, 22 – 24.