Inland production of marine fish

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Introduction

Inland saline water is already successfully used to grow barramundi (*Lates calcarifer*) in NSW in an indoor, intensive recirculating system. Similarly, it has been used to farm a range of algae, crustaceans, and finfish such as tilapia, red drum, sea bream, eels and channel catfish in North America and the Middle East.

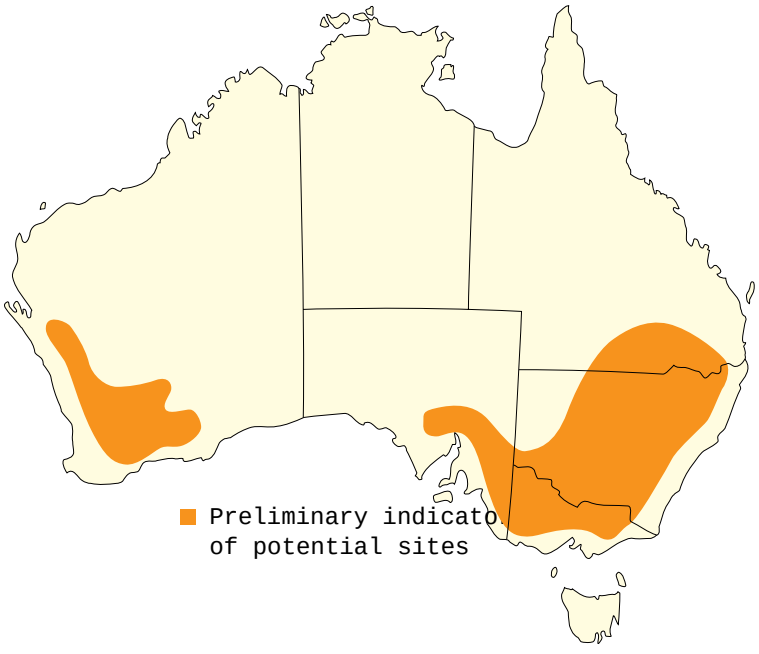
In Australia, investigations are under way to determine if snapper *(Pagrus auratus*), mulloway (*Argyrosomus japonicus*), black bream (*Acanthopagrus butcheri*), Atlantic salmon (*Salmo salar*) and the freshwater silver perch (*Bidyanus bidyanus*) can be farmed in inland saline water. Australia has a great deal of inland, saline ground water and excellent potential exists to use this for the farming of temperate marine finfish.

Rising saline ground water tables and increasing river salinity are major problems in the semi-arid agricultural regions of Australia. In order to retain arable land, a method of pumping saline ground water into purpose-built, on-farm evaporation ponds or sacrificial basins, is being used in Western Australia, South Australia, New South Wales and Victoria. These evaporation ponds may be suitable for growing marine fish if the water chemistry is suitable for their survival and growth.

Although a number of species could be grown in inland saline ponds, this article focuses on snapper and mulloway, temperate species being investigated in NSW. General fish husbandry for barramundi and silver perch is covered elsewhere in this book.

Snapper is seen as an excellent candidate for farming in temperate Australia. It is the same species as the Japanese red sea bream, which has been cultured for more than 20 years in Japan using intensive larval rearing followed by grow-out in sea cages. In 1987, aquaculture production in Japan totalled 38,000 t. Snapper is a popular commercial species and commands a high market price.

Mulloway is also an excellent candidate for inland farming because it is very similar to the American red drum. Technology for red drum production is well developed and the species has been successfully grown in inland saline ponds in the USA. Mulloway are a popular commercial and recreational species in Australia and the wild fishery is declining. Mulloway also command a high market price.



The technology for snapper and mulloway production is developing and a commercial industry for coastal farming of snapper is beginning in Australia. However, a major constraint to industry development is the limited number of suitable sites for sea-cage farming. To date, production of market-size snapper and mulloway in Australia has been confined to a pilot commercial scale research project conducted by NSW Fisheries using sea cages in Botany Bay. However, a commercial sea-cage farm in SA should harvest snapper soon.

If research demonstrates that marine fish can be farmed in inland saline water, a new industry will be developed for inland farmers. Given a sound understanding of primary production and the associated pitfalls, these farmers will need to develop fish husbandry and marketing skills.

Marketing issues

Not enough wild-caught snapper are at present reaching markets in Australia. Catches in New South Wales declined from 1000 t in 1980 to 513 t in 1994–95, and the deficit is currently made up with imports from New Zealand. There is clearly a market for farmed snapper, at least to replace imports.

Because the snapper farming industry is developing, only small quantities of snapper were sold in 1995 as fresh, whole or live product (400 g and up). These fish were sold on the Sydney auction floor and the price ranged from $5.50 to $10.00/kg. Live fish sold in Sydney returned $17.00/kg.

The dark skin colour of farmed snapper resulted in lower prices than wild-caught snapper of the same size. Once a technique was developed to lighten the skin colour of farmed snapper, higher prices were received.

To date, only small numbers of mulloway have been farmed by NSW Fisheries, so only limited marketing has been possible. Some buyers believe that small mulloway (< about 3 kg), referred to as 'soapies', are not very palatable. However, live mulloway of 1–1.5 kg sold to the Asian restaurant trade in Sydney were highly regarded. The preferred market size for farmed mulloway appears to be 500–700 g.

Other farmed fish, such as barramundi, are sold direct to wholesalers on consignment.

A substantial export market for snapper exists in Asia, particularly for live fish.

Production requirements

Marine fish could be farmed in inland Australia by using a range of techniques. The first would involve grow-out of fish directly in the evaporation basins. Alternatively, fish could be grown in floating cages situated in the evaporation basins. This is the most common technique used to farm barramundi in freshwater ponds in north Queensland. Another technique, which requires greater infrastructure and capital inputs but provides more control over the farming environment, involves grow-out of fish in

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intensive, indoor recirculation systems. Barramundi are already farmed in this manner in inland NSW using saline ground water.

Snapper and mulloway are temperate marine species and have been cultured in coastal NSW in temperatures ranging from 13° to 25°C and salinity's of 30–35 ppt. Growth of both species is affected by water temperature. However, low temperatures of 15 to18°C cause a greater reduction in growth of snapper than mulloway. Mulloway also grow almost twice as quickly as snapper. The upper and lower temperature and salinity tolerances for Australian snapper are not yet known, but Japanese red sea bream can survive temperatures in the range of 5.5° to 30°C and salinity as low as 16 ppt. Mulloway can tolerate a wide range of salinity from 5–35 ppt.

Inland areas where snapper and mulloway could potentially be farmed will depend on factors such as the type of production system used, the chemistry and temperature of the pumped ground water, and the volume of daily exchange water. Open-pond production will most likely be restricted to the southern inland areas of Australia because of the extremes in ambient air temperature. Pond construction will require either impermeable soils or plastic liners. Intensive indoor systems could be operated anywhere in Australia provided that the saline ground water chemistry is suitable. The cost of production of all farming systems will be influenced by the proximity to infrastructure and markets.

The main environmental feature of using inland saline water for fish culture is that it makes it possible to use ground water and land degraded by salt intrusion. Pond-based fish-farming would involve no release of effluent water into natural waterways, so the environmental impact of farming activities would be limited.

Key statistics

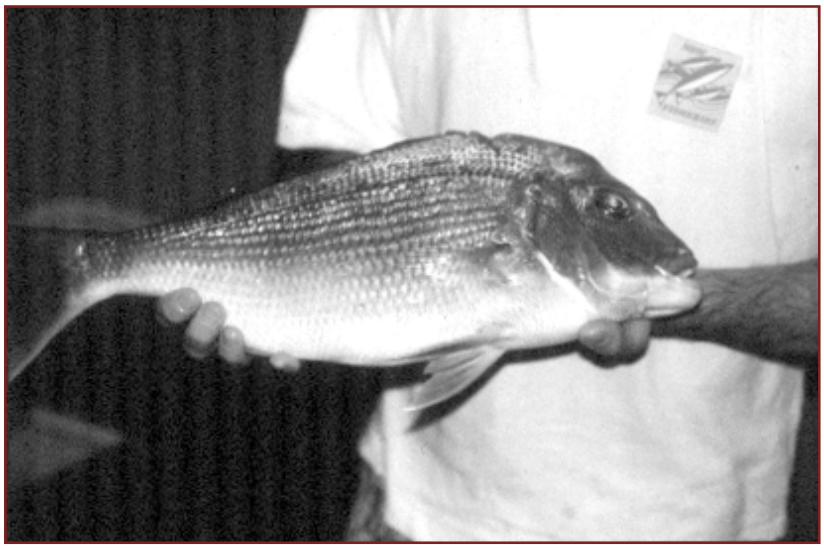
Statistics for farmed snapper and mulloway are not available. Statistics for the 1994–95 Australian wild catch fishery for snapper are:

Varieties

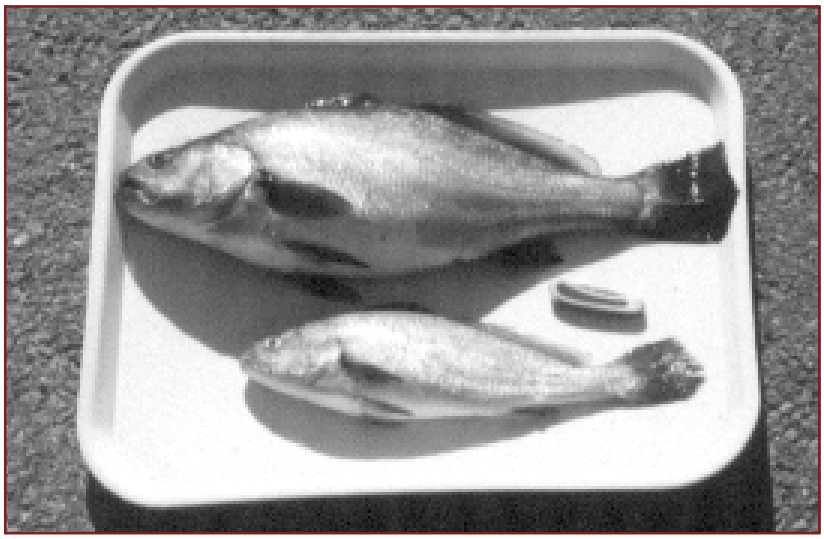
Apart from Atlantic salmon, there has been no selective breeding of marine fish species farmed in Australia. First and second generation hatchery-reared broodstock are available for some species such as snapper, mulloway and barramundi but broodstock selection has not yet become a component of formal breeding programs.

Fish husbandry

A reliable supply of cheap, healthy fingerlings is essential for snapper farming. To date, only relatively small numbers (tens of thousands) of fingerlings have been produced by research organisations in Australia for grow-out in pilot-scale projects. Several commercial hatcheries are now poised to produce snapper fingerlings and research is going on to improve existing and develop new techniques for low-cost fingerling production.



The Australian snapper is an excellent candidate for farming in saline groundwater in temperate areas of inland Australia.



Mulloway can grow in water with salinities ranging from almost fresh to full strength seawater and have excellent potential for farming in inland saline groundwater.

Methods for spawning wild and captive broodstock are fairly well developed. Induced spawning occurs after the injection of reproductive hormones or natural spawning can occur after the manipulation of temperature and photoperiod. Several research facilities have been able to induce out-of-season spawning by controlling the temperature and photoperiod, thus potentially allowing year-round spawning.

The main method of snapper fingerling production in Australia has used intensive, clear-water methods. Intensive hatcheries need high-technology, dedicated facilities, excellent saltwater quality and well-trained staff and consequently are expensive to operate. Some early success has been achieved with the use of extensive, fertilised, brackish-water ponds for snapper fingerling production and large numbers of mulloway have already been produced using this method. This technique is used to rear a wide range of marine and freshwater fish species; it requires less sophisticated facilities and is easier to manage than intensive hatcheries. The cost of fingerling production is also lower when using extensive rather than intensive rearing techniques. Research is continuing to develop extensive techniques for snapper.

In an intensive hatchery, the larvae must then be fed plankton, which is specially grown. In extensive systems, natural plankton is encouraged to grow in ponds by the addition of fertilisers. Once the larvae have metamorphosed into true fish (34–39 days old and 10–12 mm), they are generally transferred from the hatchery to a nursery, where they are weaned off live food onto a formulated pellet diet. The fingerlings will remain in the nursery until transfer to the grow-out site which usually occurs when fish are 40 mm long.

The fingerlings are then released directly either into earthen ponds or floating cages for grow-out. To date, snapper and mulloway have not been farmed to market-size in ponds in Australia, but there are no obvious reasons why this will not be possible. Ponds used to grow freshwater fish are usually 0.1–1 ha in area and 1–1.5 m deep. Fingerlings are generally stocked into aerated ponds at 5,000–20,000/ha and harvested at 400–500 g. Snapper and mulloway are fed a formulated pellet diet which is readily available from several feed producers. Smaller fish need frequent feeding, up to six times a day, but as fish become larger feeding can be reduced to once or twice a day.

Good water quality is essential for the good growth and survival of any farmed fish. Dissolved oxygen, temperature, pH and water clarity must be monitored regularly. Depending on stocking density and the quantity of food required, water exchange may be necessary to optimise the ponds' water quality.

Key messages

- E Excellent potential for new industry
- E Potential for limited environmental impact
- E Water resource currently not used
- E Techniques need developing

Snapper farmed in sea-cages in Australia reached market size (400 g) in 20–24 months. Mulloway grew faster than snapper and reached 1100 g in 26 months. Fingerlings were stocked in late summer and

consequently were grown through two winters. However, if fingerlings were available for stocking into ponds in early spring, the time to market could be reduced to 12–18 months.

Pest and disease control

Farmed marine fish are susceptible to a range of pests and diseases. Disease outbreaks often occur after the fish are stressed as a result of suboptimal environmental conditions or husbandry practices. Low water temperature, dissolved oxygen, and pH outside of the 6–9 range can cause stress which can result in disease. Rough handling of fish during transport to the farm or sorting for market, and overcrowding, can remove skin and scales from the fish which then become more susceptible to infection.

Vibriosis is a bacterial infection which has caused the death of snapper farmed in sea-cages. The dominant bacterium, *Vibrio splendidus*, was isolated from dying snapper when water temperatures declined from 20° to 15°C. Vibriosis typically appears as white, circular lesions on the sides of fish. Infected fish are dark in colour, sluggish, do not feed well and can die in large numbers. Fingerlings are usually more susceptible to vibriosis than advanced fish. Outbreaks of vibriosis can be controlled by antibiotics, such as oxytetracycline, added to the pellet diet. Other options for prevention may include stocking fingerlings well before the onset of winter and avoiding handling the fish during winter.

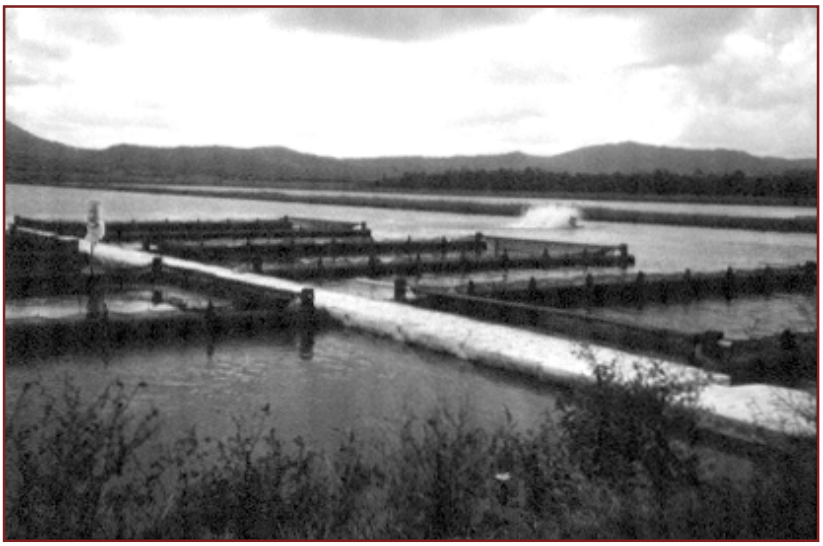
The gill fluke parasite, *Bivagina pagrosomi*, has also caused disease in farmed snapper. The adult flukes attach to the gills and skin and when present in large numbers can cause severe blood loss. Infected fish are dark and sluggish and do not feed well. Gill flukes can be treated by subjecting fish to a formalin bath. Fish infected with gill flukes may also be more susceptible to secondary bacterial infections.

One viral disease, lymphocystis, has been found in snapper. It generally does not kill but disfigures the external appearance of the fish by forming wart-like lesions. There is no known treatment and fish generally overcome the infection in time.

Mulloway farmed in sea-cages did not suffer much disease but cannibalism and cormorants caused some deaths. Cannibalism can be reduced by the regular size-grading of fish. Cormorants are fish-eating birds and are a problem for farming fish in ponds and sea-cages. The ponds must be covered with bird-proof netting to keep the birds out.

Harvesting, processing and packaging

The harvesting of fish from ponds initially requires the concentration of the stock into an accessible area. This can be achieved either by draining water from the pond or running a seine net through it. The fish are then lifted out in hand nets or by mechanical devices such as fish pumps. Fish are usually euthanased by placing them directly into an ice/brine slurry. Freshwater fish can be affected by 'off'-flavours and require 'purging'. Purging involves holding the fish in tanks supplied with clean water, usually for one to three weeks before market. It is unlikely that 'off'-flavours will be a problem in inland saline water, but if they are, then purging will be necessary.



Inland saline groundwater has potential for use in ponds or intensive systems to farm marine fish. Similar facilities to these freshwater ponds, used for barramundi, are currently being evaluated.

Most farmed fish are sold with the head on and gut in, so processing is minimal. The fish are transported to a licensed packing shed, removed from the slurry and packed into lined, Styrofoam boxes. At least one layer of crushed ice is placed on the fish before the box is sealed. The chilled product is then transported to market by road or air.

Fish must be handled as little as possible to reduce external damage and keep them looking their best. Specialist transporting facilities such as tanks with more than 2000 L capacity and filtration and oxygenation are needed to carry high densities of fish.

Economics of production

Insufficient data on the farming of fish in inland saline water are available to estimate the economics of production. However, an economic analysis of the sea-cage farming of snapper and mulloway is made in *Proceedings of a Marine Finfish Farming Workshop*.

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Key references

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