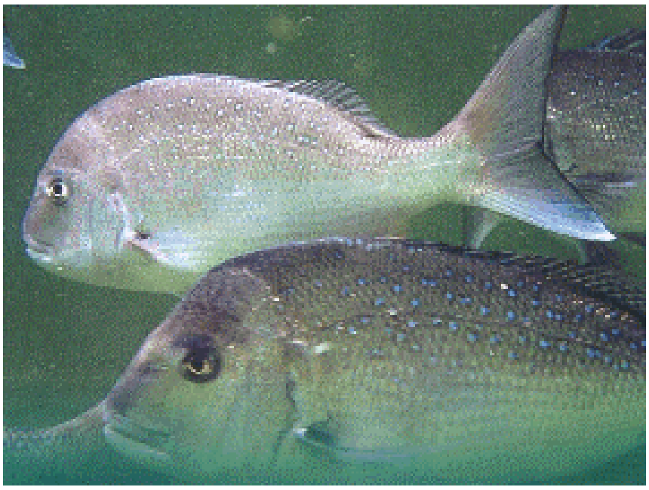
Snapper aquaculture in South Australia



Interest in Snapper (*Pagrus auratus*) farming in South Australia has grown steadily over the last five years. However, the introduction of Yellowtail kingfish and Mulloway for aquaculture, in the last two and one years respectively, has seen a decline in interest in culturing snapper. This can be attributed to a number of issues, namely the slow growth of snapper in local waters and respectively the faster growth rates achieved with Yellowtail kingfish and possibly Mulloway. Southern and northern hemisphere snapper stocks were once considered to be two separate species, *Chrysophyrs auratus* and *Pagrus major*. However, they are now regarded as the one species, *Pagrus auratus*, with independent and reproductively isolated populations in both hemispheres. Outside of Australasia they are commonly known as sea bream.

Aquaculture

The farming of snapper is a relatively new concept in Australia, with farms currently now being developing in Western Australia, South Australia and New South Wales. New Zealand has also conducted research and development programs, and has been successful in growing snapper to a commercial size.

The majority of research into snapper farming has been conducted in Japan, where the species has been reared experimentally since the early 1900's and successfully commercially farmed since 1965. Consequently, most of the information available on snapper farming is based on Japanese experience. In 1995, Japan produced 70,000 tonnes of red sea bream (snapper) from aquaculture. This figure is more than 6 times the catch of this species from wild fisheries in that country. The success of snapper culture in Japan has been built on a thorough knowledge of this species biology and behaviour in the wild. In addition, sound applied research into nutritional requirements, larval production and equipment for culture have facilitated technology transfer from research agencies to industry.

In Australia, research is required to confirm that juvenile production techniques, optimal stocking densities, feed formulations and feed rates developed elsewhere are applicable to snapper in the local environment.

The technology and methods developed overseas have been based on the economics of supplying fresh fish into local markets at premium prices. Snapper culture within Australia will therefore need to minimise production costs in order to absorb the added expense of freight and handling. An economic appraisal of snapper culture in New Zealand has been undertaken and provides a synopsis for potential farmers. It highlights production costs, feed costs and market values for farmed snapper in Japan as constraints upon the viability of aquaculture. More recently, Japanese snapper farmers have had to contend with lower prices being realised for their cultured stock than prices being paid for wild caught fish plus an oversupply of cultured snapper on local markets.

In Japan, several important factors can be cited as contributing to the beginning of full-scale culture of red sea bream after 1970:

- The successful development of methods for the artificial mass production of red sea bream fry for culture purposes around 1970 made a staple supply of juveniles available to culture operators for the first time.
- Improvements in rearing techniques made it possible to raise red sea bream to a saleable size of 1 kg within two and a half to three years.
- Research and development in composite feeds and feeding methods.

Culture methods

Internationally, snapper have been cultured in ponds, lakes, tanks, pens and sea cages. In Egypt, snapper have been successfully stocked into coastal lakes that have become saline due to evaporation and run off from agriculture.

The culture of snapper in tanks is possible, but the most common form and the form most suitable for Australian conditions is the use of floating sea cages. More than 90% of the Japanese commercial production is farmed using this method.

Cage management

In order to rear healthy fish under favourable growth conditions, it is essential to maintain a proper population density within the culture cages. Although the actual density will vary according to sea conditions, in the case of 10m x 10m x 5m cages, farmers in Japan maintain a density of less than $35kg/m^2$. In relation to the mesh size of nets used, the larger the mesh size the better, because a large mesh size will allow for better exchange of water between the cage and the surrounding sea. Also, when nets are left in the sea for long periods of time marine organisms begin to grow on them, thus clogging the mesh and further restricting water flow.

Grading and net changing are two basic environmental control practices that directly effect how efficiently feeding will take place and how fast the fish will grow. They also have a great affect on the material, labour and feed costs of the culture operation. Each operator searches for their own techniques and answers with regard to these two practices, and their degree of diligence in these two tasks will account for considerable differences in the effectiveness of individual culture operations.

Site selection

Although the culture of snapper has been achieved in water temperatures varying from 13^0C to 28^0C, the optimum growth for snapper is 20^0C to 28^0C. When water temperatures fall below 20^0C the amount of food consumed begins to decline and feeding will stop completely at water temperatures below 10^0C. Mortalities occur if the temperature drops below 4^0C. Growth is enhanced in warmer waters and may be twice that experienced in cooler locations. When the water temperature exceeds 29^0C, the feeding habits become quite irregular, and the fish become susceptible to physiological disorders.

Dissolved oxygen levels should be maintained above 3 parts per million (ppm). Although the minimum concentration of dissolved oxygen that may be withstood is 1.5 ppm, at levels below 3.5 ppm feeding decreases. Culture may only occur where salinity remains above 16 parts per thousand (ppt).

In summary, the following are some of the more important conditions that should be considered when selecting a suitable site for snapper aquaculture:

- The yearly water temperature should range between 13°C and 28°C and to ensure rapid growth, it is best if the winter low does not ever drop below 13°C or 14°C for a prolonged period.
- The depth of water should be more than twice the cage depth of 5 to 7m.
- The site should have a good flow of seawater or a good exchange of waters due to tidal movement.
- Cages should be in quiet waters protected from the direct effects of wind and waves from the outer sea.
- The site should be free of the threat of water quality deterioration due to excessive inflow of fresh water or industrial wastewaters.
- There should be good access to support industries, feed supply and transport for the harvested fish.

Juvenile production

Snapper are functional gonochorists, that is, during its life may spawn as a male or a female, but not both. Protogynous (female to male) sex inversion (change) occurs in only some of the population. Prior to becoming sexually mature, juvenile snapper may undergo sex inversion to become functional males, those individuals which do not undergo this sex inversion, will mature to become functional females. The age at which sex inversion occurs varies between populations.

In Australia, snapper are known to spawn when the water temperature reaches 18^0C, although in Japan they may spawn at water temperatures between 15^0C and 22^0C. Natural spawning occurs at dusk and evenings.

Females spawn repeatedly over a 3 to 4 month spawning season. In a spawning season, a 3 year old female may produce 250,000 eggs, a 1.5kg female may produce 300,00 to 400,000 eggs and a 10 year old female may produce 5 million eggs.

Fish can mature after 2 years. Mature broodstock are usually held in spawning tanks or floating net cages, at a sex ratio of 1:1 and a density between 0.5 and 1.5kg/m^3. Females with oocytes (eggs before the completion of maturation) greater than 0.9 mm in diameter can be readily induced to ovulate using hormone induction. Induced spawning techniques using human chorionic gonadotropin (HCG) are well developed, however, natural spawning produces better quality eggs.

Fertilised eggs are between 0.9 and 1.0 mm in diameter. Positively buoyant eggs have a higher hatching rate than do negatively buoyant eggs, which are generally unfertilised, immature or overripe. Consequently, eggs are often collected from tank overflows. Egg quality is related to broodstock nutritional state and the age of the females.

Eggs are incubated in the dark either in tanks with volumes generally ranging from 50 to 100 m^3 at a density of 20,000 to 30,000 eggs/m^3, or more intensively in smaller tanks with a volume of 0.5 m^3 and a density of 40,000 eggs/m^3. Although egg development is closely related to water temperature, eggs generally hatch into 3.1 mm yolksac larvae approximately 28 hours after fertilisation.

After hatching, larvae are grown at a density of 10,000 to 15,000 m^3. Higher densities result in cannibalism. Failure of the swim bladder to inflate at around days 7 to 11 has been a major problem in rearing snapper larvae.

Fry production is divided into a primary rearing stage conducted in tanks on land, and a secondary stage in net cages set up on the surface of the sea. About 20 days after hatching the larva reach a body length of about 7 mm.

When they reach a body length of about 30 to 50 mm, they are moved to net cages set up in the sea and the second stage of rearing begins. Difference in fry size will cause significant losses due to cannibalism. Rearing density in the cages should be low enough to prevent substantial losses. When moved to the new environment the fry must have the durability to withstand changes in water conditions and other physical stresses. By the time snapper fry reach a body length of 7 mm they acquire the swimming abilities necessary to accommodate flowing water. At this stage in their growth they also have the strength to withstand the stresses of handling and transport. Their feed changes from zooplankton to a composite feed in crumble form.

The number of fish stocked and relative mesh size in a 10m x 10m x 5m floating cage is presented in the table below.

Year	Size	Mesh size	Number
1st	Fry – 100g	23.3mm	10,000
2nd	100 – 800g	33.6mm	5000
3rd	800 – 1300g	50.5mm	3000
4th	1300 – 1500g	75.8mm	3000

Regular access to fry and fingerlings is essential for the development of a snapper aquaculture industry. For every 100 tonnes of aquacultured market size fish, up to one million juveniles would need to be produced.

A marine fish hatchery requires access to clean oceanic water. As broodstock have to be held on site, the cost of building such a hatchery could be several million dollars, including land costs.

Sea cage grow-out

In Japan, selective breeding over 5 generations has produced a 40% increase in growth rate of cultured snapper compared with wild populations. This has halved the required culture time of snapper from 3 years to 18 months. This genetic improvement is reported to save the Japanese farmers 30% in culture costs.

In NSW trials were undertaken by the Fisheries Research Institute on snapper growth in a large saltwater pool and fibreglass tanks but both survival and growth were highest in sea cages. Snapper were found to grow to market size (28 cm fork length) in 21 months with an average food conversion ration (FCR) of 2.2:1 and survival in excess of 50%. The suggested maximum stocking density is 3 kg/m^3 for the first winter when the fish are about 30g. In common with many other species, snapper are particularly prone to disease during their first winter in a sea cage. Therefore the stocking density should be kept low to minimise losses. In NSW the stocking density at harvest was 6 to 10 kg/m^3.

The South Australian snapper aquaculture industry has expanded rapidly in recent years, with hatcheries and grow-out facilities now established in the upper Spencer Gulf region.

Feed

Early life stages

In culture, by day 2 snapper larvae absorb their yolksac. Their oil globule is absorbed at day 6 and feeding on rotifers usually commences at this day also.

Snapper juveniles are fed rotifers at a density of 10 per ml for days 4 to 27 after hatching. From days 23 to 40, juveniles are fed live artemia at a density of 0.4 to 1.5 per ml. Snapper larval mortalities have been attributed to omega 3 highly unsaturated fatty acid deficiency in cultured rotifers. Rotifers and artemia are therefore enriched either with algae or by encapsulation of artificial enrichment agents to overcome this deficiency. Juvenile snapper will take inert food and may be weaned on to artificial pelleted diets at days 30 to 35. Adult snapper will readily take artificial feeds.

The time and expense involved in providing live food to snapper larvae have led to considerable research into developing suitable formulated micro particulate diets for snapper. Consequently, micro particulate diets are now commercially available. Artificial diets formulated for both juvenile and adult snapper involve high levels of protein, usually between 40% to 50%, fat at 3% to 6% and less than 20% carbohydrates. Vitamins can be added to the feed.

Advanced stage (cage grow-out)

Artificial feed development has advanced significantly in recent years. Artificial feeds meet the nutritional requirement for maximum growth, as well as being more convenient in terms of transport, storage and handling than using fresh or trash fish feeds.

Moist pellets have been developed which combines the characteristics of both fresh fish and composite feeds. The benefits of moist pellet feeds include the fact that it can be changed to suit the growth stage of the cultured fish, necessary nutritional supplements can be mixed in, the amount of feed necessary per feeding is less when using only fresh fish, and the fact that there is less pollution of the culture environment resulting from the accumulation of uneaten feed.

Food and feeding are the major costs for the more intensive fish farming operations and uneaten or poorly digested food is the major source of environmental pollution for fish farms.

Disease

As the aquaculture of snapper is still in the early stages of development in Australia, the status of disease is unknown. However, research by the NSW Fisheries Research Institute have identified three diseases as having the potential to impact significantly on the farming of snapper in cages. These are vibriosis (especially following procedures causing injury to the skin), gill infection and a viral disease called lymphocystis.

Mortalities can be minimised by good husbandry. Any stressing of juvenile snapper (eg. by measuring, handling, moving) during their first winter in a sea cage should be avoided if possible. Outbreaks of vibriosis are controlled by feeding pellets medicated with an antibiotic. Trematode infestations can be treated on site by formalin bath for one hour. Lymphocystis does not normally cause significant mortality, but it can seriously degrade the appearance of fish and lower their value. Lymphocystis is a virus and there is no known treatment. Lymphocystis may also increase the susceptibility of snapper to other pathogens.

In hatcheries, mortalities of over 40% have been reported due to vertebral malformation known as lordosis. Most health problems experienced with adults have been attributed to either handling stress or poor diets. Snapper held in sea cages can also suffer from eye and skin damage caused through contact with the net.

Economic considerations

A cost-benefit analysis for snapper farming in cages has been developed by the NSW Northern Rivers Regional Development Board Inc. Their economic model is based on a farm producing 100 tonnes per annum. Other basic assumptions include a juvenile cost of $1 each, survival to market size (500g) of 60%, a FCR of 2:1, cost of food at $1,200 pr tonne, a grow-out period of 2 years, an initial stocking density of 3 to 4 kg/m^3 and a density at harvest of 10 kg/m^3.

Estimated capital costs are around $460,000 with depreciation (cages, nets and moorings) of $57,000 each year, annual operating costs could be $1.16 million. On these figures the fish would need to return more than $11 to $12 per kg (dressed weight) before the farmer could make a profit. It recommends that the live fish market for Asian restaurants should be targeted. Live snapper can command $18 per kg at present, but this would expect to drop back at least to $14.50 as availability increased. A question remains over the capacity of this market to accommodate significant increase in tonnage.

As the figures used in this analysis are estimates, they could vary between projects. Significant reductions in operating costs might be expected as management and production techniques improve with experience.

Although actual production costs differ greatly between the NSW figures and Japan, the end result (profit over selling price) is in agreement – i.e. around 31 or 32%. In Australia the market size of 500g is reached in 22 months while in Japan 1 kg fish are grown in 27 months. A comparison of economic analysis between Australia and Japanese snapper farming are shown in the following table.

	Aust '95 (A$ / fish)	**Japan '90 (A$ / fish)**
Juvenile costs	1.60	1.25
Food costs	1.20	10.00
Wages, depreciation & maintenance	1.98	0.63
Live storage and handling	0.22	Local sales
Total cost	5.00	11.88
Sale price	7.25	17.5
Profit per fish	2.25	5.62
Profit / sale price	31%	32%

Based on a bank loan to provide funds for the project, it could be up to 10 years before the real benefits are reached.

When a fish species requires a long culture period, it means not only increased feed and labour costs but also a lengthening of the period of investment turnover.

All persons wishing to become involved in any form of aquaculture should make their own investigations in to the economic value of the aquaculture activity.

Aquaculture development regulations

Aquaculture continues to emerge as a significant issue affecting the ongoing use and management of the coastal land and water bodies. It is an industry that has significant economic potential. At the same time, poorly sited and managed aquaculture developments can create undesirable impacts. Effective management controls and policies relating to aquaculture are therefore essential.

The policy of the South Australian Government is to provide a basis for sound management of aquaculture, so that benefits will continue to flow to stakeholders and land users now and in the future.

An effective approvals process has been developed for aquaculture developments at sea. Applicants must obtain three key approvals in order to proceed. These are:

- Development approval pursuant to the Development Act;
- A licence to farm fish pursuant to the *Fisheries Act 1982*
- A lease for land on, or over, which aquaculture will take place pursuant to the Harbours and Navigation Act.

Development at sea is usually outside the jurisdiction of local councils and therefore assessment is made by the Aquaculture Committee under delegation for the Development Assessment Commission.

Aquaculture Management Plans have been developed for coastal waters of South Australia. These documents provide direction and guidance for the Aquaculture Committee in assessing applications. A clear process has been established with Management Plans stating the policies of each of the key agencies and a single committee receiving a single application and assessing the application in conjunction with comments from relevant government agencies.

Any person who wishes to participate in marine aquaculture are strongly advised to read these management plans, which can be found on the PIRSA website, before submitting an application.

References and recommended reading

This fact sheet is designed to provide some basic information on the biology and farming of snapper in South Australia. It is not meant to be a full guide to the culture of the species. As the culture of snapper in Australia is relatively new, much of the information is based on the successful Japanese industry.

The majority of information in this fact sheet came from the publications:

- Australian Fisheries Resources (1993). Bureau of Resource Sciences, DPIE and FRDC Canberra;
- Aquaculture WA, Fact sheet number 9 - Pink Snapper (1993) Fisheries Department of Western Australia;
- Red Sea Bream Culture (1990) Fishery journal No 33 – published by Yamaha;
- 'Marine fish sea cage farming for snapper has limited potential for NSW,' – by D O'Sullivan, September 1995, published by Austasia Aquaculture : 9 (5);

Other references that provide a more detailed analysis of aspects that have been covered in this fact sheet are:

- Battaglen, SC & Talbot RB (1992) Induced spawning and larval rearing of snapper *Pagrus auratus* (Pisces: Sparidae), from Australian waters. New Zealand Journal of Marine and Freshwater Research 26 (2): 179 – 185
- Bell, JD; Quartararo, N & Henry GW (1991) Growth of snapper, *Pagrus auratus*, from south eastern Australia in captivity. New Zealand Journal of Marine and Freshwater Research, 25 (2): 117 -121
- Cosh, DE (1982) Economic aspects of snapper farming in New Zealand. In Smith, PJ & Taylor, JL (eds), Prospects for snapper farming and reseeding in New Zealand. Fisheries Research Division Occasional Publication (NZ Ministry of Agriculture and Fisheries) , 37: 24-26
- Foscarini, R (1988) A review: Intensive farming procedure for red sea bream (*Pagrus major*) in Japan. Aquaculture, 72 (3): 191-246

- Smith, PJ & Hataya, M (eds) (1982) Larval rearing and reseeding of Red Sea Bream (*Chrysophrys major*) in Japan. Fisheries Research Division Occasional Publication (NZ Ministry of Agriculture and Fisheries), 39, 17p

It is recommended that should you be seeking further information on this topic that you contact the SARDI library at 2 Hamra Avenue West Beach. The Internet also contains a significant quantity of information on aquaculture. Please call the librarian on 8200 2423 to make an appointment.

A financial model for snapper has been developed by PIRSA Aquaculture SA. An order form for the Financial planner can be obtained from PIRSA Aquaculture SA (8226 0314) or by downloading the form from the website www.pir.sa.gov.au/aquaculture.

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