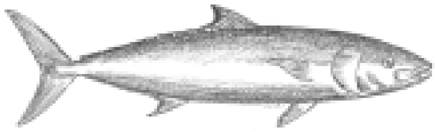
Yellowtail Kingfish Aquaculture in SA

Aquaculture SA

General Information



Characteristics

The Yellowtail kingfish *S. lalandi* belongs to the Carangidae family of fishes, along with several other species commonly cultured in Japan such as the Yellowtail (*S. quinqueradiata*), Amberjack (*S. dumerili*) and Striped Jack (*Caranx delicatissimus*). The Yellowtail kingfish, *Seriola lalandi*, also known as the gold striped amberjack or commonly as 'yellowtail' or 'kingie', is a marine species of finfish inhabiting temperate to warm temperate water, mainly near the coastline and offshore islands and reefs. Yellowtail kingfish have countershaded bodies (common to many fish), meaning they have darker colours on the top part of the body and lighter colours on the lower. Adults are bluish or greenish above and silvery white below with a yellowish band from snout to near the tail base. Yellowtail kingfish are distinguished by their yellow caudal fins.

The major commercial fishery for Yellowtail kingfish is in New South Wales. In Queensland, Yellowtail kingfish are taken as an incidental catch in the snapper handline fishery. Yellowtail kingfish are an important species for recreational anglers, with most effort concentrated in the summer months. This species prefers water temperatures of 18-24^{0}C but is occasionally found in cooler waters.

Yellowtail kingfish can grow to a maximum size of 2.5 metres or 70kg, but are more commonly found at 100 cm or 10-15 kg. In good conditions wild Yellowtail kingfish may grow up to 3.0 kg in 12 months.

Distribution

Yellowtail kingfish are distributed globally in the cool temperate waters of the Pacific and Indian Oceans of South Africa, Japan, southern Australia and the United States of America. This species is considered a circumglobal species supporting commercial and recreational fisheries worldwide. In Australian waters, Yellowtail kingfish are distributed from North Reef in Queensland and around the southern coast to Trigg Island in Western Australia. They also occur off the east coast of Tasmania, around Lord Howe and Norfolk Islands.

The Yellowtail kingfish is a pelagic, schooling fish, usually seen as adults in small to large numbers. In general they inhabit rocky shores, reefs and islands and are often found adjacent sandy areas in coastal waters and occasionally entering estuaries. They are commonly found in water depths to 50 meters, although have been recorded from over 300 metres deep. Adults generally feed at dawn and dusk on small fish, squid and crustaceans. Young fish up to 7kg are known to form shoals of up to several hundred fish and are generally found in offshore waters often near or beyond the continental shelf.

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Juvenile fish are rarely seen, as they are often found far from land associated with floating debris or weeds that provide camouflage. They feed on micro-organisms and small fishes while drifting with the seaweed. During the day they swim around the seaweed and hide inside at night. Juveniles feed actively at sunrise and sunset when swarms of zooplankton also can be seen. During daytime they feed on small fishes.

Potential for Aquaculture

Overview

Yellowtail kingfish has been identified as a good candidate species for aquaculture, especially on the Eyre Peninsula, South Australia. There is increasing demand for the species in domestic and export markets with culture technologies being developed in places such as South Australia, other Australian states and New Zealand.

Culture of Yellowtail kingfish is in its early stages in Australia with similar technology being developed in New Zealand. A closely related species called the Yellowtail, *Seriola quinqueradiata*, is the basis of a major aquaculture industry in Japan, where wild caught juveniles are grown out in sea cages. This species has been cultured in Japan for the last 70 years, but production did not increase substantially until the mid 1950s with the replacement of farming in tidal enclosures by organised offshore cage culture. For the past 10 years the annual production has been consistently over 150, 000 tonnes. This species contributes over 90% of the total marine finfish produced by aquaculture in Japan. Most Yellowtail kingfish grow out in Japan has been carried out in sea cages, however preliminary work in other countries suggests that the species may be well suited to intensive production in intensive, tank farming systems.

Japanese production relies almost totally on the collection of wild caught juveniles and at present is about 100 million fingerlings per year, which are grown out in some 3000 farms. More valuable species than Yellowtail have recently been cultured in Japan such as amberjack (*Seriola dumerili*), goldstriped amberjack (*S. lalandi*) and striped jack (*Caranx delicatissimus*). Of these the Yellowtail kingfish is especially popular in some areas. It gets the highest evaluation as a sashimi grade fish, especially during the Japanese Summer because of low fat content. The hatchery production of juveniles has been achieved in Japan; however the cost of hatchery reared juveniles is higher than that of wild caught juveniles. The limited numbers of Yellowtail kingfish that have been held in captivity in Australia have shown some susceptibility to disease. In Japan, the Yellowtail kingfish aquaculture industry has experienced significant problems with diseases and parasites.

Production efficiency

Growth rate is very temperature dependent. Yellowtail kingfish have an excellent growth rate at higher temperatures, in intensive culture in tropical to sub-tropical conditions they can grow at least 1.5 kg and possibly up to 2.5 kg within 12 months. The FCR for the species is largely unknown but likely to be reasonably good. The FCR for closely related species has been reported at 2:1 to 2.5:1 on a dry to wet basis. Growth rates will be faster at higher temperatures, so any aquaculture industry in South Australia will need to consider future competition from operations that may be lodged in warmer areas.

Attributes for culture

- There are existing producers of fingerlings for production.
- Yellowtail kingfish have fast growth rates in good conditions grown with good management practises.
- There is an existing domestic market and export potential.
- There is potential for selling fingerlings to other growers

- Yellowtail kingfish is highly regarded for fresh consumption in Japan (sushi and sashimi) with high farm gate prices
- Is a relatively hardy fish when past larval stage
- Adjusts well to sea cage culture, a technology well developed and known in Australia.

Issues or problems for culture

- High dissolved oxygen levels are required to be maintained constantly
- There is a general lack of scientific and farming knowledge for this species, however culture and biology can be related to Japanese culture of Yellowtail *Seriola quinqueradiata* and other related overseas species.
- Issues such as disease, pests, on winter temperatures, optimum feeds etc and their effects on culture are relatively unknown
- Hatchery supply is limited requiring an improvement in reliability and volume of production.

Juvenile Production

The ultimate success of all aquaculture enterprises depends on the reliability of supplies to the market and the maintenance of stable prices. Control over spawning is essential to ensure the predictable supply of a cultured product that is consistent in size and quality.

There is currently two hatcheries producing Yellowtail kingfish fingerlings in South Australia, one of these has been established for a couple of years, the other a recently new establishment. The total production for 1999/ 2000 is unknown. It is uncertain if there will be enough supply from these two hatcheries to meet demand in the future, and will depend on the degree of expansion of the industry.

At 4-5 years of age and around 74 cm in length, Yellowtail kingfish reach sexual maturity. Yellowtail kingfish are highly fecund with females producing between 0.5 and 2 million eggs in a single spawning event. First spawning occurs at approximately 2 years of age and occurs in the wild between the months of October and January.

Broodstock

Broodstock are caught from the wild and are maintained in large indoor broodstock tanks of greater than 90 m^3 and 2 metres deep. Special permits are required before capture of wild broodstock, and must comply with the Broodstock Policy for Yellowtail kingfish being formed by Aquaculture SA, PIRSA. Wild caught fish should be kept in a hatchery under quarantine conditions for a minimum of four weeks or until it can be determined that they are free of any signs of clinical disease. Generally, fish can be considered to have survived the trauma of capture when they begin feeding, generally after one week.

Broodstock Nutrition

In addition to the influence it has on factors such as maturation and fecundity, broodstock nutrition is an important determinant of egg quality. Accordingly, broodstock should only be fed premium quality diets, principally comprising items such as chopped fish, squid and vitamin and mineral supplements. Any wet diets that are to be offered to broodstock should be stored for a minimum of two weeks at a temperature of -20^0C to ensure that any potentially pathogenic spores they may contain are destroyed. Pellet feeds should be fed at a daily ration of between 1% and 3% of total weight. Daily feeding rates for wet diets may vary according to appetite and other factors, but usually average about 10% of the total weight of the broodstock. While many hatchery operators feed to satiation, it is often considered good practice to feed to approximately 75-80 % satiation.

Maturation and Spawning

Spawning methods for Yellowtail kingfish can be relatively simple; mature fish have been reported to spawn spontaneously in captivity with no hormonal inducement or manipulation. The lighting and temperature source can be manipulated to induce spawning. Where natural spawning is likely to occur, screens should be placed in the overflow of the broodstock holding tank to ensure the eggs are collected. Fish that do not spawn can be stripped manually or induced to spawn by applying certain hormones.

Yellowtail kingfish eggs are spherical and pelagic and usually measure 1.19 – 1.27 mm diameter. Within a water temperature range of 18.0 – 20.0^{0}C, the incubation period is approximately 40 hours.

Hatching and Larval Rearing

Sloping bottom tanks can be used and are maintained under 12:12 photoperiod conditions. Hatching of the eggs occurs within 2-3 days depending on temperature. Hatched larvae must be kept suspended in the water column using air stones etc. which helps to decrease larval deformities and mortality. Surface skimmers are essential in larviculture to ensure that the water surface is clean and to permit the larvae to gulp air to inflate their swim bladders. Larval Yellowtail kingfish average 4 mm in length. Good water quality is essential. Water should be sand filtered and UV sterilised. Water temperature, water quality, dissolved oxygen and light are the main physio-chemical water quality parameters that need to be monitored in larviculture systems. Un-ionised ammonia is extremely toxic to fish larvae in low concentrations and needs to be monitored very carefully. Early larval mortality may be expected. Due to possible cannibalism and rapid growth rates, larval rearing tanks should be stocked at low levels with high growth volumes. High quality Yellowtail kingfish eggs should be stocked in a prepared larviculture tank at an optimum density that has yet to be ascertained, likely to be greater then 20 eggs/ L. Water flow rates in a 5,000 L tank are progressively increased with the age of the fish from an initial flow rate of 4L/minute at the time of stocking to 20 L/minute immediately before weaning.

Larvae are offered enriched rotifers at first feeding, then enriched artemia as soon as they are capable of ingesting the metanauplii. Since early larvae are relatively inefficient predators, initial live food concentrations are maintained at a fairly high constant level throughout the daily feeding hours.

Juvenile Rearing and Nurseries

Mortalities are almost invariably high during the weaning period with survival seldom better than 80% and more often between 50 and 70%. Before first feeding of juveniles, which generally occurs between two and three day’s post hatch, enriched rotifers should be stocked in the tank to bring the live food density to a minimum of 10/mL. The rotifer density can be decreased gradually as artemia are added. Enriched artemia metanauplii are added from days twelve to twenty-eight at a density of 2/mL. Weaning onto inert commercial marine fish diet begins at day twenty and is usually complete by day thirty. The early growth of Yellowtail kingfish is relatively rapid, by day sixteen the fish range between 6 and 20 mm fork length and by day twenty five the largest individuals can reach 35 mm fork length. High dissolved oxygen levels must be maintained. Fish can be transferred to sea cages for grow out at approximately 5 grams size.

Sea Cage Culture

Site Selection

Site selection is probably the single most important factor that determines the commercial viability of an aquaculture operation. An aquaculture operation should be located, designed and operated to provide optimum water quality and to avoid conditions that may induce stress, reduce growth or predispose the fish to disease. If the species farmed is found naturally in a given location, this is often a good first sign that conditions for culture may be favourable.

There are a limited amount of areas suitably zoned for the culture of Yellowtail kingfish in the coastal waters of South Australia. Information on site availability and areas zoned for aquaculture can be found in the Aquaculture Management Plans for each coastal region of South Australia (on the PIRSA website). The Management Plans are reviewed every 5 years, and as such there are often different areas becoming available for aquaculture.

Culture Techniques

Sea cages can be relatively productive and, in a suitable site, support high stocking densities; however the need for adequate clearance beneath cages and suitable flushing characteristics may limit the suitability of many nearshore areas for large scale sea cage production systems. Sea cages may have an impact on the environment if large quantities of uneaten food and faeces sink to the bottom beneath the cages, which may effect the water quality, stock condition and create deleterious impacts on the surrounding environment. However, a well managed farm with good husbandry practises will produce negligible impacts on the environment.

Fundamental design criteria should take into consideration accessibility for feeding, ease of maintenance and the safety of the complete system. The design and engineering of sea cage aquaculture production systems should give consideration to the following five principle elements: the net or cage bag; frames; collars and supports; linkages and groupings; and mooring systems.

The culture density of Yellowtail is determined by the depth, area and speed of the water current at the culture grounds. A maximum of 10 kg of fish may be cultured in one cubic metre of net-cage volume, allowable under South Australian aquaculture licence conditions. The mesh size of the netting should be increased as the fish grows. The netting should be replaced when it becomes clogged with organic matter to ensure a high water exchange rate.

The major reason for the growth potential of properly fed fish not being fully realised is that stocking density may have exceeded the carrying capacity of the system. Optimum density and proper feeding rates are essential for economical production. If rearing records are accumulated at a particular site for at least three years, the optimum stocking density and feeding rate for maximum growth and feed efficiency relative to season and fish size can be estimated.

Yellowtail kingfish are ideally grown out in high quality seawater with very low turbidity. In open systems using sea cages, the tidal or current flow needs to be sufficient to remove uneaten food, faeces and soluble waste products such as ammonia and maintain a dissolved oxygen concentration above 4mg/L.

There is established grow out sites in sea cages off the Eyre Peninsula in South Australia at Fitzgerald Bay, Cowell and Port Lincoln. The general size of cages used at these sites is 25 metres diameter and 4 to 8 metres deep.

Stock Management

According to their size, for many cultured marine species, between 100 and 200 conditioned, ex-hatchery juveniles can be stocked per cubic metre of sea cages. Stocking densities can be increased as the fish grow and, in sea cages, may reach about 10 kg/m^3 in suitable growing areas. Yellowtail kingfish in sea cages grow rapidly: conditioned, ex-hatchery juveniles weighing between 8 and 50 grams can reach 1.5 kg by the end of a growing season lasting about six to eight months. The bigger fish may be harvested at this time, but in areas with suitable temperatures over the winter period, the smaller fish are more efficiently grown on and harvested the following growing season.

Nutrition and Feeding

Dry extruded pellets that have been adapted for marine fish are best for one year olds. Pellets that have greater than 20% fat are used most efficiently. Fish should be fed one to four times a week. The Food Conversion Ratio (FCR) for one year old fish can be as low as 1:2. Fish older than three years prefer raw fish.

Feeding a nutritionally adequate diet is essential for producing high quality fish for the market. Traditionally, wet fish have been used to feed yellowtail cultured in Japan. However this form of feeding is generally more costly than pelletised diets and has been associated with local pollution and diseases (the FCR that is attained using a diet of wet fish only is in the region of 8:1). The high content of unsaturated fatty acids in some wet fish is prone to oxidation and the products of the oxidative process can harm the fish. In areas where quantities of good quality trash fish are available, the best feeding strategy is to alternate the two feed types.

Grow out feeds generally constitute a significant component of the variable operating costs of a farm, so optimum and cost effective feed formulations and conversion efficiencies play a major role in determining the profitability of an aquaculture operation.

On land Culture

Culture Techniques

Onshore flow through systems would be the next most viable production system after sea cages. There is the possibility of onshore recirculation systems but would be expensive with low numbers of fish produced. The dissolved oxygen demand may be too high for tank culture.

Onshore tanks used for Yellowtail kingfish grow out can be circular, octagonal or elongated, D-ended tanks with central dividing panels. It is necessary to redistribute the fish as they grow and they can be easily graded according to size at this time. Frequent grading and distribution permits better production control and allows control for proper feed management. These management options provide significant advantages over the more traditional (and less expensive) sea cage farming systems.

Filtration to reduce the introduction of particulate material is one of the few control measures that can be implemented economically in an on shore flow through system.

Due to the higher stocking densities that can be supported in intensive grow out tanks, the minimum dissolved oxygen concentration is higher than for sea cages and should ideally always be greater than 7 mg/L.

Stock Management

Stocking densities can be considerably higher in intensive tanks, provided that the loading is kept low by maintaining high water-flow rates. Water used can be either marine water pumped ashore or inland saline ground water. The stocking rates that may be attained for Yellowtail kingfish in these systems is unknown as yet, however similar systems growing European sea bass and sea bream support densities in the order of 40 kg/m^3 for fish weighing between 70 and 400 grams. Advantages of on shore culture include increased control over the culture environment, access to fish, control over water quality, ease of harvesting etc.

Economic Considerations

Ponds have not been widely used for culturing marine finfish. Tank and recirculating systems are a possibility. Models undertaken for onshore, intensive marine finfish aquaculture using flow through tanks under the economic conditions that generally prevail in Australia suggest that some ventures could be economically feasible however exact financial returns are not yet known.

Water Quality Parameters

High dissolved oxygen levels must be maintained with proper net cleaning and management essential. The water quality range for Yellowtail kingfish grow out should be within the limits outlined in the following table

Parameter	Limits
Temperature range	14 – 26^{0}C
Dissolved Oxygen	> 7 mg/L
PH	6 – 9
Unionised ammonia	< 0.01 mg/L
Total hardness	NC
Total alkalinity	> 10 – 400 mg/L
Carbon dioxide	< 10 mg/L
Chlorine	< 0.04 mg/L
Hydrogen Sulphide	< 0.002 mg/L
Nitrate	< 100 mg/L
Nitrite	< 0.2 mg/L
Salinity	34-35 g/L
Toxins	Not detectable

Disease

The extent of diseases effecting cultured Yellowtail kingfish is largely unknown in South Australian conditions, although some mortalities have been observed due to the monogenian gill fluke. There are several research projects currently in progress to solve this problem. There are substantial disease problems overseas with kingfish culture, the most serious problem in Japan in recent years has been the Iridovirus infection introduced from Southeast Asia. The occurrence of diseases under Australian conditions have yet to be fully determined, however effective diagnosis and treatments will be important to preclude economic losses.

Healthy fish in the wild and in aquaculture systems can continuously harbour potential pathogens without suffering any ill effects. Diseases can arise not only as a result of pathogenic organisms, but also can be caused by poor nutrition, bad management or unsatisfactory water quality. Stressed fish are highly susceptible to disease and optimum conditions should be maintained in high density systems to minimise stress factors. The primary causes of disease in many aquaculture systems are protozoan and metazoan organisms, bacterial infections and nutritional deficiencies.
Removal of dead fish is the first step in prevention of further spread of disease. Both sick and dead fish should be removed from affected net pens. The amount of feed consumed in cages where disease has occurred should be recorded. Sick fish will not feed as well as healthy fish, and it is usually necessary to reduce the feeding rate to 60 to 70% of normal.

Disease prevention and control measures that are important components of day-to-day aquaculture practices include the:

- rapid removal of moribund, dead or dying fish;
- maintenance of optimum water quality conditions;
- periodic removal of biofouling agents from tank walls and floor including algae and bacterial slime;
- disinfection of all equipment used in tanks.

Disease Management

The control of disease in aquaculture should concentrate on prevention rather than chemical treatment, which should only be used as a last resort. Disease control depends on three main interrelated factors, namely correct diagnosis, the inclusion of suitable preventative methods in the management program and correct treatment.

Daily observations of the fish in each tank in the hatchery and grow out farm, or in each sea cage, are vitally important. Changes in colour, feeding or swimming behaviour may indicate disease. More advanced signs include flashing, excessive jumping or mucous secretion by stressed fish, faster and erratic swimming behaviour, gaping mouths and flared opercula.

Harvest

Unless fish are required in live form, fish selected for harvesting should be killed, bled and immediately placed in an ice slurry within an insulated container. Fish harvested in this way can then be transported to processing or packing facilities.

The harvesting process should be carried out in such a way that stress is minimised: harvesting techniques that prevent vigorous swimming or excessive activity should be used. High activity levels result in serum glycogen being utilised and consequently leads to high flesh pH levels. High pH levels are associated with soft, gaping flesh; lower pH levels are preferred since they yield fish that have a firm texture. Excessive struggling may also result in physical damage that adversely affects the final appearance of the product, which is very important to avoid in a sashimi grade fish.

Indicators of well preserved fish are a transparent sheen over the fish, clear eyes with the cornea still curved and moist, and bright red gill filaments.

Marketing

Yellowtail kingfish are usually marketed as whole fish. They are also sold on the domestic market in cutlet or fillet form, with better quality fish being sold for sashimi. Smaller Yellowtail kingfish from colder waters are generally considered better quality, a factor that favours their commercial culture in South Australia. The fish is well accepted in the various market segments and is popular with consumers. As a result of the increasing Asian population, demand is steadily increasing throughout the Australasian region. This has a major effect on eating habits generally and sashimi, a dish for which Yellowtail kingfish is in demand, is becoming increasingly popular. The colour of the raw fillet is variable, white to pink or reddish to dark of firm texture, coarse in larger fish. It has a low to high fat content with a mild to strong flavour.

	Domestic	***Export***
Location	NSW has the best consumer acceptance; interest Australia wide including Adelaide and Melbourne	Potential and current markets to Japan, Asia, Los Angeles and the UK, especially with sashimi
Condition	Not yet known	Good clean fish, high quality
Appearance	Not yet known	Not yet known
Live or processed	Whole plate sized fish; cutlets	Whole plate sized fish; cutlets
Size (range)	1 kg, usually 3 kg+	3 – 5 kg
$/kg (range)	SFM 1998/ 1999 price $7.80/kg. Currently $9 - $11 per kg farm gate and up to $13 per kg for sashimi	Not yet known; up to $20 per kg for sashimi. 1,500 – 3,000 yen/kg consumer.
Seasonality	Not yet known	Not yet known

Competitors	Domestic wild caught fish and imports of chilled whole fish from NZ. Other oily fish suitable for sushi/ sashimi eg. Tuna, salmon and trevally	Not yet known
Issues	No issues as yet	Care must be taken not to bruise the fish as this decreases the price of sashimi

Yellowtail kingfish are more popular than Yellowtail in Japan because they can be kept for more than three days under refrigeration without losing their flavour, colour and firmness. Currently demand exceeds the supply in Japan. Access and penetration of certain markets may rely on the price of the Australian dollar in the future.

Economic Considerations

Under suitable site conditions, offshore cage farming systems would usually be expected to be cheaper to establish and operate than onshore farms with equivalent production capabilities and provide more attractive financial returns on invested capital. However, the suitability of the site will be an important factor. The full production cycle takes between 12 – 18 months depending on what size fish is required and can take between one and two years for larger sized fish. No farms are currently selling commercial quantities of market sized fish, however the economic outlook appears promising with several farmers now growing Yellowtail kingfish. It has been suggested that for a farm to be economically viable it should be producing at least 250 tonne of fish per year utilising at least 12 grow out cages.

In Australia, the number of sheltered sites with the features needed for successful cage culture is limited. Those that may be available will be subject to strict environmental controls and may have competing use for the resource. Increasing constraints are likely to be placed on the expansion of nearshore cage farms, particularly those with the potential to affect the seagrass meadows found along many of the temperate coastlines. As such, the growth of the industry may be limited unless more exposed sites further from shore are used.

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

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