NSW DEPARTMENT OF
PRIMARY INDUSTRIES

NSW North Coast Sustainable Aquaculture Strategy-Land Based Aquaculture

Readers' Note

This document is part of a larger publication. The remaining parts and full version of the publication can be found at:

http://www.dpi.nsw.gov.au/fisheries/aquaculture/publications/general-management-and-policy/nsw-north-coast-sustainable-aquaculture-strategy

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Species selection

NSW North Coast Sustainable Aquaculture Strategy
Land-based Aquaculture
August 2000

A NSW Government Initiative

North Coast Sustainable Aquaculture Strategy

A NSW Government initiative of NSW Fisheries, Department of Urban Affairs and Planning, Department of State and Regional Development, Environment Protection Authority, Department of Land and Water Conservation, National Parks and Wildlife Services and NSW Agriculture to encourage sustainable aquaculture in New South Wales

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1. Selecting the species

The species selected for cultivation will affect the design of the facility as well as the viability of the aquaculture business. More than one species may be cultivated at a facility. In designing the facility, a certain amount of flexibility should be built into the design and layout so that the species can be switched later to meet opportunities created by changing markets.

In selecting species, the Translocation Policy to protect NSW's native fish populations must be considered. The selection of the species will also affect the level of assessment and type of approvals required.

Factors in the selection of species include:

- translocation policy
- genetic factors, availability of seed stock (reliability, quality, quantity, season) and documented performance of the species in the aquaculture system proposed
- market factors and potential profitability
- site specific attributes (eg market distance, scale required, flood liability, temperature and water requirements (quality/quantity)
- feed and other management factors issues
- disease factors.

In some situations, "polyculture" (ie more than one species within the one pond or in ponds in sequence) could provide opportunities for maximising returns and minimising environmental risk. In many circumstances, these types of multi-tiers systems can lead to more economical use of water, feed and energy, for example mullet grown in the prawn recirculation ponds.

Table 6 lists species cultivated or with the potential to be cultivated in NSW.

Table 6. Aquaculture Species cultivated in NSW

Scientific name	Common name	Culture status				Habitat	Origin
		F	*P*	*S*	*H*		
FIN FISH							
Acanthopagrus australis	Silver bream		X			E	AUS
Anguilla australis	Short-finned eel	X	X			FE	AUS
Anguilla reinhardtii	Long-finned eel	X				FE	AUS
Argyrosomus hololepidotus	Mulloway	X	X			EM	NSW
Bidyanus bidyanus	Silver perch	X		X		F	AUS
Carassius auratus	Gold fish		X	X	X	F	ALIEN
Coryphaena hypurrus	Dolphin fish		X			M	AUS
Cyprinus carpio	Koi carp	X			X	F	ALIEN
Hypseleotris compressa	Empire gudgeon	X				F	AUS
Lates calcarifer	Barramundi	X			X	FE	AUS
Lutjanus argentimaculatus	Mangrove jack		X			FM	AUS
Maccullochella peelii	Murray cod	X		X	X	F	AUS
Maccullochella maquarensis	Trout cod		X			F	NSW
Maccullochella ikei	Eastern cod		X			F	NSW
Macquaria ambigua	Golden perch		X			F	AUS
Macquaria australasica	Macquarie perch		X			F	AUS
Macquaria colonorum	Estuarine perch		X			EF	AUS
Macquaria novemaculeata	Australian bass	X				EF	AUS
Melanotaenia sp.	Rainbow fish		X			F	AUS

Scientific name	Common name	Culture status				Habitat	Origin
		F	*P*	*S*	*H*		
Mugil cephalus	Mullet		X			EF	AUS
Myxus petardi	Freshwater mullet		X			F	AUS
Oncorhynchus mykiss	Rainbow trout	X		X		F	ALIEN
Oxyeleotris lineolatus	Sleepy cod	X		X	X	FE	AUS
Pagrus auratus	Snapper	X				ME	AUS
Pseudomugil signifer	Pacific blue eye		X			F	AUS
Salmo salar	Atlantic salmon	X		X		F	ALIEN
Salmo trutta	Brown trout	X		X		F	ALIEN
Salvenius fontinalis	Brook trout	X		X		F	ALIEN
Scartum barcoo	Barcoo grunter	X		X	X	FE	AUS
Sillago ciliata	Sand whiting		X			EM	AUS
Tandanus tandanus	Eel-tailed catfish	X		X	X	F	AUS
MOLLUSCEA							
Katelysia rhytiphora	Clam		X			E	AUS
Tapes dorsatus	TapestryClam		X			E	AUS
Pinctada albina	Native Pearl		X			E	NSW
Pinctada imbricata	Aloya Pearl	X				E	NSW
Haliotis rubra	Blacklip Abalone		X			M	NSW
Velusunio ambiguus	Freshwater Mussel	X	X			F	AUS
Crassostria gigas	Pacific Oyster	X		X	X	E	OS
Ostrea angasi	Flat Oyster	X				E	NSW
Saccostrea glomerata	Sydney Rock Oyster	X				E	NSW
CRUSTACEA							
Artemia sp.	Brine shrimp	X		X		E	ALIEN
Cherax albidus	White yabby	X				F	OS
Cherax cuspidatus	Cusped crayfish		X			F	NSW
Cherax destructor	Common yabby	X				F	AUS
Cherax quadricarinatus	Red claw	X		X		F	OS
Cherax rotundus	Rotund crayfish		X			F	NSW
Cherax tenuimanus	Marron	X		X		F	OS
Eustacus valentulus	Strong crayfish		X			F	AUS
Eustacus armatus	Murray crayfish		X			F	AUS
Eustacus spinifer	Sydney crayfish		X			F	NSW
Family Atyidae	Shrimp		X			F	AUS
Macrobrachium australiense	Freshwater prawn	X				F	AUS
Metapenaeus bennettae	Greasyback prawn		X			EM	NSW
Metapenaeus ensis	Offshore greasyback prawn		X			M	NSW
Metapenaeus macleayi	School prawn	X				ME	NSW
Penaeus esculentus	Brown tiger prawn		X			ME	NSW
Penaeus merguiensis	Banana prawn		X			ME	NSW
Penaeus japonicus	Kuruma Prawn	X				ME	NSW
Penaeus monodon	Jumbo Tiger Prawn	X				ME	NSW
Penaeus plebejus	Eastern King Prawn		X			ME	NSW
Scylla serrata	Mud Crab		X			E	AUS
Stenopus hispidus	Banded Coral Shrimp		X			M	NSW

Keys to Culture Status
F = Farmed,
P = Potential for Farming,
S = Security Issue
***H** = High Security Issue*
Note: the security status may vary with the location

Keys to Habitat
E = Estuarine,
F = Freshwater,
M = Marine

Keys to Origin
NSW = only in NSW – endemic to NSW
AUS = in other States as well as NSW
OS = in Other States, not NSW
Alien = Introduced from overseas

2. Translocation issues

One of the potential risks of aquaculture is the inadvertent introduction of species into waterways beyond their natural range or to areas within their natural range that have genetic stocks or populations that are distinct from the aquaculture stock. This is called translocation. Translocation of non-indigenous species can be sanctioned in some catchments, for example as a result of trout stocking for recreational fishing. In other circumstances, it may occur accidentally or deliberately but illegally.

Translocation of aquatic organisms has a number of inherent risks for the receiving aquatic habitats as well as for endemic organisms including:

- Predation
- Introduction of disease or parasites
- Competition, directly or indirectly for food and space
- Adverse impacts on habitat and the native aquatic ecology
- Hybridisation with native fish that can affect genetic integrity.

The National Translocation Policy Guidelines has been developed to meet the needs of Australia's aquaculture and aquarium industries for the translocation of species within jurisdictions and across jurisdictional boundaries. These guidelines set out a risk assessment process for considering translocation issues. All proposals must be assessed according to the Translocation Policy. NSW Fisheries is currently refining the NSW Translocation Policy in the context of the National Translocation Policy Guidelines. However, for the purposes of this AIDP the principles in Table 7 and 8 apply.

A number of the freshwater species considered in the AIDP are not indigenous to the Region and have been assessed as higher risk and consequently have been determined as **High Security** species for the Coastal Region of NSW. High security species will have stricter requirements in terms of site selection, design and operational parameters. (*See Site selection, Planning and Design and Operating the Site).*

Table 7. Key Translocation Principles in the Coastal Region

1. Non-endemic species to NSW are not permitted to be translocated into estuarine pond systems.
2. Non-endemic species to NSW must meet prescribed health testing protocols for stock to be translocated from interstate.
3. Non-endemic species to NSW with high security status such as barramundi are permitted only in tank systems. Imported stocks must be disease free and discharge water treatment and disposal must meet the relevant AIDP performance criteria.
4. Non-endemic species to the Region with a high security status such as Murray Cod, Barcoo Grunter and Sleepy Cod are only permitted if site selection, design and operational components meet the relevant AIDP performance criteria. Murray Cod are not permitted in the Clarence and Richmond Catchments but may be cultured in other catchments.
5. Other non-endemic species to the Region such as Silver, Golden and Macquarie Perch are permitted in freshwater pond systems that meet the relevant AIDP performance criteria.
6. Threatened indigenous species such as Eastern Cod are permitted in the Clarence and Richmond Catchments in accordance with Threatened Species Protocols if sourced from accredited hatcheries.

Table 8. Species Selection Translocation Issues for the NSW Coastal Region

Pond and Tank Species	Implications of the Translocation Policy	
	in terms of site selection	in terms of design & operation
SALINE WATER CULTURE		
Saline water fin fish Flathead, Mulloway, Snapper, Whiting	No specific translocation constraints	No specific translocation constraints
Saline water shell/crust Abalone	No specific translocation constraints; Susceptible to temperature maximums	No specific translocation constraints
Prawns - king, tiger, kuruma, school	No specific translocation constraints	No specific translocation constraints
FRESHWATER CULTURE		
Freshwater fish Silver, Golden & Macquarie Perch, Australian Bass	No specific translocation constraints	No specific translocation constraints
Murray Cod	Not in Clarence and Richmond Catchments; In other catchments High Security status	High Security Status
Sleepy Cod & Barcoo Grunter	High Security Status	High Security Status
Eel-tailed catfish	High Security Status	High Security Status
Eastern Cod	In Clarence and Richmond Catchments above the 1:100 yr; In other catchments, no specific translocation constraints	No sourcing of broodstock from wild. Must be sourced from approved hatcheries
Trout Cod	No specific translocation constraints	No sourcing of broodstock from wild. Must be sourced from approved hatcheries
Eels	No translocation constraints	Eels must be sourced from an approved collector. Eels sourced from interstate must have a health certificate plus quarantine protocol
Barramundi	High Security Status; Constructed no closer than 500m to waterway and above the PMF	High Security Status; Tank systems only; Specific treatment requirements for discharge water (eg chlorination) prior to disposal/use
Trout/Salmonoids	No specific translocation constraints – Susceptible to temperature maximums	Strategy does not apply to flow-through freshwater farms**;** zoning policy for epizootic hepatic necrosis (EHNV).
Freshwater Shellfish Yabbies	No translocation constraints	No translocation constraints; Barrier screens required in some locations
Redclaw, Marron	No translocation constraints. Susceptible to temperature minimums	No translocation constraints; Barrier screens required around ponds.

3. Hatchery and Genetic Factors

3.1 Quality of Hatchery Progeny

Hatchery-reared juveniles can be used by the producers; sold to other aquaculture enterprises or the aquarium industry; or used for stocking into farm dams or for a NSW Fisheries approved stock enhancement program in a natural waterway. It is the hatchery operators responsibility to ensure that:

- the juveniles are healthy before sale (it is illegal to sell diseased fish);
- the stock is not tainted with exotic invertebrates and vertebrates.

It is the hatchery's responsibility to ensure that the unintentional escape of cultured stock is minimised to prevent potential contamination of the genetic diversity of any endemic stocks and possible environmental impacts. Decisions relating to species and hatchery management will affect the planning and design of a facility and its operation (See *Hatchery Section Planning and Design*).

3.2 Broodstock Management

The efficient production by hatchery facilities of quality, healthy juveniles in sufficient quantities to meet the increasing demands is dependent on the availability of adequate numbers of quality broodstock. The appropriate number of broodstock is determined by the number of eggs needed to produce the required number of juveniles, with normal losses taken into account. Other factors include the lifecycle of species, when broodstock are retired, genetic lines of broodstock and whether demand for juveniles is seasonal or continuous.

The assessment of the quality of broodstock usually focuses on factors such as:

- broodstock reproduction rates
- performance of broodstock and survival of under hatchery conditions
- genetic characteristics
- progeny characteristics.

In the future as translocation issues and stock enhancement of wild fisheries becomes more important, hatchery breeding programs will be called upon to meet an increasing demands from the aquaculture industry as well as from specific stock enhancement programs or other fishery programs with more emphasis being placed on broodstock genetics.

3.3 Acquisition and Maintenance of Broodstock

Broodstock can be collected from the wild under the provisions of a permit, grown and maintained in a hatchery or purchased from a commercial supplier. Currently, broodstock of Australian Bass and Trout are mostly captured in the wild prior to spawning, whereas broodstock of Silver and Golden Perch, Murray Cod, Snapper and Mulloway are maintained at the hatchery or in farm dams.

The reliability of spawning and quality of eggs from wild-caught broodstock varies with species. Reliance on the capture of wild broodstock limits the availability of eggs to the natural spawning period each year. Wild-caught broodstock are often used only once for spawning and then returned to the wild. Maintenance of broodstock in tanks with controls over day length and temperature can provide more flexibility in the supply of eggs and broodstock. For example, for many species, the period of spawning can be extended from several months to year round.

Proper care of broodstock is essential for good production of eggs, larvae and juveniles. Methods differ with species, but the hatchery operators must provide optimum conditions for maturation and spawning. Factors for consideration include pond management, water quality and temperature, disease control, food supply, broodstock age, density and sex ratios.

3.4 Broodstock Genetic Management

The characteristics of fish as with domesticated plants and animals can be improved by implementing breeding programs. For example, long-term breeding programs for chickens have resulted in significant improvements in productivity.

In any hatchery breeding program, a comprehensive record keeping system is necessary to track and evaluate progress of the program and to ensure weaknesses are not being introduced as a result of inbreeding.

Selective breeding program to improve stock

Fish stocks may be improved by selective breeding, hybridisation and crossbreeding. For example selective breeding of trout has resulted in improved strains in relation to growth rates, spawning time and the age of maturation. Broodstock may be selected on a range of criteria such as size, colour, shape, growth, feed conversion rates, time of spawning, age at maturity, reproductive capacity and past survival rates. These criteria may vary with different hatcheries.

Selective Breeding Program to avoid inbreeding

Selective breeding involves selected mating of fish of a single strain and species and results in a reduction in the genetic variability in the population. Broodstock managers must be aware of the potential for inbreeding and manage the breeding program to minimise the risks of inbreeding problems arising. Inbreeding can occur when mates selected from a population of hatchery broodstock are closely related. The proportion of genes that fish parents have in common determines the degree to which a particular fish has been inbred. Problems that can occur after only one generation of brother-sister mating include reduced growth rates, lower survival, lower food conversion rates, increased numbers of deformed fry and increased susceptibility to disease. A system for selective breeding of trout has been developed to reduce the likelihood of inbreeding. The method involves maintaining three or more distinct breeding lines in a rotational line-crossing system. The number of fish required for the program can be set at any level necessary to satisfy the egg production requirements of a particular hatchery. Groups of fish can be held in separate tanks or combined, provided fish are individually tagged.

Hybridisation and Cross breeding Programs

Hybridisation between species of fish and crossbreeding between strains of the same species can result in significant increases in growth, better food conversion, increased disease resistance and tolerance to environmental stressors. Hybrid vigour is responsible for the stock improvements; however this may not be achieved in all crosses.

Special program management for stock enhancement

If hatchery-reared progeny are destined for a stock enhancement program, rather than aquaculture facility, maintenance of genetic diversity is extremely important. Broodstock should be obtained from the wild and mated pairs should be randomly selected from the population.

4. Market and Pricing Factors

4.1 There must be a market

In addition to a species being biologically suitable for aquaculture production, it must have market acceptance. The aim of commercial aquaculture is to make a profit. The farm must produce fish that are marketable in sufficient quantities at acceptable prices. All to often, a decision is made to farm a species based on biological factors with little consideration given to its market acceptance. These factors must be taken into consideration in the preparation of the Business Plan (*see Business Plan section).*

Domestic Market

The live fish market in Australia is still developing, particularly for native freshwater species. There is still significant potential for expansion. However, once this market niche that returns very attractive prices has been filled, alternative higher volume markets are likely to return lower prices. In some cases, these prices may not be sufficient to cover production costs. If a number of farmers independently decide to target the live fish and other boutique markets at the same time, this may saturate the market leading to price wars and lower returns to farmers. It is important that farmers network with each other to ensure that a steady and reliable supply of quality product is supplied to meet market specifications and requirements. This approach will assist in increasing demand, help to smooth out periods of glut and short supply, thereby leading to more reliable prices for the farmed products. In addition, industry groups are better placed to develop and promote markets for new aquaculture products than individual producers.

A most important segment in the domestic market is Asian restauranteurs and fish retailers. By contrast the non-Asian retail trade is relatively small and more price sensitive. It is considered that this segment is capable of substantial growth with market promotion to improve consumer awareness.

In the longer term, it is considered that significant growth in the aquaculture fish “fillets” market will occur to meet the demand of the Australian consumers preference in the home and restaurant trade for skinless boneless fillets.

Export markets

There is excellent potential to promote the *clean green* image of Australian aquaculture products. In addition, it is anticipated that there will be great potential for Australian producers to step in and replace some of the shortfall in supply that may arise overseas. Australia and in particular NSW are fortunate to have avoided most of the problems experienced by other countries associated with waterway pollution and disease. This *clean green* image is increasingly important because of growing concerns associated with the spread of disease and pest species with importing of fish especially live fish. As a result the development and implementation of best practice in production and quality assurance programs to guarantee the quality of the product is increasingly important for the expansion of the export market.

4.2 Factors affecting market value and price

There are many factors likely to affect the price achieved in the market place ranging from global economic issues (eg value of the A$ and the buoyancy of the Asian economy) to supply and demand factors (eg competition from other fish products, consumer preference, the season and fads in eating). The price gained for a product will also vary with the market sector and its geographic location. For example there can be significant difference in price achieve in the local market and the Sydney, Brisbane and Melbourne markets and between wholesalers or overseas distributors, retailers (super markets and fishmonger), restaurateurs and the take-away-food sector.

It is important that the farmer becomes well informed about options and the implications in relation to the costs in getting the product to the particular market and the likely differentials in returns. For example:

- Where is the product to be positioned in the market place – economy or luxury?
- What are competitors offering and what prices are they achieving?
- What is the price range of potential customers and for what volume? Is there a potential for repeat business?

The lowest acceptable price should be equal to the cost per kilogram to produce the product taking into consideration both fixed and variable costs. The highest price may be what is achievable by selling the best of the stock into a niche market. The base price is generally somewhere between the two.

Table 9. Indicative prices from selected fish sales 1998/1999
(Ruello & Assoc Market Report 1999)

Fish/product whole or gilled and gutted (GG)	Wholesale or auction price approximate $/kg	Median Sydney Retail price approximate $/kg
Golden perch GG wild	13.50	20.00
Barramundi whole farm	10.00	19.00
Snapper GG wild	9.00	15.00
Silver perch whole farm	8.50	13.00
Silver bream whole wild	8.00	13.00
Rainbow trout GG farm	5.70	10.50

MARKET FACTORS

Prawns

The Australian aquaculture production of prawns is estimated at about 2,700 t/year. Much is exported. Farm-gate prices vary around an average of $15/kg for black tiger prawns, and up to as much as $70/kg for live kuruma prawns sold on the Tokyo markets.

Crayfish

The size of the market for the three freshwater crayfish species grown in NSW is unknown. Redclaw have a meat yield (meat to body weight ratio) of 22 to 25 per cent; the meat yield is comparable in marron but slightly lower in the yabby. Yabbies have been marketed in small quantities from the wild fishery for years (up to $8 kg). Much higher prices (up to $35/kg) have been obtained for all three species by supplying live crayfish of a particular size to restaurants. These prices are for very small quantities, however prices in the range of $8 to $15 can be expected as supply increases. Crayfish are likely to feature in the highly competitive "entree" market (along with such delicacies as prawns, oysters and smoked salmon), and this may make it difficult to permanently establish a market niche. The size of any export market is impossible to evaluate until supply can be maintained. There is certainly a market for crayfish in Europe, as crayfish are regarded as a delicacy and local stocks

have been largely wiped out by the "crayfish plague". However, the market in some European countries (for example, Sweden) is highly seasonal. Trial shipments have suggested that Cherax species would be accepted in the marketplace.

Silver Perch

Most of the silver perch currently produced has been targeted for the live fish trade in Sydney's Asian restaurants. The live fish market requires fish to be 600-800g in weight and have a good physical appearance (no marks or blemishes on skin, fins intact, good colour etc). Silver perch has been readily accepted into this market, with farmers receiving strong prices ($9-10/kg live) at the farm gate. It is expected that this price will drop in time as more producers enter the industry. Some live product is sold at the Brisbane and Melbourne Fish Markets, with small amounts sold regionally. Fish not suitable for the live trade is usually sold whole chilled on the Sydney Fish Market auction floor with a small quantity sold in the Brisbane and Melbourne Fish Markets.

In a recent report by Ruello Associates Pty. Ltd entitled "*Silver Perch Market Assessment*", it was considered that the market for whole silver perch is near saturated, and is only capable of growth of about 20-30% over the next few years. The report concluded that the long-term future for fish farming lies with fillets. The Australian consumers preference is overwhelmingly for a skinless boneless fillet rather than a fish with its head and bones.

Local markets for fillets appear to be relatively unfulfilled with the potential domestic markets not yet fully explored with some researchers predicting that silver perch industry was capable of supplying over 10,000 tonnes/annum. There may also be future potential to supplement some of the $500 million worth of fish imported into Australia every year, predominantly in the form of cheap, processed/frozen, white flesh fillets eg hoki and hake. Export markets for silver perch are still relatively unexplored.

Like most freshwater fish, silver perch has a tendency to develop a muddy flavour. This occurs as a result of fatty tissues in the fish absorbing compounds released by blue green algae in the culture ponds. The only way to remove the *off-flavour* is by purging in clean water for 3-21 days, depending on the extent of tainting. Purging the fish in clean water expels the compounds that cause the taste, and the fish is then ready for market. The presence of off-flavours in marketed product has the potential to impact the industry. In order to encourage quality assurance and to assist maintain product standards, it is recommended that all silver perch are purged to reduce the potential for off-flavoured fish entering the markets. It is essential that the industry as a whole implement best management quality assurance practices so a high quality product is consistently available to the consumer.

Barramundi

One advantage to barramundi farmers is that the species has been commercially fished for a number of years, and as such has a well-established "elite" position in the market place. There are a number of options available to producers, including the live fish trade, plate size whole (300-500g) trade, and fillet or larger whole fish (2kg) trade. The reputation of barramundi as well as its premium edible properties (white, firm, mild tasting) also provides a good marketing platform for new producers. Barramundi (cultured and wild-caught) is sold in most major fish market or retail outlets, with aquaculture barramundi usually in the form of the whole plate size product. Live fish are also sold, targeted at the Asian restaurant trade. Farmers receive an average price of around $9-10/kg at the farm gate for barramundi, with higher prices for value-added products eg fillets. The average price used to be higher, but has been driven down by the number of new producers entering the industry, as well as cheap imports from places such as Vietnam. Due to the higher production costs associated with barramundi culture compared to overseas producers, there is probably only limited potential to create export markets for this species.

Murray Cod

Murray Cod has generated much interest in the live fish trade, due to its appearance and premium quality flesh and taste. Murray Cod sold as a live product has been very well received, and is perceived by some chefs to be one of the best tasting freshwater fish in the world. This is reflected in the average price paid for live Murray Cod; around $25-30/kg at the farm gate. There is also good potential for a gilled/gutted product fetching prices of $18-22/kg regularly on the Sydney Fish Markets auction floor. While most of the product is sold domestically, there may be potential for export trade of cod when production is increased. Overseas traders have expressed interest in the product. Most live product is purchased by Asian restaurants, indicating its acceptance within the Asian community. Although it is expected that average prices for live product will drop as more producers come on line, the almost legendary status of the cod, its excellent flavour and excellent appearance should ensure its place in the top range of the market.

Snapper

While marine fish are more usually grown in cages in estuaries, bays or the ocean, pond-rearing trials have also produced a high quality product. Snapper are relatively easy to market. The majority of the existing demand is for plate-size fish (400 g), which are sold and served whole. Two ways to expand the market for Australian snapper have been identified. The first is to export live and sashimi-quality snapper to Japan based on technology developed in New Zealand to export live wild snapper. The second is to develop a local market for live and sashimi snapper.

Mulloway

Marketing mulloway is a different proposition to snapper. Large mulloway (more than 2.5 kg) currently fetch the best price. Wild-caught smaller mulloway (soapies) have poorer consumer acceptance, however informal taste tests of 1kg mulloway grown in seacages were very favourable, and pond rearing trials have also produced a high quality product. Little is known of the export potential for mulloway.

Eels

More than 130,000 tonnes/yr of eels is produced worldwide, with the main producers being China, Japan and Taiwan. Over 70% of this product is produced for the Japanese 'Kabayaki' market. Kabayaki is a style of serving eels, where eels of around 150-200g are butterflied, placed on skewers, basted in a thick soy based sauce, and steamed or grilled. More than 90% of eels consumed in Japan are served this way, with eel being the most widely consumed freshwater fish in Japan. The Australian shortfin eel (Anguilla australis) is very similar in appearance to the species of eel favoured by the Japanese market (A. japonica). As such, the shortfin eel is well accepted in Japan and attracts similar prices to A. Japonica, averaging around $10-15kg at the farm gate (live). There is good potential for Australian producers to export shortfin eels to Japan for this market. The long fin eel (A. reinhardtii) is different in appearance to the A. japonica species, and as such is not well accepted in Japan, leading to lower prices.

However, the long fin eel is similar to the species favoured in China (Anguilla mamorata), and as such there is some potential to export this species there. For eels, it is hard to evaluate the size of any potential markets for Australian producers. Certainly the export markets are present and active, however the very nature of eel farming (i.e. reliance on glass eels for seedstock, seasonal nature of glass eel collection, limited technical know-how etc) can to some extent prohibit its development. Declining eels stocks overseas may work to the advantage of Australian producers. Furthermore, as Australia's multicultural population increases, there may be opportunity for a small domestic market for eels to develop.

Trout

Trout have high meat yields and sell well. Fresh trout has become cheaper than other prime fish such as snapper, mulloway and barramundi. They command medium prices for quality fish (rainbow trout retails for approximately $8 per kg fresh and $10 smoked; with approximately $4-6 at the Sydney Market). At present, a few large producers dominate the market and control the maximum price. Value-added products (eg smoked trout) demand higher prices. New marketing techniques (eg. fillets and cutlets in supermarkets) are being developed.

4.3 Product specification and adding-value

Like other primary industries, if the aquaculture industry is to be sustainable, it must constantly adapt to changing preferences and expectations of consumers, and to changing market conditions. To do this, the industry needs to focus on meeting the market and where possible value-adding. The following outlines marketing options:

- Live fish, prawns or other species (to remain alive for 5 days)
- Chilled whole fish (shelf life for 1 week at 5°C) (eg. GU=Gutted, GH=Headed/Gutted, GG=Gilled/Gutted)
- Cooked prawns and yabbies - whole or peeled – frozen or chilled
- Skinless and boneless chilled or frozen fillets (FI=Fillets) – chunks, steaks, fillets, nuggets etc
- Smoked (hot or cold smoking), pickled or other processed products.

The size of the fish can also be a key factor in market returns and consideration should be given to the grading specifications at the Sydney Markets which may change from time to time.

Table 10. Current Grading Specifications at the Sydney Markets

Aquaculture species	***Extra small***	***Small***	***Medium***	***Large***	***Extra large***
Barramundi *gms*		< 450	450 - 600	600 - 800	800 +
Silver Perch *gms*		300 - 450	450 - 550	> 550	
Black Tiger Prawns (P.monodon) *Number/kg*	>66	56 - 66	45 - 56	22 - 44	<21

Market sectors exhibit a preference for certain sized fish – for example for silver perch (Ruello & Assoc):

- Large whole fresh or live fish for the Asian “shared plate” dining range typically from 500 gms – 1kg and up to over 2 kg at times. There is likely to be greater demand for this size at holiday periods.
- Chilled whole fish for non-Asian cuisine ranging from 400 gms – 1kg.
- Chilled plate-sized for Asian and non-Asian cuisine sold mostly whole or some gutted ranging from 350 - 500 grams.
- Fillets mostly for non-Asian cuisine – 100 –200 gms fillets from fish 300 – 800 gms.

Packaging and presentation of products into the retailing market is an issue that requires more consideration. Bulk fish packaging is usually in clean styrene cases with a polyethylene liner bag in 10 kg or 15-18 kg lots. Cooked king prawn supply is a mix of plastic tubs (20-25 kg) and styrene cases (10 kg and 16-18 kg type).

Positioning speciality products through the use of well-designed packaging can add value and increase returns. Key to success with value-added products is a good quality assurance program to ensure that consistently high quality products reaches the consumer. All products should meet the National Food Standards (See *Operating the Farm Section* and Australian Seafood Industry Quality Assurance Project by Seafood Services Australia *www.dpi.qld.gov.au/cft/ssaust).*

5. Temperature factors in selecting species

Water temperature profoundly affects the growth rates and health of fish. Most species of finfish that are farmed successfully reach minimum market sizes (40-500 grams) in 12 -18 months. Prawns will typically reach market size in 3-6 months. To enable maximum growth, the temperature range of the selected site should match with the optimum temperature growing regime for the selected species. Regions where lethal temperatures are reached, or even approached, are unsuitable for pond culture of the particular species. Consideration of the site/system design in terms of likely water temperature ranges/growing season is essential for the species under consideration. Below is a table of optimal temperatures for various species under consideration that should be considered during site selection (See *Site Selection Section*).

Table 11. Temperature range for breeding and grow-out

Species	Ideal Temperature	
	Hatcheries	Grow-out facilities
Prawn - Black tiger	28 - 32°C	25 - 32°C
Prawns - Kuruma	25 - 30°C	20 - 28°C
Prawns - School	-	2l - 27°C
Crustacea - Redclaw	27 - 30°C	27 - 32°C
Crustacea - Yabbies	15 - 20°C	23 - 25°C
Barramundi	27 - 30°C	26 - 30°C
Eels	-	23 - 28°C
Kingfish	21 - 24°C	15 - 25°C
Mahe-Mahe	25 - 30°C	25 - 30°C
Mulloway	21 - 26°C	14 - 30°C
Murray Cod	19 - 21°C	23 - 26°C
Silver Perch	20 - 25°C	23 - 28°C
Snapper	21 - 24°C	17 - 30°C
Trout Brown	*6 - 10°C	4 - 19°C
Trout Rainbow	*9 - 14°C	10 - 22°C

**for spawning and egg production*

6. Feed Factors

Intensive fish culture is based on the use of medium to high stocking densities, prepared feeds (usually specially formulated dry pellets) and, with some species, fertilisation of pond water. Very high production rates can only be achieved with species that accept prepared feed. Not all species readily accept pellet rations (eg Australian bass and golden perch) and consequently there has been limited progress with intensive cultivation of these species.

Species vary in their optimal protein and nutrient intake. Generally, more carnivorous species such as snapper and kuruma prawns require a higher animal protein component whereas species with lower protein requirements such as silver perch are often more amenable to diets with inclusion of plant protein sources. For aquaculture to continue to expand significantly, fish meal based diets must be replaced with other protein sources.

The food conversion ratio (FCR) is the ratio of dry weight of food, to the wet weight gain of fish. The lower the ratio, the more efficiently food has been converted to fish flesh. Feed costs often constitute 40-55% of total production costs, so it is essential to use species that convert food

efficiently. Modern diets enable food conversion ratios of 2:1 or better in freshwater species such as trout. Species that have high meat to total body weight ratio are desirable because of their more efficient conversion of feed into edible flesh. This is particularly important if the end product is to be processed.

7. Disease factors

Although all species are susceptible to disease under culture conditions, the interactions that cause disease outbreaks relate to three components referred to as the epidemiological triad namely:

- the disease agent,
- the host, and
- environmental factors.

These factors are usually inter-dependent so that rather than a chain of causes, there is usually a causal web. These inter-relationships should be considered when selecting a species for aquaculture, choosing a site and designing grow-out facilities and management practices.

Avoid stress

Appropriate growing conditions that do not stress the fish are essential for successful culture. While species can tolerate sub-optimal conditions for short periods (eg for prawns, short periods of low temperature, dissolved oxygen levels or salinity levels), they will become stressed with reduced FCRs and greater susceptibly to disease than species better suited to those conditions.

Many of the potential disease parasites, viruses and bacteria occur naturally in the environments and may be present in the ponds or tanks. The natural defence systems of healthy fish will ward off infection. However once a fish becomes stressed, opportunity for the disease to cause infection increases via the lowering of the immune systems. The stress may also occur during handling (eg grading, harvesting, transferring between ponds, transport to market), heavy predation from predators (such as cormorants), drug treatments, poor water quality, undernourishment or overcrowding.

Prevention of stress is fundamental to maintaining disease free stock. Good husbandry techniques for disease prevention include:

- maintenance of appropriate water quality standards
- maintenance of optimum stocking rates to prevent overcrowding
- quarantine management for new stock before introduction into the ponds
- development of feeding regimes to maintain water quality
- regular inspection of fish should be undertaken to monitor health and implement of disease management protocols if necessary.

Disease management protocols

Some diseases are not naturally occurring and every effort should be taken to ensure that these are not introduced onto the farm from hatcheries, other farms or the wider environment. Measures should include stock protocols, worker protocols and in some circumstances exclusion of birds. A useful website on this subject is www.dah.csiro.gov.au. Many of the disease outbreaks (if caught early) are easily treatable, with little or no effect on the productivity of the crop. However some fish diseases are difficult to treat and cause widespread mortality in the aquaculture facilities as well as in the wild. Disease in hatcheries can be a particular problem, both in terms of losses in the hatcheries but also through putting at risk customer farms or native fish stocks (through restocking programs).

Good practice for disease management should include:

- Upon the first signs of disease outbreak specimens should be removed and analysed for disease symptoms and water quality should be checked. If no obvious manageable causes are found then a qualified veterinarian should be consulted immediately.
- Appropriate training for all staff on health management and disease recognition but in particular key personnel who should have specialised training in the recognition and diagnosis of common fish diseases. These personnel should be made aware of the importance of keeping up-to-date with the latest disease identification and management.
- Appropriate equipment on site to assist in the accurate diagnosis of diseases including a microscope and testing kits.
- Appropriate protocols to prevent the inadvertent introduction of disease onto the farm from stock movement, employees, visitors or equipment.
- Appropriate protocols to deal with disease notification and management should an outbreak occur.

DISEASE PROFILES

Prawns

To protect native prawn species and reduce the risk of disease introduction, no live penaeids are allowed into Australia. So far, this appears to have prevented the introduction of major penaeid viral diseases such as infectious hypodermal-haematopoietic necrosis virus disease (IHHNV), yellow-head and white spot virus, which has caused very serious problems in countries that have allowed importations. Other viral diseases have occurred in Australia (for example Baculovirus), although this only appears to be a problem in hatcheries cultured prawns under sub-optimum conditions. Although bacterial, fungal and protozoan infections have been recorded in Australian prawn hatcheries and ponds, very few have caused serious problems.

Freshwater crayfish

Australian freshwater crayfish appear to have only one major disease, the so-called porcelain or white tail disease, caused by a microsporidian. The disease appears to be transmitted through cannibalism of dead individuals. The disease cannot be treated, but can be managed in aquaculture if stocks are periodically examined, and diseased animals removed. Microsporidians have been found in all three Cherax species.

Silver and Golden Perch

Infection with disease and parasites is a response by perch to stressors occurring in their environment. The most common of these would be deterioration of water quality. Most pathogens and parasites occur naturally in ponds and natural aquatic environments, however the natural defence systems of healthy fish will help ward off infection. Once fish become stressed with a lowering of its immunity defences, opportunity for the disease to infect increases. Infection may also occur when fish are handled e.g. grading, harvesting, moving between ponds, or stress caused by heavy presence of predators such as cormorants, or from inappropriately high stocking densities.

Prevention is the best cure, and a combination of good husbandry and management techniques will ensure that stock remains relatively disease free. General husbandry should include quarantine of all new stock to the site, with regular salt baths of new batches at a concentration of 5-10ppt for at least 1 hour before placement into any of the nursery ponds. Optimum water quality should be maintained to relieve stress on the fish, and regular inspections to monitor health. Upon the first signs of a disease outbreak a sample of fish should be removed and analysed for obvious disease symptoms, and water quality should be checked. If a source of infection or disease cannot be identified, a qualified fish veterinarian should be consulted. Most fungal and parasitic infections can be treated with a combination of salt bathes and formalin.

Trout

Trout are vulnerable to disease if stressed. Temperature stress is the most common problem in NSW, then overcrowding and low oxygen. Common parasites include Ichthyophthirius ('Ich' or 'whitespot') and Trichodina, both protozoans. Poor hygiene is also a common cause of bacterial disease in hatcheries, where any disease can spread rapidly if not identified and treated. Introduced trout diseases in the river stocks are a source of concern. In particular, outbreaks of trout EHN virus have resulted in new quarantine regulations.

Murray Cod

Like any fish, Murray Cod can be susceptible to various pathogens and diseases. Disease outbreaks are often in response to stressors being placed on the stock, which in most cases could be avoided. Prevention is the best cure, and a combination of good husbandry and management techniques will ensure that stock remains relatively disease free. General husbandry should include quarantine of all new stocks to the site, with regular salt baths of new batches at a concentration of 5-10ppt for at least 1-hour before placement into any of the grow-out tanks. Water quality should be maintained to relieve stress on the fish, and regular inspection of fish should be undertaken to monitor health. Upon the first signs of a disease outbreak a sample of fish should be inspected for obvious disease symptoms, and water quality should be checked. If a source of infection or disease cannot be identified, a qualified fish veterinarian should be consulted.

Barramundi

Barramundi are naturally susceptible to most bacterial, fungal and parasitic infections, particularly at times of stress. This is can usually be avoided by appropriately quarantining new stock before release into culture tanks, maintaining water quality and a stress free environment, and regular disease monitoring of stock. In the event of disease outbreak, stock can sometimes be effectively treated by salt or freshwater bathes, or via veterinarian prescripted medicines. The barramundi is known to be a potential carrier of the Barramundi Encephalitis Virus (BEV) which has potential to affect a number of species native to NSW. As such NSW Fisheries has imposed tight restrictions on the culture of barramundi in this State. To address these concerns NSW Fisheries have included provision within the Barramundi Farming Policy for the sterilisation of all effluent to be removed, as well as a specific protocol for the importation of barramundi fingerlings from out of state. This includes the testing of fingerlings for presence of the BEV as well as other diseases and virus. This policy will not only reduce the chance of translocating the virus to NSW, but also ensures that the farmer has a guarantee of healthy good quality seedstock.

Eels

Because glass eels are sourced from the wild, they may already be infested with various parasites or diseases, or alternatively act as disease carriers. However, the acclimatisation to freshwater that usually occurs after capture eliminates most parasitic infections through osmotic forces. Bacterial and fungal infections on eels raised in freshwater can usually be treated by simple salt baths at a rate of around 10ppt. Eels, like most fish, are particularly susceptible to infection at times of high stress, for example when water quality has deteriorated, there is constant presence of predators in ponds, or at times of harvesting and handling. While eels are generally quite tough, they still need to be handled with care. As in most forms of aquaculture, the best cure is prevention and a combination of good husbandry and management techniques will ensure that stock remains relatively disease free. The maintenance of disease free stock involves the quarantining of all new eels to the site, and regular salt bathing of eels in quarantine facilities. Water quality should be maintained to relieve stress, and regular inspection of eels or elvers should be undertaken to monitor health and condition. At the first signs of a disease outbreak a sample of eels should be inspected for obvious disease symptoms, and water quality should be monitored. If a source of infection or disease cannot be identified, a professional fish veterinarian should be consulted.

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