DEPARTMENT OF
PRIMARY INDUSTRIES

Victorian Open Water Murray Cod Aquaculture Industry Development Plan

November 2009

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EXECUTIVE SUMMARY

The Murray cod (*Maccullochella peelii peelii*) is Australia's largest freshwater fish, growing to over 100 kilograms. In New South Wales, strata dating from 26 million years ago have unearthed fossil evidence of the Murray cod, however it is possible that the species is as old as the Murray Darling basin itself – 50 to 60 millions years old.

Named after the Murray River, the Murray cod holds a place in Australian indigenous culture as an iconic species. The Murray cod (or Ngurunderi) is the subject of Aboriginal dreamtime legends, and the Ngarrindjeri people of the Lower Murray believe that the Murray River was created by a giant Murray cod, fleeing down a small creek to escape a hunter. As a result, this ancient giant species of the inland remain deeply connected to the Australian landscape and culture.

Distributed throughout the Murray-Darling River system, the Murray cod is highly valued as a recreational and commercial finfish species. The Murray cod was once widely spread and abundant. However, due to its highly regarded eating qualities and marketability, interest in Murray cod has now intensified and it is now listed as a vulnerable species both in Victoria and across Australia.

Open water Murray cod aquaculture is an outstanding prospect for developing sustainable diversification ventures in Northern Victoria. It is a highly marketable fish species, possessing a number of qualities that appeal to increasingly health conscious market segments.

This report investigates the strengths and weaknesses of Open Murray Cod Aquaculture as an area for potential industry development. Outlined within this document are key considerations that have been identified to ensure steady industry development in the short, medium and long term.

The industry has also developed a number of priority actions that require attention, collaboration and investment for the long-term development of a sustainable industry sector. These include:

- Securing scale and reliability in the supply of advanced stockers
- Attraction of additional open water grower industry participants
- Implementing sustainable increases in production volumes
- Formalising collaborative structures and agreements for industry participants at all levels in the supply chain
- Formulation of tailored nutrition/diet rations and an improved feed manufacturing arrangements

- Investment in, or contracting of, processing facilities and value added product development
- Adoption of production and market targets for both export and domestic market development, with consequent investment in marketing activities
- Development of clear branding and corporate design support materials
- Documentation of risk mitigation guidelines
- Application of breeding technologies to extend seasonal availability of stock
- Continuing genetic improvement through selective breeding (ie commercialisation and ongoing development of the Our Rural Landscapes (ORL) selective breeding program)
- Product diversification to include portion control, longer shelf life packaging and other value adding
- Development of new markets at least 18 months in advance of intended supply.

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1.1.1 Murray cod: The Iconic Fish of the Inland

The Murray cod (*Maccullochella peelii peelii*) is Australia's largest freshwater fish, growing to over 100 kilograms. In New South Wales, strata dating from 26 million years ago have unearthed fossil evidence of the Murray cod, however it is possible that the species is as old as the Murray Darling basin itself – 50 to 60 millions years old.

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1.1.2 Prospects for Open Water Aquaculture of Murray cod

Open water Murray cod aquaculture is an outstanding prospect for developing sustainable diversification ventures in Northern Victoria.

Murray cod is a highly marketable fish species, possessing a number of qualities that appeal to increasingly health conscious market segments, including

- firm white flesh
- indications of strong market acceptance in Asian markets
- low-medium fat content
- a high omega-3 fatty acid profile, and
- an attractive appearance as a whole, filleted, or banquet fish.

Commercial aquaculture production of Murray cod for human consumption has been in progress since the mid-1990's, and husbandry and culture techniques are well developed throughout the production cycle[1]. To date, the level of commercialisation has been modest. However, opportunities exist for

[1] From manipulated spawning to larval and nursery rearing and final grow out on artificial diets in a range of aquaculture systems, including ponds, cages and recirculating aquaculture systems (RAS).

agricultural businesses wishing to diversify, and open water aquaculture presents an exciting alternative to previous aquaculture business models.

In the face of ongoing drought, open water Murray cod aquaculture also enables agricultural enterprises to increase the value and sustainability of precious water resources through multiple uses. The integration of aquaculture and agricultural systems means that open water aquaculture has the potential to improve the profitability and sustainability of irrigated farming (Gooley et al., 2007). In Northern Victoria, horticultural and dairy irrigators could undertake open water aquaculture of Murray cod, without any increase in water usage.

1.2 Current status of the industry

1.2.1 Snapshot of Industry Situation

Fishing pressure over the last 200 years, combined with the impact of introduced species on its natural river systems has led to a reduction in natural populations of Murray cod in the wild. The species is no longer caught commercially in the wild, and seasonal restrictions and fishing limits exist on recreational fishing in an effort to maintain this natural population.

The current position of the commercial Murray cod industry in Victoria is influenced by a number of factors of historical and economic significance. A snapshot of the current industry situation reveals:

- In Victoria, the current total aquaculture production of Murray for commercial markets is less than 30 tonnes per annum. Although there has been considerable research and a history of Murray cod aquaculture in recirculated aquaculture systems (RAS), there has been very little commercialisation of product or a history of consistent significant product supply.

- Farm gate prices for open water Murray cod have been in the range $14 to $25 per kilogram over recent seasons. A long-term sustainable minimum target of $12 per kilogram has been set.

- At present, there is one emerging (and vertically integrated) supply chain in the industry, operating under the name 'Murray Gold'. The supply chain 'captain' for Murray Gold is Thurla Farms, based near Mildura. Thurla Farms is involved in
    - development and marketing of grow out systems
    - attraction, and negotiation, with new supply chain participants
    - grow out of advanced stockers to commercial sized fish
    - coordination of processing
    - coordination of marketing.

- The Victorian Department of Primary Industries (DPI) under its "Our Rural Landscapes" (ORL) initiatives has provided commercially focused support to the emerging open water Murray cod sector. A five year project titled "Multiple Water Use: Adding Value and Sustainability to Water in Agricultural Landscapes" was responsible for the genesis of the industry, attracting the main industry participants and making research and development progress through its selective breeding program.

Table 1.1 Strengths and Weakness of Open Water Murray Cod Aquaculture

Strengths	Weaknesses
• Australian indigenous fish species with iconic status • A highly marketable product, with good appearance and flavour, functional food benefits, and healthy eating attributes • Access to leading R&D, including Fisheries Victoria's selective breeding program • Environmentally sustainable and a demonstrably effective additional use of irrigation water • Use of open water systems appears to present much greater prospects for commercial viability and production scale than previously developed aquaculture systems • Regionally committed entrepreneurs and investors • Appropriate technology • Opportunities for farm diversification in the Murray Basin, at a time when horticultural production is under enormous pressure • Lower investment than RAS and other intensive aquaculture options	• Some aspects of open water Murray cod aquaculture remain developmental and unproven • Volumes low. Predicted 5-7 years before supply capabilities reach substantial proportions. • Gaps in the supply chain. At present, only one genuine, vertically integrated supply chain (Murray Gold) exists. • The supply of advanced stockers is currently undeveloped and unreliable. • The existing market base is extremely small. Product diversification and value-adding required to grow market base and satisfy different markets. • Experience with Atlantic salmon suggests that export markets may need to be established before tackling domestic markets • Reduced, and occasional 'zero', irrigation water allocations place a degree of uncertainty over the quality of water available for the industry in the future (potentially requiring recycling and water purification technology solutions). There is a need to exchange/refresh water at least four times during open water grow out.

1.3 Murray Cod Aquaculture

Murray cod (*Maccullochella peelii peelii*) is Australia's largest native freshwater fish and is highly valued for recreational, commercial and conservation purposes. It is highly regarded as a table fish and for many decades supported a small but lucrative commercial wild catch fishery.

In the 1970's to 1990's, techniques were developed which enabled large-scale hatchery production of Murray cod. However, this technology was largely limited to the seasonal production of fry and small fingerlings (30-50 millimetres and 0.5-1.5 grams).

State government and private fish hatcheries, principally in New South Wales and Victoria, annually produce fish for stocking public and private waterways for both recreational and conservation purposes. There has also been considerable industry interest (both from potential producers and markets) in the grow-out of Murray cod as a table fish to satisfy perceived domestic and export demand. This interest was initially converted into grower investment in intensive/semi-intensive farming in tank-based, indoor recirculating aquaculture systems (RAS).

In the early 1980's, breeding techniques for Murray cod were developed and stock enhancement programs were established within New South Wales and Victoria to help increase the numbers of this fish. However, it was not until the 1990's that Murray cod was farmed commercially as a table fish. The farming attributes of Murray cod include the fish's ability to adapt to artificial environments, efficient feed conversion and high stocking density tolerance.

The majority of farmed Murray cod produced since the inception of aquaculture initiatives (in the 1990's) have been in RAS installations. Murray cod adapts well in intensive recirculation tank systems. The stocking of Murray cod at high densities reduces the opportunities for fish to establish territories and consequently they become a schooling fish. In addition, the grow out culture of Murray cod is undertaken on a very limited basis, extensively in ponds. In the past, it was originally thought that Murray cod was unsuitable for intensive, tank culture because of its aggressive and territorial nature. As a result, Murray cod have been extensively cultured for grow-out in farm dams and ponds in very small numbers. However, this technique results in lower yields and variable growth rates compared with intensive culture. It is likely that future commercial production from extensive culture will be very limited.

Prospects for grow out of Murray cod in RAS faces an uncertain future as most farms are relatively small, few in number and production and market penetration is limited. RAS profitability is variable and new capital investment in this sector is also presently low.

Open-water farming of Murray cod is an emerging regional development opportunity for Northern Victoria (particularly the Sunraysia and the Mid Murray regions). This follows a recently completed Victorian Department of Primary Industries (DPI) research and development project funded as part of the Victorian Governments Our Rural Landscapes (ORL) initiative. This project, entitled "ORL 1.3 Multiple water-use; adding value and sustainability to water in agricultural landscapes", commenced in July 2003 and finished in June 2007.

The project initiated trials and partnerships with three, large-scale, irrigated horticulture farms at Red Cliffs near Mildura. The trials involved pilot commercial scale production of Murray cod and other species in production systems which were floated in existing, privately-owned, large-scale irrigation storage dams, so that the aquaculture enterprise could be fully integrated within existing, diversified, horticulture enterprises. The "ORL 1.3 Multiple water-use; adding value and

sustainability to water in agricultural landscapes" project was followed by the ORL extension (ORLE) E project which investigated and published standard operating procedures for alternative fish health treatments, post-harvest activities and marketing.

More recently, work in the Murray cod industry from a DPI perspective has been targeted at the "Tools for Sustainable Seafood Value Chain Development" project; designed to further facilitate post-harvest processes, market and value chain development in this emerging sector. DPI partnered with industry and the Department of Industry, Innovation and Regional Development (DIIRD) to produce a Murray cod industry network feasibility analysis. This analysis identified business planning models, priorities for the industry and made recommendations toward a development plan for this new industry sector.

1.4 Scope of the Development Plan

The overriding objective of the industry development plan is?:

"To prepare an industry development plan for 'open-water' farming of Murray cod in north-western Victoria, with particular emphasis on guidelines for requisite investment, infrastructure, capability, networking, production targets, research and development, risk mitigation, seasonality, processing, product development, marketing, promotion, logistics and distribution."

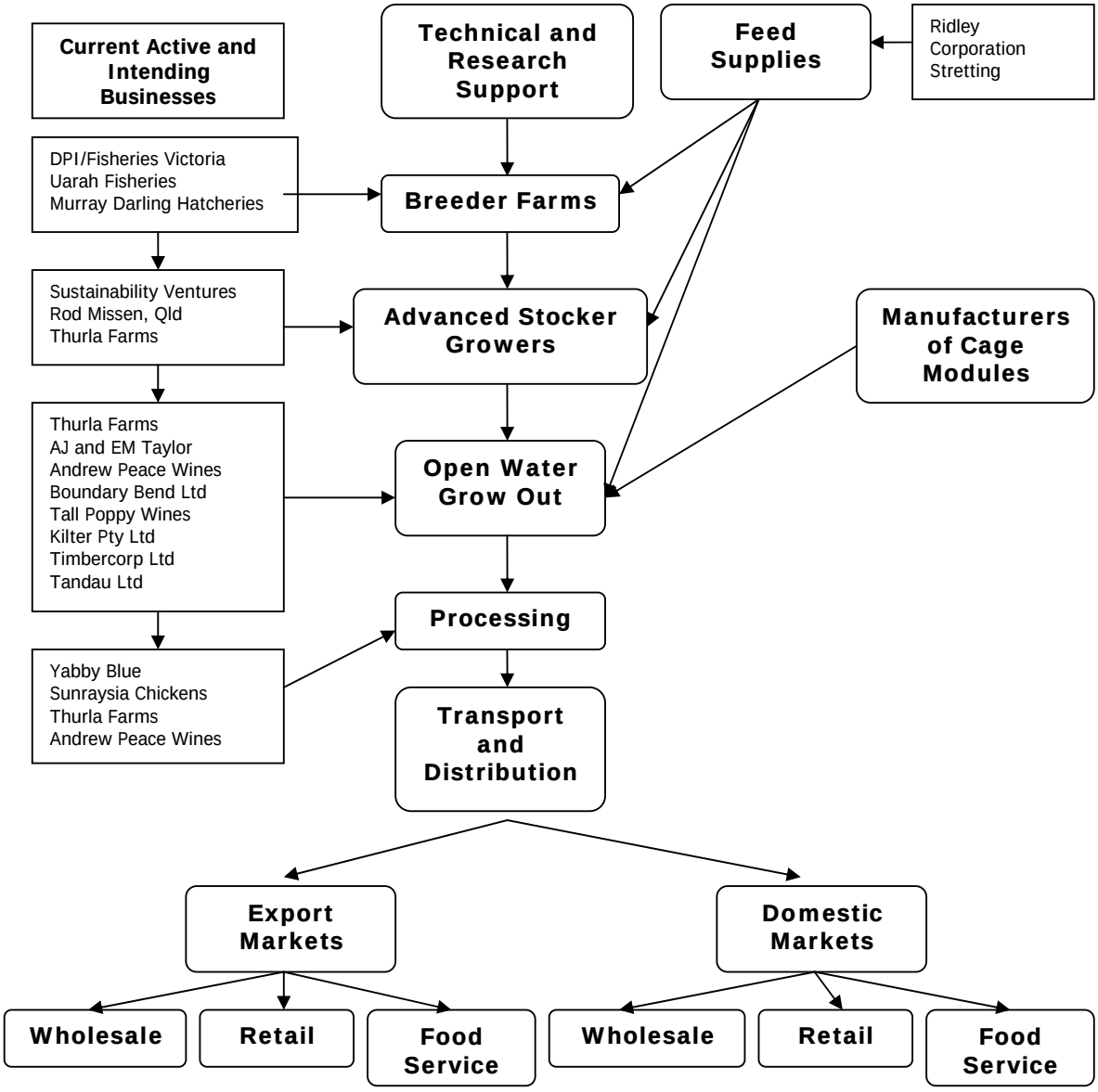
Intermediate objectives were to identify the challenges, issues and future horizons for the development of the industry. That is to:

- Define the position of the industry into the future and considerations of the requirements of industry for growth and sustainability including:
  - Market segmentation
  - Engagement with appropriate stakeholders (both industry and Government)
  - Industry maintenance and viability with increasing volume of product

- Consideration of possible investment platforms, such as:
  - Market Planning and Development
  - Optimising Industry Resources
  - Industry Sustainability and the Environment
  - Viable Funding and Investment Model for the open water Murray cod Sector

- Set targets and milestones for appropriate short, medium and long-term horizons (eg shorter term 2008-2013, medium term 2014-2019 and long term 2015-2020).

Figure 1.1 Dimensions of the Victorian Open Water Murray cod Industry, January 2009



2. INVESTMENT AND INDUSTRY ESTABLISHMENT

2.1 Investment Considerations

Open water Murray cod aquaculture is based on an assumption that growing fish can be undertaken as a value-adding activity within a broader farming enterprise producing a highly marketable co-product while simultaneously increasing the value of water used for irrigation.

A viable Murray cod open water grower would require the ability to produce at least 20,000 commercial market sized fish and a capital investment of about $150,000. An investment of $250,000 would provide the capability to produce up to 50,000 commercial market-sized fish and should include a floating cage system, monitoring and measuring hardware and software, installation and training.

There is also a strong opportunity for Murray cod growers to increase their return by holding equity in the supply chain "beyond the farm gate". Through vertical integration, growers in the chain may extend their interests (either through direct investment, joint venture, or contracting of services) into a variety of post-farm gate links in the supply chain, including processing, value adding, and logistics and marketing.

Other areas of investment opportunity in the open water Murray cod supply chain are

- Breeding stock.
  Ongoing research and development is required to achieve genetic improvement (through selective breeding) for both production efficiencies and product quality attributes. This is expected to require an industry investment of around $400,000 per annum, to retain a small research and development team in Mildura, and to have the rights over future intellectual property associated with the research outcomes.

- Breeding facilities.
  At present, it is expected that existing facilities/organisations will have sufficient capacity for breeding Murray cod from genetically improved parent stock to meet the immediate needs of the industry. They include
  - Fisheries Victoria/Department of Primary Industries, Victoria
  - Uarah Fisheries (Bruce Malcolm)
  - Murray Darling Fisheries (Noel Penfold)
  - Glencoe Fisheries (Rowena Henry)
  - Thurla Farms
  - Deakin University, Warrnambool campus
  - Ishwinroo Colin Dickson

- Advanced stocker production.
  This is an area of the supply chain that requires further investment. Sustainability Ventures Pty Ltd is in the process of recruiting dairy farmers to diversify their

operations by installing semi-intensive RAS systems (utilising a water filtration system designed and used in Israel). If this initiative is not successful, other advanced stocker suppliers such as Rod Missen (Queensland) and Thurla Farms (as part of full integration) may be considered.

2.2 Infrastructure

Infrastructure required to produce at least 20,000 commercial sized fish, deemed to be a viable level would require

- the use of a dam that could hold around 100 megalitres of water (with 4 metres of water depth). It is estimated there are currently over 100 dams in the Mildura to Swan Hill region, along the irrigation areas, holding over 100 megalitres of water.
- access to sufficient annual irrigation water that would enable 4 exchanges of water in a year, or water flow through an irrigation pump dam.

The industry is ideally suited to agricultural enterprises with secure irrigation water, or access to other secure and sustainable water supply.

In addition, growers require access to:

- inbound and outbound supply chain links (through Murray Gold or other arrangements).
- adequate fish feed supplies. This is an area that will need to strengthen as the industry grows. There is not yet a specifically formulated feed pellet ration for Murray cod (at various life cycle stages – fingerlings, stockers, grow out and finishing).

2.3 Networking and Supply Chain Development

There is a genuine opportunity to build the emerging open water aquaculture industry as a networked/collaborative supply chain, or groups of collaborative supply chains.

A "whole of supply chain" approach to commercial collaboration in the open-water farmed Murray cod industry, such as the structure proposed by Murray Gold, represents a sensible approach to building industry networks.

Implementing a whole-of-chain and collaborative approach could:

- provide a vehicle to establish alliances for packaging, product development, market research, processing, branding and marketing
- facilitate the formation of subsidiaries or related entities to enable expanded roles.

The formation of two new entities, "Murray Gold Pty Ltd", and "Murray Gold Research and Development Ltd", as outlined in the Murray cod Aquaculture Network report (Street Ryan, 2006), remains a valid proposition for progressing linkages in the industry and to set a strong foundation for an integrated, collaborative group. These

companies could provide a commercial vehicle for intellectual property (in the form of brands and promotional materials), relationships and agreements with supply chain partners and for undertaking future collaborative initiatives (such as trade missions and research and development projects) within and outside the chain, thereby providing a vehicle for collaboration across the whole industry sector. It was further suggested that Murray Gold be established as a proprietary company (with A Class and B Class shareholders) with

- invited shareholdings from major participating growers and selected supply chain partners
- contracts with other hatcheries and nurseries
- responsibility for establishing or appointing and managing the processing and marketing functions.

3.0 MARKET AND INDUSTRY DEVELOPMENT

3.1 Domestic Market Development

Australia's domestic fish and seafood markets are highly reliant on imported product (which is usually frozen or further processed on arrival). Table 3.1 shows that the country is a net importer of seafood, and especially finfish, products. Although there are some positive trade balances in the export of higher value seafood species (notably prawns, rock lobster, abalone, scallops and tuna) there is a large, and growing, deficit in Australian finfish trade.

Australian per capita consumption of seafood is lower than many other countries where the management of the category in supermarkets, and the retail supply chain, is effective.

Overall, Australia's aquaculture sector (seafood and finfish farming) has an annual sales turnover of $1.16 billion of which salmon, tuna, and oyster farming (including pearls) contributes 82% of the revenue(IBIS World, 2009) To date Australia has had a very small inland fishery; about 2,700 tonnes produced annually, at a value of around $5 million. Major environmental changes (associated with dams, locks or impoundments) and water used for irrigation purposes have tended to be a limiting factor for inland fisheries, until now.

Some aquaculture species are produced almost exclusively for the export market. Others are sold mostly on the domestic market. For example, southern bluefin tuna is farmed primarily for export to Japan, and abalone for export to East Asia. Conversely, trout, silver perch, barramundi, prawns, redclaw, edible oysters and mussels are sold mostly on the domestic market. Yabbies and marron are sold on both the domestic and the export markets. When production of Atlantic salmon first started the product was primarily sold to export markets, but as production has risen, more Atlantic salmon is being sold to the domestic market(IBIS World, 2008)

Table 3.1: Australian Seafood Market Segments

	Domestic Fresh '000 tonnes	**Exported** '000 tonnes	**Domestic Processed** '000 tonnes	**Total** '000 tonnes	**%**
Wild Catch	63	19	0	82	28.9%
Aquaculture	18	6	0	24	8.4%
Imported	107	0	71	178	62.7%
Total	**188**	**25**	**71**	**284**	**100.0%**

Source: Spencer S, and Kneebone M (2007) Foodmap: A comparative analysis of Australian food distribution channels, Australian Government Department of Agriculture Fisheries and Forestry, Canberra

On a world scale, growth of aquaculture will continue for many years into the future as the fish industries progressively shift emphasis from the limited and unsustainable resources of wild stocks to cultured stocks. Fish harvesting is comparatively behind land based agricultural practices, with 84% of production still reliant on wild catch resources. Climate change and the heightened value of water

resources also places pressure on aquaculture practices to be efficient in the use of water, with multiple uses clearly preferable.

Figure 3.1 provides a map of the market channels for Australia's domestic seafood industry. Supermarkets have a low share of the retail seafood category by comparison with their achievements in other perishable categories (such as fruit, vegetables, meat and poultry). Combined supermarket fresh seafood annual sales amount to approximately $250 million of an estimated $1.5 billion retail market, implying that supermarkets hold about 17% market share. In other perishable categories, the supermarkets share is 50-70%. This could be described as a weakness in the ability of the market to distribute product to mainstream consumers, and this weakness limits per capita seafood consumption in Australia.

In part, the low retail supermarket share of seafood can be attributed to a lack of development of informed supply chains in the seafood catching and aquaculture sectors compared with those in the agricultural sectors. In the broader agriculture sector meat, fruit and vegetable producers and processors have developed direct relationships with food service and retail customers. However, in the seafood industry, these relationships have not evolved. This is due to a number of factors, which include:

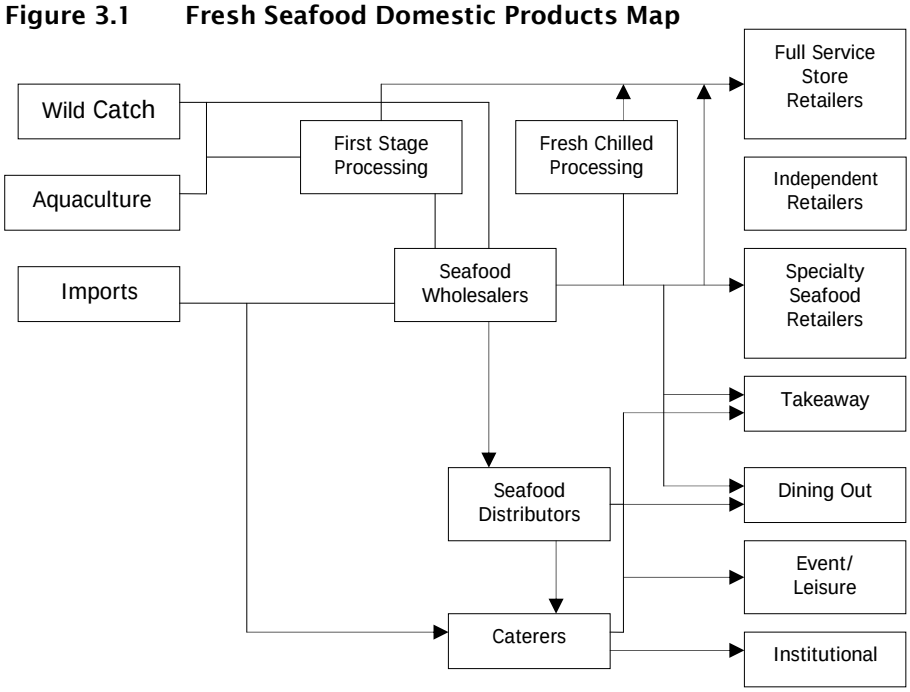
- The range and value volatility caused by supply variations of the wild catch
- Building and maintaining the skill requirements at retail stores
- Generating the self-fulfilling "volume sales" required to keep product fresh, confident and appealing to consumers
- Logistics solutions that lock in involvement with wholesale infrastructure and limit the ability of primary producers to access customer information and requirements.

Fish wholesalers play an important role in sourcing and securing products to reach major markets (including fresh and frozen fish and fillets). However, the fish wholesalers also have a major "gatekeeper" role in the chain.

With approximately 17% of domestic fresh seafood sales occurring in supermarkets, about 40% of sales are made through independent fishmongers, making the latter the largest volume channel for seafood products. (Spencer and Kneebone, 2007) Takeaway fish outlets and dining venues account for the remainder.

The clear opportunity to increase "share of stomach" is not being achieved through increased sales volume to domestic producers. Wild catch is diminishing and imports are rising. Increasing volumes are being sourced from imported farmed fish rather than domestic farmed fish.

Figure 3.1 Fresh Seafood Domestic Products Map



The domestic market for farmed Murray cod is largely under-developed in Australia, with only a few producers who sell the Murray cod commercially. Most producers sell direct or through a distributor. To date, the open water producers have concentrated on exploring and testing export markets.

In general, live Murray cod products, from RAS, have been sold to the niche gourmet/restaurant market in Melbourne and Sydney, although some product has been exported. Only small quantities have been sold on the Sydney and Melbourne fish markets. RAS-produced farmed Murray cod, sold live, is mostly purchased by Asian restaurants and is a popular fish among Chinese communities.

Currently the main sizes at which Murray cod is sold are

- Plate size, 350-500 and up to 800 grams (10-18 months old)
- Fillet, portion size, up to 2 kilograms (18 months to 2 years old)
- Banquet size, around 2 kilograms plus (1-2+ years old) for Chinese banquets.

Prices for farmed Murray cod on the domestic market vary according to size, grade and market. Average farm gate prices for Murray cod sold to restaurants ranges between $9.50 and $21.50 a kilogram for 350 gram fish and between $10.50 and $22.50 a kilogram for 500 gram fish. However, some producers receive $25-30 a kilogram for small quantities. Average prices for Murray cod sold on the Sydney fish markets have recently sold in the range of $20-29 per kilogram for open water farmed fish.

As farmed Murray cod is a newly developed industry, there is uncertainty whether current prices can be sustained if production increases. Currently, Murray cod has a high market profile in Australia owing to its recreational value and its cultural and

historical significance with indigenous people. It is sought after as a table fish by the restaurant industry, as it possesses highly regarded eating qualities such as firm white flesh that is considered ideal for steaming. As a consequence, farmed (and previously wild) Murray cod has achieved premium prices in niche markets. However, expected increases in supply are likely to place downward pressure on prices in the medium term. Some issues with product quality for RAS fish, specifically external physical damage and off-flavour (due to unmanaged purging practices), has impacted on some markets.

A local market assessment in the early 2000's found a positive response to Murray cod's firm white flesh and the fact that bones were easily separated. Limited overseas feedback was also positive. However, with increased domestic production, it was predicted that prices would fall without appropriate promotion.

The fresh chilled Murray cod product has a shelf life of up to seven days provided it is kept chilled to the appropriate temperatures. Current logistics and distribution arrangements for the open water Murray cod product, within Australia, are arranged through available, local freight forwarders/transport companies. Product for export is sent to Yabby Blue in Melbourne for packaging and consolidation into refrigerated airfreight containers and some filleting.

It is expected, as production grows (in excess of 100 tonnes per annum), arrangements for dedicated warehousing and distribution will become an area requiring industry consideration. Murray Gold is the most likely structure for coordinating (or outsourcing) this function, although non-Murray Gold industry participants may wish to make separate arrangements (especially if they have distinct markets and/or product forms to those offered by Murray Gold).

3.2 Export Markets

Open water farmed Murray cod is considered to be a high value, export quality product, able to be differentiated from other farmed fish (including RAS produced Murray cod) on the basis of credence characteristics of 'clean, green, indigenous, healthy and safe'. The product presents with a very natural appearance that retains natural flesh flavour and texture.

Currently, exports of Murray cod are limited because of the lack of supply, market development, and the price of Murray cod relative to the prices of other farmed freshwater fish domestically available in Asian markets, such as carp. Packaging and freight costs also reduce the competitiveness of Murray cod in world markets. In addition, Murray cod is relatively unrecognised in overseas markets and may take some time to gain market acceptance in the face of competition from more established and better-known species such as farmed tilapia and Nile perch. However, in the medium term, opportunities for exports of live Murray cod to Asia are believed to exist if it were available at a competitive price. In 1999, a market taste test evaluation on Murray cod was undertaken by Austrade in Asia, which received favourable feedback.

Export market development work to date for the 'open-water' Murray cod network has been facilitated by DPI Agribusiness, in the Singapore, Thailand and Japan markets. The points of difference emphasised are

- "quality assured 'open water' farmed fish". The open water fish is a unique product in terms of quality, freshness and appearance.
- available for export from Sunraysia at present.

A significant 'prototype' value chain for Murray cod into Singapore and Bangkok has been trialled from farm ponds in Mildura, through to the post-harvest phase (processing and freight to Melbourne consolidator/freight forwarder) to the food services sector wholesalers in the destination countries.

Export prices are in the order of $12-15/kg for whole fish, free-on-board (FOB) from Melbourne. Initial demand (and indications of future/potential demand), has proven to be strong with excellent customer feedback from, mostly, 5 star hotel chains. The ability to supply is severely limited by production capacity at this stage.

Long-term demand potential for export is difficult to quantify but current indications suggest that scale is in the order of at least hundreds of tonnes per annum, if not significantly more.

For freshwater native fish in general, production is expected to increase when drought conditions subside. Product quality varies considerably, with off flavours and poor grading and handling practices reportedly reducing market acceptance of some species, although this is not as apparent for Murray cod as it is for other native fish species.

3.3 Open Water Murray Cod Marketing Directions

3.3.1 Market Segments

There is a need for the Victorian open water Murray cod sector to develop strategies for three distinct market segments.

- **Domestic markets**. This market should retain the focus on the Murray cod name, which is already well known in Australia, as well as the brand for the relevant supply chain (eg Murray Gold). The new Seafood Services Australia fish names standard® also proposes that licensed businesses/participants consistently use the name Murray cod when marketing product. Branding for this segment also needs to convey messages that help to position open water Murray cod as:
    - Australia's iconic indigenous fish
    - Product from sustainable and environmentally efficient aquaculture systems (especially water efficient)
    - Having generic and specific health benefits

  Open water Murray cod aquaculture production, with regular and consistent output, provides an opportunity to develop a new supply chain to market which is not captive to the wholesale markets.

- **Asian export markets**, which could retain the name "Murray", combined with a supply chain brand (eg Murray Gold), in order to prevent any confusion with northern hemisphere marine cod species, which are unrelated to the Murray cod,[2] or perhaps "Murray Goodoo" (although this name has been declared obsolete by the Seafood Services Australia naming system). This branding would also focus on Australia's clean and green food reputation, nutritional features of the product and the Murray cod legends.

- **European and North American export markets** could focus on the indigenous Australian nature of Murray cod and the functional and nutritional benefits. The use of Indigenous artwork and references to indigenous Australian species is preferred.

3.3.2 Branding and Image

The successful branding differentiation of Murray cod will vary depending on whether it is targeted at food service and retail markets.

- For food service markets, the key factors for open water farmed Murray cod are
    - Relationships with the suppliers (or supplier representatives)
    - Consistency of supply and quality
    - Product of Australia (and particularly, indigenous product of Australia).

- For retail markets, the key factors for open water farmed Murray cod are
    - Labelling (attractive and recognisable label with uncluttered messages)
    - Product information
    - Health and nutritional attributes
    - Product of Australia
    - Being produced in 'open water'
    - Consistency of supply and quality
    - The ability to offer a range with both fresh and longer life processed products
    - Ability to meet agreed price points that achieve the necessary store throughput rates ("hurdle rates")
    - Preparedness to contribute to product promotions.

The open water Murray cod sector is in a healthy market position where demand clearly exceeds supply, but this can rapidly change as supply moves to a new order of magnitude (eg from a current level of about 20 tonnes per annum to 1,000). To cater for the forecast increase in supply domestic markets must be developed concurrently with international markets. Examples of this process have been provided with various seafood products, including the Atlantic salmon aquaculture sector

[2] The naming of Murray cod was introduced in the 1800's. It was clearly called Murray after the Murray River, and cod by early settlers because it reminded them of European Cods although it is not related to these cod. The Aboriginal names are Ponde and Goodoo

Murray cod has a unique marketing quality in that it forms part of the indigenous food industry. While this is a fledgling industry, dominated by small operators with fragmented and limited supply arrangements, positioning Murray cod as an Australian indigenous product offers a distinctive marketing edge. Although demand exceeds supply at present it is critical to have targets and plans in place to service additional market segments, particularly domestic retail markets and markets for value added product.

Open water Murray cod branding and image materials should be designed to include

- Use of distinctive fish shape on logos and artwork
- Indigenous recipe booklets and other point of sale material (such as those used in the indigenous plant products industry)
- An informative and communicative website, structured with the following menu items
    - History
    - Why open water aquaculture
    - Health and nutrition
    - Environment and water
    - Contacts
    - News
    - Products
    - Where to buy
    - Links

3.3.3 Market Targets

Suggested open water Murray cod aquaculture targets are presented in Tables 3.2 and 3.3, they are

- 3 year targets: 60 tonnes
- 7 year targets: 650 tonnes
- 11 year targets: 1,000 tonnes.

These targets assume that product development, to meet the needs of each market will be achieved by the industry (through long life and cooked or other processed products). They also assume careful and sustainable approaches are applied to new markets (not opportunistic "spot sales") with each new market segment being explored and implemented over a minimum of eighteen months.

Implicit in achieving these sales targets is the need to overcome current gaps in the production end of the open water Murray cod supply chain, as well as

- establishing a processing facility/capability
- implementing relationships with value adding companies
- further product development and testing
- implementation of quality and food safety protocols, and
- establishment of central distribution facilities and long term domestic and international freight and logistics arrangements.

Table 3.2 Market Targets: Short and Medium Term

	2009/10 (tonnes)	2010/11 (tonnes)	2011/12 (tonnes)	2012/13 (tonnes)	2013/14 (tonnes)	2014/15 (tonnes)	2015/16 (tonnes)
Domestic							
Food Service and Wholesale	10	12	15	20	25	30	50
Retail*	0	0	10	50	200	250	300
Export – Asia							
Food Service	15	30	35	100	150	150	150
Retail	0	0	0	0	0	50	100
Export Europe/America							
Food Service	0	0	0	0	0	0	50
Retail	0	0	0	0	0	0	0
TOTAL	**25**	**42**	**60**	**170**	**375**	**480**	**650**

*6 kilograms per store per week (eg 50 tonnes = 300 x 6 x 167 stores and 200 tonnes = 670 stores)

Table 3.3: Market Targets: Long Term

	2016/17 (tonnes)	2017/18 (tonnes)	2018/19 (tonnes)	2019/20 (tonnes)
Domestic				
Food Service	50	50	50	50
Retail*	300	300	300	300
Export – Asia				
Food Service	150	150	150	200
Retail	100	150	200	300
Export -Europe/America				
Food Service	100	100	100	100
Retail	20	50	50	50
TOTAL	**720**	**800**	**850**	**1,000**

* 6 kilograms per store per week (eg 50 tonnes = 300 x 6 x 167 stores and 200 tonnes = 670 stores)

4. PRODUCTION AND CAPABILITY DEVELOPMENT

4.1 Production Steps in the Value Chain

The key production steps in the open water Murray cod production value chain are as follows.

4.1.1 Hatchery

- Seasonal spawning of broodfish in small, static ponds (0.1-0.4 Ha). Alternatively use hormone injection to trigger ovulation, requiring manual stripping and fertilization of eggs
- Fertilised eggs removed to onsite hatchery
- Larvae up to 14 days old transferred to outdoor zooplankton ponds or maintained in tanks on Artemia diet for nursery rearing stage
- Weaning at 1-2 months onto artificial diets to about 1 gram
- Current level of production 1-2 million fingerlings (2 months old, 1 gram)
- It is likely that the businesses and organisations that already have capacity for breeding from genetically improved parent stock will be sufficient to meet the foreseeable needs of the industry. They include
    - Fisheries Victoria/Department of Primary Industries, Victoria
    - Urah Fisheries (Bruce Malcolm)
    - Murray Darling Fisheries (Noel Penfold)
    - Ishwinroo (Col Dickson)
    - Glencoe Fisheries (Rowena Henry)
    - Thurla Farms
    - Deakin University, Warrnambool campus.
- Ongoing research and development is required to achieve genetic (selective breeding) improvement for both production efficiencies and product quality attributes.

4.1.2 Stocker production

- 1 gram fingerlings grown in ponds or RAS, may reach 100 gram in as little as 12 weeks, but generally 4-6 months
- Current level of production is very low
- This is considered by many to be a very difficult stage of the value chain, as cost of production from 1 gram -100 gram is high, and high mortalities are experienced in this phase
- This major gap in the supply chain needs further investment. Sustainability Ventures Pty Ltd is in the process of recruiting dairy farmers to diversify their operations by installing semi-intensive RAS systems (utilising a water filtration system designed and used in Israel). If this initiative is not successful, other advanced stocker suppliers such as Rod

Missen (Queensland) and Thurla Farms (as part of full integration) may be considered

4.1.3 Grow out

- Growth to market size (minimum 600g, maximum 3kg) may take 12-24 months from 1g fingerling size. RAS systems may turn out fish of 600-800g in less than 9 months; production is slower but less costly in ponds subject to ambient temperature variability, the size the fish are when they enter the system and at what time of year.
- There is greater capacity for grow out than nursery production with three main fingerling producers (>50,000 per annum each, at 1gram plus), based in NSW and one based in Victoria.
- One of the most compelling features of open-water Murray cod aquaculture is that it is based on an assumption that growing fish can be undertaken as a value-adding activity within a broader farming enterprise - producing of a highly marketable co-product while simultaneously increasing the value of water used for irrigation.

4.2 Advanced Stocker Production

4.2.1 The Need for Advanced Stocker Production

A key issue facing the development of integrated open water Murray cod aquaculture is the supply of advanced stockers (ie fish of 50-100 grams) to be then grown out in open water systems. This stage is considered the most difficult of the value chain, as the cost of production from 1 gram to 100grams is high, and high mortalities are experienced. RAS technology is probably the most cost-effective means to efficiently produce reliable volumes of advanced stockers, however the capital and operating costs are typically high, resulting in prices of $2.50-$3.00 per fish at 100 grams.

At present there are few regular suppliers of advanced Murray cod stockers. The existing suppliers are Thurla Farms (supplying some stockers for its own use) with one interstate supplier. Neither of these arrangements is considered viable in the long term, as the volumes which will ultimately be required to support the anticipated production targets (1,000 tonnes per annum, rising to 5,000 to 6,000 tonnes in the extended longer term) will demand much greater production capacity for stockers than is presently available. Logically, production will be more efficient if it is located in close proximity to grow out operations, ruling out long term supply of stockers from remote locations.

The integration of aquaculture with irrigated agriculture has many environmental, economic and resource management benefits, and is particularly applicable to the open water grow out phase of Murray cod production where risks are relatively low and manageable. However the

intermediate phase of advanced stocker production contains greater inherent risk associated with disease, weaning, cannibalism, water quality etc. This phase should first be driven by the need to supply seedstock to growout operations, with integration with irrigation practices, a secondary imperative. This link in the supply chain requires dedicated facilities and trained and experienced staff, and needs to be profitable in its own right.

The production of stockers, while potentially able to be integrated into an existing agricultural business, should be done so as an independent operation with some dedicated staff and resources, and not entirely an adjunct to the core business of another operation.

A stand-alone advanced stocker production facility could potentially be established and operate around the following parameters:

- RAS with initial >50 tonnes production capacity with capacity to expand.
- Supply contract (1-5g fingerlings, preferably weaned) with existing hatcheries
- Supply contract with Murray Gold for 100g stockers
- Could be part of Murray Gold or separate (inc. CLG owned by Murray Gold)
- Staffed full time with suitably qualified & experienced staff
- Could use an existing local system or integrate new system into irrigated horticulture operation in Mildura area.

4.2.2 Potential for Sustainability Ventures in the Supply Chain

Sustainability Ventures Pty Ltd has established in Australia to introduce water efficient systems to the agribusiness sector and, at the same time, to offer diversification opportunities for Victorian farmers.

Sustainability Ventures has decided that its initial focus will be on the production of Murray cod advanced stockers by Northern Victorian (Goulburn Valley) dairy farmers. This will potentially provide a new diversification opportunity for the farmers, and fill a much-needed gap in the Murray cod aquaculture supply chain.

Sustainability Ventures is now actively marketing an operational pilot which (the company suggests) offers

- Low entry cost (both in operating and capital expenditure)
- High rates of production
- Ease of use
- Low water consumption
- High value product
- An integration of Sustainability Ventures, DPI and Israeli technology
- Integration into existing farm environments.

Sustainability Ventures Pty Ltd is investigating cost-effective, semi-intensive nursery production of Murray cod advanced stockers in saline groundwater semi-intensive RAS (in poly-greenhouses) and this is a further potential diversification opportunity for dairy farmers in the Shepparton Irrigation Region (Goulburn Valley).

4.3 Seasonality and Complementary Species

Based on Murray cod breeding habits, typically once per year, around September, advanced stockers would be available for grow out only during April, May and June, creating a restriction on market availability out of season.

Strategies for overcoming this limitation include developing out of season breeding programs and/or by reducing the advanced stocker sizes to 50 - 70 grams and, therefore, receiving the stockers for grow out over an extended time scale during the year. Only Glencoe Fisheries claims to currently have the capability to produce out of season breeding stock.

Simulating breeding climatic conditions at other times of the year could extend the season. Deakin University and Glencoe Fisheries have achieved successful out of season breeding in their controlled environment RAS system.

Growers might consider growing additional fish species at times that Murray cod is out-of-season. Rainbow trout and silver perch are two other species that can be grown to complement open water Murray cod, in order to provide increased business cash flow/viability and an extended production season.

- *Rainbow trout*

  Rainbow trout is produced in both freshwater and seawater systems, with the bulk (2,300 tonnes) produced in freshwater. Of this, over 1,500 tonnes was produced in freshwater ponds in Victoria in 2005/06. Farm gate price for freshwater rainbow trout is $5.60-$9.96/kg and many farms operate a tourism “fish out” operation, where higher farm gate prices are achieved, assisting cash flow year round. Value-adding (eg smoked products and pate) is undertaken by many growers.

  Freshwater trout production is also directly affected by drought conditions with many farms decreasing stock holdings. In the Mildura and mid-Murray regions, trout have a very limited growing season (over winter). Water temperatures above 21degrees Celsius cause mortalities.

- *Silver perch*

  About 700,000 fingerlings and 432.5 tonnes of market sized silver perch were produced in 2005/06. Silver perch received $12-15/kg live and $8-10/kg gilled and gutted.

4.4 Further Improvements in the Value Chain

The requirement to assure reliable quality seedstock is presently a major concern. Most hatchery/nursery production is of fry (1g), much of which is used for restocking of waterways. There is only one major supplier of reliable quality 100g stockers, however, at least 5 or 6 in close proximity to grow out operations are needed for the industry to develop further.

The use of advanced stockers, available in early spring, will reduce the grow out period by up to 6 months, thus enabling the open water grow out period to be less than 12 months.

There appears to be a large interest in Murray cod aquaculture using Australian produced fingerlings (1g) overseas, including in Asia, Israel and Canada. Orders have been placed for over 50,000-100,000 fingerlings from at least two NSW hatcheries for export to Asian countries, namely China, Taiwan and Philippines. This may create competition for the domestic Murray cod grow out industry in the future, with the potential to impact both export and domestic markets.

Out of season production of juveniles will provide advanced stockers over a longer timeframe, allowing production timing and cycles to be optimised. Presently, the supply of seedstock is limited to late summer/autumn which allows only a short period of optimum growing temperatures prior to winter, particularly where open water/cage/pond aquaculture is undertaken.

The number of hatcheries producing seedstock has decreased due to drought conditions resulting in reduced demand from grow out operations and farmers wanting to stock farm dams.

4.4.1 Cooperative or Contractual Agreements

It is anticipated that up to 10 growers could each produce 500-600 tonnes of marketable Murray cod in the Mid Murray region. This represents a fifty-fold increase on current production levels. To support this scale, about 5.5 million stockers at 100g would be required (allowing 10% mortality) annually. This would require approximately 7 million fry to be produced from hatcheries (allowing for minimum 20% mortality during this stage of production). Present commercial hatchery capacity would need to quadruple to meet such demand, without accounting for other existing demand on fingerlings. It may be possible for existing hatchery producers to double their present level of production with a lead up period of 18-24 months, however in order to meet the projected new demand for fry and stockers, a substantial increase in hatchery and nursery capacity would be required.

Production of 100g stockers is the most difficult and costly part of Murray cod aquaculture, and episodes of high mortality can be expected during this phase. This stage of production requires expert and dedicated attention and should be undertaken as a vertically integrated component of either the hatchery phase or of the grow-out phase. Alternatively, a central dedicated weaning facility employing expert staff and purpose-built facilities would be

an appropriate means of linking the hatchery and grow-out components of the industry. It is not considered feasible that the production of stockers be integrated into an existing agriculture business as an adjunct to the core business of an operation. Rather this phase of production needs to be core business in itself.

4.4.2 Multiple Use of Irrigation Water and Private Storages in New Irrigation Developments

The Government's and industry's aspiration is for irrigation to be increasingly productive, with minimal environmental impact. The key challenges of the "Our Water Our Future" White Paper relating to the irrigation sector, which also apply to the integration of aquaculture into irrigated agriculture, include:

- moving water to higher-value uses;
- reconfiguring irrigation infrastructure;
- innovating and adopting new technology and
- improving on-farm water use.

The integration of aquaculture with irrigated agriculture and the associated multiple use of water resources is a concept which was established with the origin of aquaculture itself some 2000 years ago in Asia, where fish production was practised in parallel and in combination with other agricultural practices, utilising the same water resource. Modern day irrigated agriculture however provides an opportunity for increased yields from all integrated enterprises using advanced technology and improved husbandry techniques. At present there are over 50 water storages holding over 100ML each in the Mildura region alone, which have potential for integration of aquaculture with irrigated horticulture. Specifically, integrated agri/aquaculture in the Mildura region could include integration of Murray cod (and other species) grow out with wine grapes, dry cropping, horticulture, or feedlot production.

4.4.3 Production Targets

Achievable short, medium and long-term production targets, also consistent with market development timescales are:

- short term (3 years): 60 tonnes
- medium term (7 years): 650 tonnes
- long term (11 years): 1,000 tonnes.

The impact of these targets on the investment and business model for the industry is that an attractive return on investment will not be achieved until the medium term (5-7 years) as shown in Table 4.1. This approach will be based on building production systems and markets on a secure platform, which is sustainable and increasingly attractive. Industry participants who are becoming involved as part of a long term diversification strategy, or as a hedge against future horticultural or dairying uncertainty should not be discouraged by a medium term return on investment.

Table 4.1 Estimated Investment and Financial Targets

	Short Term 2011/12 ($ million)	Medium Term 2015/16 ($ million)	Long Term 2019/20 ($ million)
Annual Sales Revenue	$1.2	$10.4	$15.0
Total Capital Investment*	$3.5	$5.0	$7.0
Total Research and Development and Marketing Investment*	$1.5	$2.8	$4.4

* Industry investment

5. RESEARCH AND DEVELOPMENT

5.1 Selective Breeding Program

In 2002, Victorian Department of Sustainability and Environment (DSE) researchers reported to the Commonwealth Department of Agriculture, Fisheries and Forestry that some of the Murray cod released into Victorian catchments in one year were not genetically well-matched to the wild populations into which they were introduced (Bearlin & Tikel, 2003). It was clear that Murray cod from some southern and eastern catchment areas had significant genetic differences.

Prior to the DPI "Our Rural Landscape (ORL)" (Victorian Department of Primary Industries, 2007) program, scientists at DPI Attwood developed an enriched DNA library for Murray cod and identified a small number of microsatellite markers. Microsatellite markers are short repetitive stretches of DNA that are inherited from one generation to the next. They are useful for assigning parentage as well as for detecting genetic differences between populations and therefore facilitating genetic interrogation to achieve production and commercial objectives.

The ORL project titled "High value aquaculture in sustainable rural landscapes" aimed to develop genetic and reproduction technologies to produce new domesticated strains of Murray cod for aquaculture as well as supporting the management of wild Murray cod populations. Selective breeding of Murray cod for aquaculture is based on the identification of genetic markers for useful production traits (such as disease resistance, good flesh texture, and rapid growth). Elite strains of Murray cod can be grown in recirculation systems, or in 'open water' systems. (Victorian Department of Primary Industries, 2007)

There have been a number of significant achievements resulting from this project (Victorian Department of Primary Industries, 2007), including

- Identification of traits of interest to the Murray cod industry
- Isolation and characterisation of 102 new microsatellite markers
- Genetic mapping of Murray cod
- Genetic markers linked to traits of commercial interest
- The refinement of controlled spawning procedures for Murray cod
- The development of reproduction techniques (triploidy and hybridisation) that will enhance production and may provide IP biosecurity and protection.
- A method to cryopreserve Murray cod sperm
- A non-destructive method of identifying female Murray cod
- An understanding of the population structure of naturally occurring contemporary Murray cod populations
- An understanding of the population structure of naturally occurring historical Murray cod populations
- An understanding of the impact of re-stocking on naturally occurring populations
- An understanding of the mating behaviour of Murray cod in breeding ponds.

The project has established a Murray cod founder population and developed a Murray cod marker assisted selection system to a pre-commercialisation stage. Uptake of a selective breeding program by industry will assist the sustainable and profitable development of the Murray cod aquaculture industry and will assist expansion of the industry into new markets (such as the export of new strains of Murray cod fry to overseas aquaculture industries).

The selective breeding program has already delivered tangible results in improved fish growth for open water environments, and the industry participants are convinced that the continuation of selective breeding/genetic improvement will be critical in meeting future commercial objectives and in providing "intellectual property protected" competitive advantages.

The 2006 Murray cod Aquaculture Networking Plan (Street Ryan, 2006) recommended that the industry take a formal stake in the selective breeding program, either through a joint venture arrangement with DPI, direct financial contributions to future research activities, and/or a "phased buyout" of the research program and the research and development capability of the program. The Murray Gold supply chain has now agreed to

- pay annual operational costs to maintain a small research and development team in Mildura
- secure future intellectual property rights, and
- pay a royalty for the use of intellectual property developed to date.

5.2 Future Farming Initiative

The Future Farming Initiative (Aquaculture Futures Initiative) will continue to implement an open water Murray cod research and development work program over the next 3 to 4 years. This will be part of a larger program encompassing mussel and eel aquaculture, as well as Murray cod. It will have a value of $1 million per annum, and the current priorities for research in Murray cod aquaculture are

- Genetic improvement - continuation from the ORL project
- Selective breeding, proof of concept/commercialisation
- Project "Marker-assisted mass selection" (ORL 2.3)
    - Need to develop sterile elite strains for aquaculture
    - Develop sterile strains (triploid production, hybrid MC/TC)
    - Increase breeding volumes of F2 stock and evaluate performance
    - Improve gamete quality and quantity produced
    - Improve efficiency of production
        - Controlled spawning/reproductive technology (Apply Cryopreservation of sperm to breeding program)
        - Science of production
    - Carrying capacity of storage dams
    - Integration of irrigation enterprises
    - Whole farm modelling, water use
    - Water budgets
    - Whole farm planning
- General husbandry

- Nutrition (in collaboration with Deakin University)
  - Feed Conversion Ratio improvement
  - Commercial diet development
  - Grow out and finishing diets
  - Fortified diets (eg bioactive diets)
- Fish health
  - Improve access to industry
  - Develop guidelines and strategies
  - Water quality
- Market Development
  - Increasing involvement with Asia-Pacific region
  - Develop formal engagement with Asia (international generally)
  - NACA (Network of Aquaculture Centres in Asia)
  - Progressing a potential joint venture in the Philippines
  - Hosting visiting scientists
  - Industry and scientific exchange
- Fish health and biosecurity
- Use of intellectual property
- Screening for bioactive compounds in Murray cod
- Investigating Murray cod as a functional food

The involvement of the industry in all the research and development initiatives would be both welcomed and expected.

Fisheries Victoria/DPI is keen to transfer responsibility for further commercialisation to the industry and has structured a technology transfer agreement to be implemented over the next 3 years in Mildura.

5.3 Sustainable Farming Practices

It is intended to develop an economically efficient and viable open water aquaculture industry for Murray cod that is undertaken in an ecologically sustainable manner, meeting or exceeding community expectation, by:

- increasing the knowledge of environmental impacts of Murray cod aquaculture and the assimilative capacity of the farming environment
- assessing impacts to the environment (including genetic impacts) arising from translocation and non-intentional release of Murray cod into the environment
- increasing and applying knowledge on site selection factors and open water farming techniques to maximise the sustainable productivity of open water Murray cod aquaculture
- developing efficient feeds and feeding regimes to maximise feed conversion rates (FCR) and reduce pollutants and impacts of discharges
- developing cost effective baseline studies and environmental monitoring protocols

- developing staff training programs, increase extension and improve awareness of sustainable open farming practices to industry and other stakeholders.

5.4 Fish Health

Fish health is critical to the long-term reputation and growth of the industry. The highest level of fish health is anticipated, based on appropriate risk planning and management by:

- improving and sharing knowledge of diseases and pests of Murray cod
- developing appropriate surveillance, monitoring, reporting and technology to identify risk, including rapid diagnostic capacity
- identifying and developing environmentally sustainable methods of preventing fish diseases
- identifying and developing sustainable treatments
- establishing and maintaining a health emergency response plan for Murray cod aquaculture
- developing staff training programs, increase extension and awareness of fish health risks, treatment and fish health protocols to ndustry and other stakeholders.

5.5 Improved Production Capacity

There is a need to ensure that the optimal grow out systems, feed and feeding strategies and husbandry techniques, including quality and consistency of broodstock, are developed to increase production, disease resistance, marketability and economic performance of the industry.

This will require commitment and action in the following areas:

- initiation of cost effective programs to develop sufficient quantities of broodstock that have optimal growth rates, disease resistance and other preferred traits, whilst maintaining appropriate genetic diversity
- investigation of the economics and operational issues involved in agri-aquaculture farming of open water Murray cod, including assessing the appropriateness of the three systems in place (i.e. floating cage, floating raceway or floating tank systems)
- development of efficient and effective? grow out and husbandry strategies
- development of cost-effective feeds and feeding strategies, including options to reduce the volume of fish protein required for feed
- identification of the risks to open water farming associated with water availability, especially in light of possible impacts of climate change
- development of staff training programs, increased extension and awareness to ensure that there is transfer to industry of completed research relating to production capacity.

5.6 Market/Supply Chain Development

There is a need to undertake research to determine appropriate and realistic target markets and identify customer requirements so as to develop, implement and maintain an industry marketing plan and supply chain which positions open water Murray cod as a premium product.

Actions required:

- develop an industry group to represent the open water Murray cod industry
- investigate the benefits of developing a marketing group
- undertake realistic economics and market appraisal of Murray cod
- determine target customer requirements, including packaging, volume, traceability
- identify drivers that will determine market demand in the future
- develop an appropriate brand and industry standard that reflects customer requirements
- define and improve distribution channels and logistics for the product
- develop an industry wide marketing plan based on market and demand requirements
- develop training programs and increase extension to allow the industry and the supply chain to operate in order to meet customer requirements in accordance with the marketing plan and supply chain requirements.

5.7 Fish Quality and Food Safety

There is a need to ensure that open water Murray cod is produced in such a way that it becomes recognised by the market at the highest international standard for its quality and food safety.

Actions required:

- identify any risks to open water farming arising from on-farm or upstream impacts, such as the use of fertilisers or pesticides
- identify the evidence required by target and potential markets and consumers in order to prove quality and safety
- develop industry standards for producing, processing, packaging and transporting open water Murray cod
- identify and establish relevant food safety protocols for growing, harvesting, processing and transporting Murray cod
- obtain appropriate local, national and international certification
- develop a market monitoring program
- develop staff training programs, increase extension and awareness of fish quality and food safety to the industry and other stakeholders.

5.8 Processing

At present, some processing of Murray cod is being conducted by Thurla Farms, which has recently been accredited by PrimeSafe Sunraysia Chickens, a local food processing business with some filleting at Yabby Blue Pty Ltd. Processing currently involves bleeding or gutting, cleaning and packaging.

Further product development and processing arrangements need to be established for value added product such as

- Filleting and piecing
- Long life packaging (cryovac, modified atmosphere packaging (MAP), and possibly retort packaging)
- Cooking and smoking
- Fish in sauce portions.

In order to obtain the highest value and return on investment for the product, it is necessary to ensure that appropriate standards and facilities for processing are available to meet customer requirements.

Actions required:

- determine the present and future processing and value adding requirements of customers
- establish, or improve, technology to meet customer requirements in the areas of processing, packaging, improved product quality and shelf life
- develop industry standards for processing, with a focus on value adding opportunities
- develop a feedback mechanism to assess customer requirements and industry return
- develop staff training programs, increase extension and awareness of processing requirements and value adding options for the ndustry.

5.9 People Development

The growth of the industry requires that those involved in the Murray cod aquaculture industry have appropriate knowledge and skill and can apply that knowledge and skill on the job.

Actions required:

- determine the knowledge and skills (including operational, business and research and development (R&D) skills) required by people working in the Murray cod aquaculture industry, including the supply chain
- determine how this knowledge and skills can be applied and assessed on the job
- develop and implement an occupational health and safety plan for the ndustry
- determine and deliver the most appropriate forms of training and assessment

- convert Codes of Practice or protocols into training programs which can assess competence
- develop a process to assess effectiveness of any training programs through the supply chain.

5.10 Communication

A sound communication program will ensure that relevant information is shared ndustry wide and the integrity and positive aspects of the ndustry are shared and accepted by relevant stakeholders.

Actions required:

- develop a communication strategy for the open water Murray cod industry and supply chain
- improve the participation, consultation and communication processes between the industry, supply chain, customers and other stakeholders
- assist government, stakeholders and communities to understand the industry, its value and sustainable development strategies to the public, via a range of media
- communicate appropriate results of R&D projects and transfer technology to the ndustry and stakeholders, where this does not affect the maintenance of the industry's international commercial advantage.

5.11 Management and Legislation

The development of policies, legislation and management practices across all relevant agencies at local, national and international level are necessary to allow and encourage the development of a viable open water Murray cod industry.

Actions required:

- develop a risk assessment framework to determine avenues of R&D that will most benefit and influence sound policies, legislation and management practices
- identify processes that lead to improvements in sustainability and profitability of open water Murray cod aquaculture.

6. INDUSTRY RISK AND BENEFITS ASSESSMENT

Risk assessment is used widely to address the risks associated with industrial processes, and can serve as a useful tool to support an informed precautionary approach for open water aquaculture development. Risk assessments identify the likelihood of an event occurring and the possible subsequent level of consequence. The risk assessment process can be divided into three phases: problem identification, problem analysis and risk characterisation.

Initial research indicates that existing information on aquaculture in general can be applied to this new industry. As such the risks may be based on issues that have been identified at a generic aquaculture level, but have tried to take into account the expected issues that will arise with the ndustry based on its current and predicted future growth and direction.

The industry's R&D program should address key risks for the industry in conjunction with industry's need. As such, the R&D program should reflect a strategic approach to achieving these objectives. This requires the development of a framework to determine avenues of R&D that will most benefit and influence sound policies, legislation and management practices that will lead to improved opportunities and reduced constraints to sustainable profitable aquaculture of open water Murray cod. This also requires a review of publications and guidelines on environmental, social and economic risk assessment and should explore their application to inland open water farming of Murray cod.

As there is a lack of specific information available to make decisions at this stage of the industry's development, there is a high level of uncertainty in many potential participants. This can be reduced by including stakeholders in the process to gain the best possible outcome for the ndustry and to share the combined knowledge.

6.1 An Environmentally Sustainable Industry

If the open water Murray cod aquaculture industry wishes to operate in an ecologically sustainable manner that meets or exceeds community expectation whilst still retaining its profitability, the following key risk elements need to be considered.

6.1.1 Risks from Impacts of Released Aquaculture Water on Environmental Water Quality

Under the proposed farming technology for this project, the effect of waste load through the release of wastewater into rivers is minimal so the environmental risk is considered low. Any changes in farming practices that see water being released back to the system should consider treatments to reduce the impact on environmental water quality.

The use of medications and chemicals, such as antibiotics or disinfectants, for the treatment of infection in aquaculture should also be carefully

considered, as the subsequent release of these agents directly into the environment, either onto crops or back into streams, may have environmental impacts. Under the farming technology proposed for this project the likelihood of large volumes being released back directly into the rivers is low, however appropriate practices should be developed to mitigate any possible negative outcome in the event of an incident.

When considering the impacts of the release of waste waters, the assimilative capacity of the receiving water must be considered, taking into account activities from other aquaculture operations, as well as agricultural activities, both current or proposed. Management plans for overflows and system upsets must be developed to cope with possible events and to minimise any environmental impacts.

6.1.2 Risks from Impacts Arising from Nutrient Build up in Dams

The low energy conditions created through the farming process proposed for open water aquaculture of Murray cod may allow organic matter (uneaten food, faeces, mortalities and runoff) to be deposited, causing it to accumulate on the pond floor directly below or near aquaculture structures. An increase in sediment and dissolved nutrient concentration may lead to a range of possible risks, such as hypernutrification, which can contribute to eutrophication of the pond, and phytoplankton blooms and subsequent die-offs that lead to depletion of dissolved oxygen, changes to pH and bacterial build up.

Depending on stocking and feeding rates, this issue has the capacity to negatively impact on production and may necessitate the removal of sediment and sludge. The sediment and sludge removed from the pond would need to be transported to a safe site for denitrification.

6.1.3 Risks from Disease Transfer to the Environment

Disease may be introduced through feed, fingerlings, water supply or by other animals. It can also occur due to poor stock or water management regimes. The releases of bacteria, pathogens and escapees from aquaculture operations are a major environmental concern, and the consequences may be severe. However, if sound practices are in place, the risks should be low.

Excessive stocking density can lead to poor water quality and cause stress on the fish, making them more susceptible to diseases and parasites. These can be transmitted within the farmed population, or more seriously, may be transmitted to wild stocks by escapees. Good management practices should keep this as a low/medium risk.

Diseased fingerlings may also contaminate the aquaculture site, but sound management protocols and testing procedures should ensure that this is a low risk.

Disease can be brought into farms through diseased imported or poorly prepared feed. The use of reputable and thoroughly tested feed should minimise any risk from this source.

If sound management practices and disease protocols are in place, the associated risks of major disease outbreak are low, but a disease management program should be developed with the relevant agencies to deal with any potential outbreak.

6.1.4 Risks from impacts arising from potential genetic pollution of wild stocks

The escape of cultured organisms can occur as a result of human error, system failure, storm, predator interactions or inadvertent release during transport. The escape of farmed species and their potential for their establishment in the wild can lead to genetic pollution with significant possible implications for biodiversity. In some overseas examples, such as salmon, many of the fish in the wild are from farmed stock background. To mitigate against this potential issue, all steps must be made to minimise the chance of escape and to only use genetically appropriate broodstock for stocking dams.

Using the aquaculture techniques proposed for open water Murray cod the chance of this occurring is low, but the potential environmental impact is high if farm based stocks develop in the wild.

6.1.5 Risks from negative interactions with wildlife arising from aquaculture activity

Aquaculture may attract predators, commensals and other species to areas where they do not normally aggregate, altering the balance and natural behaviour of species in the area, as well as the amenity value. In some instances this may lead susceptible animals to unnatural dangers, such as legal or illegal culling to protect cultured organisms. It is likely that the farming of Murray cod will attract wildlife seeking feed and management practices must be developed to minimise stock losses and negative interactions with wildlife, especially protected species.

6.2 Fish Health

Poor fish health can significantly affect profitability and have a negative impact on of the environment. Intensive production aquaculture has the propensity to increase stress levels and subsequent spread of disease. Concerns have been expressed about the difficultly and high risks in controlling disease in big dams.

6.2.1 Risk to fish health arising from diseased seed stock

Diseased fingerlings or other stock supplied to aquaculture operations can have the potential to infect previously healthy stock. This may be controlled through a system of certification, whereby cultured organisms are declared to be free of known disease or pathogens by a reputable authority. This will reduce the risk of disease entering an operation.

6.2.2 Risk to fish health arising from inferior water quality

Poor water quality has the potential to adversely impact on fish health. Key risks arise from over stocking, the accumulation of organic wastes arising from uneaten food, faeces, mortality, poor aeration and pond sediment management.

As well as increased risks of disease and mortality, poor water quality can significantly affect growth rates and habits of stock, subsequently leading to decreased profitability. The development of appropriate feeding regimes and water management protocols can reduce the risks associated with poor water quality.

6.2.3 Risks arising from inadequate pathogen and disease control and dam management

Many pathogens have been identified in wild fish populations living in source waters used by the aquaculture operations. Under normal conditions, the impacts of these pathogens on the wild fish populations may be insignificant. However, if careful disease management practices are not employed, aquaculture operations may be responsible for changes in the natural environment of these wild fish populations, causing stress and potential spread of pathogens, disease and parasites to the fish and surrounding wildlife.

Sound farm management practices, in conjunction with well constructed testing and monitoring programs, can allow operators to manage these risks. This requires communication and understanding of the various pathological and sub-lethal fish health issues, the development of appropriate methods to treat infections and a process to improve and share knowledge of diseases and controls for Murray cod.

6.3 Production

Production levels in the open water Murray cod at a commercial level are unknown at this stage for optimal production purposes with respect to factors relating to

hatchery and culture technology, nutritional regimes, baseline environmental requirements and the benefits of developing a coordinated value chain.

6.3.1 Benefits that can be achieved through improved commercial hatchery technology

A major limiting factor to growth in the open water Murray cod aquaculture industry will arise from the need for the coordinated development of the nursery sector to produce a reliable cost effective supply of Murray cod fingerlings to the industry. If the proposed 1,000 tonne annual production is to be reached it will be critical to increase capacity, timing and reliability.

The industry will need to initiate cost effective programs to develop sufficient quantities of broodstock that produce progeny with optimal growth rates, disease resistance and other preferred traits, whilst maintaining appropriate genetic diversity.

As part of the hatchery development, a selective Breeding Program could provide the industry with a production and marketing edge, and potentially provide access to an ongoing mechanism for productivity and quality improvements.

6.3.2 Risks associated with inadequate or inefficient culture systems

To really understand factors affecting the culture system it is important to have an understanding of the baseline environmental requirements (eg optimal temperature, feed, water quality, light) for open water Murray cod.

There is a need for industry to investigate the economics and operational issues involved in agri-aquaculture farming of Murray cod, including assessing the appropriateness of the three proposed systems in various situations (i.e. floating cage, floating raceway or floating tank systems as tested in ORL 1.3.

Concerns have been identified relating to severe growth variations, associated husbandry problems and the difficulties of keeping Murray cod in dams over winter.

Means to minimise costs related to pumping, aeration, harvesting, monitoring a range of parameters and treating disease, along with improving water quality and feed regimes will all assist in enhancing the culture system for open water Murray cod. Identifying these matters should be a high priority to reduce the level of risk.

6.3.3 Risks associated with inadequate or inefficient nutrition regimes

Cost effective and ecologically appropriate feed is a key requirement for an efficient and economically viable open water Murray cod aquaculture industry. Developing and maintaining an efficient feeding regime requires an understanding of interactions and relationships between fish size, feed type and formulation, feeding rates and methods, water temperature and quality. The feeding regime also has important implications for the environment, as the selection of the feed type, in terms of makeup and physical attributes, can greatly influence the food conversion rate (FCR), the amount of waste produced at a facility and the resulting environmental impacts.

If the industry could reduce the amount of feed required to farm each kilogram of fish, through nutrient-dense and high energy feed, this would lead to improved feed conversion efficiencies. This would subsequently result in improved growth and less waste production leading to improved water quality.

The need to develop a properly formulated compound diet for Murray cod, along with access to sufficient quantities of feed, are critical long-term factors for the growth of the fishery.

6.4 Market

Some key sensitivities that affect the market for aquaculture product in Australia include price, environmental performance, quality and food safety. Although the taste of open water Murray cod has been identified as being 'good', or even 'unique', the image and price of the product is also a very important factor in the long term development of the industry. New or unfamiliar species often attract lower prices, especially in new markets overseas. AusTrade commissioners and business development officers suggested that substantial market development will be needed to secure long term export sales relationships for this product.

Due to the relative infancy of the open water Murray cod aquaculture industry, there are significant benefits in developing an industry group to represent the industry. The benefits of a coordinated industry group could relate to determining, developing or instigating:

- aggregated product input purchasing
- base husbandry guidelines
- target customer requirements, including packaging, volume and traceability
- an industry wide marketing plan based on market and demand requirements
- an appropriate brand and industry standard that reflects customer requirements
- Murray cod products to meet the range of market preferences
- local, regional, state, national and export distribution arrangements, channels and logistics for the product
- staff allocation, training and skills development throughout the ndustry

- an understanding of the drivers that will determine market demand in the future.

The cooperative arrangements that would arise from the ongoing development of a network, and integrated supply chain, working cooperatively on the above issues could provide significant benefits and efficiencies leading to a subsequent reduction in operating expenses, increased profitability and greater market acceptance of open water Murray cod.

6.5 Quality and Food Safety

Australia's seafood, including farmed fish, is generally regarded as a reliable source of healthy, safe and high quality food. To maintain or improve market penetration, it is critical that parameters for quality and safety are maintained and improved and where possible, third party audited. Unsafe or poor quality seafood is a major threat to the development or ongoing growth of the open water Murray cod fishery.

6.5.1 Risks associated with the use of medications and chemicals in respect to seafood quality and safety

A variety of chemical substances are used during the operation of an aquaculture farm. The purposes for chemical use include water treatment, enhancement of aquatic productivity, feed formulation, manipulation and enhancement of reproduction, growth promotion, health management and value adding the final product.

As part of the development of farming protocols for open water Murray cod an audit and risk assessment should be undertaken with respect to the chemicals that are proposed to be used by the industry. Protocols for their use should then be developed and adopted by industry to the satisfaction of relevant authorities and customers.

6.5.2 Risks to seafood quality and safety associated with the intake of chemicals from upstream or off-farm

The water to be used to farm Murray cod using the proposed open water system, is subject to the upstream impacts arising from other operations and the use of chemicals such as fertilizers or pesticides. As is common, this is not under the control of the aquaculturalists, and methods must be developed to identify, assess and monitor risks arising from potential chemical contamination into ponds through water pumping.

6.5.3 Risks to seafood quality and safety associated with the intake of chemicals from on-farm activities

As with off-farm activities, on-farm activities could also lead to chemicals entering the ponds, or other water supplies, being used for open water Murray cod farming. Farmers must be aware of any possible contamination

threats and develop protocols to ensure the safety of the fish they are farming from any chemical contamination. Methods must be developed to identify, assess and monitor risks arising from potential chemical contamination of ponds used for aquaculture.

As the release of these agents directly into the environment can have environmental impacts, extreme on-farm care must be taken with respect to possible chemical contamination.

6.5.4 Risks to seafood quality and safety associated with poor industry practices

Poor handling and farming practices can lead to the production of poor quality or unsafe seafood. The development of a HACCP food safety plan and Good Production Procedures (GPP) should be developed as a matter of urgency for the industry to put in place protocols and procedures to provide safe food that meet quality specification in line with customer demands. Failure to do so will significantly impact on the economic performance of the industry.

6.5.5 Benefits arising from producing quality seafood

To achieve a premium price in the market, the open water Murray cod industry must position their product as being of the highest quality that continues to meet or exceed consumer expectations. Seafood quality is the responsibility of the entire supply chain, but it starts from the time of fingerling grow out. As a general rule, the higher the quality of the fish, the greater will be its value and demand when it is sold downstream. There are three initial steps involved in developing and maintaining a quality seafood product:

- determine what evidence is required by relevant authorities, target and potential markets and consumers in order to prove quality and safety
- develop industry standards for producing, processing, packaging and transporting the product to meet quality and safety standards
- obtain appropriate local, national and international certification to identify that the product has been produced in line with the necessary standards.

6.6 Processing and Value-Adding

As part of any planned development for the open water Murray cod industry, it is necessary to ensure that appropriate standards and sufficient facilities are available for processing to meet customer requirements and to obtain the highest value and return to industry for the product, including options for value adding.

Economies of scale and the integration of production with value adding activities will enable the industry to spread its costs over a wider range of production, which will ultimately lead to higher returns.

6.6.1 Benefits to industry in developing systems to take advantage of economies of scale

If all operators are required to establish their own processing facilities, the complexities of packaging and branding could lead to a range of inefficiencies, as well as a potentially fragmented industry.

Economies of scale and the integration of the production with value adding activities will enable producers to spread costs over a wider range of production costs and products across the industry. This will ultimately lead to higher returns.

6.6.2 Benefits to industry of using of production techniques that add value to base products

As part of the industry's marketing plan, it will be critical to determine the present and future processing and value adding requirements of customers. This will allow ndustry to establish, or improve, technology to meet customer requirements in the areas of processing, packaging, improved product quality and shelf life. This can lead to developing industry standards for processing, with a focus on value adding opportunities for open water Murray cod.

The development of a wider product base will provide the industry with the capacity to adapt to changing market needs and wants. A narrow market focus could lead to marketing problems, particularly in the event of a specific market collapse or change in market direction.

6.6.3 Benefits to industry of managing supply to market

The ability for the industry to manage supply to the market will allow the industry to work more efficiently and will maximise returns.

The development of a feedback mechanism to assess customer requirements and industry returns will allow industry to ascertain the market status from which supply can be managed.

6.7 Skills Development

As a developing and growing industry, it is extremely important for the open water Murray cod industry to invest in developing the appropriate knowledge and skills of industry participants.

Skills shortages are a major limiting factor in most primary industries, equally so in the aquaculture sector.

6.7.1 Risks to the industry arising from a lack of skilled labour

Without appropriately trained staff and managers in all sectors of the supply chain, the industry cannot operate effectively and supply chain breakdowns may lead to market failure. As an initial step, it is important for the industry to assess the knowledge and skills (including operational, business and R&D skills) required by people working in the Murray cod aquaculture industry, including the extended supply chain.

6.7.2 Benefits of developing appropriate training programs to meet the industry's training needs

Through the completion of a skills audit, it will be possible to develop a tailored program to meet the industry's specific training and development requirements. This will also need to include determining how knowledge and skills can be applied and assessed on the job and the most appropriate forms of training and assessment that suit the industry's characteristics.

The initial development of codes of practice, plans and protocols should lead to their conversion into training programs which meet industry's needs and can be used to assess competencies.

It is also crucial to develop a process to assess effectiveness of any training programs through the supply chain.

6.8 Communication

To achieve a clear industry message it is crucial to develop a professional communication strategy for the open water Murray cod industry and supply chain that provides information to stakeholders, government and the public via the most appropriate media. Such a strategy will allow for improved participation, consultation and communication processes between the industry, supply chain, customers and other stakeholders. In addition, it allows the network and group to be kept informed of the latest R&D and provides a conduit to the most recent and efficient technology, techniques, policies and procedures for the industry and relevant stakeholders.

A fragmented and ill informed industry, stakeholder groups, community and agencies can lead to issues with developing forward looking business arrangements for the industry and providing a positive industry vision.

6.9 Management and Legislation

For long term viability, it is necessary for industry to ensure that appropriate policies, legislation and management practices are developed, or are in place, across all relevant agencies at local, national and international level to allow and encourage the development of a viable open water Murray cod industry.

Lack of clearly defined farming rights and access, inadequate legislation and approval processes can lead to industry collapse, or significant restraint in developing a sustainable and profitable future. Many of the previous key elements, such as developing an environmentally sustainable industry, sound production methods, food safety plans, quality and fish health measures and ensuring that a communication strategy is in place, will provide some certainty to the management agencies when developing legislation.

6.9.1 Risks to the open water Murray cod industry arising from inadequate management arrangements and legislation

Due to the restricted nature of most aquaculture operations it is vital to have legislation and processes in place to support the development of a sustainable and profitable open water Murray cod ndustry. If not, development will stall and enterprise and industry profitability could be severely diminished.

As a first step it is important to identify processes that lead to constraints to sustainable and profitable aquaculture of open water Murray cod. This should lead to the development of a risk assessment framework to determine avenues of R&D that will most benefit and influence sound policies, legislation and management practices.

6.9.2 Risks associated with possible changes in water allocations and rights

The success of the open water Murray cod industry relies on the integration of agricultural practices and aquaculture, with both relying on an adequate and accessible allocation of water suitable for both types of operation.

There is a need to identify the risks to open water farming associated with water availability and quality, especially in light of possible impacts of climate change.

7 INDUSTRY DEVELOPMENT ACTION PLAN

This action plan outlines critical steps in key areas required by industry to drive development of the open water Murray cod industry.

7.1 Organisation and Value Chain Development Actions

Action 1	Use the Murray Gold Supply Chain as the appropriate model, and the initial entity, to implement both networking and market development initiatives. An "investor's guide"/ prospectus-style document is currently being prepared and this should clearly show the means by which new supply chain partners can formally join, or have equity, in the industry/chain and outline the linkages in the chain (including relationships with Fisheries Victoria's selective breeding program and the associated intellectual property).
Action 2	Completion of a formal agreement between Murray Gold, Department of Primary Industries and any other Victorian industry participants[3]
Action 3	Attract processing and marketing partners and alliances (including the enactment of joint venture agreements) through networking, this Industry Development Plan and the Murray Gold investor's guide.
Action 4	"Plugging the supply chain gap": Advanced stockers.
Action 5	"Plugging the supply chain gap": Processing.
Action 6	Expanding the open water industry by recruiting new growers, with standards, systems and quality control
Action 7	Develop and adopt a 'controlled varieties' type management model for controlling the intellectual property and the licensing of grower agreements with genetically improved elite Murray cod stock (similar to the approaches now entrenched in Australia's fruit horticulture sector)
Action 8	Development of an industry tracking and tracing system

[3] Other industry participants that are prepared to invest in continuing open water Murray cod research and development initiatives and work programs

7.2 Marketing Actions

Action 1	Develop strategies, with 18 months lead time allowed for each major initiative for Victorian Murray cod for three distinct market segments. • Domestic markets, • Asian export markets, and • European and North American export markets.
Action 2	Develop branding and image materials including • Use of distinctive fish shape on logos and artwork • Indigenous recipe booklets and other point of sale material • Website – with menu items, information on its history, why open water aquaculture, health and nutrition, environment and water, contacts, news, products, where to buy.
Action 3	Associated with the branding and image development will be the creation of product fact sheets.
Action 4	Adopt market development targets of 600 tonnes of product by 2015/16 and 1,000 tonnes by 2019/20.
Action 5	Continue export market investigations/research utilising the services of Austrade and the Victorian Government's overseas export development managers, coupled with selected inbound and outbound trade missions.

7.3 Research and Development Actions

Action 1	Develop and implement product development initiatives for several forms of the product • Fillets and pieces • Fresh long life • Cooked and smoked • Portion control packs • Fish in sauce products.
Action 2	Conduct formal research on the functional and nutritional benefits. This could involve commissioning research to prove the nutritional features and the functional benefits (testing for biological inhibitors, for example obesity, diabetes, specific cancers, cardio-vascular).
Action 3	Conduct a feasibility assessment into the establishment of a Victorian aquaculture stock feed manufacturing facility.
Action 4	Conduct a project on the practicalities and technical issues associated with extending the breeding season, achieving out of season breeding and/or using smaller advanced stockers for grow out.
Action 5	Conduct further work on cost effective shedding (or glasshouse/shade house) and systems for semi-intensive RAS production of advanced stockers.

7.4 Operations Development Actions

Action 1	Prepare a comprehensive risk management guideline document.
Action 2	Prepare complementary quality standards and sales and marketing protocol documents for all industry participants.
Action 3	Conduct further testing on optimum water turnover and flows in horticultural dams for health of Murray cod.

7.5 Action Schedule

A suggested implementation time schedule for the industry development actions is presented in Table 7.1, to assist in discussions, applying for financial support and in allocating resources and priorities.

Table 7.1 Networking and Marketing Implementation Program

	Probable Participants	Possible Funding Support	Short Term (1-3 years)	Medium Term (4-7 years)	Long Term (8+ years)
Organisation and Value Chain Development Actions					
Action 1: Investor's guide/ prospectus-style document	TF, SV, DPI, RDV	RDV			
Action 2: Completion of formal agreements	AIP, DPI, DU	n.a.			
Action 3: Attraction of processing and marketing participants	MG, RDV, DPI, RCSH, SMEDB	n.a.			
Action 4: "Plugging the supply chain gap": Advanced stockers	TF, SV, DPI, DU	n.a.			
Action 5: "Plugging the supply chain gap": Processing.	MG, RDV	RDV			
Action 6: Expanding the open water industry by recruiting new growers	MG, RDV, DPI, RCSH, SMEDB	n.a.			
Action 7: Controlled varieties type management model for intellectual property	MG, DPI	DPI			
Action 8: Industry tracking and tracing system	DPI, MG, SV, DU	FRDC			
Market Development Actions					
Action 1: Strategies for three distinct market segments	AIP, DPI, RDV, AT	RDV			
Action 2: Branding and image materials	AIP	RDV			
Action 3: Product fact sheets	AIP, DPI, RDV, RCSH, SMEDB	RDV			
Action 4: Delivery of sales targets	AIP	n.a.			
Action 5: Continue export market investigations/research	AIP, DPI, RDV, RCSH, SMEDB, AT	AT, RDV			

Table 7.1 (continued) Networking and Marketing Implementation Program

	Probable Participants	Possible Funding Support	Short Term (1-3 years)	Medium Term (4-7 years)	Long Term (8+ years)
Research and Development Actions					
Action 1: Develop and implement product development initiatives for several forms of the product	AIP, DPI	RDV, DAFF, FRDC			
Action 2: Functional Nutritional Research	DPI, DU, AIP	RDV, FRDC, DAFF, DPI			
Action 3: Stock feed manufacturing assessment	MG, DPI, RDV	RDV, DPI			
Action 4: Practicalities and technical issues to extend breeding season	MG, SV, GF,	DPI			
Action 5: Cost effective shedding and systems for semi-intensive RAS production of advanced stockers	SV, DPI	DPI			
Operations Development Actions					
Action 1: Risk management guidelines	AIP, DPI	n.a.			
Action 2: Quality standards and sales protocols	AIP, DPI	n.a.			
Action 3: Testing on optimum water turnover and flows	All open water growers, DPI	DAFF			

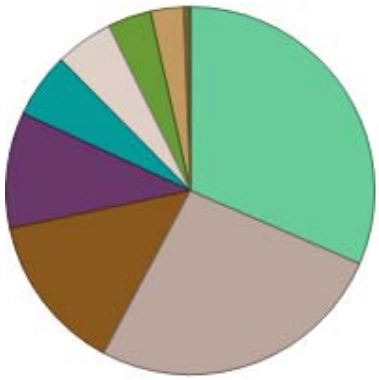
KEY: IP = Industry participants, DPI = Department of Primary Industries, RDV = Regional Development Victoria, FRDC = Fisheries Research and Development Corporation, DAFF = Department of Agriculture Fisheries and Forestry, RDV = Regional Development Victoria, MG = Murray Gold, TF = Thurla Farms, SV = Sustainability Victoria, GF = Glencoe Fisheries, RCSH = Rural City of Swan Hill, SMEDB = Sunraysia Mallee Economic Development Board, AT = Austrade

APPENDIX A: AUSTRALIAN SEAFOOD AND FINFISH AQUACULTURE INDUSTRY OVERVIEW (IBIS World, 2009)

A1 Segmentation

Salmonoids are the major contributor to Australian seafood and finfish industry revenue and is estimated to account for 31.5% of the production value in 2008-09, up from 17.4% in 2003-04 and 11.8% since 1998-99. The rise is mostly due to higher volumes, but also an increase in price. Salmonoids account for about 42.3% of industry production. Salmonoids are mainly produced in Tasmania and in 2005-06 became the largest product segment of this industry. The change reflects large increase in salmonoid production and decreases in tuna production. Salmon production growth has been boosted by growth in demand as a result of increased marketing of salmon to Australian consumers and by research and development including better disease control measures and feeding techniques.

Figure A1 Products and Service Segmentation



Product/Services	Share
Salmon	31.5%
Tuna	26.3%
Pearls	13.9%
Edible Oysters	10.2%
Other	5.7%
Prawns	5.1%
Other Fish	3.8%
Other Molluscs	2.9%
Other Crustaceans	0.6%

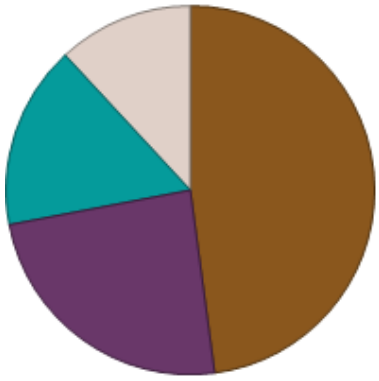
Tuna represents the second largest proportion of industry revenue. It is expected to account for 26.3% of industry revenue in 2008-09. Tuna earnings accounted for 35.6% of industry revenue in 2001-02, 22% in 2003-04, and 17.4% in 2006-07. The decrease in proportion of industry earnings is due to large drops in production and prices in 2003-04 and in 2004-05. The large decline in prices was due to increased tuna production in Mexico and Spain, flooding the Japanese market. This was in addition to the poor economic conditions in Japan. However, IBISWorld forecasts a strong recovery in tuna earnings due to higher prices for tuna given falls in the global production of Southern Bluefin tuna due to over fishing.

Pearls are the next biggest earner for the industry. Pearls have declined as a proportion of industry revenue (23.9% in 2001-02). Pearl prices appear to have declined with increased competition from South East Asia and China, although these pearls are of lower quality. Australian operators produce the South Sea Pearl and account for approximately 25% of global pearl production. The South Sea Pearl is rare and highly prized, accounting for 11% of global production by weight and 44% by value.

Edible oysters contribute roughly 10.2% to industry revenue, which has decreased from its share in 2003-04 of 16.9%. Edible oysters share of production and average prices declined marginally between 2003-04 and 2006-07.

Prawns are estimated to account for 5.1% of revenue, which has decreased from 9% in 2001-02 and 8% in 2003-04. In 2004-05, production volumes of prawns declined significantly and have not yet recovered as average prices for prawns have decreased due to competition from cheaper imports from South East Asia and an appreciating Australian dollar.
Other finfish grown in Australian farms include, among others, barramundi, silver perch and kingfish. Other molluscs include mussels, scallops, giant clams and abalone. Other crustaceans include yabbies, marron and redclaw.

Figure A2 Major Market Segments



Market Segment	Share
Seafood Processors	47.9%
Export Markets	24.1%
Jewellery Makers	16.1%
Fish Wholesalers	11.9%

The majority of the industry's products (an estimated 47.9%) are sold to seafood processors for manufacture into consumer foods prior to distribution to wholesalers and retailers. However, some products are sold completely unprocessed (sometimes live) to wholesalers, who then sell to restaurants and other retail outlets. A significant market is the jewellery industry, which purchases approximately 16.1% of the value of industry sales.

The market segments have been quite volatile over the last five years, due to changing demand internationally and domestically.

Some aquaculture species are produced almost exclusively for the export market. Others are sold mostly on the domestic market. Southern bluefin tuna and kuruma prawns are farmed primarily for export to Japan, and abalone for export to east Asia. On the other hand, trout, silver perch, barramundi, prawns, redclaw, edible oysters and mussels are sold mostly on the domestic market. Yabbies and marron are sold on both the domestic and the export markets. When production first commenced at low levels, salmon producers sold mainly to the export market, but as production has risen, more Atlantic salmon is being sold to the domestic market.

Revenue from domestic sales is mainly from the wholesaling of industry products. However, some operators have downstream businesses, which take output for further processing.

A large proportion of pearls produced are sold and/or marketed through Japanese and Hong Kong auctions. The auction process, which often includes product from a number of

suppliers, enables the seller to optimise pearl lot combinations to most appeal to buyers. Some pearls may be further processed and sold in Australia through wholesalers and retailers.

Most salmon production is processed in some way prior to sale. Export sales approach half of production with target markets including Asia and Europe. Tassal has a Japanese subsidiary that promotes sales in that country.

Most of the other production is exported following further processing. About 90% of Southern bluefin tuna is exported to Japan after processing. Oysters, however, are mainly sold on the domestic market.

A2 Industry Concentration

The level of industry concentration is low.

The degree of concentration varies significantly between the various industry segments and the overall industry is believed to have a medium level of concentration, with the top four producers accounting a forecast 35% of the industry revenue in 2008-09.

Concentration is rising as firms focus their efforts on one or two key products and consolidate to achieve economies of scale. For instance, Tassal and Webster's deal in 2005 and Clean Seas Tuna's acquisition of South Australian Aquaculture Management in 2006. Consolidation is also occurring as firms try to gain access to aquaculture areas, larger labour markets and to consumer markets.

There are also a few large players in the pearl farming segment, one of the largest the Paspaley group is believed to account for 70%-75% of Australian pearl production.

A3 Market Size

The Fish and Seafood Farming industry is a growing industry. Over the five years to the end of the 2008-09 fiscal year, industry production is forecast to grow by roughly 5.6% per annum. However, industry revenue is forecast to increase by 0.5% per annum on average to $1163.4 million. Revenue growth was dampened by falling prices. Prices for aquaculture seafood decreased due to a higher Australian dollar over most of the period, increased competition in Australia from cheap imported seafood, increased competition in the world market from other aquaculture producers, and in some cases, increases in the production of seafood.

IBISWorld estimates that in 2008-09 industry revenue will increase by 3.0% year-on-year. The industry is expected to benefit from an increase in production. IBISWorld expects, however, that the industry will be negatively affected by a decrease in demand from export markets and domestically due to a slowdown in world and Australian economic growth, which will dampen prices. World economic growth has been slowing due to weaker economic growth in the United States, which impacts other countries through reduced export demand; reduced business spending given the credit crunch following the subprime mortgage market crisis in

the US; and reduced consumer confidence and wealth with the fall in sharemarkets. Australia's economic growth has also been negatively affected by higher interest rates, which are at the top of their cycle. The industry should benefit to some extent though from a depreciation in the Australian dollar.

IBISWorld forecasts that in the five years to 2013-14, revenue from aquaculture production will increase at an average annual rate of 6.7% to $1247.1 million. Growth in the industry is expected to come largely from increases in production, but also through some price increases. Domestic and international demand prospects for aquaculture products are favourable. The global demand for seafood is expected to rise at a rate of about 2% per year over the next five years, based on studies undertaken by the UN Food and Agriculture Organisation (FAO) and International Food Policy Research Institute (IFPRI), but the scope for expanding fisheries production from natural resources, however, is declining due to depletion, creating a significant opportunity for aquaculture to meet demand. Studies by the FAO and IFPRI forecast marginal real per annum growth in fish prices, depending on the species, over the coming 5 to 10 years. Species that are expected to grow strongly are Tasmanian salmon, yellowtail kingfish, barramundi and southern bluefin tuna. Other fish whose production is expected to grow are mulloway and cobia. Prawns are also expected to increase.

A4 Demand Determinants

Demand for any product depends on a variety of factors, including the price of the product, the price of substitutes, quality and freshness, income and tastes.

- In the case of products of aquaculture, many products are considered to be luxury items, therefore demand is relatively responsive to price variations. Demand is also dependant on the price of aquaculture seafood relative to wild caught seafood and alternative sources of protein, such as chicken.
- Both oysters and cultivated fish products are relatively expensive and are most likely to be eaten away from home (i.e. at restaurants). The frequency with which meals are eaten away from home is closely related to income.
- Demand tends to be closely related to changes in real disposable income. Disposable income is in turn influenced by wages, taxation rates, interest rates and unemployment.
- Tastes are also an important determinant of demand. An increasing concern with health and diet has caused a shift in tastes in favour of fish as a protein source as it is a low fat protein source and has many important nutrients such as Omega 3 oils.
- Export demand is responsive to the price of Australian production, relative to supplies of similar products from other countries, which is influenced by exchange rates and the cost of Australian production.

Demand is also a function of quality. Aquaculture products sell at a lower price than wild caught fish as some people believe there is a taste difference. Quality is particularly important for the demand for pearls; pearls are graded according to their quality based on colour, size, lustre, and the number of defects. The ability to deliver fresh seafood is also an important factor in demand.

The major export markets for aquaculture products in 2007-08 were (although a significant percentage of data was not attributed to a particular country):

- Japan (65%)
- Hong Kong (17.1%)
- US (1.3%)
- Taiwan (0.5%)
- Singapore (0.5%)

A5 Key Success Factors

The key success factors in the Fish and Seafood Farming industry are:

- Access to the necessary amount of land/type of property. A suitable site with appropriate water conditions is crucial to growing fish and seafood.
- Ability to control total supply on market. Ability to control the volume of production coming on to the market and have the foresight to take aquaculture expansion into account and its effect on production volumes and prices is beneficial.
- Ability to alter mix of inputs in line with cost. Ability to vary input mixes as costs change will enable producers to maximise returns.
- Access to the latest available and most efficient technology and techniques. Access to production technology and an ability to adapt these to local conditions will improve output efficiency and industry know-how.
- Economies of scale. Economies of scale and integration of the production with value adding activities will enable the producer to spread its costs over a wider range of production. This will ultimately lead to higher returns.
- Ability to effectively manage risk. Environmental and financial risk is very real for an aquaculture producer. It ranges from disease to pollution to falling prices.
- Must have licence. State governments allocate licences to those operators who have proven systems for rearing fish in farms.
- Use of production techniques that add value to base product(s). The higher the quality of the fish, the higher its value when sold downstream.

A6 Major Company - Tassal (Market Share: 13.0%)

Tassal is the largest aquaculture company in Australia. It is based in Tasmania and is vertically integrated with operations in hatcheries, farming, processing and wholesaling. It is Australia's largest producer and exporter of Atlantic Salmon, marketed under the Royal Tasmanian salmon brand. The company's salmon is sold to restaurants, supermarkets and fish markets in Australia, Japan and elsewhere. The company has over 18 marine sites in Tasmania.

Tassal undertakes significant research and development in aquaculture. The company has a particular focus on fish husbandry and selective breeding. The company has seen improvements in fish survivability and fertility through its selective breeding program.
In November 2003 Tassal Group Limited completed the acquisition of the business and assets of Tassal Limited. In February 2005, a deal was announced between Tassal and Webster's salmon subsidiary, Aquatas. Under the deal, Tassal acquired Aquatas, and in return Webster received one third of Tassal's issued share capital. Webster now owns one-quarter of Tassal's bigger capital base. In March 2006, Tassal and Huan Aquaculture Holdings Pty Ltd, the second largest salmon aquaculture company in Australia, jointly acquired (50/50 basis) Springfield Fisheries Pty Ltd. Springfield is a salmon and trout

hatchery business operating in several sites in north-eastern Tasmania. The company is separate to Tassal and has been renamed to Springfield Hatcheries Pty Ltd.

In January 2008, Tassal raised $67.2 million through an institutional share placement. The funds were used to buy Superior Gold, a global pre-packaged salmon and trout processor and distributor, from National Foods for $26.5 million. The remaining funds were used to reduce debt and to invest in capital to aid growth and efficiency.

A7 Historical Performance

Aquaculture activities have been undertaken for over 50 years, but on a commercial basis the history of this industry is very short, beginning in the late 1970's-early 1980's, with oyster farms. Its development was stimulated by concerns about declining natural supplies of fish. Most state governments financed research directed towards identifying the most suitable fish species for cultivation. Initially, the emphasis was on oysters, but a variety of other fish (especially Atlantic salmon) were soon added. Southern bluefin tuna farming came as consumer tastes and demands changed, therefore the previous way of catching tuna, which damaged and bruised the fish was no longer viable. Tuna fishers then found that they could increase their returns if they bought their catch into the shore and then set up cages to allow the tuna to continue growing, until they reached the most profitable size.

In the early years of the industry, optimism about its growth prospects resulted in over-capitalisation, and in many cases returns were low and many ventures incurred substantial losses. Another factor responsible for poor performance at this time was the adoption of unsuitable technologies, which had to be replaced or modified on the basis of experience. Another problem limiting the performance of participants initially was the lack of support services and feed. Often, not enough research and understanding of the interrelation of the farms and the environmental surroundings led farmers to over stock their farms, which the farm and natural surroundings were not able to support.

A7.1 Production and Revenue

Over the five years to June 2002, the Aquaculture industry experienced rapid growth in most key economic statistics. Industry revenue is estimated to have average growth of 8.5% per year over the five years to 2001-02, increasing from $590.1 million in 1996-97 to $886.2 million in 2001-02. The industry expansion was largely due to increasing production, which grew by a similar growth rate over the five years.

The large growth is due to the beginning stage of the industry's life cycle in many of the segments of the industry. Many new operators established farms over this time, with establishment numbers increasing from 1,783 in 1996-97, to 2,691 in 2001-02. These new operations also led to the expansion of the labour force for the Fish and Seafood Farming industry, which is estimated to have grown by 10.6% per annum over the five years to June 2002.

Domestic and international demand prospects for aquaculture products are favourable. The global demand for seafood is expected to rise at a rate of about 2% per year over the next five years, based on studies undertaken by the UN Food and Agriculture Organisation (FAO) and International Food Policy Research Institute (IFPRI), due to population growth and economic development, mainly in developing countries. Within developed countries, there has also been a change in tastes in favour of protein derived from low fat sources, including fish. The scope for expanding fisheries production from natural resources, however, is declining due to depletion. This excess demand is a significant growth opportunity for aquaculture. Global aquaculture production is forecast to expand at about 2% per year to 2015 as higher prices encourage greater cultivation. Higher cultivation will ultimately cause some easing of prices, which has already been seen in some fish prices, such as barramundi. Nevertheless, studies by the FAO and IFPRI forecast marginal real per annum growth in fish prices, depending on the species, over the coming 5 to 10 years.

Growth in the industry is expected to come largely from increases in production, but also through some price increases. In 2008 the chairman of the peak body representing Australia's aquaculture industry, the National Aquaculture Council, said the industry hoped to increase its production from 60,000 tonnes to 100,000 tonnes by 2015, representing an annual increase of about 7.6% from 2008-09 to 2014-15. The council saw expansion in Queensland, Western Australia and Northern Territory, where there is access to new aquaculture sites. Species that are expected to grow strongly are Tasmanian salmon, yellowtail kingfish, barramundi and southern bluefin tuna. Other fish whose production is expected to grow are mulloway and cobia. Prawns are also expected to increase. Some of the expansion by Australian companies, however, will be through overseas operations. For instance, a small company called Cell Aquaculture in Western Australia is forming a joint venture with local government in a Malaysian state to produce barramundi. Tassal is also considering opportunities overseas.

There is expected to be an upward price trend for most aquaculture products due to the global supply and demand fundamentals, as discussed above. Based on the study by IFPRI, prices for high-value finfish and crustaceans are expected to increase by the greatest amount compared with molluscs and low-value finfish. Over the next few years, there may be short-term price fluctuations in response to particular variations in demand and supply and demand will also fluctuate with economic conditions. The extent to which Australian aquaculture producers are able to control their own supply, so as to not flood markets for their specific species and cause depressions in the prices, will also be important.

A7.2 Revenue

IBISWorld forecasts that in the five years to 2013-14, revenue from aquaculture production will increase at an average annual rate of 6.7% to $1247.1 million. In 2009-10 the industry is expected to be negatively affected by the slowdown in global

and Australian economic growth, but global and Australian economic growth are forecast to recover in the remaining of the years over the outlook period.

Revenue growth is expected to be assisted by increasing export demand. Japan is the largest export market for the industry. Like other countries, it is expected to experience slowing economic growth in 2009-10 given reduced export demand from the US and the credit crunch due to the global financial crisis. However, over the rest of the outlook period, the Japanese economy is expected to continue to have moderate growth. Export growth to Japan will also be aided by high prices for southern bluefin tuna. Export growth to Japan and other countries will be boosted by a forecast depreciation of the Australian dollar. Export demand from China is expected to grow strongly given its strong economic growth and growing taste for sushi.

Revenue growth will also be dependant on the domestic market. Per capita consumption of seafood is expected to decline due to forecast lower fish availability and associated higher fish prices; however, total domestic consumption is forecast to grow marginally over the period as the population is forecast to grow. Seafood demand will likely benefit to a small extent from expected strong growth in the Australian economy over the outlook period of 3.1% per annum, as Australian consumers will demand more high quality seafood. Seafood consumption should also continue to benefit from trends towards healthy eating as fish is a low-fat source of protein, and contains omega-3 oils, which reduce cholesterol, but consumption will also be dependant on relative prices with other proteins, such as chicken. Competition from imports should ease to some extent over the outlook period due to the forecast depreciation of the Australian dollar.

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