PRIME MINISTER'S SCIENCE, ENGINEERING AND

INNOVATION COUNCIL

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AGENDA ITEM 4

SUSTAINABLE AQUACULTURE

A paper prepared by an independent working group:

Professor Peter Hoj (Chair)	PMSEIC Council member
Dr Wendy Craik	Chair, Australian Fishery Management Authority
Mr Brian Jeffriess	President, Tuna Boat Owners Association
Professor George Kailis	Univ. Notre Dame; ED of the MG Kailis Group
Dr Russell Reichelt	CEO of the CRC Reef Research Centre
Dr Peter Rothlisberg	Program Leader, Aquaculture & Biotechnology

(representing Dr Nan Bray, Chief, CSIRO Division of Marine Research)

The working group will be represented by:

Professor Peter Hoj
Dr Wendy Craik
Mr Brian Jeffriess

Terms of Reference:

Prepare a paper and presentation for PMSEIC which:

- Briefly outlines the size, state and contribution of the industry in Australia in relation to global opportunities.
- Describes the role of science, engineering, innovation and education in the viability and competitiveness of the industry today.
- Flags the major opportunities and obstacles (including environmental) for industry growth this decade, noting international regional developments and associated market drivers.
- Describes the potential role of science, engineering, innovation and education in future industry growth; and
- Recommends practical ways for governments and business to stimulate growth of the industry, particularly through science, engineering, innovation and education initiatives.

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. This paper was prepared by an independent working group for PMSEIC. Its views are those of the group, not necessarily those of the Commonwealth Government.

EXECUTIVE SUMMARY

It is a generally held view that most known commercial fish species are at or near full exploitation. With many capture fisheries now fished beyond their sustainable limit, scientists, governments and international organizations point to aquaculture as the most important means to increase global fish supplies. *The Food and Agriculture Organisation of the United Nations* (FAO) predicts that increases in global seafood demand will be met by aquaculture resources and not by wild-catch fisheries. Aquaculture sources are expected to dominate global fish supplies by 2030, with less than half of the fish consumed coming from wild capture fisheries.[1]

Global aquaculture production is currently worth about A$100 billion per annum and growing at more than 10% per year, compared with 3% for terrestrial livestock and little or no growth for capture fisheries.[2]

Although Asian aquaculture farmers continue to contribute about 90% of the world's aquaculture production, major aquaculture industries (each worth more than A$500 million per annum) have emerged in North America, several European countries and Australia.

Against this global background, the potential for growth in the Australian aquaculture industry appears very substantial.[3] Currently 60% of all seafood consumed in Australia is imported at relatively low prices and is of average grade compared to our high value exports. The *Fisheries Research & Development Corporation* (FRDC) has estimated a possible shortfall here of 80,000 tonnes[4] of this grade of fish for human consumption in the future, unless imports expand or demand is met by other means, possibly through domestic aquaculture.

The aquaculture industry is export focussed with 60% of its production sold overseas and contributing strongly to Australia's $2.2 billion total fisheries exports in 2000-01.

At the *National Aquaculture Workshop* in Canberra in 1999, the Australian aquaculture industry set itself a vision for 2010. This states that a sustainable, vibrant and rapidly growing Australian aquaculture industry will achieve at least $2.5 billion in annual sales in 2010. The Australian industry will be one of the world's most globally competitive producers and will not only secure strong export income for Australia but subject to affordability also contribute to filling the emerging gap between demand and supply for seafood in Australia.

Australian aquaculture is focused principally on enterprises producing premium value species rather than mass production of protein and it involves a large number of underpinning activities such as transport, engineering, marketing, education and R&D. Most Australian aquaculture production is from the coastal[5] zone including tropical,

[1] *State of World Fisheries and Aquaculture 2000*, FAO Fisheries Department, Rome

[2] *State of World Fisheries and Aquaculture 2000*, FAO Fisheries Department, Rome

[3] Compare comments in *Investing for Tomorrow's Fish: the FRDC's R&D Plan 2000 to 2005*, Canberra; and in *The Australian Aquaculture Industry*, Food and Agribusiness Industry Note, Fiona Boal, Rabobank International 2001

[4] FRDC 5-year plan page 98

[5] While 95% is based in coastal areas, there is significant potential for freshwater and saltwater inland development.

sub-tropical and temperate sectors. The most valuable species are southern blue-fin tuna, pearl oysters, Atlantic salmon, edible oysters and prawns with real potential for species such as trout, barramundi, abalone, and yellowtail kingfish to further contribute to industry growth in the short to medium term.

These species and many others form the basis for a diverse range of Australian aquaculture enterprises, many at different stages of development. These enterprises depend to differing extents on factors such as science, engineering and technology (SET), processing and production infrastructure, and international marketing. The industry is therefore fairly fragmented. In the global scene, where wholesale and retail distribution channels aggregate and increasingly are controlled by a few major players, such fragmentation can lead to loss of opportunities due to limited brand building and due to an inability to guarantee supply in the large and continuous volumes required. Success is often associated with economies of scale, characteristic of large operations (such as the wine industry). Small-scale operations may need to find suitable products for filling niches, linking into the distribution channels of the larger players. There is therefore a strong requirement for a unified approach to industry planning, development and promotion in the Australian aquaculture industry.

Industry initiatives included formation of the *Australian Aquaculture Forum* in the first instance. This was followed by creation of the *National Aquaculture Council*. Tangible outcomes are evident, such as a voluntary 'Code of Conduct for Australian Aquaculture'. This needs to be built upon. Strengthening of peak body activities is a priority to formulate and implement holistic industry strategies for future global success.

Australia's natural endowments include vast land and water resources and the largest east-west temperate coastline in the world. There are inland freshwater and saltwater lakes suitable for aquaculture production. Access to these resources must be managed carefully as the public and the retail sector increasingly will demand ecologically and economically sustainable development of the industry. A national regulatory framework incorporating state and federal processes must therefore be in place to ensure sustainable development. This represents both an imperative for maintaining current market access and an opportunity for future growth in market share.

On the growth pathway to 2010, the industry will increasingly depend on science, engineering and innovation, particularly in relation to species husbandry, 'label' integrity and development of environmentally sustainable processes. Public funding for aquaculture R&D in Australia amounts to about $20 million pa and is funnelled through a number of different bodies. This may explain a tendency to spread available research funds over a large number of species (up to 70 appear under development in Australia), some of which appear to contribute relatively little to industry development and future profitability. The *Fisheries R&D Corporation* has made a strategic decision to reduce the number of species under investigation through its grants, and primarily to invest in the five most valuable species only. However, there appears to be a need to address this issue on a national basis across all funding providers to ensure investment is focussed and critical mass is built upon commercially established species or species with a high potential for commercialisation. Such strategic planning must be informed by market imperatives and industry defined priorities. It should, if implemented successfully to

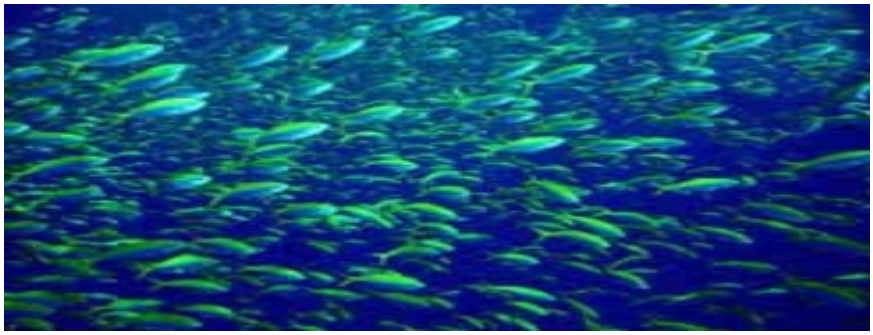
yield tangible outcomes, secure enhanced investment in R&D through private initiatives and *via* industry levies and matching Commonwealth funding.

The paper contains a relatively detailed analysis of some aspects pertaining to development of the Australian aquaculture industry. Based on this analysis, three global recommendations are made relating to strengthening of aquaculture peak body activities; streamlining the regulatory environment, and enhancing R&D capacity and outcomes. A fourth recommendation is about fostering scientific collaboration.

CONCLUSION

Against the background of a growing world population; static levels of wild catch fisheries; an increasing recognition of seafood as part of a healthy diet and growing affluence amongst the populations of some key export markets; the working group is of the view that further development of our aquaculture industry towards production of premium species represents an enormous opportunity for Australia. Full implementation of the recommendations and a joint partnership of industry and governments towards ecologically sustainable development and genuine environmental stewardship are essential to realise this opportunity and thereby increase:

- high value exports of seafood and pearls;
- employment and growth opportunities in regional Australia;
- export of environmental technologies and know how; and
- the availability of a healthy and stable food source for Australians.



RECOMMENDATIONS

Recommendation 1: Strengthen national peak body activities.

That the multiple aquaculture industry stakeholders with initial administrative and financial assistance from Government strengthen national aquaculture peak body activities to form collective views and actions relating to a sustainable development and conduct of the Australian aquaculture industry.

The peak body would formulate policy and priorities, related to:

- efficient communication and promotion;
- resource access, environmental concerns and ecologically sustainable development;
- risk management;
- adoption of best practice, and consistency, across the States and Territories;
- uptake and implementation of measures to enhance aquatic animal health;
- provision of a one stop shop for information on the regulatory, planning and management framework for aquaculture;
- formulation of national aquaculture R&D priorities and their communication to research providers;
- fostering of innovation;
- attracting sound investment to the industry; and
- export promotion through label integrity programs and brand building similar to that seen for other successful export commodities.

Recommendation 2: Streamline the operating environment.

Through the *Primary Industries Ministerial Council*, the Commonwealth, State and Territory Governments[6] should seek to streamline the industry's operating environment by developing transparent and nationally consistent management, development and approval guidelines/policies that can be readily managed.

Elements of these guideline and policy areas include:

- resource access;
- a national plan for aquatic health including import and quarantine issues;
- ecologically sustainable development and business conduct;
- governments' role in generic branding and promotion of Australian aquaculture products;
- regional management planning and approvals framework;
- environmental monitoring criteria and requirements;
- use of antibiotics and pesticides in aquaculture; and
- wildlife management (dolphins, seals etc).

[6] State and Territories Governments plan, manage and regulate aquaculture on a day to day basis.

Recommendation 3: An industry levy and Government contribution.

It is recommended that, following development of industry R&D priorities and actions as drivers, for each and all sectors of the industry a compulsory minimum levy of 0.25% of GVP be introduced. The Commonwealth Government should maintain its current commitments and extend these to the newly emerging aquaculture sectors.[7]

The introduction of the levy based on GVP would account for the needs of different aquaculture sectors, and secure finances to address R&D issues, including:

- attracting the best, most durable and most appropriate R&D provision for an industry in its formative stages;
- identifying and expand the farming of fish species in which Australia has a comparative advantage;
- reducing dependence on fishmeal and fish oil production;
- developing environmentally sustainable production systems;
- decreasing dependence on wild stock through application of genetics, biology, and husbandry developments;
- evaluating potential for restocking and reseeding fish populations;
- monitoring international developments; and
- collecting statistical information and associated research that facilitate market access.

Recommendation 4: Fostering scientific collaboration.

Encourage greater focus, wider collaboration and synergy amongst R&D providers on key research topics, with science agencies such as CSIRO and AIMS taking a leading national role in concert with other relevant bodies such as the Aquafin CRC. An example is provided by the collaborative research project to domesticate the black tiger prawn, where contributing organisations each bring their own special skills and perspectives to the project. Organisations or bodies that encourage efficient and cost effective collaboration, networking and coordination of research efforts between agencies are to be commended.

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[7] Tuna, salmon, prawn and many other sectors already contribute production levies for R&D.

1 INTRODUCTION

Fisheries

More than 90 percent of Australians eat seafood and domestic consumption continues to grow. The landed gross value of Australian fisheries production was $2.48 billion in 2000-01.[8] People are attracted to fresh seafood for its texture and flavour and informed consumers are recognising seafood's nutritional qualities and its role in a balanced, healthy diet. Overseas, growing populations and affluence are boosting demand for Australia's quality seafood.

Supply from Australia's exclusive economic zone provides about 800 marine and freshwater seafood species sold under about 300 names, however most of these are at or near full exploitation; and several have been over-exploited.[9] Indeed, Australia is a large importer of relatively cheap seafood, importing $1.15 billion of fisheries products in 2000-01, which account for 50-60% of all seafood consumed in Australia.[10]

Globally, it is a generally held view that most known wild caught seafood species are at or near full exploitation. With many capture fisheries peaking, scientists, governments and international organizations point to aquaculture as the most important means to increase global fish supplies. Although aquaculture could meet an 80,000 tonnes shortfall predicted by the *Fisheries R&D Corporation* (FRDC) for Australia's 300,000 tonnes requirement in 2020, it is not certain Australians would be prepared to pay the price such produce can attract in competing export markets.

Aquaculture is an emerging sector of fisheries, where those responsible for the environment, industry, health science, and regional development share interests. Government support for and appropriate regulation of aquaculture growth will be a major force affecting its sustainability. Government funded R&D plays a major role in the development of new technologies for aquaculture. An important recent policy development step has been the release of an *Aquaculture Industry Action Agenda* discussion paper in June 2001.[11]

The purpose of the present paper is to explore aquaculture in an Australian context and its future potential to not only help supply a stable seafood resource for Australians but also a valuable export commodity with consequential benefits for the Australian economy. The working group believes that a narrow consideration of *science, engineering and technology* issues (SET) related to aquaculture would not do justice to the topic and is not warranted. The innovation summit in 1999 and the substantial background work conducted for this event,[12] along with earlier PMSEIC papers on innovation clearly outline a multitude of issues that must be addressed to encourage

[8] Australian Fisheries Statistics 2001, ABARE, released in April 2002.

[9] Bureau of Resource Sciences, ABARE, and others have commented on this; see also Investing for Tomorrow's Fish: the FRDC's R&D Plan 2000 to 2005, page 31.

[10] Rabobank International, Industry note 004-2001 page 1

[11] The report to Government of the *National Aquaculture Development Committee* on an Action Agenda for aquaculture is currently being finalised.

[12] Details available on www.industry.gov.au.

innovation, bridge the gap between science and its application and secure commercial outcomes and benefits to society from Government and private R&D investment.

This paper will consider aquaculture in a broad and balanced industry development context, discussing the opportunities and obstacles to development, with due emphasis given to the impact of SET. The working group believes that a consideration of the aquaculture industry needs to be in the context of substantial wild-catch commercial and recreational fisheries, and against a background of the Commonwealth's Oceans Policy and COAG's agreement to pursue a National Representative System of Marine Protected Areas.

What is Aquaculture?

The *Food and Agricultural Organisation* (FAO) of the United Nations defines aquaculture as:

> "Farming of aquatic organisms including fish, molluscs, crustaceans and plants, with some form of intervention in the rearing process to enhance production, such as regular stocking, feeding, protection from predators etc. Farming also implies individual or corporate ownership of the stock being cultivated."

Fish farming typically involves the enclosure of fish in a secure system under conditions in which they can thrive. Aquaculture is usually dependent on natural ecosystems. It can impact freshwater supplies, modify coastal habitats, compete with the commercial wild catch, or through escape, introduce non-indigenous organisms and disease to new environments. Successful aquaculture development involves a breadth of activities spanning areas such as engineering, environmental management, transport, education, marketing and R&D.

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2 THE GLOBAL AQUACULTURE PICTURE

Global wild fisheries catch in 1999 amounted to about 90 million tonnes, little different from the annual catch of between 84 and 92 million tonnes since 1990 (see Figure 1). Most ocean fisheries stocks are now recognised as over or fully fished.[13] [14]

Global aquaculture[15] production of fish grew from 14 to 32 million tonnes from 1990 to 1998. Farmed fish currently provide over 25% of fish consumption by humans. Asia (mostly China) accounts for roughly 90% of global aquaculture production comprising low value fish destined for local markets. As China may be overestimating its wild catch and aquaculture production, these data are upper limits.

Collectively, North America, Japan and Europe consume the bulk of seafood traded internationally, especially high value species.[16]

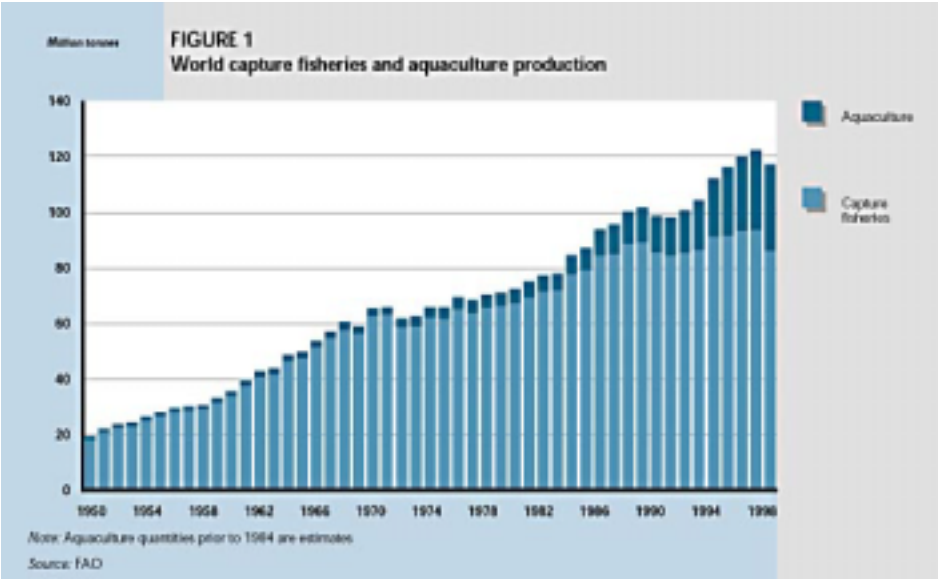

FIGURE 1
World capture fisheries and aquaculture production

More than 220 species of finfish and shellfish are farmed worldwide.[17] The range includes giant clams that feed on algae, and salmon that are carnivorous.

The impetus for the global growth of aquaculture shown in Figure 1 appears to be demand for seafood in the face of static commercial wild-catch levels. Enabling growth are R&D advances, in areas such as fish health and life cycle knowledge; new information technologies and biotechnologies can provide better monitoring and diagnostic capabilities.

[13] The State of World Fisheries and Aquaculture, FAO, discusses a decline in marine capture fisheries from 1998 to 1999. The report indicates half of the global fish stocks are fully exploited and 70% are in urgent need of management.

[14] 'Sustaining Marine Fisheries', National Research Council, National Academy Press, Washington, 1999.

[15] The common dictionary definition of *aquaculture* is: 'the rearing of aquatic animals or the cultivation of aquatic plants, for food'.

[16] 'Aquaculture Industry Action Agenda', Discussion paper, National Aquaculture Development Committee, Australia, June 2001.

[17] "Effect of Aquaculture on World Fish Supplies", Nature, 405. 29 June 2000, page 1017.

However, growth has resulted in adverse environmental consequences overseas, particularly in Asia. These effects are the subject of much effort by researchers and debate.[18] Alaska has prohibited net-pen and cage farming in coastal waters for the protection of native salmon populations and the human communities dependent upon them.[19]

The United Nations FAO predicts that any further increases in global consumption of seafood will be met by aquaculture. FAO predict that aquaculture will dominate fish supplies and less than half of the fish consumed will come from capture fisheries by 2030.[20] [21]

In some nations, such as the US, aquaculture is sometimes viewed as the fastest growing segment of agri-business. With growth, policy options are needed to ensure it is sustainable from an economic, social and environmental perspective.

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[18] *Effect of Aquaculture on World Fish Supplies*, Nature, vol 405, 29 June 2000, page 1017; *Ecological and Economic Impacts and Contributions of Fish farming and Capture Fisheries*, Tidwell & Allan, 2001 CSIRO)

[19] Marine Aquaculture in the United States: Environmental Impacts and Policy Options, Pew Oceans Commission, Goldburg et al., 2001, page 4.

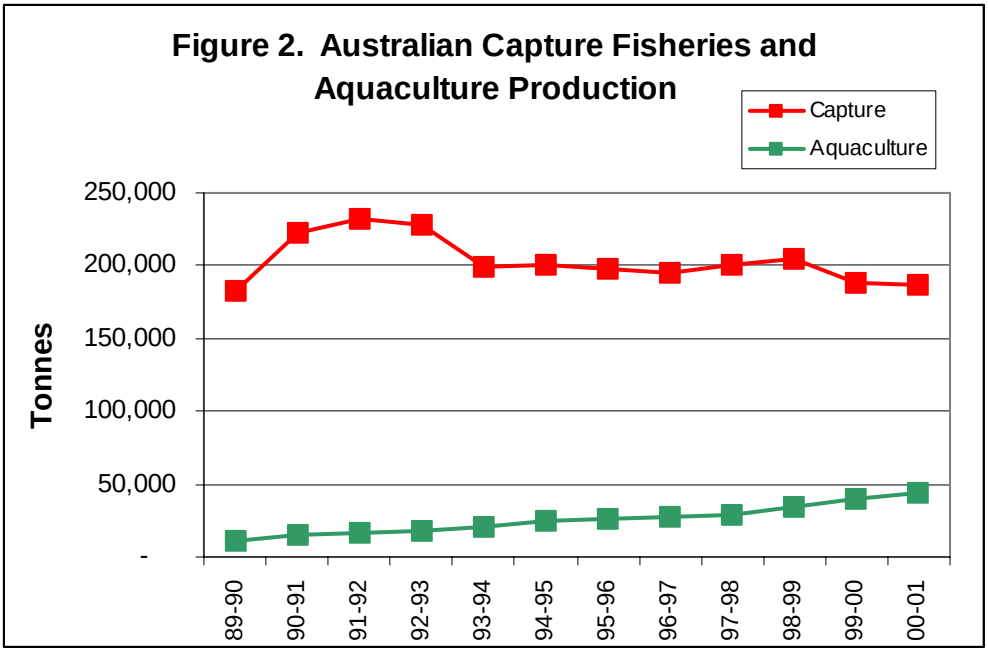
[20] FAO 1999, 2000.

[21] Should the global aquaculture industry enter into a Kyoto type agreement? In the interim, international reports by experts are being produced, such as Planning and Management for Sustainable Coastal Aquaculture Development, (ftp://ftp.fao.org/fi/document/gesamp/Y1818e00.pdf).

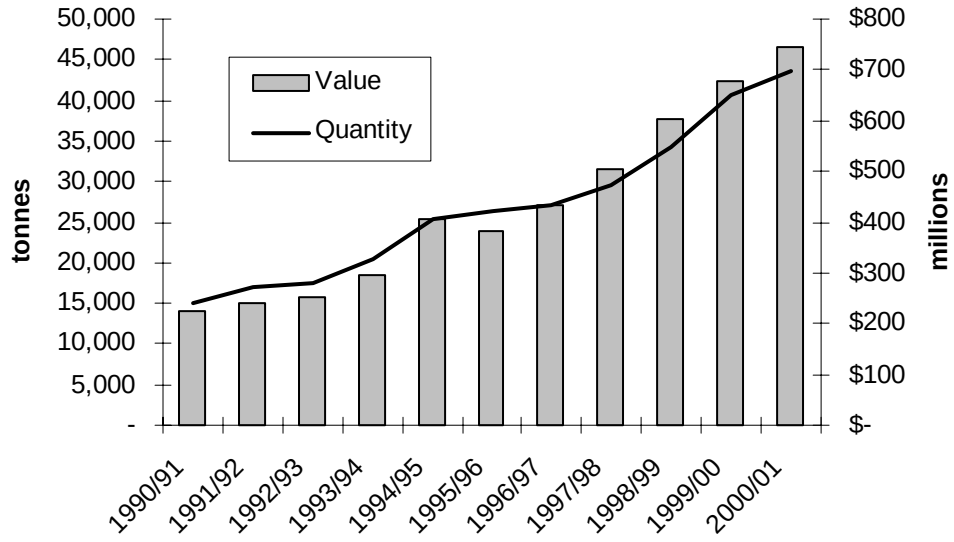
3 THE AUSTRALIAN STORY SO FAR

Production

The aquaculture industry's growth in Australia has been significant, particularly in farming premium value species. Captured Australian wildfish tonnages levelled off during the 1990s, and aquaculture production grew at about 13% (Figure 2).

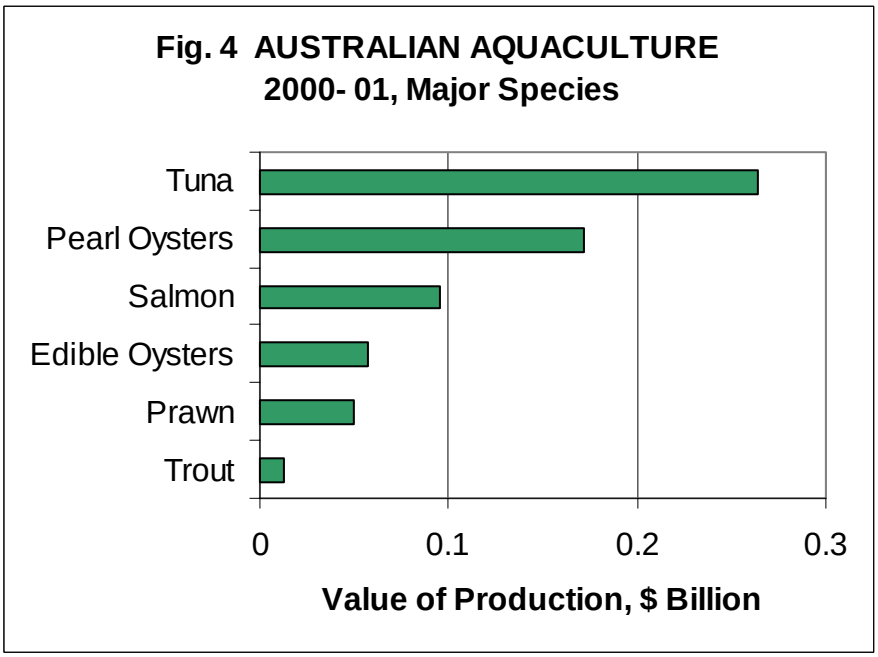


In value terms, the rise in farmgate production over the last decade indicates a newly emerging industry with considerable potential. Growth averaged 13% pa to reach $0.747 billion in 2000-01, or 30% of total Australian fisheries production (Fig. 3).[22]



[22] *Australian Fisheries Statistics 2001*, Australian Bureau of Agricultural and Resource Economics.

In Australia, around 70 fisheries species are under aquaculture development and around 40 species are produced commercially. Five species dominate Australian aquaculture, representing production of $687 million (92%), while trout together with the remaining categories represent $58.5 million in 2000-01[23] (Figure 4).



New species such as abalone, snapper and yellowtail kingfish, freshwater crayfish, barramundi and native freshwater fish show growth potential and are the subject of R&D efforts. Nevertheless, the process by which the species to be farmed in Australia are chosen for development in relation to market opportunities, suitability for Australian conditions, sites and competitive advantages can possibly be strengthened.

The aquaculture industry is more diverse than, for example, the wine and dairy industries and appears not to have the same degree of unity. It is perhaps akin to the horticultural industry – where a large range of diverse players as well as a large range of 'products' exist - some more suited to commercial development than others. Individual aquaculture production systems are very different and at various stages of development. This situation mandates greater effort to achieve a seamless unity to satisfy increasingly demanding customers and informed consumers.

Australia is a minor contributor to total global aquaculture production but production is aimed at the international premium market place. While Australian production contributed 0.09% of global tonnage in 1999, this represented 0.6% of global value. An example of high value product is southern bluefin tuna, a previously lowly valued seafood product that has been transformed from 'canned' status to a sought after delicacy, where individual fish fetch an average of $1200 and where all are caught by hand to preserve maximum product freshness.

Given static wild-catch levels, and growing demand, the Australian seafood industry sometimes speaks of a 'tsunami' for Australian aquaculture development. This may be a

[23] Data are slightly different from ABARE data due to reclassification of some products from NT – personal communication, Patrick Hone, FRDC.

little ambitious, with the aquaculture industry itself projecting growth from production worth $746m in 2000-01, to a target of $2500m in 2010.[24] Growth will be based on premium products, rather than lower value seafood.

Even so, such growth may carry some external impacts for Australia. There may be environmental impacts in Australia's coastal regions, or competition with commercial Australian wild catch. Other risks include food borne diseases from intensive farming, or upsetting ecologically balanced systems if pollutants are discharged in large quantities and/or if farmed non-indigenous fish escape and breed.

One specific example of the impact already occurring in Asia is in the use of mangroves and coastal wetlands for aquaculture[25]. Unsustainable practices resulted in loss of essential ecosystem services generated by mangroves. These lost services include the provision of nursery habitat, coastal protection, flood control, sediment trapping and water treatment. Scientific research has shown that mangrove forests serve as nurseries for many juvenile finfish and shellfish which are caught as adults in coastal and offshore fisheries. Other biological research shows how mangroves are linked to health and habitat conditions of coral reefs and seagrass beds.[26]

Generally, all Australian marine farming is licensed by the relevant state or territory authority. Proposals for aquaculture developments in sensitive areas such as wetlands in Western Port Bay, Victoria, have been strenuously opposed, while other sections of the community are reported as viewing the ecological sensitivity of other bays and inlets and their aesthetic value as precluding marine aquaculture.[27] [28] The *Commonwealth Environment Protection and Biodiversity Conservation Act 1999* increases the scrutiny that marine aquaculture operations may need to undergo.

If public perception is of an environmentally damaging industry, aquaculture will encounter resistance in Australia and may indeed be deemed irrelevant by larger retailers who increasingly move towards buying products from producers exhibiting genuine environmental stewardship.

Sectors of the aquaculture industry in Australia recognise the requirement for environmental stewardship as a prerequisite for industry viability. For example, the *Australian Aquaculture Forum*, in concert with *FRDC* and *Environment Australia* published a voluntary "Code of Conduct for Australian Aquaculture".

In Victoria in July 2002, the *FRDC* and the *Victorian Department of Natural Resources and Environment* are convening a National workshop titled "Sustainable Australian Aquaculture: Practical solutions to achieving ESD".

The potential environmental impact of an expanded aquaculture effort in Australia suggests a need for continued careful planning and to further expand a responsible R&D based approach to the management of environmental impacts. Consistent and

[24] National Aquaculture Beyond 2000 Workshop.

[25] *Effect of Aquaculture on World Fish Supplies*, Nature vol 405, 29 June 2000, page 1020.

[26] Clearing of mangroves in Australia is prohibited by Federal and State laws.

[27] Marine Matters – Atlas of marine activities and coastal communities in Australia's south-east marine region, AFFA, 2002, page 158.

[28] One example is Recherche Archipelago in WA for community concerns regarding finfish aquaculture in the bay.

well-enforced regulations by states and territories fisheries and environmental agencies are needed. These actions are for aquaculture, as for many other industries in Australia, both an imperative for maintaining current market access and an opportunity for future growth in market share.

Exports

Records of Australian fisheries exports are not differentiated on the basis of whether the product comes from aquaculture or wild fisheries. Table 1 provides an estimate of the level of aquaculture exports over the last couple of years. About 60% of production is exported and has helped maintain Australia's international reputation as a reliable supplier of high quality seafood.[29]

Table 1: Major Australian Aquaculture Exports[30]

Aquaculture Export ($m)	1999-2000	2000-01
Tuna	202	263
Pearls	436	419
Salmon	9	18
Other	14	15
TOTAL	**661**	**715**

Total fisheries exports were valued at $2.17 billion in 2000-01, a doubling in real terms over the last decade. Farmed Australian tuna is one of the main products contributing to this export expansion. This expansion has been helped by the depreciation of the Australian dollar relative to the US dollar and Japanese yen[31]

As a comparison, the Australian wine industry exported product worth around $1 billion in 1999 growing to $1.8 billion in 2002. Similarly, the dairy industry exported produce worth about $700 million in 1992, growing steadily to $2.8 billion in 2001.

Pearls and southern bluefin tuna dominate Australian aquaculture exports. Salmon exports are around 15% of production. Exports are primarily sold to overseas-based wholesalers or trading houses.

Australia has the advantage of being able to farm a large variety of fish from southern temperate, cold, and tropical regions and to supply northern hemisphere markets out of season.

Asia is Australia's major market for fisheries (including aquaculture) exports. In 2000-01, it accounted for about 70 per cent of the $2.17 billion in these exports. The major Asian markets were Japan, Hong Kong, Chinese-Taipei, and Singapore.

[29] Agri-Chains Solutions Ltd 2001, Asian Foodbuyers Survey, Canberra. In a survey of seafood in Asia, the report states "Australia's performance as a supplier of premium quality seafood is excellent. Quality was equated with both the species of product that Australia provides and the image of Australia. Australia is known as having a large coastline, abundant seafood resources and a pollution-free environment."

[30] From Table C on page 9 of *Aquaculture Industry Action Agenda*, Discussion paper, June 2001.

[31] Australian Fisheries Statistics, ABARE, 2001, page 5.

Atlantic Salmon

The basis of Tasmania's aquaculture industry, Atlantic salmon originate as sea-going fish of streams, rivers and lakes draining into the North Atlantic Ocean.

Salmon are versatile for the table – from raw sashimi to seared steaks, or baked whole, poached, smoked, cured, or pan-fried – and have been farmed in sea cages in the coldest waters of Tasmania since the 1980s.

While Tasmanian producers benefit from the "clean and green" environment for both production and marketing, the industry is not without its problems. Increasingly warm summers, potentially due to global warming, have affected reproductive fitness of broodstock; and the incidence of amoebic gill disease has affected survival and increased production costs.

To exacerbate these problems world production of aquaculture salmon has increased (largely due to Chile) and oversupply has lowered market prices and squeezed profitability.

The industry is investing in the *Sustainable Aquaculture of Finfish CRC* to remedy some of these production issues, and in environmental management systems to satisfy regulatory requirements and maintain the clean and green environment so essential for the industry. Further, a selective breeding program is being considered to enhance production efficiency.

The Fisheries Research and Development Corporation (FRDC)

FRDC is a statutory research and development corporation responsible for planning, funding and managing R&D programs in fisheries; and facilitating the dissemination, adoption and commercialisation of the results of R&D. Stakeholders are the fishing industry, the governments (both state and federal), and the people of Australia.

FRDC's primary revenue source (PIERD Act) is:

- A Commonwealth contribution of 0.5% of GVP for public good R&D purposes;
- A further Commonwealth contribution of up to 0.25% of GVP, matching the voluntary industry contribution from fishers using Commonwealth/States/Territories fisheries and aquaculturalists, (which may be more or less than 0.25%).

The FRDC adopts an ecologically sustainable approach to fisheries development. Its forward plan "Investing for Tomorrow's Fish" identifies nine challenges that will be important to meet in the next 20 years, several of those are pertinent for aquaculture:

Challenge 1: *"Reaching sustainable levels of fisheries productivity."*
Challenge 2: *"Increasing production through aquaculture"*. This vision may be met by steps such as use of saline groundwater in inland areas, whether it be from the large evaporation basins used in salt disposal schemes, or use of the many permanent saline lakes in Australia.
Challenge 5: *"Reducing the quantity of fish protein fed to terrestrial and aquatic livestock so that it becomes available in the food chain to satisfy environmental and human needs."* Aquaculture in Australia and overseas relies heavily on fresh fish, fishmeal and fish oils as nutrients for higher-value aquaculture species. Identifying alternative protein and fatty acid sources is a high priority for fisheries R&D.
Challenge 7: '*Achieving objectively based, secure access to fisheries and natural resources."*:
Challenge 8: *"Optimising market development, maximising seafood value and securing equitable financial returns."* "Maintaining worldwide recognition of Australia's seafood as "premium brand" will also rely on continuing to build a reputation for clean seas and sound environmental management.
Challenge 9: '*Developing and using the knowledge and skills of people in and supporting the Australian fishing industry*'

World fisheries exports were US$51.3 billion in 1998. Live, fresh or chilled fish represents a small (perhaps 10%) but growing share of world fish trade. Improved distribution logistics and preservation technologies will diminish the geographical

disadvantage Australia's distance from markets have, further strengthening Australia's ability to deliver high value fresh produce at competitive prices.

Regional Character and Employment

Aquaculture is now geographically widespread in regional and rural Australia (see figure 5 below). Over 7,000 people are estimated as directly employed (casually and full time) in aquaculture in 1997/98, with another 22,000 indirectly employed through processing, marketing, retailing, etc.[32]

Figure 5: The geographic spread of aquaculture activities in Australia (*courtesy of P. Montague, Sustainable Aquaculture of Finfish CRC*).

The aquaculture industry makes a significant and positive contribution to regional development. Aquaculture provides diversity to a region's economic base and creates demand for secondary educational industries and training, extension services, infrastructure and locally produced goods. In Tasmania, for example, it is now a major industry, with 145 marine farms registered in 1999 and the growth of supporting

[32] Drawn from Table A, page 5 of *Aquaculture Industry Action Agenda*, Discussion Paper, June 2001.

industries. In this development, a uniform and directed process of 'site selection' has not taken place to any great extent.

Australia's aquaculture production occurs in open and closed systems, recirculation and flow-through systems. It comes from marine cages, racks and long lines located in coastal waters and estuaries, on-land and in-land in ponds, dams, raceways and tanks, using saline and freshwater. Its production involves the breeding, hatching, rearing and processing of aquatic organisms including fish, molluscs, crustaceans and exotic plants.

Yellowtail Kingfish

The Yellowtail Kingfish, known in Japanese as 'hiramasa', inhabits the Great Southern Ocean. Port Lincoln based *Australian Hiramasa* pioneered production of disease free juvenile Yellowtail Kingfish in saltwater hatcheries.

Premium quality matured fish is now exported to North America, Europe and Asia. The Yellowtail Kingfish offers firm white flesh suited to both Occidental and Oriental cuisines, and can be used in classic and modern recipes. Quality control, such as the introduction of the "Hazard Analysis Critical Control Point System", has played a key role in the company's ongoing success. Managing Director, Tom Dawson, recently predicted a 2002 harvest exceeding 500 tonnes[33].

If the industry's vision of future growth is realised ($2.5 billion production by 2010) many jobs are likely to be created.

For the entire Australian fisheries industry, *Australian Bureau of Statistics* data show employment levels of 19,000 direct jobs for 2000-01 (with production of $2.5 billion), and the Bureau ranked aquaculture as the fourth fastest job creator in Australia. Projections suggest direct employment of around 36,000 if aquaculture production reaches $2.5 billion in 2010.

Further, for each job directly generated by the aquaculture industry, it is estimated that another 2.2 jobs are created upstream and downstream. For every dollar of sales generated, another $1.8 may be earned by related businesses.[34]

Value-added

In the last ten years a number of fisheries sectors (tuna, prawns, salmon, rock lobster) have been vertically integrating the processing, marketing, retailing and transport into their businesses to add more value to the farmed product and to increase efficiencies in the supply chain from producer to consumer.

Value added for Atlantic salmon is significant. Aquaculture production was $84.8 million in 1999-00, predominantly in Tasmania. The reported sales by salmon farming companies in the same year was about $136 million, the extra value arising from activities post farm-gate, such as smoking, vacuum packing, marketing, freight.[35] This is a little akin to the value added to winegrapes (around $800 million annual harvest value) when processed into wine (around $4000 million product value).

[33] See www.australianhiramasa.com.

[34] A summary of a study by EconSearch Pty Ltd on the economic impacts of aquaculture in South Australia. Reported on page 5 of *Aquaculture Industry Action Agenda.*

[35] Deloitte, Touche, Tohmatsu *Tasmanian Farmed Aquaculture Industry Survey 2000,* A report prepared for the Tasmanian Aquaculture Council, Hobart.

However, fisheries industry leaders believe that the growth potential through value adding can be accelerated with improved processing and marketing. An important external consideration to potential future value adding will be the careful selection of sites for aquaculture. Issues such as distance to transport, processing facilities and market are critical.

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4 GROWTH OF AQUACULTURE

(1) Obstacles and opportunities

For regional development and value adding to grow, discussed in the last section, a partnership between government and industry must be further developed. This will ensure that a responsible but user-friendly regulatory environment is in place and that all players recognise the imperative that responsible environmental management is essential for long-term success.[36] The recent initiation and development of an *Aquaculture Industry Action Agenda* and the pending implementation thereof is an important step in this direction.

Michael Porter's economic analysis on competitive nations and industry clustering[37] considers that the need for government-industry interactions is increasing rather than decreasing. In Porter's opinion, some business views such as 'governments annoy us' and 'government action should be based on free market forces alone' are unlikely to realise maximum potential. These views may also be applicable to the further development of the Australian aquaculture industry.

A Strengths-Weaknesses-Opportunities-Threats (SWOT) analysis of the Australian aquaculture industry was carried out by the working group, with a summary in Table 2 below, and details in appendix (1). From this analysis, the working group believes that in addition to the crucial issue of the industry's need for a sustained and focussed R&D effort, two major issues stand out for a joint consideration by Government and industry together. They are scale and marketing, and environment and sustainability. Each is briefly discussed below.

STRENGTHS	WEAKNESSES	OPPORTUNITIES	THREATS
Strong export seafood markets developed	Fragmentation	Industry vision	Pollution and environmental backlash
Land & water resources	Slow start-ups	National planning	Feed costs and shortfall of supply
Science, Engineering and Technology base	Low Investment	Strategic R&D direction setting and priorities	Foreign fish diseases and lack of registered treatment agents
	Lack of specific animal husbandry knowledge	Learning and education	Lack of research and innovation
	Lack of site knowledge	Luxury seafood demand	Weakening overseas markets; foreign competition
	Lack of industry skills related to fish health and disease	Use of inland saline groundwater	Land and water resources could be allocated for other uses, eg marine parks, coastal developments, commercial and recreational fishing
	Scale	Action Agenda implementation	

Table 2: Summary of SWOT Analysis on Australian Aquaculture

[36] The 'Aquaculture Industry Action Agenda' (AFFA, June 2000)www.affa.gov.au/docs/fisheries/aquaculture/action_agenda.index.html) outlines in greater detail many of the issues of relevance here.

[37] Further relevant work by Michael Porter is in the Global Competitiveness Report – Enhancing the Micro-Economic Forum, Oxford University Press. These may emphasise the need for more sophisticated interactions between public and private sectors to increase competitiveness.

(2) Scale and marketing

The market strength of Australia's aquaculture and wild caught fisheries has historically been in high value niche markets, especially the food service and restaurant sectors. Successful large-scale expansion of Australian aquaculture will give rise to a need to develop outside these niche markets. At the same time we can expect distribution channels for food and beverage products to continue to aggregate on a global scale with fewer but larger retail giants who will set specifications for product quality and quantity prior to purchase. In this environment aquaculture exports, like other food exports, almost certainly need to make adjustments to their sales and marketing strategies to enjoy future export success.

There may need to be large-scale specialised producers able to fill large orders and guarantee supply in a similar fashion to the Australian wine industry. Australian aquaculture farmers again, emulating the wine industry, may need to use the same kind of generic marketing that has spearheaded Australian wine's assault on the British market over the last 10 years.

Unlike most Australian primary industries, the commercial fisheries industry does not have a dedicated national marketing entity.[38] As the aquaculture industry grows, a possible option for future market development is the establishment by the Government of a body comparable to the *Australian Wine and Brandy Corporation* and its associated *Australian Wine Export Council*.[39] The *Australian Wine and Brandy Corporation* supports the wine industry by several means: negotiation of overseas market access; labelling responsibilities; standard settings; and it is funded almost wholly through levies. Alternatively, given a considerable (but not complete) overlap of interests with wild caught products, it may be more appropriate to have a body representing Australian seafood products, i.e. fisheries & aquaculture. An FRDC initiative is *Seafood Services Australia*, which engages in some marketing activities but is mainly oriented towards other activities.[40]

[38] Investing for Tomorrow's Fish, FRDC, page 60.

[39] See www.awbc.com.au.

[40] *Investing for Tomorrow's Fish*, FRDC, see page 126 for a description of SSA.

A Marketing Connection - between health and seafood consumption[41]

Discovery of the essential role of the "omega-3" fatty acids in the human diet shows deficiencies are associated with cardiovascular disease, diabetes, certain cancers, osteoporosis, and central nervous system disorders.

The best source of the "long-chain omega-3 polyunsaturated fatty acids" is seafood.

The evidence is now largely unequivocal that, provided a person has no individual sensitivity, some fish each week is an advantage to health and longevity. Small amounts of fish – up to three or four servings of about 100 grams of finfish a week – are enough to optimise this aspect of health.

(3) Environment and sustainability.

As aquaculture production increases there will be a need to use technological advances in waste minimisation. This is analogous to developments in sewage treatment technologies as Australia's population increases within the coastal zone. Industry needs to invest in technical innovation that reduces waste and credibly underpins Australia's reputation and market advantage as a "clean-green" seafood supplier.

Enforced environmental regulations can translate to a market advantage and will eventually become an imperative. Government can foster the development of such an environment and co-invest with industry in the development of environmentally sustainable production systems. The expertise gained through this process alone can develop into an export commodity itself, much like that seen for mining services[42] and can further impact on other important Australian industries such as our growing $12.8 billion tourism industry. Access to diving and fishing contributes an important component of tourist expectations and such activities can supplement income for some aquaculture operators. Major tourist attractions include trout and barramundi farms with fishing rights and pearl farms with visitor centres and retail centres.

[41] Based on the booklet *What's so healthy about seafood?*, A Guide for Seafood Marketers, Fisheries R&D Corporation, 2001; available on www.frdc.com.au/bookshop.

[42] See Australia's Mineral Exploration, PMSEIC agenda paper, 28 June 2001; www.dest.gov.au.

THE SEAS, NOT A LIMITLESS RESOURCE -Finding Alternatives to Aquaculture Feeds

Salmon and many other species are carnivores and rely on large amounts of fishmeal and fish oil in their diets. About a third of the global catch of "forage fish", primarily small oily fish such as sardines and anchovies, are processed into meal for aquaculture and land based farm animals.

Substitutes that are equally nutritious and digestible are needed for aquaculture to avoid its indirect effects on marine ecosystems far from fish farms. Similarly, the demand for fish oils is a concern and its scarcity and cost will constitute an impediment to future growth of the industry. One of the FRDC's identified challenges is the development of alternative feeds for aquaculture. Encouraging progress has now been made in this area of FRDC and CRC funded research.

The expanding Australian tuna farming industry is currently based on feeding sardines and similar feeds. Over 80% of these feeds are imported because of strict catch quotas in Australia. Replacement plant based pellet feeds are expected within five years, based on R&D that reached commercial trials in 2001.

SUSTAINABLE PRODUCTION SYSTEMS: A PREREQUISITE FOR FUTURE MARKET ACCESS? - Supermarkets

Changes are happening in the big food marketeers. In the UK, Sainsbury's has the first *Marine Stewardship Council* (MSC) certified wild Alaskan salmon on its shelves. (MSC is an international, independent organisation, which aims to ensure sustainable fishing practices.)

Sainsbury's were the first UK retailer to sign up to MSC principles, and became the first UK retailer to offer the Australian Rock Lobster. Acknowledged as the world's premium cold water rock lobster, the Western Australian Rock Lobster (*Panulirus cygnus*) is government regulated as a sustainable resource.

Sainsbury's also markets sustainable wild Alaskan salmon. A chain of custody certificates were created for sustainable salmon supplies from these fisheries. Sainsbury's put the first MSC-certified wild Alaskan salmon on shelves. This salmon is one of their most popular chilled, value added products.

Sainsbury's is also funding, with MSC, a project to protect and conserve tuna. The three-year project will investigate the management of tuna fisheries around the world and aim to provide a sustainable source of fresh tuna for future Sainsbury's customers. Sainsbury's sells 665,000 cans of tuna each week.

Stuart Mitchell, Sainsbury's Assistant Managing Director said: "We are confident that this partnership will enable the MSC to bring certified tuna to Sainsbury's shelves. MSC's success in certifying Alaska Salmon fisheries has proved that it is possible to tackle the big sustainability issues."

Sainsbury's sells in excess of £300 million a year in fresh, frozen and canned seafood.

Unilever has also engaged in a partnership with the MSC, and has also committed to buy all its fish from sustainable sources by 2005, a process which has already started.

The desirable attributes of a sustainable aquaculture industry have been defined in a review *The Effect of Aquaculture on World Fish Supplies.*[43] The review suggests that world aquaculture needs to prioritise the following four goals, which were discussed by the group:

> *Expansion of the farming of low trophic*[44] *fish.* Although desirable as a substitute feed source in Asia it is not appropriate for the Australian domestic

[43] *Nature*, vol 405, 29 June 2000, page 1017.

[44] Levels in the food chain are classified according to trophic levels. Producers make up the first trophic level (eg marine phytoplankton which use energy from the sun). Animals consuming plant material are primary consumers. Animals eating primary consumers are secondary consumers etc.

industry. Internationally, Australia plays a key role in aquaculture R&D aimed at poverty alleviation, principally via ACIAR.

Reduction of fishmeal and fish oil inputs in aquaculture feed. This is already happening in Australia by R&D into formulated feeds via initiatives of the FRDC & both the former Aquaculture CRC and the *Sustainable Aquaculture of Finfish CRC,* but further development is necessary to address cost and quality issues for many species. There is a need to be vigilant in this area as concerns about BSE in Europe have impacted on the use of animal-based meals, and as concerns increase about concentration of contaminants such as dioxins from fish-based nutrient sources.

Promotion of environmentally sound aquaculture practices and resource management. Australia has a critical and internationally acknowledged lead role in this aspect.

Development of integrated farming systems. This issue is intricately linked with the suite of avenues that must be considered as one option for environmentally sustainable production.

The sustainability of aquaculture is the crucial over-riding issue. If public perception is of an unsustainable industry sector, the early growth may wither. A national framework for aquaculture development must address the sustainability of the industry, including practical measures related to ESD principles.

5 INNOVATION IN AUSTRALIAN AQUACULTURE: Key Issues

(1) Level of R&D Support

Government - inputs

Aquaculture R&D is carried out in Commonwealth Government science agencies, Australian universities, and State or Territory agriculture departments.

TABLE 3. Government R&D Support for Aquaculture

	Expenditure 98/99	Expenditure 99/00
Qld	$3,000,000	$3,000,000
Vic	$740,000	$600,000
NSW	$1,250,000	$1,258,534
NT	$768,800	$708,280
Tas	$734,807	$843,613
WA	$1,325,300	$1,390,000
SA	$847,000	$1,126,000
CSIRO	$4,470,000	$4,520,000
CRC for Aquaculture	$2,250,100	$1,687,400
AIMS	$1,500,000	$1,500,000
FRDC	$3,980,000	$3,990,000
Total	$20,866,007	$20,623,827
Sate and Territory Funding	$8,665,907	
National Funding	$12,200,100	

(Substantial other funding is also accessed through the R&D Start program (~$7 million since 1999/00) and the Australian Research Council ($200,000 for discovery projects and $638,000 for linkage projects in 2002).

Funding support for this R&D is spread between the Commonwealth Government and the States / Territories Governments (Table 3). In 1999/00 the total Commonwealth and State/Territory government expenditure on aquaculture R&D (excluding the R&D start program, COMET and ARC) was $20.6 million, representing about 3 per cent of the gross value of production (GVP) for that year.[45] Of this total almost $9 million is contributed by the State / Territory governments.

[45] (Patrick Hone, FRDC personal communication November 2001)

PRAWN FARMING

Prawn farming is an expanding, high-value industry in coastal areas of Australia. There are approximately 500 ha of ponds distributed throughout Queensland, New South Wales, and the Northern Territory. An increase in the number of hectares under production is anticipated in these states, and the industry is expected to expand into Western Australia. The species currently farmed are *Penaeus monodon* (2,000 t), *P. merguiensis* (500 t) and *P. japonicus* (200 t), with total annual production of 2,700 t, valued at AUS $50 million. By global standards, the Australian industry is small, accounting for only 0.3% of world production of farmed shrimp.

The industry has developed in the wake of widespread concern about the poor environmental management record of large, rapidly developed shrimp farming industries in Southeast Asia, South America and Central America (Primavera 1993, Phillips *et al*. 1993, Naylor *et al*., 1998, 2000). In comparison to these countries, the high level of community awareness and strict environmental regulations in Australia has ensured that the industry has developed slowly and under close scrutiny of environmental regulators and other government agencies. However, lack of knowledge about appropriate and acceptable environmental management strategies has restricted the growth of the industry. Industry proposals have been delayed for up to 7 years pending the outcomes of research.

Research investment

Over the past decade, in the formative stages of the industry, efforts to control development and ensure the long-term survival of the industry focussed on environmental issues. This created a strong demand for scientifically rigorous information on the environmental management of the industry. In response to this demand the Australian prawn farming industry, environmental regulators and marine research community devoted a high level of resources, relative to the size and value of the industry, to collaborative environmental research (approximately $ 5 million over 10 years for a $50 million industry). More recently, once some of the environmental concerns had been addressed, research resources have been directed towards other sustainability issues such as reducing reliance on wild-broodstock and improving health management.

Research outcomes

Example 1: Development and implementation of waste management practices for the Australian prawn farming industry.

As a result of the nationally co-ordinated research funded by industry, the CRC program, and FRDC, Australian prawn farms will no longer discharge untreated pond effluent into adjacent waterways. Instead the industry will use settlement ponds to treat pond effluent prior to either recirculation or discharge to adjacent waterways. All new farms in Australia, or expansions of existing farms, now require the use of effluent treatment systems to meet effluent discharge standards. Many existing farms are also exploring the use of treatment ponds for reducing discharge loads and for recapturing otherwise wasted nutrients. The successful development of more acceptable environmental management practices should significantly enhance the progression of the industry.

Example 2: Progression from the use of wild broodstock to domesticated, selectively bred genotypes.

Until recently the Australian prawn farming industry was entirely reliant on the use of wild-broodstock. This reliance on wild broodstock is risky, inefficient and precludes the opportunity to enhance production through selective breeding and controlling the spread of disease. In response to this situation CSIRO, in close collaboration with industry partners, developed a successful domestication and genetic improvement program for the Kuruma prawn (*Penaeus japonicus*), the highest valued of all farmed prawns. This strategy has resulted in up to 20% increase in growth rates and 34% increase in value of selected genotypes.

More recently CSIRO, AIMS, QDPI, APFA, three prawn farms and FRDC have joined forces to support a $5million research project to remove the barriers to domestication of the black tiger prawn, (*Penaeus monodon*). This study will open the way to disease-free selective breeding of the world's most cultured prawn.

Industry - inputs

Total aquaculture industry R&D funding and performance is not reliably known. Activities comprise on-farm experimentation within companies, and contributions to, and cooperation with public sector agencies and funding sources.[46]

The amount of funding contributed by the aquaculture industry appears uneven between the States and Territories and is dependant on the industry sector. Support from the industry varies, with larger-scale tuna, salmon and prawns contributing substantial cash and in-kind funding to research and innovation. Individual companies or collectives provide direct funding to science agencies such as CSIRO and state departments of agriculture for specifically targeted R&D.

The *FRDC* is a major provider of government and industry funds for aquaculture R&D. The tuna, salmon and NSW oyster industries for example, make voluntary contributions and receive the benefits of being able to leverage dollar for dollar funding. Many sectors of the aquaculture industry are missing Government matching funding for R&D by not participating in leveraged programs such as those of the FRDC. This situation is not satisfactory from a whole of industry perspective and should be addressed as a matter of high priority.

Convincing small to medium scale aquaculture producers that investing in R&D is worthwhile has been difficult. This is demonstrated by experiences with the broadly based former *Aquaculture CRC*, which ended in 2000, after a seven-year term. It is replaced by the *Sustainable Aquaculture of Finfish CRC*, announced in 2001. Despite extensive industry consultation across all sectors, only the larger salmon and tuna industries saw the value in partnership in a CRC. These industries also have set levies for supporting R&D, and these funds flow to the CRC via the FRDC.

In a positive development, and perhaps a sign of things to come, the Australian prawn-farming sector endorsed collection of a compulsory levy based on production, to fund R&D in the prawn aquaculture sector (see Appendix 2).

[46] (Cox, Davies, Hardcastle and Stubbs, 2001 *Aquaculture Development in Australia: A Review of Key Economic Issues,* A report prepared for the Fisheries Resources Research Fund, Canberra.

REBUILDING A REGION THROUGH INNOVATION

In 1990, the Australian Southern Bluefin Tuna (SBT) industry was in official or *de facto* receivership. The catch quota had been cut 67%, the same as the other international SBT agreement countries, Japan and NZ.

After this, one of the most successful innovations in the aquaculture industry was developed near Port Lincoln in South Australia - the fattening of wild-caught tuna.

It was driven by the dramatic reduction of Southern Bluefin Tuna quotas in the late 1980s to allow the spawning stock to regain the abundance levels that it had in 1980. Following the cuts in quota, an experimental tuna farm was set up by the *Japanese Overseas Fishery Cooperation Foundation* (OFCF) in collaboration with the South Australian Government and the *Tuna Boat Owners of Australia Association* (TBOAA). This aimed to fatten the tuna caught in the Great Australian Bight. and included a world-first experiment to farm (grow-out) wild SBT.

This experiment has been an astounding success. Today, the quota limit for Australia's catch is 5,265 tonnes. By catching this quota live, and fattening it in cages near Port Lincoln, over 8,000 tonnes of high-grade sushi tuna are exported to the Japanese market. The industry is now directly selling to the lucrative Japanese market and is the most valuable aquaculture sector in Australia

Farming has converted the Australian SBT industry from a $1 / kg industry to $40 / kg. And from $6 million to over $300 million exports.

All farmed tuna production is exported. It competes against farmed and wild tuna from Asia, Europe and North America. Notably, farmed tuna from these other countries is all based on Australian technology, and is substantially owned by South Australian interests.

The scale of the Australian farmed tuna industry provides the critical mass for major CRC and FRDC research programs, driving new technologies and converting Australian expertise into export dollars.

The focus is on ensuring environmental sustainability via the twin pillars of research and training. To retain Australia's competitive advantage, tuna farmers must heavily invest in leading edge R&D on environmental measuring technology and fish health expertise.

SBT farming has created sustained prosperity in the large SA Eyre Peninsula region. The spin-off benefits include a new tertiary education and research institute; tourism; new transport systems for other products; 3000 new jobs; and the "demonstration effect" growth of other new industries.

FRDC provided a portion of the research and development support over the decade aimed at driving the growth of this expansion in tuna farming. The return on investment in relation to tuna farming is very substantial and has been independently calculated as 44:1.

The tuna industry applies the same principle to its tuna cannery – the largest private employer in rural SA. It is expanding – despite having no tariff protection, and being required to use mostly imported tuna.

Together these industries have generated around 4000 jobs to rebuild the economy of Eyre Peninsula from a depressed rural area into a globally competitive centre.

Total R&D funding for aquaculture is not reliably known. The best estimate, taking into account publicly known funding and the likely efforts by industry and universities, suggests a figure of around $37m pa.

(2) Maintain international links.

The importance of international networking has been pointed out consistently by policy advisors in the SET area, and relevant activities are supported through the *Innovation Access Program* announced in *Backing Australia's Ability*, and through ACIAR and the *Network of Aquaculture Centres in the Asia-Pacific* (NACA). It has been said that international science and technology links made by Australia are as valuable as international trade in relation to Australia's future competitiveness and economic growth.[47] Research agencies and industry should enhance existing schemes, and where necessary create new schemes to ensure that Australian industries are able to access global innovation through benchmarking, exchange schemes, study tours, collaborative research projects and strategic investment in overseas companies.

The benefits to the Australian aquaculture industry that can be derived from strengthening these international alliances would include:

- Learning from global research, experience and expertise;
- The opportunity for Australia to sell and showcase Australian R&D;
- Accelerated knowledge and technology transfer to the Australian aquaculture industry through increased international research and technology gathering activities;
- Making Australia a 'visible' and active participant in the global production of knowledge; and
- Maintenance of Australia's participation in global decision-making regarding aquaculture matters.

Information and trade sharing agreements are already established with both China and Thailand. Australia is a member of the *Network of Aquaculture Centres in the Asia-Pacific* (NACA), *Food and Agriculture Organisation* (FAO) and *Asia-Pacific Economic Cooperation Forum* (APEC). These arrangements provide opportunities for technical exchanges with overseas researchers, yet to date, much of this opportunity remains under-utilised. Nevertheless, recent achievements arising wholly or partially from access to overseas innovation systems include: development of good management practices for shrimp (prawn) aquaculture; increased participation of women in aquaculture; development of regional guidelines and policies for live aquatic animal quarantine; numerous technical expert and staff exchanges; development of regional cooperative educational programs; and improved hatchery and grow-out technology for coral reef fish aquaculture in the Asia-Pacific region. Many arrangements carry the need for sound business skills related to intellectual property and commercialization.

(3) Establish Strategic R&D Directions, and Durable Funding based on whole of industry contributions

Opinion leaders in aquaculture believe that the SET base has played an important role in helping aquaculture grow to its present size and examples of beneficial outcomes are many. The working group members endorse this view and feel that for the aquaculture industry to truly reach its potential, a sustained R&D effort defined by end-user needs

[47] *The Chance to Change*, Final Report of the Science Capability Review, Canberra, 2000

and funded at a higher level than currently seen must be put in place to address the major opportunities and obstacles for future ecologically sustainable growth.

At the *National Aquaculture Beyond 2000 Workshop,* aquaculture industry representatives voiced their concerns regarding a perceived lack of strategic targeting of aquaculture R&D. The tendency is to spread available research funds from a diverse range of providers over a large number of species (~70), some of which appear to contribute relatively little to potential industry development and profitability. The working group is under the impression, that many R&D funding allocations are made using a 'bottom up approach' where researchers put forward a well intentioned research proposal for funding, formulated in the absence of clear nationally articulated and coordinated industry research needs and priorities.

The FRDC has decided to reduce the number of species under investigation and to focus aquaculture R&D investment on the five most valuable species. However, there appears to be a need to address this issue on a national basis across the multitude of funding providers to ensure investment is focussed on commercially established species or species with a high potential for commercialisation. Equally, the need to fund emergent industries and find patrons must also be considered.

Such strategic planning must be informed by industry priorities communicated through a recognised peak body or the like. In parallel, potential alliances between research funding programs and research providers also need to be identified. Increased communication between funding programs would help to ensure that only the best research ideas are supported and that fewer but more robustly funded 'centres of excellence' can be supported. For example, an entity such as *The Australian Wine Research Institute* has relevance as a paradigm for the aquaculture industry.

While recognising the significant value of basic curiosity driven research, a more substantial proportion of available funding should be earmarked for 'commissioned research'. Outcomes should be defined by a representative 'industry priority reference group' informed by an agreed industry plan and opportunities that new scientific developments provide. In most cases, researchers must make industry aware of such developments and new research projects should be formulated through an informed dialogue with the research community.

The developing aquaculture industry will be critically dependent for its competitiveness and sustainability on private and public R&D investment. Given significant potential for aquaculture, industry participants must jointly with government enhance funding to attract and retain the best researchers. Planning must address the issue of an industry wide levy, and of how government sets priorities for investment in industries yet to attain a critical mass and level of cohesiveness sufficient to fund their own R&D.

With increasing demands on the aquaculture industry to be internationally competitive, improve ecological sustainable development and improve fish health management, there is a corresponding demand for large-scale R&D projects. Undertaking large-scale R&D is usually out of reach for individual producers or research providers. Examples of large-scale R&D, which could greatly benefit the Australian aquaculture industry, are the development of low impact production systems, development of alternative and economically viable feed sources, propagation in new areas of southern bluefin tuna and

prawns, and cultivation of rock lobster. Success in these endeavours could potentially lead to the aquaculture industry far surpassing the 2010 target of $2.5 billion annual sales.

(4) Enhance Industry Uptake and Commercial Outcomes of R&D

A business model tailored to the commercialisation of aquaculture research outcomes is central to success. The 'development' side of R& D is highly relevant to firms.
Government has a role to play in aiding the linkage between researchers, graduates and industry by ensuring that appropriate mechanisms and incentives are implemented to build strong links between funding bodies, research providers and industry.

Recipients of government funding need to be encouraged to play a greater role in the promotion of research findings to the wider industry and community. Such a commitment will show the value of R&D and demonstrate the benefit to the whole aquaculture industry.

Options for improving this include:

- A clause in government funding applications that there will be a demonstrated element of "greater-good" to come out of the research;
- Development of a yearly national workshop series for researchers to "showcase" their research to industry and other interest groups;
- Involving industry and researchers more effectively in contributing their knowledge and experience to research priority setting;
- The establishment of strategically placed demonstration farms; or
- An acknowledgement by various research agencies that promotion criteria should include a strong 'industry impact/connectivity' criterion.

(5) Promote Learning and Education

Successful innovation systems depend on three core ingredients:

- Availability of resources to conduct R&D;
- Effective communication of the outcomes of R&D; and
- A workforce able to take up research findings and then critically evaluate, adapt and further enhance outcomes of R&D within individual firms.

The aquaculture industry needs the right mix of skills and knowledge to achieve its potential. Partnerships will need to be created, involving those in education, research, business and government. Some of the issues discussed in this section have been identified through the recent industry consultation process for the Aquaculture Action Agenda and have previously been discussed in a PMSEIC Occasional paper on innovation in the wine industry.[48]

It is well beyond the scope of this paper to review in detail the strengths and weaknesses of current educational offerings and technology diffusion models for the aquaculture industry other than to observe the need for the industry to undertake a review of this area in relation to strategic industry plans. Long term, industry's failure to engage

[48] The Australian Wine Industry, Occasional Paper Number 3, PMSEIC, 26 November 1999.

strongly with the education system through a coordinated approach will equate to lost opportunities for sustainable and competitive growth.

Australia now has more than 20 institutions, including TAFE colleges, universities, fisheries colleges and other registered training organisations offering aquaculture specific courses or units in aquaculture. These facilities span many of Australia's vital aquaculture hubs. As the industry grows and employment opportunities are enhanced, there will be a tendency for more institutions to establish aquaculture related programs. Given the finite pool of resources and teaching talent available, the industry should carefully consider whether a proliferation of courses is in its best interest or whether a consolidation into fully resourced 'centres of excellence' is preferable.[49]

Those courses that best meet the industries' needs at all levels should be identified and access to these programs improved through the use of modern training, education and communication tools (i.e., internet and distance learning) as well as training scholarships.

Fundamental to this process is that networking between institutions, agencies and industry is improved. Improving linkages will reduce the time lapse between new knowledge and its application. It will ensure that graduates entering the industry are equipped with relevant knowledge of the most recent research and innovations.

The utilisation of a participatory approach to curriculum development is one option to assist in providing a balance of practical and theoretical approaches to train farmers and provide the industry with more skilful and innovative staff. The potential for the integration of competency based training, such as the *National Seafood Training Package*, into university qualifications should also be examined. Flinders University of South Australia is one example of where this is already occurring.

Despite many institutes now catering for aquaculture training, few boast adequate on-campus facilities (such as tanks and a demonstration hatchery set up). It is imperative that industry allows greater access to on-farm training and education (work placements) to ensure that graduates have a chance to experience the commercial reality of the industry and gain the appropriate skills and knowledge.

Programs such as the *R & D Start Graduate Scheme* administered through AusIndustry should also be considered as a means of allowing aquaculture businesses to grasp the new and rapidly emerging opportunities that exist. The R&D Start Graduate Scheme currently places graduates in industry with the aim of exposing them to commercialisation, to help raise awareness in business of the value of employing people with these qualifications, and build closer links with the university system. The importance of the aquaculture industry defining and articulating its needs for educational activities cannot be overestimated. This issue yet again brings the focus back to the need for a unified industry approach to further development.

[49] Cooperative arrangements exist across universities for teaching in the earth sciences, and also in wine production, which may be models for aquaculture teaching. In oenology, The University of Western Australia (UWA) and The University of Adelaide (UA) provide a joint degree, with students enrolled in a dually badged four year degree, spending three years at UWA and one year at UA. This allows UWA to offer WA students an oenology education but takes advantage of the infrastructure and specialist oenological teaching staff of the UA Waite Campus. In earth sciences, several Australian universities engage in a cooperative teaching arrangement.

6 RECOMMENDATIONS AND CONCLUSION

The potential for aquaculture as a global growth industry is undisputed. Aquaculture remains a young, emerging industry in Australia, and, in the view of the working group, if managed well, holds very substantial promise for growth in economic returns and for growth in employment in regional areas. Australia has geographical advantages that can ensure expansion not possible in many other parts of the world, but such expansion should only occur if undertaken within a framework addressing substantial environmental and ESD issues associated with aquaculture production.

In the view of the working group, the example of the aquaculture industry presents an interesting parallel to the wine industry prior to its strong export growth in the early 1990s. The initiatives necessary to succeed are cultural, organisational and SET related.[50]

The present paper contains a relatively detailed but by no means all-encompassing analysis of aspects pertaining to development of the Australian aquaculture industry. Based on this 'big picture' analyses, the working group formulated four recommendations, which in its view must be addressed to realise the aquaculture industry's growth potential.

Finding – A young, emerging industry, which lacks industry unity and will benefit from economies of scale

One of the major problems in the Australian aquaculture industry is the diversity of production systems and spread of resources, with over 70 species (ranging from seahorses, tuna and rock lobsters to pearls) under development. Such diversity of activities is evident both in the commercial sphere and in the R&D arena. Limited available resources would be better concentrated on far fewer species at this point in time but it appears that the mechanisms to ensure such an outcome do not exist. Communication with markets, government, R&D providers etc is not as effective as it should be and industry-wide strategic planning is difficult to achieve.

Recommendation 1: Strengthen national peak body activities.

That the multiple aquaculture industry stakeholders with initial administrative and financial assistance from Government strengthen national aquaculture peak body activities to form collective views and actions relating to a sustainable development and conduct of the Australian aquaculture industry.

The peak body would formulate policy and priorities, related to:

- efficient communication and promotion;
- resource access, environmental concerns and ecologically sustainable development;
- risk management;

[50] Many of these issues have been picked up by others in parallel activities including the significant effort that currently is put into the development of an aquaculture action agenda by the aquaculture industry and Federal Government through the National Aquaculture Development Committee. The Australian Seafood Council, The Australian Aquaculture Forum and The FRDC are also formulating views in respect of aquaculture.

- adoption of best practice, and consistency, across the States and Territories;
- uptake and implementation of measures to enhance aquatic animal health;
- provision of a one stop shop for information on the regulatory, planning and management framework for aquaculture;
- formulation of national aquaculture R&D priorities and their communication to research providers;
- fostering of innovation;
- attracting sound investment to the industry; and
- export promotion through label integrity programs and brand building similar to that seen for other successful export commodities.

Finding - Approval processes and the operating environment can be improved.

A major impediment is the plethora of government instrumentalities (local, State and Federal) with which prospective aquaculture operators must interact. There was also concern about the uncertainty new operators were facing during start-up and planning phases due to the lack of uniform guidelines/laws relating to aquaculture.

In parallel with the development of a unified aquaculture industry body (recommendation 1) as a portal for the formulation and communication of collective views as well as negotiation with government/regulatory authorities, there appears to be a very good reason to develop an operating environment in which government instrumentalities establish nationally consistent guidelines for management and development of aquaculture. Where possible, one-stop interfaces between industry and regulatory authorities should be put in place. This could for instance happen by accreditation of State/Territory Government processes, provided they comply with relevant Commonwealth acts (eg the *Environment Protection and Biodiversity Act 1999).*

Recommendation 2: Streamline the operating environment.

Through the *Primary Industries Ministerial Council*, the Commonwealth, State and Territory Governments[51] should seek to streamline the industry's operating environment by developing transparent and nationally consistent management, development and approval guidelines/policies that can be readily managed.

Elements of these guideline and policy areas include:

- resource access;
- a national plan for aquatic health including import and quarantine issues;
- ecologically sustainable development and business conduct;
- governments' role in generic branding and promotion of Australian aquaculture products;
- regional management planning and approvals framework;
- environmental monitoring criteria and requirements;
- use of antibiotics and pesticides in aquaculture; and
- wildlife management (dolphins, seals etc).

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[51] State and Territories Governments plan, manage and regulate aquaculture on a day to day basis.

Finding - Research and innovation effort can be better focussed through coordinated industry R&D planning and funding allocations.

The working group noted that the efforts of scientists and funding agencies in the past have been of great benefit to the industry. It was considered that current practices in funding allocation and project design often are conducted in a 'bottom up approach' where researchers will put forward a well intentioned research proposal for funding without sufficient guidance of prevailing industry research needs and priorities. For example, through various R&D bodies, research on many marine species is conducted although a proportion of these, from a 'business planning' perspective, perhaps could be considered not worth researching. It appears that at least a part of available funding should be earmarked for 'commissioned research' with output targets defined by a representative industry reference group, informed by an industry plan.

Notwithstanding the significant research funding being allocated to aquaculture research relative to the size of the industry, the working group was further concerned about the manner in which a fledgling industry, with high potential, can gain access to researchers of high quality and fund sufficient research in its formative years, while a sector-specific industry contribution to R&D is relatively low. This dilemma is further underscored by research organisations increasingly having to earn their funding from sources external to government. While this practice has significant merit, it can favour investment in well-established industries with streams of research funding while discouraging investment in fledgling industries of the future.

Based on detailed planning and growth scenarios, the industry must ensure research priorities are defined in a robust and strategic fashion and that the research agenda in a large part is determined by these priorities through appropriately constituted and run 'industry reference priority groups'. A focussed and sustained research agenda is needed for new and embryonic research industries. Given the significant potential of aquaculture, industry should jointly with government not only secure present funding but further enhance this to attract the best research capacity. The means by which this is done must address the issue of an industry wide levy, perhaps modelled on the prawn industry R&D levy, and how government sets priorities for investment in emerging industries which have yet to attain a critical mass sufficient to fund their own research to capture opportunities of national benefit.

Recommendation 3: An industry levy and Government contribution.

It is recommended that, following development of industry R&D priorities and actions as drivers, for each and all sectors of the industry a compulsory minimum levy of 0.25% of GVP be introduced. The Commonwealth Government should maintain its current commitments and extend these to the newly emerging aquaculture sectors.[52]

The introduction of the levy based on GVP would account for the needs of different aquaculture sectors, and secure finances to address R&D issues, including:

- attracting the best, most durable and most appropriate R&D provision for an industry in its formative stages;

[52] Tuna, salmon, prawn and many other sectors already contribute production levies for R&D.

- identifying and expand the farming of fish species in which Australia has a comparative advantage;
- reducing dependence on fishmeal and fish oil production;
- developing environmentally sustainable production systems;
- decreasing dependence on wild stock through application of genetics, biology, and husbandry developments;
- evaluating potential for restocking and reseeding fish populations;
- monitoring international developments; and
- collecting statistical information and associated research that facilitate market access.

Finding: Need to increase collaborative R&D.

Australia has a very strong SET base but with expertise and complementary capacity often spread across institutional boundaries. In parallel with the further development of focussed research priorities, alliances between research funding programs and research providers also need to be identified to secure critical mass and avoid duplication of effort. Increased communication between funding programs would help to ensure that only the best research ideas are supported and that fewer but more robustly funded 'centres of excellence' can be supported. Examples of current collaboration include that between CSIRO, AIMS, Australian Prawn Farmers Association, Queensland Department of Primary Industries, and industry on prawn research; and the collaborative effort through the *Sustainable Aquaculture of Finfish CRC* (Aquafin CRC) on salmon and tuna research.

Recommendation 4: Fostering scientific collaboration.

Encourage greater focus, wider collaboration and synergy amongst R&D providers on key research topics, with science agencies such as CSIRO and AIMS taking a leading national role in concert with other relevant bodies such as the Aquafin CRC. An example is provided by the collaborative research project to domesticate the black tiger prawn, where contributing organisations each bring their own special skills and perspectives to the project. Organisations or bodies that encourage efficient and cost effective collaboration, networking and coordination of research efforts between agencies are to be commended.

Conclusion

Against the background of a growing world population, static levels of wild catch fisheries, an increasing recognition of seafood as part of a healthy diet and growing affluence amongst the populations of some key export markets, further development of our aquaculture industry in the view of the working group represents an enormous opportunity for Australia. Implementation of the recommendations above and a joint partnership of industry and governments towards ecologically sustainable development and genuine environmental stewardship will realistically contribute to:

- high value export of seafood and pearls;
- employment and growth opportunities in regional Australia;
- export of environmental technologies and know how; and
- availability of a healthy and stable food source for Australians.

APPENDIX 1

SWOT Analysis

Some characteristics of the Australian aquaculture industry have been broadly described in the sections above. Further to this, the working group considered it useful to tabulate its perceptions of the industry's strengths, weaknesses, opportunities and threats (SWOT).

STRENGTHS	WEAKNESSES	OPPORTUNITIES	THREATS
Strong export seafood markets developed	Fragmentation	Industry vision	Pollution and environmental backlash
Land & water resources	Slow start-ups	National planning	Feed costs and shortfall of supply
Science, Engineering and Technology base	Low Investment	Strategic R&D direction setting and priorities	Foreign fish diseases and lack of registered treatment agents
	Lack of specific animal husbandry knowledge	Learning and education	Lack of research and innovation
	Lack of site knowledge	Luxury seafood demand	Weakening overseas markets; foreign competition
	Lack of industry skills related to fish health and disease	Use of inland saline groundwater	Land and water resources could be allocated for other uses, eg marine parks, coastal developments, commercial and recreational fishing
	Scale	Action Agenda implementation	

Table 2: Summary of SWOT Analysis on Australian Aquaculture

Strengths:

International Trade - Australia has established expertise in the sale and delivery of seafood into premium world markets. Thus live product (e.g., Kuruma prawns and coral trout) is delivered by air to local and overseas markets. In the longer term, synergies between marketing of individual export commodities could release further potential.

Natural Resources - Australia has access to natural marine, estuary river and aquifer ecosystems.

SET Base - Australia has access to a science, engineering and technology base of very high calibre and expertise.

Weaknesses:

Fragmented - The industry is fragmented, with around 70 species cultivated or under development. Leadership is needed to form a whole of industry approach to planning, promotion, information sharing etc. These issues are being addressed through the proposed *Aquaculture Action Agenda*, but a recommendation for an industry government partnership in this regard is warranted.

Red tape - A lengthy and often unpredictable approval process exists for the start-up of new enterprises in some states. A one-stop shop approach of governments to regulatory matters would expedite matters.

Investment gap - A lack of tax-incentives exists to attract investment in this young industry. There are still relatively few successful enterprises that have overcome the obstacles to provide inspiration to others.

Husbandry technologies - A lack of specific knowledge on the economics and suitability of individual species and appropriate husbandry techniques (including unique native species) for Australian conditions due to the lack of research intensity and focus

Site assessment - A lack of knowledge about the suitability of Australian sites for specific aquaculture purposes. A natural resource mapping plan coincident with aquaculture zoning would help guide aquaculture site selection and facilitate approval processes.

Threats:

Ecologically unsustainable practice – Unsuitable husbandry practices would ruin the industry's reputation as a whole. With a flow on effect to other exported Australian products and services

Feed prices - A production cost blow out due to a shortage in supply or an increased demand for fish oil and fishmeal feed products would affect profitability of high value species in Australia.

Fish disease - Introduction of 'new' diseases through mechanisms such as feed importation, ballast water release.

R&D support - A future lack of critical mass and quality in R&D provision and funding.

Market collapse - Adverse external economic developments such as a collapse of the economies in target markets (eg Japan) and unfavourable exchange rate developments.

International competition – aquaculture may expand, such as salmon farming has in Europe.

Opportunities:

Vision - Develop a whole of industry shared vision for future development. This would incorporate market and competitor analyses. It would advocate the desirability of seafood as stable component of a healthy diet. A clear and strategic R&D strategy focussed on outcomes would be highlighted. It would outline desirable taxation and depreciation arrangements for the industry to thrive.

Good Manufacturing Practice (GMP) – This would be a code of practice for new industry entrants, and enhance the image of the industry nationally and internationally. Its elements would be incorporated in marketing produce. The 'Code of Conduct'

published jointly by the *Australian Aquaculture Forum,* FRDC and *Environment Australia* is an indication of what is needed in future.

Government(s)–Industry Interaction - Discussions to develop tools to ease the development of the industry, including a national plan for resource mapping and an Action Agenda.

The considerable activities and detailed forward planning by the FRDC is noted and commendable. However, further planning with Government is needed to put in place a national R&D funding model which serves to utilise the totality of aquaculture R&D funds in an optimal manner and through this to attract the best, most durable and most appropriate R&D support for an industry in its formative stages. The R&D effort would aim to identify and expand the farming of fish species in which Australia has a comparative advantage; reduce dependence on fishmeal and fish oil production; develop environmentally sustainable production systems; decrease dependence on wild stock through application of genetics, biology, and husbandry developments; evaluate the potential for restocking and reseeding fish populations; benefit the industry by monitoring international developments.

Learning and education - The development and implementation of appropriate educational strategies including a mapping of the need for geographical distribution of educational providers; the required core elements of courses; the mode of delivery and types of courses (TAFE, undergraduate, postgraduate research, postgraduate coursework, short courses, industry conferences to instil a culture of innovative thinking and behaviour).

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APPENDIX 2

National Statutory R&D Levy for the Australian Prawn Farming Industry

Australian prawn farming comprises around 45 active prawn farms in Queensland, New South Wales, Western Australia and the Northern Territory, serviced by 8 feed suppliers. Gross value of production at farm-gate (GVP) was around $50 million in 1999/2000. The industry is growing at a compound rate of approximately 12% per year. GVP is expected to reach $200 million by 2010. The industry currently provides some 600 direct jobs and 1800 indirect jobs.

Without a comprehensive research program the industry realised it would be unable to develop further, nor would it be able to compete with improved overseas technology. It also realised that it was too dependent on government R&D funding and lacked control in setting R&D priorities.

Prior to implementation of a national statutory levy, prawn farming R&D was funded through voluntary contributions from APFA and State, Northern Territory and Commonwealth Governments. Prior attempts by the prawn industry to increase voluntary contributions had failed, largely because the industry lacked the tools and resources to put in place a suitable and equitable mechanism for collecting, managing and disbursing R&D funds.

Implementing compulsory collection of a prawn farm R&D levy was not an easy task and required a number of factors to bring it about. One of the driving factors was the need for R&D in prawn health and environmental management on farms. Further, other primary industries had well established levy systems for R&D support, while CSIRO and the FRDC were both threatening to reduce funding for prawn R&D unless industry contributed itself, and not just in the form of in-kind contributions. A vote at the Australian Prawn Farmers Annual General Meeting demonstrated over 90% support for the proposed levy and levy rate. Consideration may be given to this model to ensure that all sectors contribute fairly to R & D funding in the future.

A national statutory levy, collected by the Commonwealth Government has the following benefits over voluntary collection by state/territory government or industry:

- Administratively easier and cheaper than collection by states or industry.
- Everyone in the industry contributes.
- A national approach to R&D investment for the Australian prawn farming sector.
- A cohesive national industry managing shared R&D initiatives.
- New technology will be available to all industry members resulting in increased adoption.
- The capacity to commission long-term projects confidant that the ongoing funding required would be available for the life of the project.
- Industry's research and development direction set by the industry.
- All participants in the prawn farming industry, governments and community can share and build on the outcomes of prawn farming R&D.

Consultants were engaged by APFA to identify options for increasing industry funding for R&D. Three industry surveys were conducted in 1998, 1999, and 2000 to determine industry views to the intended implementation of a national statutory R&D levy. The national industry surveys addressed the issues of a statutory R&D levy, its implementation mechanisms and collection rate.

The outcomes of the surveys and consultants recommendations were discussed at length at the APFA Annual General Meeting on 30 July 2000. At the meeting, APFA members agreed that government could no longer be expected to invest in the industry, if the industry was not willing to invest in itself. The APFA identified support for a compulsory levy based on annual prawn production tonnage.

> "The levy will help raise up to $500,000 annually for investment in prawn aquaculture R&D. In collaboration with Fisheries Research & Development Corporation, industry will direct funding to a number of core areas as outlined in the APFA Research & Development Plan 2000-2005." - Martin Breen, APFA.

The Fisheries Research and Development Corporation (FRDC) is responsible for administering funds collected under the national statutory R&D levy. Prawn farmers and the FRDC determine R&D priorities annually. This ensures that industry and public funds are properly targeted toward sectoral needs and that R&D is relevant, dynamic and strategic. Under the *Commonwealth Authorities and Companies Act 1997*, both APFA and FRDC are accountable to the levy payers and the Commonwealth for the funds invested.

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