INLAND AQUACULTURE IN WESTERN AUSTRALIA

Establishing an aquaculture operation

Overview and licensing

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Government of **Western Australia**
Department of **Fisheries**

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Government of **Western Australia**
Department of **Agriculture and Food**

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1.0 INTRODUCTION

1.1 Aquaculture in Western Australia

Aquaculture is one of Australia's fastest growing primary industries and, with the exception of the pearl oyster (*Pinctada maxima*) sector, the gross value production of aquaculture in Western Australia (WA) has shown a growth trend over the last ten years to 2011 – 12. In both the marine and inland environments there are currently 470 active aquaculture licence holders, 39 per cent of which are focused on freshwater marron farming, generating $1.5 million per annum. Other significant inland aquaculture productions involve the production of yabbies and finfish species including silver perch and rainbow trout.

Inland aquaculture opportunities are continuing to increase in response to improved infrastructure and service capacity, improved technology, increased production capability and more secure markets.

The Department of Fisheries (Department) is continuing to improve the efficiency and transparency of the regulatory assessment processes for prospective aquaculture ventures, and is in the process of implementing initiatives to increase competitiveness and attract private investment for some larger-scale aquaculture proposals. Support provided by the Department, particularly in areas such as fish health, has contributed to the growth of the industry, which will be underpinned by a secure and informed policy platform to facilitate future growth.

1.2 Western Australian bioregions

To manage and conserve the aquatic (marine and freshwater) environment, the Department uses an Ecosystem Based Fisheries Management (EBFM) framework, based on Ecologically Sustainable Development (ESD) principles. The EBFM arrangements divide WA into six specific bioregions, the boundaries of which are broadly determined by common physical features and climatic processes. The bioregions are South Coast; Southern Inland; West Coast; Gascoyne Coast; North Coast; and Northern Inland.

This document relates to freshwater aquaculture in the Northern and Southern Inland bioregions.

Southern Inland Bioregion

Aquaculture in the Southern Inland Bioregion predominantly involves marron production in purpose-built ponds. Annual production rates are about 50 – 60 tonnes with a gross value of approximately $1.5 million. Yabbies are also seasonally produced in farm dams, subject to rainfall, and annual production can reach up to 200 tonnes.

In recent years there has been an increasing interest in finfish aquaculture.

Northern Inland Bioregion

There is currently little aquaculture activity in the Northern Inland Bioregion because of limited rainfall, with the exception of a focus on Lake Argyle, a large, permanent water body considered to have some aquaculture potential. Between 1994 and 2004, Lake Argyle was the site of a barramundi aquaculture operation.

1.3 Scope

Relatively high prices and market opportunity can make aquaculture enterprises appear superficially attractive; however, before making any investment decision, it is important to undertake adequate research based on the best available information to ensure all potential environmental (including biosecurity, climate, suitability of fish species, suitability of site), logistical (including access, infrastructure, food and water requirements) and economic (short and long-term viability) matters are identified early in the planning process.

This paper identifies some of the important factors that need to be considered before undertaking and/or investing in an inland aquaculture enterprise. It assumes suitable land is available to develop an aquaculture project.

2.0 SITE SELECTION

Selecting an appropriate site for the aquaculture operation is critical to a successful operation. Key issues to consider include an adequate and consistent water supply, suitable soil and climatic conditions, and adequate infrastructure.

2.1 Water requirements

An adequate supply of suitable-quality water at the site is a critical component of any aquaculture operation. Water quality can be influenced by climatic conditions including temperature (annual range), wind and humidity. Both water quality and quantity have a direct bearing on what fish species can be grown at a particular site.

Testing for a number of parameters is necessary to develop an understanding of the water quality at the site. Testing can also help determine the suitability of particular fish species for aquaculture, or alternatively, identify management arrangements required to determine remediation actions to optimise a successful operation. These parameters include:

- annual temperature range (°C);
- pH (pH units at 25°C);
- conductivity (MS/m at 25°C);
- salinity and total dissolved salts (by evaporation after micro-filtration – sampling programs should include testing during the middle or end of summer;
- cations – sodium, potassium, calcium and magnesium;
- anions – chloride, bicarbonate, carbonate and sulphate;
- heavy metals – copper, iron (dissolved iron flocculated after aeration), zinc; also check pond soil for leachable copper and zinc (do not analyse destructively);
- cadmium – often a contaminant in fertilisers;
- toxic metabolites – hydrogen sulphide, ammonia nitrogen, nitrate nitrogen and nitrite nitrogen;
- turbidity;
- productivity – calcium – total hardness, total alkalinity;
- gases (in situ, specify the temperature) – dissolved oxygen and dissolved nitrogen; and
- pesticides, in particular DDT and Dieldrin.

Temperature and salinity conversion tables are included in Appendix 1.

Careful thought also needs to be given as to how water supply will be maintained. This will be determined by the nature of aquaculture operations and species to be produced. Options include:

- Raceway and tank systems – require a continual supply of clean water but have the potential to produce relatively high quantities of fish per unit area under more intensive conditions;
- Ponds – require the least amount of water as loss is from evaporation only, but stagnation can be an issue. Production volumes are generally lower because systems are mainly semi-intensive or extensive; and
- Recirculating systems – require only small amounts of water but must maintain good water

quality. These systems are usually intensive and characterised by high production volumes per unit area.

Appendix 2 provides a detailed summary of a variety of different forms of aquaculture systems.

2.2 Soil suitability

Details of soil characteristics of inland WA can be obtained at local offices of the Department of Agriculture and Food WA. These maps should be used as a primary source of information as they are often broad scale. A more detailed site-specific survey is also recommended, to determine the suitability of the surface and subsurface of the site for pond construction, compaction and seepage properties, and site topography (contours). Soil at the site should also be tested for pesticide residue, particularly if the area was once used for agricultural purposes.

2.3 Infrastructure requirements

A functional aquaculture site is likely to require infrastructure and services that include (but may not be limited to):

- accommodation;
- workshop(s);
- processing facility and feed silos;
- water supply, discharge and treatment systems;
- vehicle access;
- power supply (including back-up) and support poles for overhead pond covers;
- ponds constructed by a qualified earthmover experienced in aquaculture; and
- room for future expansion, for example, grow-out ponds, additional water storage.

3.0 SPECIES SELECTION

The decision on which fish species is to be grown will be determined by the compatibility of the biological requirements of the fish and the physio-chemical characteristics of the site, as discussed in Section 2 above. The selection of compatible species will also have a direct bearing on operating costs and the overall successful financial outcome of any project.

A list of species potentially suitable for small to medium inland aquaculture operations is provided below, together with a brief summary of individual species requirements. The list is not intended to be exclusive or extensive in terms of the requirements for each species, but is provided as a starting point for consideration. Further information on several of the species listed below can be found on the Department's website.

Further research into the suitability of particular species and the resources and knowhow needed for their successful production is highly recommended.

Note: Any aquaculture venture that proposes the culture of non-native finfish or crustaceans requires translocation approval from the Department to ensure potential impacts on native freshwater fish and fish habitat are minimised.

3.1 Candidate species for inland aquaculture

3.1.1 Barramundi

Background:

Barramundi or Asian sea bass (*Lates calcarifer*) are native to the Indo-Pacific region and northern Australia. They are caught commercially and also produced by aquaculture. Normally grown in marine systems, barramundi can also be grown in fresh water and are amenable to high-density production in recirculating systems.

Characteristics:

Barramundi is an estuarine species of the perch family, which can grow up to 2.5 m in length, live for 20 years and weigh more than 50 kg.

Requirements:

Barramundi have a salinity tolerance of 0 – 40‰ (parts per thousand, or grams per litre) and a temperature range from 16° to 35°C. They are catadromous fish, which means they usually migrate from fresh water to saltwater estuaries to spawn, and prefer slow-moving water in rivers, creeks, swamps and estuaries. They can also be found in the nearshore marine environment, where they congregate at river mouths, offshore islands and reefs.

Considerations:

- hardy, fast-growing and regarded as a good table fish;
- highly fertile (a single female may produce 30 – 40 million eggs per spawning); and
- can be grown successfully in fresh and saline water (growing the species at higher temperatures can produce 500 – 800 g fish within 12 months and 2 – 3 kg fish within 18 to 24 months).

3.1.2 Bream

Background:

Pikey bream (*Acanthopagrus berda*) and black bream (*Acanthopagrus butcheri*) are hardy silver

to olive brown estuarine finfish species native to south-western Australia, which are known to survive in salinity or temperature extremes that would kill other finfish species.

Characteristics:

Juvenile bream tend to inhabit shallow waters while adults can be found in the bottom of deep pools in most WA rivers as far north as the Murchison River.

Requirements:

The salinity range is between 3 – 40‰, with optimal range of 10 – 35‰, and the fish complete their entire life cycle within an estuary.

Considerations:

- can survive changes from fresh water to hypersaline (highly salty) water;
- grow to about 60 cm and 4 kg; and
- are related to many highly regarded table fish such as tarwhine (silver bream), snapper (pink snapper) and western yellowfin bream.

3.1.3 Marron

Background:

Two species of marron are known to co-exist and probably interbreed in south-west WA:

Cherax tenuimanus: the critically endangered and protected hairy marron not suitable for aquaculture; and

Cherax cainii: the more common smooth marron, suitable for aquaculture.

Marron are a highly regarded and high-value product. Smooth marron has been successfully cultured on a small scale in south-west WA for many years.

Requirements:

Marron have been known to survive a salinity range of 0 – 15‰ and a temperature range between 4° and 30°C (the optimal temperature range is between 20° and 24°C).

Considerations:

Marron require a constant water supply, which can be problematic in many areas during the drier summer months.

The Marron Growers Association, which represents most marron producers in WA, can be contacted at:

Marron Growers Association of WA
PO Box 464
Northcliffe WA 6262
T: (08) 9776 6331

3.1.4 Rainbow trout

Background:

Rainbow trout (*Oncorhynchus mykiss*), also known as steelhead or salmon trout, is a salmonoid species occurring naturally in the Pacific Ocean in Asia and North America. Not native to Australia, the species was introduced into WA inland waterways for food and sport following

European colonisation.

Requirements:

Rainbow trout can tolerate a salinity range of 0 – 35‰ and a temperature range of 2° – 29°C.

Considerations:

Trout are well suited to inland aquaculture in cooler areas, but can present a translocation risk in areas where they have not yet been introduced and have the potential to out-compete native fish species. As trout is a non-native fish, any aquaculture proposal for trout will require translocation approval.

3.1.5 Ornamental fish

Background:

Ornamental fish is a broad category that includes many different tropical and sub-tropical fish species, including koi, goldfish, other various carps and cichlids. In Australia the ornamental fish trade is estimated to be worth $350 million annually.

Considerations:

Ornamental species are highly tolerant of a wide range of environmental factors and therefore well suited to aquaculture. However, marketing considerations are important. Most ornamental fish are non-native and present a significant risk to native fish in inland WA waterways. Any ornamental fish aquaculture proposal would require translocation approval and be subject to strict conditions to reduce the chance of escape.

3.1.6 Silver perch

Background:

Silver perch (*Bidyanus bidyanus*) is a freshwater fish of average size native to south-eastern Australia. Silver perch can grow to a length of 30 – 40 cm and a weight of 1.5 to 8 kg.

Requirements:

The average salinity tolerance is between 0 and 15‰. The average temperature tolerance is from 0° to 28°C. Silver perch are considered to be moderately fertile, with average egg counts around 200,000 to 300,000. Reproduction takes place at dusk or in the early hours of the night and offspring hatch within 16 to 24 hours.

Considerations:

- low-order predator eating invertebrates, small fish and some vegetative matter;
- usually spawns in late spring to early summer; and
- as silver perch is a non-native species, any aquaculture proposal will require translocation approval.

3.1.7 Yabbies

Background:

Yabbies (*Cherax albidus*) are freshwater crustaceans similar to marron and gilgies. Deliberately introduced from eastern Australia, they are found mostly in streams, brooks, dams and generally wherever there is fresh water and shelter.

Requirements:

Yabbies cannot tolerate highly polluted water but adapt well to dams with stock access. Yabbies feed on detritus (animal and plant), and can endure salinity levels of between 0 and 12‰ and temperature levels between 2° and 36°C.

Considerations:

- well suited for growing in farm dams, which can produce sustainable 'wild' populations;
- yabby aquaculture is not permitted west of the so-called 'yabby line' (generally west of Albany Highway) to help minimise the potential impacts on native marron populations;
- separation of male and female yabbies during grow-out periods can lead to increased yields and larger, single animals;
- activity significantly decreases in cold winter months, so where possible harvest should occur in warmer months; and
- proponents east of the yabby line do not need an aquaculture licence to farm yabbies but must sell to holders of aquaculture, trapping or processing licences only.

3.1.8 Murray cod

Background:

Murray cod (*Maccullochella peelii*) is a freshwater fish native to eastern Australia. They are considered excellent table fish and generally have good market demand and relatively high value, particularly for whole fish.

Requirements:

Murray cod have a preferred temperature range of 20° – 25°C and a salinity tolerance of below 8‰. Under optimum conditions Murray cod can reach a market size of between 600 g and 1.3 kg within 12 to 18 months. An average recirculating system can grow the fish at densities of 30 – 40 kg/$m^{3.}$

Considerations:

As Murray cod is a non-native species, any aquaculture proposal will require translocation approval. Where it can be grown under an appropriate biosecurity regime, Murray cod is a candidate species for inland aquaculture in WA.

4.0 FISH HEALTH AND DISEASES

4.1 Parasites

Parasites are part of any normal healthy aquatic ecosystem; however, high concentrations of fish in aquaculture facilities have the potential to significantly increase parasite activity, which can result in fish health and management problems. It is therefore essential that regular monitoring of fish stock is undertaken, with a view to early detection. Timely and effective treatment is vital.

4.2 Pathogens and disease

Pathogens, which include viruses, bacteria and fungi, have the potential to devastate an aquaculture operation if an outbreak occurs. From a fish health perspective, it is critical to ensure disease prevention and mitigation strategies are in place. Common pathogens affecting a number of WA fish species include Viral Nervous Necrosis (VNN), Big Belly Disease and Iridovirus.

Poor nutrition and management and/or unsatisfactory water quality is frequently responsible for facilitating disease outbreak in intensive aquaculture systems. Importing fish, including brood stock, without appropriate health certification and quarantine processes also increases the risk of disease outbreaks.

There are several ways to reduce the risk of introducing diseases when importing fish for aquaculture, several of which are commonly applied through the Department's aquaculture licence conditions (See Section 5.1). Relevant licence conditions may include:

1. Testing fish health before importation and obtaining a health certificate from an accredited body.
2. Keeping newly imported stock in quarantine for a specified period (subject to fish health specialist advice). Wherever possible, brood stock should be sourced from accredited hatcheries or breeding facilities.
3. Separating adult and juvenile brood stock as soon as possible.
4. Accounting for all imported fish stock (dead or alive) intended for aquaculture to minimise the risk of disease spread (and escape) into adjacent natural waterways. Dead animals must be frozen and/or preserved to allow for testing as deemed necessary by the Department.

Any unusual deaths or the sudden unexpected death of large quantities of fish can be considered a 'fish kill' and must be reported within 24 hours to the Fish Health Section of the Department of Fisheries (T: (08) 9368 3357).

A fish kill report must contain:

- the name of the species affected;
- an estimate of the number or biomass of dead aquatic organisms; and
- details of any external factors that may have contributed to the deaths; for example, power failure or extreme weather conditions.

Further information on fish health reporting requirements can be obtained on the Department's website. Appendices 3 and 4 provide further information on common diseases and the use of chemicals for aquaculture facility disinfection and cleaning options.

5.0 LICENSING AND APPROVAL REQUIREMENTS

All commercial aquaculture activities require a licence from the Department (see section 5.1). In some instances approval from other State agencies for proposals on private (freehold) land may also be required. These include:

- Department of Water (DoW) – for example, in protected water or water supply catchments; in the event that a ground water or surface licence is required (bore, stream diversion or dam) (see Section 5.2).
- Department of Environment and Conservation (DEC) – for example, in areas deemed to have high conservation value, or for projects involving the clearing of native vegetation (see Section 5.3).
- Environmental Protection Authority (EPA) – if the proposal is considered, if implemented, to have a significant potential impact on the environment (see Section 5.3).
- Local Government – consistency with local town planning schemes and relevant by-laws, building and associated infrastructure and dam permit requirements.

5.1 Department of Fisheries approvals

Aquaculture licence

Under s.90 of the *Fish Resources Management Act 1994* (FRMA), if a person intends to keep, breed or culture fish for commercial purposes, an aquaculture licence is required to ensure that, among other things, the activities being carried out do not adversely affect other fish or the aquatic environment; are in the interests of the aquaculture industry; and have been approved by other relevant authorities.

It is important to note that land-based aquaculture proposals involving the construction of a shed or building may require other approvals, such as a DEC permit to clear native vegetation, or building and planning permits from Local Government authorities. Some land-based aquaculture operations may also require approval from the Department of Water for water supply or disturbance of streams and banks (see Sections 5.2 and 5.3).

Once the appropriate approvals from other agencies have been obtained, an 'Application for an Aquaculture Licence' form should be completed together with details of the relevant species to be cultured and method of culture. The completed form and relevant application fee must be submitted to the Department.

All licence holders are required to submit production returns to allow for the Department to compile production statistics and estimate the value of the industry.

All enquiries in relation to an aquaculture licence should be directed to the Department of Fisheries Licensing Section, 3rd floor SGIO Atrium, 168 St Georges Terrace, Perth WA 6000 (T: (08) 9482 7333; F: (08) 9482 7390).

Management and Environmental Monitoring Plan

The Department manages operational, compliance and enforcement activities associated with the environmental management of the aquaculture in Western Australia.

Potential environmental impacts of aquaculture in the marine and estuarine environment, and those on public property, are managed through a Management and Environmental Monitoring Plan (MEMP). These are required to be prepared under s.92A of the FRMA, and submitted

as part of an aquaculture licence application, unless the applicant is exempt under s.92A (4). Details of MEMP requirements are outlined on the Department's website via the following link, which will be updated as further information becomes available: http://www.fish.wa.gov.au/Fishing-and-Aquaculture/Aquaculture/Aquaculture-Management/Pages/default.aspx

A MEMP policy is being finalised, and will include a list of species that, if aquacultured on private land, may be exempt from requiring a MEMP. These so-called 'prescribed species' will likely be gazetted during 2013 and listed on the Department's website.

The introduction of MEMPs does not remove the requirement to refer an aquaculture proposal for assessment under the State *Environmental Protection Act 1986* or the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*.

Translocation and quarantine matters

If an aquaculture proposal involves importing into the State live, non-native fish species such as barramundi, rainbow trout, silver perch and Murray cod, then translocation approval is required to manage the potential spread of the non-native fish into adjacent waterways. The risks associated with translocating non-native fish into and within WA include disease transfer (to wild populations or cultured stock); habitat degradation; and reduced native fish biodiversity, due to competition, predation and loss of genetic diversity.

Authorisation to translocate fish may be provided through either a 'Translocation Approval' or a 'Translocation Authority'. Translocation Approval is generally issued for species considered lower risk or for which there are existing management plans or arrangements. To translocate fish that do not meet the criteria set for a Translocation Approval, a Translocation Authority, which involves a more detailed assessment process, may be required.

For further information on translocation requirements, please refer to: http://www.fish.wa.gov.au/Sustainability-and-Environment/Aquatic-Biosecurity/Translocations-Moving-Live-Fish/Pages/Applying-To-Translocate-Fish.aspx

5.2 Water approvals and licences

DoW requires proponents to seek written approval if the aquaculture proposal:

(i) necessitates the creation or use of a bore or soak;

(ii) requires stream diversion; or

(iii) is inside a declared catchment/water reserve area.

In assessing aquaculture proposals, DoW also takes into consideration the requirements of other water users, including water supply for irrigation and domestic use, as well as water-dependent flora and fauna (environmental water requirements).

Further information is available on DoW's website, or directly on T: (08) 6364 7600
F: (08) 6364 7601 or W: Atrium.Reception@water.wa.gov.au.

5.3 Environmental approvals

The development of an aquaculture facility may involve the clearing of native vegetation. It is the proponent's responsibility to determine if any land clearing is permitted under State law (through DEC) or the relevant Local Government Authority before any clearing takes place, and arrange the relevant permits.

The owner or occupier of any land in WA has a legal requirement to give written notice to the Commissioner of Soil and Land Conservation of an intention to clear native vegetation at least 90 days before clearing starts. This may include the removal of native vegetation, severing or ring barking of trunks or stems, or other substantial damage to the land including draining, flooding, burning, grazing of stock and any other similar activity.

If an aquaculture proposal is considered likely, if implemented, to affect the natural environment, the proponent is required to develop and implement a MEMP (see Section 5.1). Large-scale proposals with the potential to have a significant impact on the environment must be referred to the EPA for more detailed assessment.

6.0 GENERAL ISSUES

6.1 Logistics

Most aquaculture products require cool storage and refrigerated transport. Aquaculture operations should have access to these facilities and services. Certain buildings may also be restricted in their use under local council by-laws. This should be checked with the relevant Local Government Authority.

6.2 Neighbours

The potential impact of chemical spray drift, intermittent odour or noise, long-term noise, dust, smoke and ash as a consequence of an aquaculture proposal should be limited and be consistent with Local Government Authority by-laws and the *Code of Practice for the use of Agricultural and Veterinary Chemicals in Western Australia*, at http://www.agric.wa.gov.au/objtwr/imported_assets/content/pw/chem/cop_bulletin.pdf

Additional information on spray drift may be obtained from the website of the Aquaculture Council of WA at http://www.aquaculturecouncilwa.com/government-and-law/spray-drift

7.0 ECONOMIC MATTERS

7.1 Marketing

A successful commercial aquaculture business needs to have regard for market requirements and demands, and so produce goods and services that match the requirements of customers and the community in four main areas:

- The production of quality fish (market demand).
- The administration of the farm (including grow-out facilities, water supply, storage and transport logistics).
- The management of technology, husbandry, production and strategy of the business (including brood stock source, harvesting times, consistency of supply, communication strategies).
- The marketing of the product (establishing networks, advertising, adequate stock at peak times, transport, distance to market, storage).

Market research for an aquaculture business may involve activities such as attending field days, conferences, workshops and grower meetings, and talking to traders or contacting the Australian Trade Commission to determine market demands and constraints.

The Sydney Fish Market (www.sydneyfishmarket.com.au) provides valuable marketing information, such as the average price obtained for various aquacultured species at different times of the year.

Seafood quality and handling practices are of high importance and bring significant benefits if done correctly. These benefits include:

- producing a clean, good-tasting product;
- consumer satisfaction and the repeat business or increased turnover that it brings;
- word-of-mouth advertising or communication through happy customers; and
- high staff morale and motivation, as well as reduced management problems.

By subscribing to a quality assurance program, it is possible to obtain advice on how to grow, harvest, grade, package and transport the product. Further information on these programs and the Code of Practice for Aquaculture can be obtained from the Aquaculture Council of WA at:

Aquaculture Council of Western Australia Inc.
PO Box 1605, Fremantle WA 6959
56 Marine Tce, Fremantle WA 6160

T: (08) 9432 7777
F: (08) 9432 7700
E: eo@aquaculturecouncilwa.com
W: www.aquaculturecouncilwa.com

7.2 Business plans and budgets

Starting an aquaculture venture offers the prospect of profitable returns, but also involves an element of risk. It is therefore important to objectively evaluate the feasibility of a proposed project and its associated costs and likely returns through, as a minimum, a feasibility study

and business plan. The development of a sound business plan, supported by a realistic budget, will address these questions and serve as a blueprint to guide the running of the operation. A sound business plan should:

- demonstrate a sound understanding and availability of a profitable market;
- identify goals, milestones and timeframes;
- outline a realistic estimate of labour requirements and associated costs;
- facilitate the employment of adequately experienced and trained staff to deliver documented outcomes;
- be guided by relevant research into the soil, climate and water quality and quantity at the proposed site, to ensure suitable fish species are cultured;
- adopt relevant management and production arrangements to suit the particular fish species proposed to be cultured;
- outline accurate and realistic budget requirements (capital and operating costs), noting this is an essential requirement when seeking a loan or applying for grants or tax exemptions;
- identify a reliable and ongoing source of funds; and
- demonstrate an awareness of and understanding of the implications and requirements of required government approval processes and fees as necessary.

In respect of funding sources, it should be noted that there are few government grant schemes available for single commercial operations.

A realistic budget should:

- identify anticipated production costs, including depreciation of capital items or the cost and supply of good labour for harvesting, grading and packing (ideally located within 20 km of the property);
- allow for market price fluctuations; and
- anticipate how much money the business may have to borrow, peak periods, and when the project is anticipated to become sustainable (ie. break even). It should be understood that aquaculture projects do not usually have positive cash flow within the first or second year and require significant initial capital investment, for example, depending on the soil type and topography, the installation of a bottom draining pond could cost more than $100,000 per hectare.

A summary of potential logistical requirements and associated operational costs for consideration as part of a business plan are listed in Appendix 5.

For further information on establishing a small business, it is advisable to contact the Small Business Development Corporation on 131 249 (131 BIZ); or visit www.smallbusiness.wa.gov.au or www.business.gov.au.

8.0 APPENDICES

Appendix 1: Temperature and salinity conversions and calculations

Approximate conversions

µS/cm	mS/cm	mS/m	mg/L (ppm)	ppt	gr/gal	Comments
500	0.50	50	275	0.275	19	Very fresh water
1,000	1.00	100	550	0.550	38	Marginally fresh
1,500	1.50	150	825	0.825	58	
2,000	2.00	200	1,100	1.100	77	Dam water starts to go clear
3,000	3.00	300	1,650	1.650	116	
4,000	4.00	400	2,200	2.200	154	
5,000	5.00	500	2,750	2.750	192	
6,000	6.00	600	3,300	3.300	231	
7,000	7.00	700	3,850	3.850	270	Just able to taste salt in water
8,000	8.00	800	4,450	4.450	308	
9,000	9.00	900	4,950	4.950	346	
10,000	10.00	1,000	5,500	5.500	385	
15,000	15.00	1,500	8,250	8.250	578	Brackish
20,000	20.00	2,000	11,000	11.00	770	
30,000	30.00	3,000	16,500	16.50	1,155	Estuarine water
40,000	40.00	4,000	22,000	22.00	1,540	
50,000	50.00	5,000	27,500	27.50	1,925	
60,000	60.00	6,000	33,000	33.00	2,310	
65,000	65.00	6,500	35,750	35.75	2,502	Sea water

Calculations

- Multiply microSiemens per centimetre (mS/cm) by 0.001 to get (mS/cm).
- Multiply mS/cm by 100 to get microSiemens per metre (mS/m).
- Multiply mS/m by 5.5 to get mg/L or parts per million (ppm).
- Divide mg/L (ppm) by 1000 to get parts per thousand (ppt).
- Multiply mg/L (ppm) by 0.07 to get grains per gallon (gr/gal).

Appendix 2: Summary of different aquaculture systems

Types of aquaculture systems	Advantages	Disadvantages
Tanks	Light and inexpensive to build Moulded into varying shapes Size is only limited by expense Proven materials such as concrete and fibreglass High water flow and high stocking density	Injection of oxygen Usually permanent after built Requires circulation
Raceways	Can quickly treat diseases and harvest fish Tolerates high stocking densities	Requires large flows of water Needs to be well oxygenated Must have an effective way to collect waste
Recirculation systems	Water discharge and a constant water supply are not needed Extracted wastes can be used to produce a second plant-based product Tanks and raceways can be included in the system as culture chambers The only water losses are through evaporation and leakage The system filters and reuses most or all of a water source	High starting costs Requires large amounts of space Requires informed maintenance Cannot be easily moved from its starting location
Earth-based ponds	Easy to construct with a qualified bulldozer operator May provide a pre-existing food source Low maintenance and area requirements Mimics nature, producing a healthier product appearance Springwater ponds can house both cold-water and warm-water species together Ponds may use run-off water	Steep pond banks are needed Can have a build-up of waste if not drained properly Aquatic plants may become a nuisance Birds may prey on stock Pond health dependent on climate and weather Ponds may stagnate Have low dissolved oxygen levels and salinity issues

Appendix 3: Common diseases and quarantine protocols

Big Belly Disease

Big Belly Disease is caused by an intracellular bacterium present in Indonesia, Singapore and Malaysia. It has only been isolated from barramundi. It occurs in 25-day-old fry, causing problems relating to clumping of internal organs. Infected stock will turn darker in colour, separate from the 'school' and lose equilibrium. This infection can, without treatment, kill much of the population.

Iridovirus

This affects tropical marine species like barramundi and grouper, attacking fish of 10 to 50 g and causes sudden fish kills of up to 80 – 90 per cent. Infected fish turn black and lose appetite; their gills will appear very pale and may bleed. Blood may leak into the iris giving a 'red eye' appearance.

Quarantine – protocol and facilities

All quarantine facilities must:

- be located out of flood-prone areas;
- include permanently numbered, disconnected, non-metallic (plastic or fibreglass resistant to corrosion) holding tanks with wastewater discharge facilities;
- include a freezer capable of holding all quarantined stock at -8ºC or less, into which dead animals are placed in clean, new plastic bags and labelled in indelible ink or pencil with the date and number of the tank;
- be lockable to prevent unauthorised entry with secure walls and sealed floors. They should also prevent unintentional escape of aquatic animals, water, other materials or other animals;
- have limited public access, with access restricted to the owner, employees, and relevant State Government officers and other approved people;
- be easy to access and inspect, with sufficient light; and
- contain sinks, tubs or other devices to enable the washing and rinsing of parts of the body that have been in contact with contaminated fish, water and/or chemicals. Anyone entering or exiting the facility is required to carry out a disinfection process.

Quarantine facilities with no further use should be disinfected and decommissioned as directed by the Department of Fisheries.

Aquaculture licensees must:

- keep an accurate record of the total number of animals showing sign of disease and/or those which have died; and
- maintain a stock register of information about aquatic organisms supplied to or by the licensee (number or biomass of aquatic organisms received, collected, supplied, bred, age, and related dates).

Appendix 4: Commonly used chemicals and cleaning options

All chemical products must be used responsibly. This means only registered chemical products approved for use in accordance with the instructions on the label and approved by the Australian Pesticides and Veterinary Medicines Authority (APVMA) should be used. Other chemical products should only be used if allowed by legislation or if a permit is issued by APVMA.

It is the proponent's responsibility to accurately report the use of chemicals on finfish and molluscs. The licensee must, on or before the reporting day each year, provide to the Department a report containing the amount and type of chemicals used in their operation for each month.

Aquaculture facilities may be cleaned using chlorination or the adding of sodium hypochlorite to yield an active chlorine level exceeding 100 ppm (= mg/litre or grams/cubic metre of water). The products can be purchased from swimming pool or farm suppliers and the solution should be left to stand for at least an hour.

Wastewater can be discharged to a sewer or onto land as per DoW legal requirements after chlorine has been neutralised. A 120 ppm solution is created by adding 1 ml of common commercial 120 gram/litre chlorine solution to each litre of water.

In cases of potential viral contamination a process called 'iodination' can be used. This involves using Povidone Iodine. The solution should be added at a rate of 200 ppm (= 200 mg/litre or 200 grams/cubic metre) and it will need to stand for at least an hour before release.

For systems using recirculating tanks or heated containers, wastewater can be heated to at least 85°C for at least 30 minutes to disinfect it before discharge.

Commonly used disinfecting solutions include:

Hydrogen peroxide

Citric acid

Iodophore

Sodium carbonate

Sodium hydroxide

Sodium hypochlorite

Virkon

Appendix 5: Potential logistical requirements and associated operational costs for consideration as part of a business plan

Capital costs	
Initial site assessment/consultant fees	
Land	
Land preparation	– clearing, where applicable.
Buildings	– sheds, storage, purging tanks.
Machinery	– tractor, harvester, grader, etc.
Establishment	– fencing, pond construction, piping, netting, etc.
Processing	– smoking machine, where applicable.
Permits, etc.	– permits, licences, memberships to associations.
Mains electrical power connection	
Working capital	
Fixed and variable operational costs	
Fingerlings	
Water	– pumping
Pond preparation	– liming
Fertilisers	– organic or inorganic
Stock protection	– netting
Harvesting	– part-time employees
Maintenance	– fencing, ponds, structures, etc
Disposal	– disposal of refuse and waste
Levies, etc.	– annual licences, industry levies, subscriptions
Yield	
Primary yield	– unit yield of primary crop
By-product yield	– where applicable