PRAWN AQUACULTURE IN WESTERN AUSTRALIA:
FINAL ESD RISK ASSESSMENT REPORT FOR PRAWN AQUACULTURE

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Government of **Western Australia**
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DISCLAIMER

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GLOSSARY

APVMA	Australian Pesticides and Veterinary Medicines Authority
Aquafin CRC	Aquafin Cooperative Research Centre
BAM Act	*Biosecurity and Agriculture Management Act*
BAMB	Biosecurity and Agriculture Management Bill
CALM	Department of Conservation and Land Management
CoP	Code of Practice
DEC	Department of Environment and Conservation
DIA	Department of Indigenous Affairs
DoF	Department of Fisheries
DoW	Department of Water
DPI	Department of Planning and Infrastructure
ESD	Ecological Sustainable Development
EMP	Environmental Monitoring Program
EMMP	Environmental Management and Monitoring Program
EPA	Environment Protection Authority
EP Act	*Environmental Protection Act 1986*
EPBC Act	*Environmental Protection and Biodiversity Conservation Act 1999*
FCR	feed conversion rate
FRDC	Fisheries Research and Development Council
FRMA	*Fish Resource Management Act 1994*
FRMR	*Fish Resources Management Regulations 1995*
GAV	Gill Associated Virus
GMO	genetically modified organism
HAB	harmful algal bloom
IHHNV	Infectious Hypodermal and Haematopoietic Necrosis Virus
IDCA	Inter-Departmental Committee of Aquaculture
IFM	Integrated Fisheries Management
MCMS	Mid-crop Mortality Syndrome
MPG8	Ministerial Policy Guideline No. 8
PIRSA	Primary Industries and Resources of South Australia
PL	post larvae
RAMSAR	The *Conservation of Wetlands of International Importance, especially as Waterfowl Habitat*, signed at Ramsar Iran, in 1971
SARDI	South Australia Research and Development Institute

Seafood CRC	Seafood Cooperative Research Centre
SMV	Spawner Mortality Virus
SBT	Southern bluefin tuna
SWQMS	State Water Quality Management Strategy
WAPC	Western Australian Planning Commission
WQ	water quality
WQPN	Water Quality Protection Note

1.0 INTRODUCTION

Aquaculture is one of the faster growing industries in Australia having grown in value by over 13 per cent over the past 10 years. It is currently valued at $743 million with an industry vision to achieve $2.5 billion in sales by 2010.

In Western Australia, the industry is still in its infancy, with a total of 446 aquaculture licensees across the State producing a variety of species from finfish (barramundi, silver perch, rainbow trout, pink snapper and black bream), to marron and yabbies, black pearls, mussels and ornamental fish. Not counting marine algae production, the value of aquaculture production in 2001/02 was around $6.5 million (338 tonnes). This value has dropped slightly over the last few years, due to a lower price being received for some products.

There are a number of potential impediments to achieving continued growth of this industry. These include the need for increased investment, an expansion in markets and ensuring environmental sustainability. However, one of the most important is meeting the growing expectations of the community that all aquaculture sectors can clearly demonstrate that they are operating within the principles of Ecologically Sustainable Development (ESD) (see Section 2).

The Western Australian Department of Fisheries is responsible for the management of aquaculture in WA and is committed to implementing ESD. These principles are contained within the objectives of the *Fish Resources Management Act 1994* and the Department is keen to demonstrate both to the Government and the broader community that these principles are being achieved. The Department developed a policy statement in 2002 - *Policy for the Implementation of Ecologically Sustainable Development for Fisheries and Aquaculture within Western Australia* - (Fletcher 2002) that described its direction to the Department on incorporating ESD within fisheries and aquaculture management.

Using the ESD Framework for Aquaculture, which was generated by the Fisheries Research and Development Council (FRDC) in conjunction with the Aquaculture Committee of the Australian Fisheries Managers Forum and the National Aquaculture Council, the prawn aquaculture sector is the second to be run through this process.

1.1 Prawn Aquaculture in WA

There has been rapid expansion of prawn farm aquaculture worldwide, underscored by an erratic production level. Record-breaking production figures followed by spectacular collapses have been repeated throughout south-east Asian countries. The principal causes of collapse have been disease, poor water quality and poor environmental management. Despite these set-backs, the industry has continued to grow.

By comparison, prawn farming in Australia has developed relatively slowly. The industry which currently produces more than 3,500 tonnes of prawns a year, valued at over $47 million, is based on approximately 900 hectares of ponds and 12 hatcheries. Queensland has the largest proportion of ponds, at 85 per cent, with New South Wales having 10 per cent and the Northern Territory and WA combined having five per cent. Only native species are farmed in Australia, the main species being the black tiger prawn (*Penaeus monodon),* and the Kuruma prawn (*Penaeus japonicus)*.

In WA, 11 licenses have been issued authorizing prawn aquaculture in hatcheries (to produce post-larvae) or in earthen ponds (to produce a food product). These are at Cone Bay, Exmouth Gulf, Derby, Broome and Carnarvon. Others, linked to tertiary education institutions are located at Maddington, Fremantle, and Bentley. A site at Learmonth is in the process of being constructed and it is hoped production will commence in 2009. The Derby site was operational

however there is no activity under this license at present. An expression of interest was undertaken for prawn farming on the Dampier Peninsula at Wyndham, with Native Title issues still being resolved.

Hatchery production of prawns has commenced in the Exmouth area, with the Kimberley Aquaculture Research Project also developing hatchery technology for the black tiger prawn. This technology has been successfully transferred to the multi-species hatchery in the Broome Tropical Aquaculture Park however the long term operation of this facility is in doubt.

It is considered that areas north of Geraldton are most suitable for the farming of black tiger prawns in coastal pond-based systems.

1.2 What is ESD?

Ecologically Sustainable Development (ESD) is:

> "*Using, conserving and enhancing the community's resources so that ecological processes, on which life depends, are maintained and the total quality of life, now and in the future, can be increased" (COAG, 1992)*.

ESD includes three key objectives:

- To enhance individual and community well-being and welfare by following a path of economic development that safeguards the welfare of future generations;
- To provide for equity within and between generations; and
- To protect biological diversity and maintain essential ecological processes and life-support systems.

To achieve these objectives will require the integration of short and long-term economic, social and environmental effects in all decision-making. Thus, to be consistent with ESD principles:

"resources not only need to be used sustainably, but how they are used, who benefits and when, along with the impacts of their use, all need to be evaluated" (Fletcher, 2002).

The desired outcomes using such a process are likely to evolve through time as society's needs and values alter. Therefore ESD should be seen as a means – not as an endpoint.

1.3 How does the ESD framework fit with Aquaculture?

Until recently, there were no methods available to implement ESD in a full and practical manner. During the past four years, work within the Fisheries Research and Development Corporation's (FRDC) subprogram on ESD Reporting and Assessment has been underway to develop a series of national ESD frameworks to enable all Australian fisheries and aquaculture sectors to demonstrate that they are operating utilising ESD principles.

The ESD framework for aquaculture has similarities to the ESD framework that was previously developed for wild-capture fisheries. Both of them help to identify the relevant environmental, social/economic and governance issues; assist with determining the appropriate level of management response using risk assessment techniques; and provide a reporting structure to document outcomes. There are, however, a number of important differences between these systems.

The major difference between the two frameworks is in the structure of the environmental components. For aquaculture, these are structured into three different spatial levels:

1) ‘whole of industry’ issues;
2) catchment/regional issues; and
3) within facility issues.

This hierarchical approach is designed to show the linkages between what is required at the operator level and the outcomes required by government/community at the regional and ‘whole of industry’ scales.

Given that most aquaculture operations are assessed/approved at an individual venture level and a large number of government agencies are usually involved in the assessment of aquaculture, the ESD framework for aquaculture can also function as a set of guidelines for coordinating processes and ensuring due diligence, not just as a method for the generation of a single report on an industry.

1.4 What are the major components of ESD for Aquaculture?

There are eight major component trees, grouped within three main categories – contributions to ecological wellbeing, contributions to human wellbeing and ability to achieve.

Contributions to Ecological Wellbeing

1) *Impacts on the General Environment (‘whole of industry’)*
   Are there issues that need to be dealt with at the ‘whole of industry’ level?
2) *Impacts within Catchment/Region*
   This deals with the cumulative impacts that may occur from multiple facilities in the one region/catchment
3) *Impacts within Facility*
   What issues need to be addressed within each facility?

Contribution to Human Wellbeing

4) *Indigenous Wellbeing*
   How does the industry sector affect indigenous communities in the area where the industry operates?
5) *Community Wellbeing*
   Are there local (including the industry itself) or regional communities that are dependent on the industry and/or are they supportive or negative about its operation?
6) *National Wellbeing*
   How does the industry/sector contribute to national issues such as employment rates, supply of fish, economic returns, reductions in trade deficit etc?

Ability to Achieve

7) *Governance*
   Are the management processes and arrangements for the industry appropriate and efficient to enable the other elements to achieve an adequate level of performance?
8) *Impacts of the Environment*
   Are there issues that may reduce or improve performance of the industry/sector and are outside of the direct control of the management agency/industry?

1.5 How does the ESD Framework operate?

There are five key elements used in the process to complete an ESD report for an aquaculture sector:

1) identifying the issues relevant to the industry/sector/individual;
2) prioritising these issues;
3) completing suitably detailed reports/management strategies for each issue (dependent upon their priority, complexity and the scope of the requirements – i.e. 'whole of industry', a region or even just a single operator);
4) compiling summary background material on the industry (where relevant), the major species affected and the environments that the industry operates within (this enables the reader to put the material presented within any report into an appropriate context); and
5) using the generated material to assist individuals or industry (e.g. for use in generating EMSs and/or COPs) or agencies as the basis for demonstrating they are achieving appropriate outcomes for government (e.g. in reports to Parliament).

1.6 How are the specific issues identified?

The first step in the ESD framework is to identify the relevant issues for the industry through the use and modification of a set of "generic component trees".

There is one generic component tree for each of the eight components of ESD. Each of these trees was developed in consultation with the Aquaculture Committee, the National Aquaculture Council and the ESD Reference Group to cover the suite of issues that are relevant to aquaculture.

These generic component trees are used as a starting point, tailoring them to suit individual industry circumstances, expanding some sub-components and collapsing or removing others, depending upon the farming methods, areas of operations and the species involved. This step was commenced during the workshop, with the remaining ratings and risks determined out of session.

1.7 Prioritising issues

Tailoring the component trees to any specific industry sector can often result in a large number of issues being identified, the importance of which often varies greatly. In nearly all cases, it is necessary to prioritise these issues so that the level of management actions and the level of detail for any reports generated are aligned with the importance of the issue.

To determine the relative priority of each issue, risk assessment methodology has been adapted to assist this process. The outcome of these risk assessment evaluations must include the justifications for the levels chosen. This enables third parties to review the logic and assumptions behind any decisions. It also facilitates future amendments if alternative information becomes available.

1.8 Risk Assessment

The Department of Fisheries conducted a Risk Assessment Workshop for the prawn aquaculture industry on 20 July 2006 with the purpose of evaluating the perceived risks of prawn aquaculture rather than the documented risks, since there is very little information available on the latter aspect for Western Australia. At the time of the workshop, the prawn species authorised for farming in WA were black tiger, brown tiger, banana, endeavour and western king prawn.

The risk assessment workshop used the National ESD reporting framework for aquaculture (Fletcher *et al.* 2004): the "How to" Guide. This guide was developed to provide a consistent framework that could be used across all aquaculture species in Australia. The framework is based on the Australian standards for risk management (AS/NZS 4360 1000), which is used to conduct risk assessments for a variety of industries. This particular framework focuses on ESD outcomes by developing operational objectives and indicators to monitor and evaluate performance of management.

Throughout the workshop, the generic component trees outlined in the guide were modified to produce trees specific to prawn aquaculture in WA (Figures 1- 6). This involved either deleting some of the issues or adding more. Component trees dealing with the *Contributions to Ecological Wellbeing* category were discussed to some degree and this report provides a summary of the workshop proceedings. Significantly more work needs to be done in future reviews of this document once more research has been completed on the other two categories – that of *Contributions to Human Wellbeing* and *Ability to Achieve*.

2.0 METHODOLOGY

The Risk Assessment Workshop was held on 20 July 2006 using the National ESD Framework for aquaculture (Fletcher *et al*. 2004), with Dr Rick Fletcher acting as workshop facilitator. A range of stakeholder groups were invited to participate (Appendix 1), representing industry, government and conservation interests.

Two scenarios were used to assist participants to work through the various component trees:

Scenario 1 tidal flush (low feed, no settlement ponds and no test) (about two tonnes/hectare/crop).

Scenario 2 managed intensive (settlement ponds, test of discharge) (about eight tonnes/hectare/crop).

The agreed scope of discussions for the day were:

- The use of only native prawns (i.e. those species already found in the State).
- Pond aquaculture will be carried out, using either seawater, river water or bore water;
- It is unknown as to what level of development may be possible within the next five to ten years.
- The tonnages produced will be modified by the methods used and the environment of the site.
- Different levels of production and/or technology will be evident within each of the regions.

The generic component trees outlined in the framework were modified so that they were specific for the prawn aquaculture industry in Western Australia (Figures 1 - 3). Issues were discussed in terms of current knowledge and management, and assigned a ranking in terms of the level of perceived risk associated with that particular issue.

The risk ranking was determined using the risk analysis tool outlined in the ESD framework, which was based on the Australian standard for risk management (AS/NZS 4360 1999). To assign a level of risk to an issue, two factors must be determined – the potential consequence arising from the particular activity, and the likelihood that this consequence will occur. The combination of consequence and likelihood produces an estimate of the risk associated with a particular issue.

The main aim of the risk assessment is to determine if current management is sufficient, and therefore the current management strategies need to be considered when determining the consequence and likelihood levels. Issues were assigned a level of consequence (from negligible to catastrophic) and likelihood (from remote to likely).

In assigning a likelihood level it was important to remember that we were assessing the likelihood of the *consequence* occurring and not the likelihood of the *activity* occurring.

The consequence and likelihood levels were determined for issues using the tables outlined in the framework (Tables 1 and 2). During the workshop, participants were asked to score the consequence and likelihood on the basis of what they expected over the next five years, not just on the current situation. The risk value and ranking for each issue were then determined using the risk matrix (Table 3). The discussions leading to these rankings are summarised in this document and are subjective.

The suggested outcomes for the determined risk rankings (Table 4) indicate that a full performance report is required for any issue determined to be of a 'moderate' risk or higher. A full performance report involves determining operational objectives, indicators, acceptable levels

and management responses for that particular issue. It is envisaged that a full performance report for each of these issues will be developed and to recommend indicators for the measurement of management.

The summaries were sent back to the workshop delegates for further comments. The risk rankings were re-assessed by the Department of Fisheries, based on both the comments made during the workshop and the submissions made on the Draft Report.

Table 1 The Consequence Table for use in ecological risk assessments related to aquaculture (from Fletcher *et al*. 2004). While this is the table used in the workshop, participants were asked to assess the situation over the next five years, and thus the wording should be read to reflect this time frame.

Level	Descriptor
'Negligible' ('0')	Ecosystem: Interactions may be occurring, but it is unlikely that there would be any change outside of natural variation.
'Minor' ('1')	Ecosystem: None of the affected species play a keystone role – only minor changes in relative abundance of other constituents.
'Moderate' ('2')	Ecosystem: measurable changes to the ecosystem components without there being a major change in function (no loss of components).
'Severe' ('3')	Ecosystem: Ecosystem function has altered measurably and some function or components are locally missing/declining/increasing outside of historical range and/or has allowed/facilitated new species to appear. Recovery measured in years.
'Major' ('4')	Ecosystem: A major change to ecosystem structure and function (different dynamics now occurs with different species/groups that are now the major components of the region). Recovery period is measured in years to decades.
'Catastrophic' ('5')	Ecosystem: Total collapse of ecosystem processes. Long-term recovery period may be greater than decades.

Table 2 Likelihood Definitions (from Fletcher *et al*. 2004).

Level	Descriptor
'Remote' ('1')	Never heard of, but not impossible
'Rare' ('2')	May occur in exceptional circumstances
'Unlikely' ('3')	Uncommon, but has been known to occur elsewhere
'Possible' ('4')	Some evidence to suggest this is possible here
'Occasional' ('5')	May occur
'Likely' ('6')	It is expected to occur

Table 3 Risk Matrix – numbers in cells indicate risk value, the colours/shades indicate risk rankings (from Fletcher *et al*. 2004) (n.b. the risk level is calculated by multiplying the likelihood value by the consequence value).

Consequence							
Likelihood		**Negligible**	**Minor**	**Moderate**	**Severe**	**Major**	**Catastrophic**
		0	1	2	3	4	5
Remote	1	0	1	2	3	4	5
Rare	2	0	2	4	6	8	10
Unlikely	3	0	3	6	9	12	15
Possible	4	0	4	8	12	16	20
Occasional	5	0	5	10	15	20	25
Likely	6	0	6	12	18	24	30

Table 4 Suggested risk rankings and outcomes (from Fletcher *et al*. 2004).

Risk Rankings	**Risk Values**	**Likely Management Response**	**Likely Reporting Requirements**
'Negligible'	0	Nil	Short Justification Only
'Low'	1 – 6	None specific	Full justification needed
'Moderate'	7 – 12	Specific management needed	Full performance report
'High'	13 – 18	Possible increases to management activities needed	Full performance report
'Extreme'	> 19	Likely additional management activities needed	Full performance report

3.0 REGIONAL/CATCHMENT AREAS FOR LEVEL 2 ASSESSMENTS

The ESD framework is structured into three different spatial levels:

1) 'Whole of industry' issues;

2) Catchment/Regional issues; and

3) Within facility issues.

This hierarchical approach is designed to show the linkages between what is required at the operator level and the outcomes wanted by government/community at the regional and 'whole of industry' scales. In order to complete the level 2 assessment, it is necessary to identify relevant regions and catchments. Using those developed through the IBRA processes provides a system already developed using ecological criteria.

In 1996, under the auspices of the Australian New Zealand Environment and Conservation Council (ANZECC), the Commonwealth Department of Environment and Heritage developed a system of ecosystem-based classification for marine and coastal areas of Australia. This system was called the *Interim Marine and Coastal Regionalisation for Australia*, or IMCRA.

A comparable system for terrestrial areas was also developed called IBRA or *Interim Biogeographical Regionalisation for Australia*.

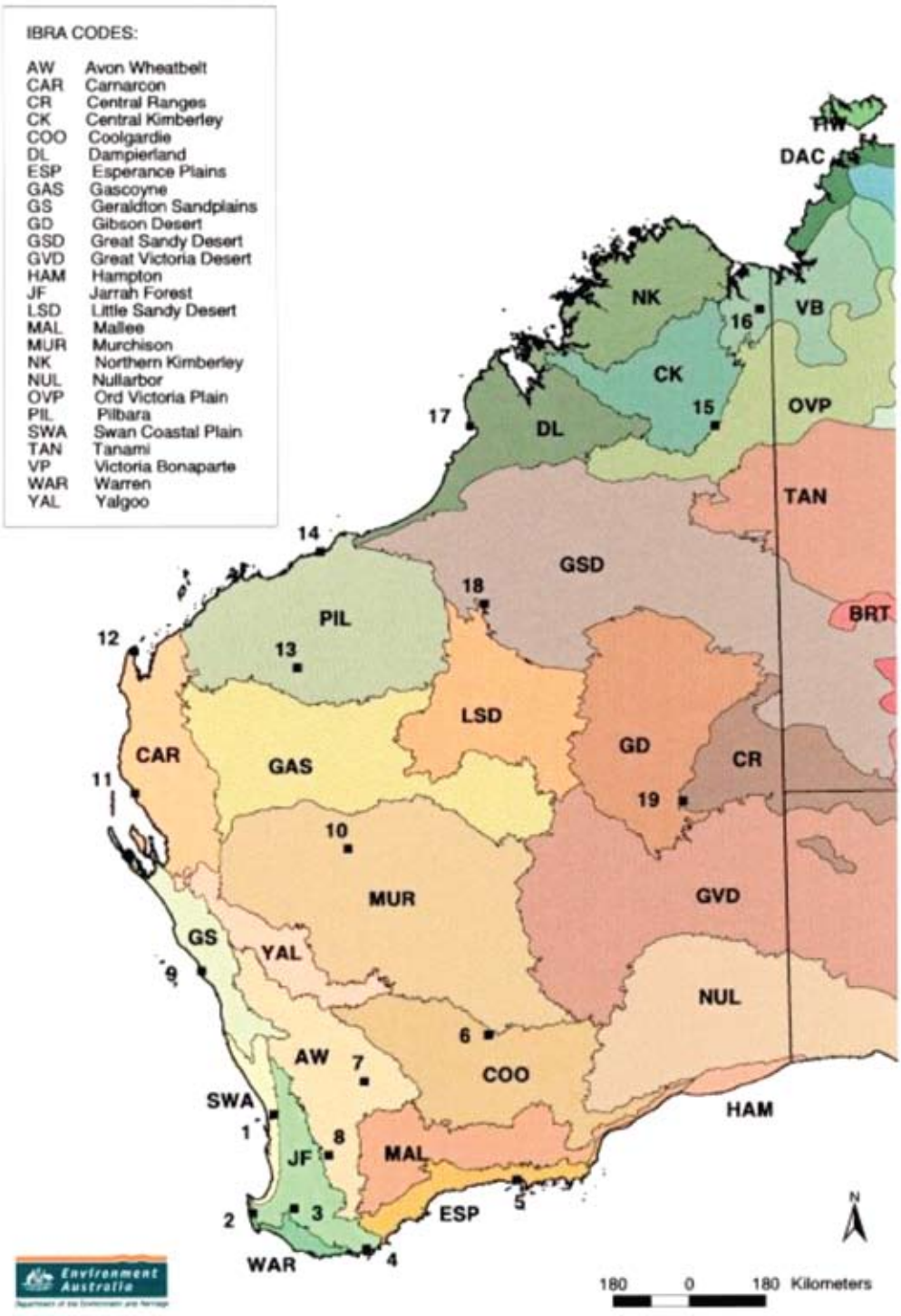
As the IMCRA report states:

"*There is growing recognition of the importance and need to protect marine biodiversity for both conservation and economic reasons. Governments, the community and all users have a shared responsibility to ensure the long term viability of the biological diversity, marine system function and resource use of the estuaries, seas and oceans. Issues of resource conflict and overuse and the need for sustainable resource use and biodiversity conservation typically occur at local and regional scales. To address these issues there is a need for a regional planning framework which encompasses data and information on ecological patterns and processes*."

These systems were developed as a regional framework for planning resource development and biodiversity conservation. As the name implies, it is based on the best available information and is able to be progressively revised as new data and information become available.

3.1 IBRA Regionalization

Interim Biogeographic Regionalization for Australia (IBRA) is a cooperative approach by all nature conservation agencies and continues to be refined as more detailed information on ecosystems or other base layers comes to hand. Utilising this ecosystem classification system links in with IMCRA, in the sense that both systems were developed with ecosystem management in mind.



Interim Biogeographical Regionalization for Australia (Ver 5.1)

4.0 RESULTS

The following diagrams show the issues as identified by participants at the workshop relevant to prawn aquaculture in WA. These component trees have been derived from Fletcher *et al* 2004.

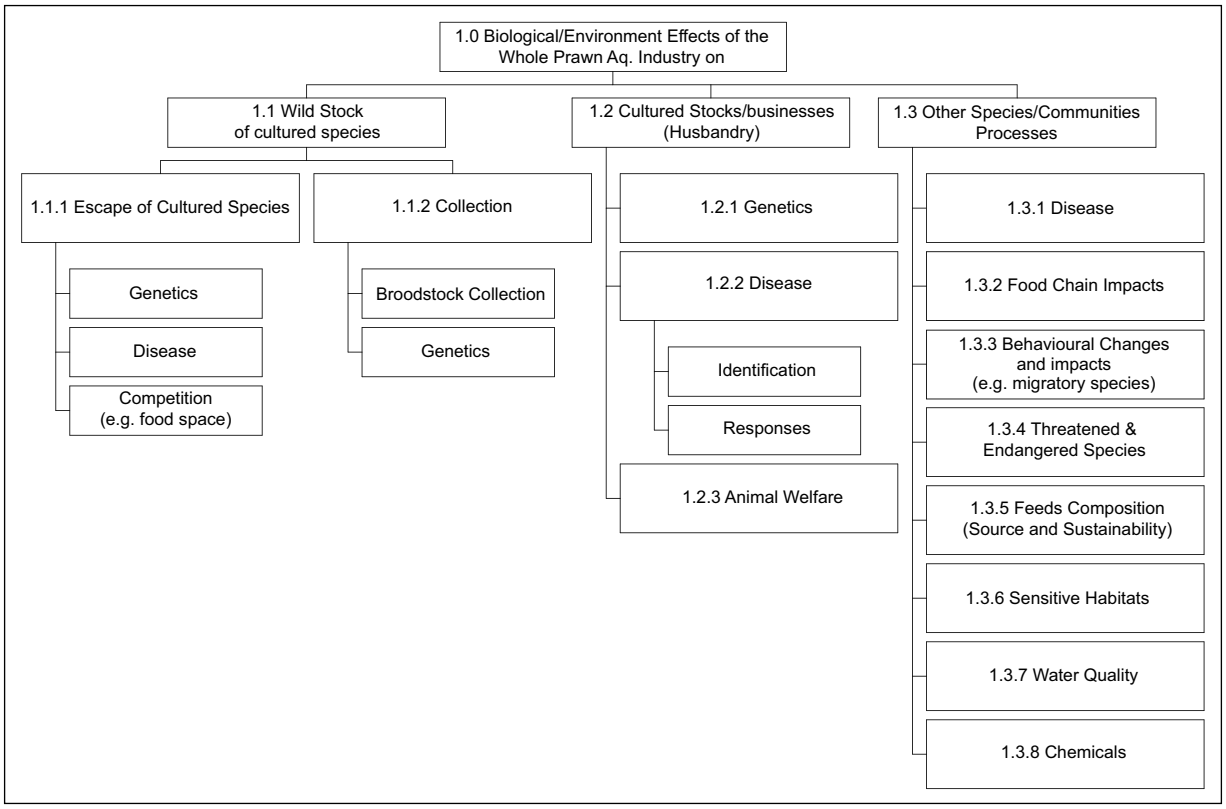


Figure 1 Component Tree 1 - Biological/Environmental Effects of the Whole Prawn Aquaculture Industry (modified from Fletcher *et al*. 2004).

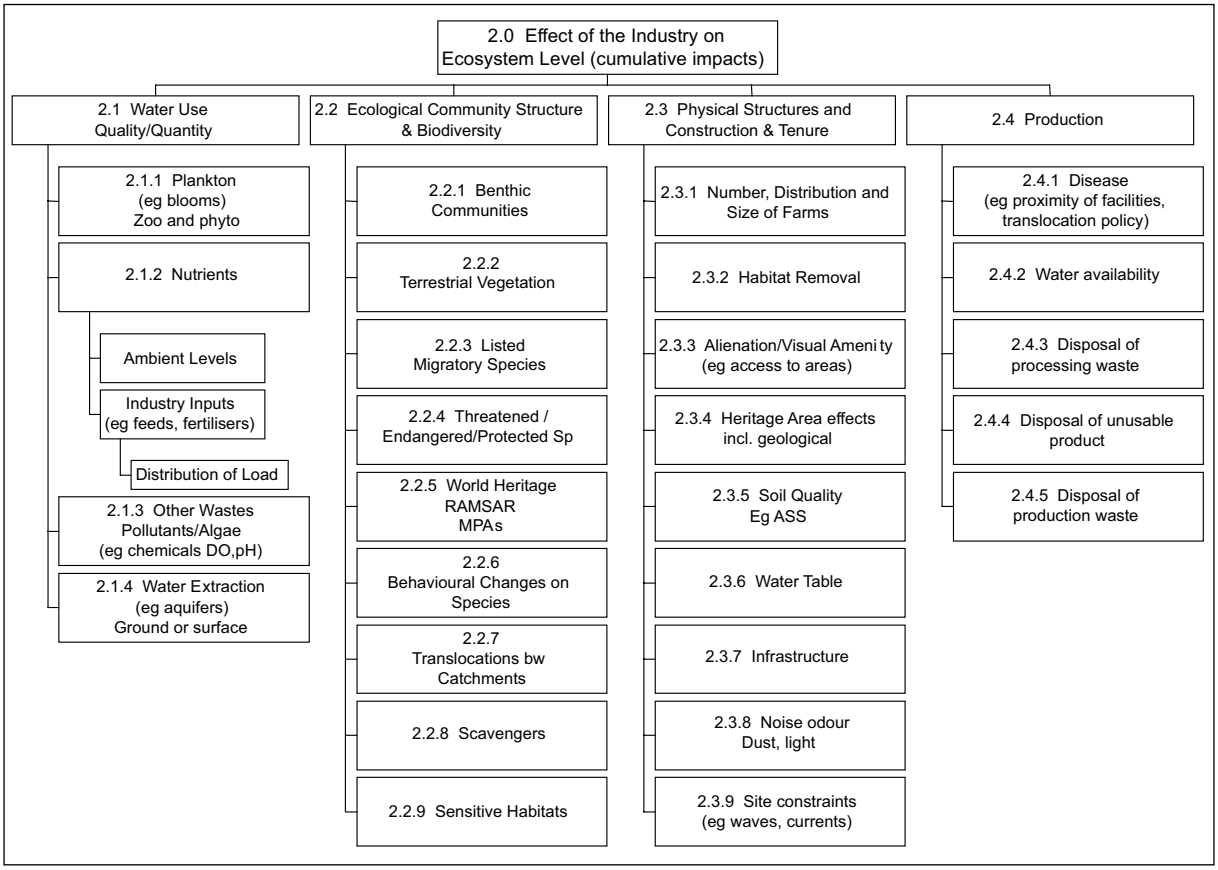


Figure 2 Component Tree 2 - Environmental Impacts of the Prawn Aquaculture Industry on the Catchment/Region (modified from Fletcher *et al.* 2004).

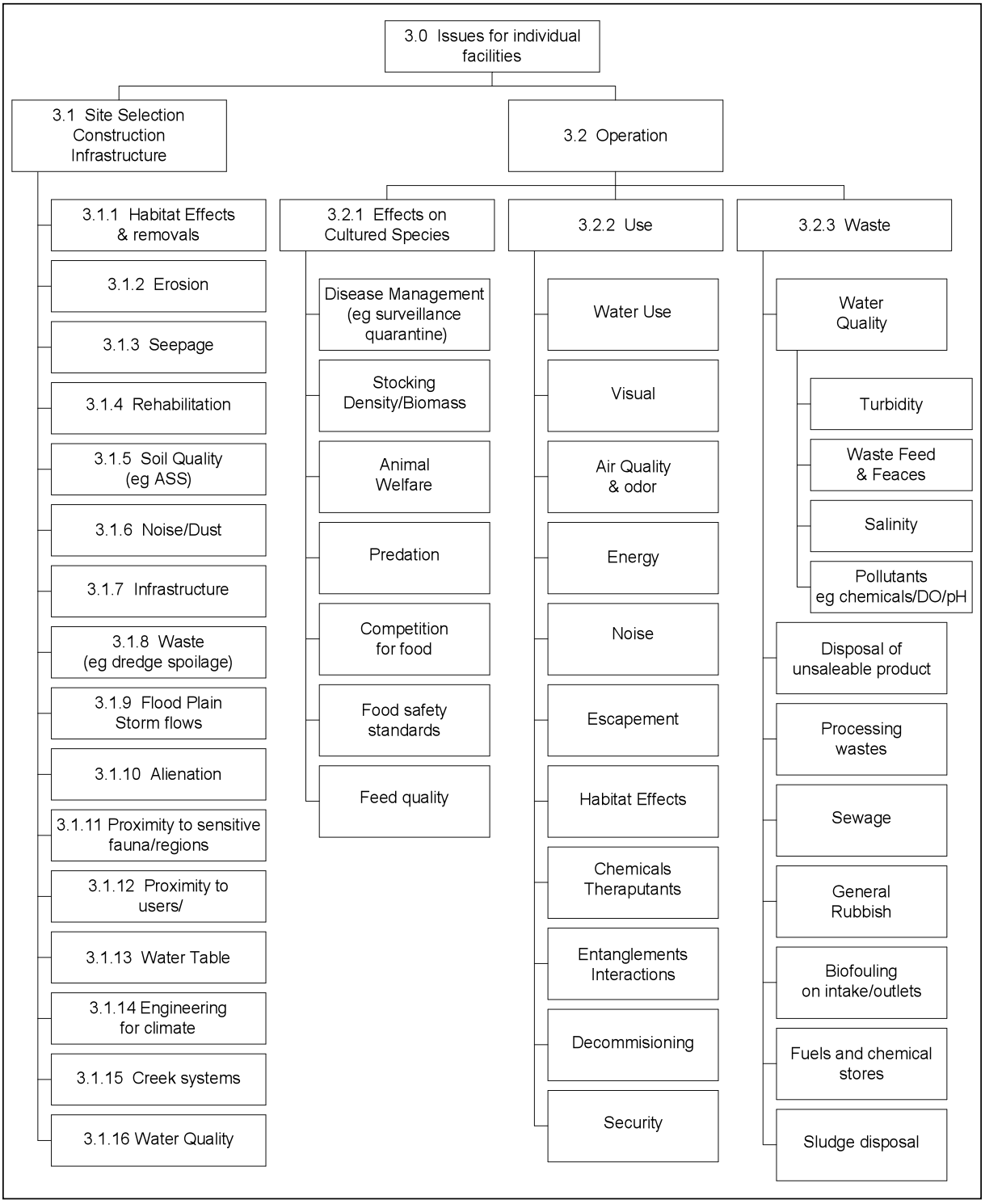


Figure 3 Component Tree 3 - Environmental Impacts of Individual Prawn Aquaculture Facilities (modified from Fletcher *et al*. 2004).

List of environmental issues for Component Tree 1. The consequence, likelihood and risk value are given.

Issue	Component Tree	Consequence	Likelihood	Risk ranking (State)	Authors ranking
Effects of escapes of cultured species causing changes to wild stock genetics (1.1.1)	1	2	1	2	Low
Effects of escape of cultured species causing disease in wildstock (1.1.1)	1	1	3	3	Low
Effects of escape of cultured species increasing competition with wildstock (1.1.1)	1	0	2	0	Negligible
Effects of over-collection of broodstock (1.1.2)	1	4	3/2	12/8	Moderate (page 26)
Minimise risk of genetic impacts on wildstock by broodstock collection (1.1.2)	1	1	1	1	Low
Effects on genetic composition of broodstock (1.2.1)	1	3	1	3	Low
Effects of disease in cultured stocks (1.2.2)	1	2	2	4	Low
Animal welfare issues (1.2.3)	1	1	1	1	Low
Effects of diseases from cultured stocks passing to wildstock (1.3.1)	1	0	1	0	Negligible
Effects of escapes on food chain (1.3.2)	1	2	1	2	Low
Effects on behaviour of individual species (1.3.3)	1	2	1	2	Low
Effects on threatened / endangered / protected species (1.3.4)	1	2	1	2	Low
Impacts on feed composition and their sustainability (1.3.5)	1	2	5	10	Moderate (page 36)
Effects on sensitive habitats (1.3.6)	1	4	1	4	Low
Impacts on applying common standards for water quality (1.3.7)	1	2	3	6	Low
Impacts on applying common approach to chemical use (1.3.8)	1	2	3	6	Low

List of environmental issues for Component Tree 2. The consequence, likelihood and risk value are given.

The regions where aquaculture operators have been considered through this process are outlined below. These are locations where operating finfish aquaculture facilities are found:

NK Northern Kimberley

CK Central Kimberley

DL Dampierland (Derby - current farm location)

PIL Pilbara

CAR Carnarvon

GS Geraldton Sandplains

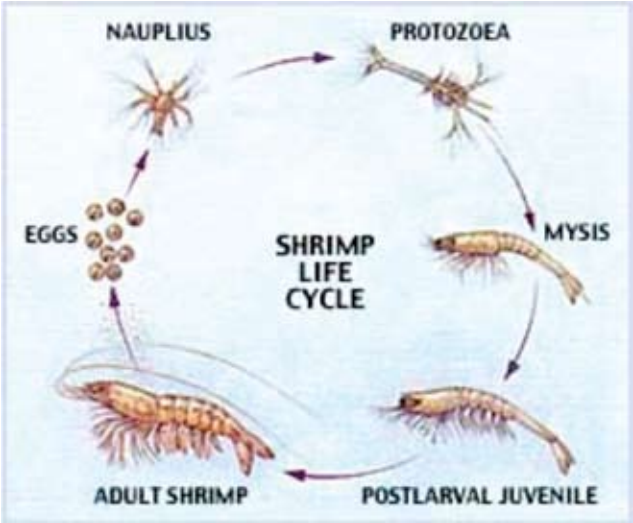
Issue	Component Tree	Consequence						Likelihood						Risk ranking (regional)						Authors rankings
		NK	CK	DL	PIL	CAR	GS	NK	CK	DL	PIL	CAR	GS	NK	CK	DL	PIL	CAR	GS	
Increased frequency/intensity/composition of plankton blooms (2.1.1)	2	2	2	3	2	4	2	3	3	3	3	3	3	6	6	9	6	12	6	Low – Mod (page 46)
Relating nutrient inputs to ambient levels (2.1.2)	2	2	2	2	1	2	3	2	2	2	2	2	2	4	4	4	2	4	6	Low
Impacts and effects of pre-existing industries (2.1.2)	2	2	2	2	2	2	2	1	1	2	3	2	3	2	2	4	6	4	6	Low
Impacts on region from release and use of chemicals (2.1.3)	2	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	Low
Impacts of limiting water extraction across the region (2.1.4)	2	2	2	2	2	2	2	3	3	3	3	3	3	6	6	6	6	6	6	Low
Changes to benthic communities (2.2.1)	2	3	3	3	3	3	3	1	1	2	1	1	1	3	3	6	3	3	3	Low
Effects on terrestrial vegetation from sedimentation and nutrients (2.2.2)	2	3	3	3	3	3	3	1	1	1	1	1	1	3	3	3	3	3	3	Low
Changes to listed migratory species in area (2.2.3)	2	2	2	4	2	2	3	3	1	3	2	2	4	6	2	12	4	4	12	Low – Mod (page 57)
Interactions between species and facilities (2.2.4)	2	4	3	4	3	2	4	3	2	3	1	3	3	12	6	12	3	6	12	Low – Mod (page 59)
Effects of aquaculture on RAMSAR/MPA/ World Heritage Areas (2.2.5)	2	2	1	2	1	2	1	3	3	3	2	3	2	6	3	6	2	6	2	Low
Effects of aquaculture on individual species behaviour (2.2.6)	2	0	0	1	0	0	0	3	3	3	3	3	3	0	0	3	0	0	0	Neg - Low
Translocation policies for stock movements (2.2.7)	2	2	2	3	1	2	2	1	1	1	1	1	1	2	2	3	1	2	2	Low

Effects on level of scavenger abundance (2.2.8)	2	0	0	2	0	0	0	1	1	4	1	1	1	0	0	8	0	0	0	Neg – Low
Effects on sensitive habitats by aquaculture (2.2.9)	2	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	Low
Total number and size of farms across region (2.3.1)	2	3	3	3	4	3	4	1	1	1	2	1	2	3	3	3	6	3	8	Low – Mod (page 68)
Impact on regional amount of native vegetation acceptably removed (2.3.2)	2	3	3	3	3	3	3	1	1	1	1	1	1	3	3	3	3	3	3	Low
Changes to visual amenity and alienation of areas (2.3.3)	2	1	1	2	1	2	2	2	2	2	3	3	3	2	2	4	3	6	6	Low
Effects of aquaculture on heritage areas (2.3.4)	2	5	5	5	5	3	3	2	2	2	2	2	2	10	10	10	10	6	6	Low – Mod (page 71)
Constraints on aquaculture due to soil type and quality (2.3.5)	2	1	1	1	1	1	1	3	3	3	3	3	3	3	3	3	3	3	3	Low
Effects on water table from extraction or discharges (2.3.6)	2	2	2	2	2	2	2	2	2	2	2	2	2	4	4	4	4	4	4	Low
Constraints on aquaculture from current infrastructure levels (2.3.7)	2	3	3	3	3	3	2	4	4	4	2	2	1	12	12	12	12	6	4	Low – Mod (page 74)
Effects on regional noise and odour levels (2.3.8)	2	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0	0	Negligible
Regional constraints to placement of aquaculture facilities (2.3.9)	2	1	1	1	1	1	1	3	3	3	3	3	3	3	3	3	3	3	3	Low
Regional effects due of disease transmission (2.4.1)	2	3	3	3	3	3	3	2	2	2	2	2	2	6	6	6	6	6	6	Low
Effects on aquaculture due to water availability (2.4.2)	2	2	2	2	2	2	2	2	2	2	2	2	2	4	4	4	4	4	4	Low
Effects of processing waste (2.4.3)	2	3	2	3	1	1	3	1	1	1	1	1	1	3	2	3	1	1	3	Low
Ability to dispose of unusable product in the region (2.4.4)	2	2	1	2	1	1	2	3	3	3	3	2	2	6	3	6	3	2	4	Low
Effect of processing product (2.4.5)	2	0	0	0	0	0	0	3	3	3	3	3	3	0	0	0	0	0	0	Negligible

5.0 DISCUSSION

Worldwide, prawn farming (grow-out) is typically undertaken in shallow earthen ponds. Stock is sourced from specialised hatcheries which use mature spawners (broodstock) to obtain fertilised eggs. Once hatched, the young pass through a series of larval stages: nauplius, zoea and mysis.

At approximately five to seven days of age, the young enter the post-larval stage (when they are commonly referred to as "PLs") and become benthic (bottom-dwelling). At approximately 15 days into the post-larval stage, the juveniles are tested for disease. If they are free of disease, the juveniles are transferred from the hatchery directly into specially-prepared earthen grow-out ponds.



Culture Systems

Earthen ponds are typically 0.5 to 1.0 hectares in size and range in depth from 1.2 to 2.0 metres. Consequently, pond volumes range from six megalitres (Ml) to 20Ml. Ponds are designed to minimise the likelihoods of erosion, maximise efficient circulation and facilitate time-effective harvesting. Reticulation systems for these ponds may be described as either:

- Flow-through - where water sourced from the ocean, a river, or bore is pumped in and used on the farm, then returned via effluent sedimentation channels and remediation ponds to the source; or
- Recirculating - where some proportion of the water in the pondage system is returned to the ponds.

Recirculating systems can require larger land areas and greater management and energy contributions than flow-through systems in order to achieve similar productivity levels to the latter. The primary reason for this is the need to treat recirculated water in order to maintain high levels of dissolved oxygen and ensure low levels of metabolic wastes (e.g. ammonia).

In the National ESD framework aquaculture guide supplement (Fletcher *et al*. 2004) a brief description of the issue to be discussed is given, which has been included in the summary of each issue. Everyone who was invited to attend the workshop was invited to comment on the workshop summary report. Any additional comments made, or alternative risk values given, were reconsidered by the Department of Fisheries and included in the summary table for each issue in the ESD Risk Assessment Report.

5.1 Impacts on the General Environment (Whole of Industry)

The topics covered in this generic component tree are relevant to, and more importantly, the management outcomes need to be set at, the level of the whole of industry. This covers issues that have a wider scope than an individual facility, or even a single catchment or region, or where identical protocols need to be implemented for all operators.

The three areas covered by this tree include the potential impact the entire industry may have on:

- the wild stock of the cultured species;
- issues affecting the husbandry of the cultured species (in closed life-cycle conditions) and;
- other species that could be affected in all areas.

5.1.1 Wild stock of cultured species

5.1.1.1 Escape of cultured species

This section covers the potential impacts that may occur to the natural stock of the species being cultivated from the accidental escape of adults, juveniles or progeny from the cultured stock. The main question is whether there can be escapes or not.

Table 5 Escape of cultured species causing changes to genetics.

Description (Fletcher *et al*. 2004)	*Are protocols needed at the 'whole of industry' level to avoid or minimise the risk of genetic impacts on the wildstock population from the escape of any cultured individuals?*			
Level of Impact	Whole of the industry			
Comment	• Translocation policies manage any interactions between farm stock and wild stock. • Farm management practices should minimise any possibility of escapes – such as the placement of farms away from flood-prone areas where the over-flowing of ponds may occur. • Genetic changes (in wildstocks) resulting from escapes from farms will be less likely, since the broodstock will be local stocks.			
Risk assessment values				
Organisation/ Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After Workshop	2	1	2	Low

Justification for Risk Ranking

Genetic issues are problematic and there is still debate over how to define genetically-distinct populations. The genome of each individual is unique and how much variation is required to define populations is difficult for managers to determine.

Black tiger prawns are endemic to WA, with the stocks being genetically dissimilar to those in the rest of Australia and the world. As a result, there may be production benefits from using WA black tiger prawns and these should be protected until genetic distinctions can be confirmed.

The main prawn hatcheries are located in Queensland and concern has been raised regarding the use of different strains of prawns to those found in WA. If these introduced strains escaped in WA, they could form breeding populations in the region before they impacted on the local strains. This is considered possible, with escapes of small black tiger prawns easily forming breeding populations or cross breeding with the local strain.

The Department of Fisheries requires all importation of fish to be assessed using its translocation policy. This policy takes a risk-based approach to the likelihood of disease being introduced through the importation of various individual organisms.

The Department of Fisheries *Emergency/Incident Management Plan* (July 2002) is designed to:

- enable the Department to respond to emergencies of any nature in a consistent and effective manner; and
- be expanded and adapted to suit specific emergencies, including the establishment of sub-plans which all have a consistent initial approach.

The plan provides a framework for the administration of all incidents in which the Department is involved as either a primary or secondary responder and includes fish kills, disease outbreaks, feral pest incursions, pollution, algal blooms and other emergencies.

Legislation such as the *Biosecurity and Agricultural Management Act 2007* provides more stringent controls on the importation of certain fish species. It may provide the impetus for the culture of WA hatchery product for prawn species.

The consequence value has been set at 'moderate' ('2') in light of the current use of specific licence conditions and the low level of importation of interstate stocks. The likelihood of any changes occurring to the genetic structure of wild stocks is considered to be 'remote' ('1') due to the current size of the industry in WA and the response plans to any escapes.

Comments in Relation to Future Management

- The current translocation protocols should be maintained.
- Recognise that regions are different and set management responses accordingly.
- Protocols need to be developed for the movement of species between regions and how to deal with any escapes that may occur across the whole industry.
- The *Biosecurity and Agricultural Management Act 2007* provides guidance on this issue.

Table 6 Escape of cultured species causing disease in wildstock.

Description (Fletcher *et al*. 2004)	*Are protocols needed at the 'whole of industry' level to minimise the risk of disease transmission to the wildstock from the escape of cultured individuals?*			
Level of Impact	Whole of the industry			
Comment	• It would be in the best interest of industry to minimize the possibility of disease in the first place rather than deal with managing outbreaks. • The industry is small enough that disease outbreaks have not been an issue. • Management practices should be used to minimize any disease outbreaks or transferrals.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	1	3	3	Low

Justification for Risk Ranking

In Australia, each state and territory has operational responsibility for the surveillance, monitoring, control and eradication of aquatic animal diseases, whether the diseases are endemic or exotic. In addition, Australia has international obligations, including reporting to the global

organisation for animal health, the *Office International des Epizooties* (OIE) and each state and territory government is responsible for gathering the information regarding notifiable aquatic animal diseases (QDPI&F 2006).

The surveillance and reporting program used by Australia and its states focuses on the fact that the country will increasingly be called upon to substantiate freedom from major diseases in order to support export certification and quarantine import policy. Gill-associated virus (known as 'GAV') has been found as far west as the Joseph Bonaparte Gulf in northern WA, while white spot disease has been identified in imported prawns. WA needs to be vigilant in detecting new diseases or outbreaks of known diseases.

The Department of Fisheries developed the *Emergency/Incident Management Plan* in July 2002 and it is designed to:

- enable the Department to respond to emergencies of any nature in a consistent and effective manner; and
- be expanded and adapted to suit specific emergencies, including the establishment of sub-plans which all have a consistent initial approach.

The plan provides a framework for the administration of all incidents in which the Department is involved as either a primary or secondary responder and includes, fish kills, disease outbreaks, feral pest incursions, pollution, algal blooms and other emergencies.

Aquaculture Licences have attached conditions requiring notification of any large escapes to the Department of Fisheries within 24 hours. The *Fish Resources Management Regulations 1995* (regulation 69) also requires all aquaculture operators notify the Department within 24 hours of becoming aware of, or suspecting, that any fish at the place where aquaculture is carried out, may be affected by diseases as specified.

The *Biosecurity and Agricultural Management Act 2007* provides more stringent controls on the importation of certain fish species. It provides the impetus for the cultivation of WA hatchery product for prawn species.

The Department of Fisheries also implements a translocation policy, to minimise the risks due to transfer of diseased animals into and around WA. In the light of these protocols already in place, together with the small size of the prawn aquaculture industry in WA, the likelihood of cultured species causing diseases in wild stocks is 'unlikely' ('3'), with the consequences considered 'minor' ('1').

Comments in Relation to Future Management

- The current protocols should be maintained.
- The *Biosecurity and Agricultural Management Act 2007* will assist in the management of this issue.
- The health certification for all post-larval animals (PLs) brought into WA should be maintained.
- Regular testing should be required if it becomes obvious that the incidence of disease has increased.
- Farm design should require that ponds are placed outside of flood-prone areas, thus minimizing potential escapes.
- The need for hatcheries and other facilities to become biosecure should be considered.

- WA should work with other states to increase the ability of testing procedures to pick up disease outbreaks.

Table 7 Escape of cultured species increasing competition with wildstock.

Description (Fletcher *et al*. 2004)	*Would the escape of cultured animals cause problems to the wildstock due to increased competition for resources (this could be food, shelter, space etc)?*			
Level of impact	Whole of the industry			
Comment	• We are unlikely to know of any impacts if this situation were to occur. • Industry needs to continue to minimise the risk of escapes, particularly at levels that may impact on the food chain. • Level of land-based aquaculture is likely to grow over the next five years. • There is a need to consider research and management arrangements. • An increase in local stocks may benefit wild stocks, as certain species may have low catch rates in regions.			
Risk assessment values				
Organisation/Persons	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	0	2	0	Negligible

Justification for Risk Ranking

Commercial fisheries reports from WA (*State of the Fisheries Report 2004/05*) identify black tiger prawns as a minor catch species in the Onslow and Nickol Bay Managed Prawn Fisheries. In both of these areas, catch is recorded as less than one tonne and mainly as bycatch. Black tiger prawns are present in the wild in low numbers naturally, which is why they are not targeted as a fishery species.

It is possible that black tiger prawns are also found in the Kimberley region, but the populations are likely to be small and outside of the areas commonly targeted by commercial fishers.

In the event that individuals escape from a prawn farm, the likely impact on local black tiger prawn stocks will be dependent on the region in which the facility is located. Should the farm be situated adjacent to areas fished by the Onslow or Nickol Bay Managed Prawn Fishery, there is a good chance that they may form part of the commercial catch. If the facility is located in areas not adjacent to a Managed Prawn Fishery, escapes may increase the local stock numbers but these increases will be small, assuming the escapees even survive.

The prawn aquaculture industry in WA utilizes post-larvals (PLs) from broodstock caught in the Nickol Bay Managed Prawn Fishery. Any escapes could be seen as placing back into the wild individual prawns that were from this stock originally – although this situation is not encouraged.

The likelihood of escapes impacting on wild stocks through increasing competition for food is considered to be ‘rare’ (‘2’) and the consequences would be ‘negligible’ (‘0’).

Comments in Relation to Future Management

- Minimise any escapes by means of agreed farm management/design protocols.
- Continue utilising broodstock from WA’s Managed Prawn Fisheries.
- Maintain the requirement for industry to notify the Department of Fisheries should any escapes occur.

5.1.1.2 Collection

This set of issues covers where industry, or someone else specifically on behalf of industry, collects material from the wild for use in the aquaculture facilities.

Table 8 Broodstock collection.

Description (Fletcher *et al*. 2004)	*Are management protocols in place (or needed) to ensure that the collection of the broodstock animals does not unduly affect the spawning stock size and/or the genetic composition of the wild population?*
Level of Impact	Whole of the industry
Comment	• Collection may have increased consequences in Exmouth Gulf with its viable prawn industry. • Direct collection is carried out using Ministerial Exemptions to fisheries rules – which means the total numbers of individuals collected is limited to a small number (set by policy). • Compliance levels vary, depending on the issue.

Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop				
• Scenario1	4	3	12	Moderate
• Scenario 2	4	2	8	Moderate

Justification for Risk Ranking

In WA, the current legislative framework allows for the granting of an Aquaculture Licence, which provides the authority to conduct aquaculture activities for commercial purposes. However, an Aquaculture Licence does not confer any approval to collect fish from the wild for farming purposes. Aquaculturists can source broodstock by various methods - purchasing from commercial fishers, other Aquaculture Licence holders or retail outlets, or by applying for a Ministerial Exemption to collect them from the wild.

A Ministerial Exemption can be applied for under Section 7 of the *Fish Resources Management Act* 1994. A draft policy statement developed by the Department of Fisheries sets out the processes to be undertaken in applying for an Exemption. The policy also sets out suggested numbers and sizes of fishes that may be taken and the methods by which they are caught.

Following the discovery of gill-associated virus (GAV) in the Joseph Bonaparte Gulf in northern WA, collection of broodstock prawns from the gulf is not permitted. Broodstock are now only collected from the Nickol Bay Prawn Managed Fishery.

The number of black tiger prawn individuals that may be taken as broodstock is 50 male or females, using trawl, netting or traps as the method of collection. If WA is to establish a 1,000 hectare industry, the likely demand for black tiger prawn broodstock is in the order of 2,000 – 3,000 female prawns and 660 – 1,000 male prawns. There may be difficulties in reaching these numbers due to low natural abundances of the prawns in WA.

In the future, this demand may be met through a closed life cycle (i.e. producing broodstock from cultured prawns). Given the size of the WA prawn aquaculture industry in comparison to the wildstock levels, the consequence of collecting broodstock is considered to be ‘major’ (‘4’) however the likelihood of the spawning stock size and/or the genetic composition of the wild population actually being unduly affected by the collection is considered ‘unlikely’ (‘3’) or ‘rare’ (‘2’) depending on the size of the aquaculture facility (i.e. how much broodstock is actually being collected).

Comments in Relation to Future Management

- Maintain the current protocol.
- Finalise the draft policy on *Access to Broodstock and Hatchery production of Endemic and Non-endemic Species for Aquaculture Purposes* (2005).
- Different protocols may be needed for different areas.

Table 9 Genetics.

Description (Fletcher *et al*. 2004)	*Will the collection of broodstock from the wild have an impact on the genetics of wild stocks?*			
Level of Impact	Whole of the industry			
Comment	• This could only be an issue if stocks are selectively bred for certain traits and these stocks have then escaped. • The location of collection may determine the genetic pool of broodstock. • The numbers of individuals collected is small. • Wild stock numbers are lower than for other prawn species, so this would mean removing a larger proportion of wild stock if the prawn aquaculture industry increases substantially over next five years and all farmers require broodstock.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	1	1	1	Low

Justification for Risk Ranking

There are several genetic issues associated with the movement of genetic material between farms and from wild populations into farms, but these are primarily farm stock management issues. The environmental questions faced by regulators are those associated with movement of genetic material from farms to wild stocks and the risk posed to the environment by such movements.

The risk is unlikely to increase unless broodstock grounds that are currently unfished are targeted. If this occurred, a decline in the natural genetic variability of the prawns is possible, although this would be no greater than for other targeted prawn species.

Under WA policy, the number of individual black tiger prawns that may be taken as broodstock is 50 male or females using trawl, netting or traps as the method of collection. Given the size of the WA prawn aquaculture industry in comparison to the wildstock population, the consequence of collecting broodstock on the genetics of wildstocks is considered to be 'minor' ('1') but the likelihood of this happening is 'remote' ('1').

Comments in Relation to Future Management

- Greater understanding of the structure of the wild stock fishery would assist in management.

5.1.2 Cultured stock/businesses (husbandry)

This branch covers issues that may affect the status of the stocks being cultivated within the facilities, which could require industry wide protocols.

5.1.2.1 Genetic composition

Table 10 Ensuring the genetic composition of wildstocks.

Description (Fletcher *et al*. 2004)	*Are protocols necessary to ensure the genetic composition of captive broodstock is maintained at appropriate levels (e.g. industry-wide agreement of genetically modified organisms [GMOs], selective breeding)?*			
Level of Impact	Whole of the industry			
Comment	• It is unlikely that the use of GMOs will be considered in WA in the near future. • Adequate levels of broodstock from the wild may negate requirement for use of GMOs.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	3	1	3	Low

Justification for Risk Ranking

The Australian Government has enacted the *Gene Technology Act 2000* and supporting *Gene Technology Regulations 2001* which underpins Australia's nationally-consistent regulatory system for gene technology. Its objective is to protect the health and safety of people and the environment by identifying risks posed by, or as a result of, gene technology, and managing those risks by regulating certain dealings with genetically modified organisms (GMOs) (Ward 2002).

The Act establishes a statutory officer to administer the legislation and make decisions under the legislation. The legislation sets out the requirements for considering applications for licences for dealings with GMOs and the matters that the Regulator must take into account before deciding whether or not to issue a licence.

Aquaculture organisms can fall into one of three categories:

- Non-genetically altered organisms (NGAOs) – produced in a hatchery either from broodstock or farmed broodstock without the implementation of a scientifically-based breeding program.
- Genetically improved organisms (GIOs) – these might be produced either through a traditional selective breeding program or through ploidy manipulations.
- Genetically modified organisms (GMOs) – these are organisms produced by the application of gene technology.

Aquatic GIOs are generally bred for traits such as faster growth rate or ones desired by consumers. Selection programs work with existing genetic variation, selecting those combinations that give improved results. As a result, the wild population will have the same genetic variation as the cultured population.

For many aquaculture operations, full physical containment of farmed stock is often difficult and gametes and/or larvae may escape. When we consider WA, the likelihood of escapes may be rare. The consequences of native NGAOs or GIOs escaping are likely to be 'low' to 'negligible', as regards effects on the existing wild gene-pool or environmental impacts.

For GMOs with similar likelihood of escapes, consequences are unknown but precautionary principles suggest they might be considered as 'severe' ('3'), giving an overall inherent risk as 'moderate'.

There has been minor discussion held regarding the use of GMOs within the WA aquaculture industry and it is not currently being considered. In light of these comments, the likelihood of GMOs being used has been lowered to 'remote' ('1'), with an overall rating of 'low'.

Comments in Relation to Future Management

- The use of GMOs should be prohibited in light of the current gap in research and knowledge of impacts.
- The current protocols should be maintained.
- Research should be considered if the policy position changes.
- Farms should have a contingency plan in case of an escape as a condition on their aquaculture licence.

5.1.2.2 Disease

Table 11 Identification and response to disease in cultured stock.

Description (Fletcher *et al*. 2004)	*Are disease monitoring, surveillance and risk minimisation programs applied across the whole of industry (e.g. identification of new diseases and any response plans to deal with a severe disease event)?*
Level of Impact	Whole of the industry
Comment	• The use of current protocols with health certification is already required. • If disease monitoring, surveillance and risk minimisation programs are not applied across the whole of industry, the consequences will be four or five diseases becoming apparent. • Gill-affected virus is a middle-of-road disease – any losses would not be catastrophic. • There is a requirement for health certification of all stock. • Translocation approvals are required for bringing specific animals into specific locations. • Feed being brought in for prawn aquaculture could be bringing in diseases. • The Commonwealth Government has processes to link diseases that are being brought in. • There are no 'sector-wide' programs operating to ensure disease outbreaks are detected as soon as possible – dealt with at facility level. • Sector-wide programs operating to ensure disease outbreaks are detected as soon as possible could be linked to the sector-wide environmental monitoring program. • It should be ensured that disease outbreaks are identified as soon as possible to minimise the need for chemical usage.

Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	2	2	4	Low

Justification for Risk Ranking

On-farm health management is vital to successful prawn farming and the focus should be on disease prevention rather than disease management. A Health Management Plan and a Disease Management Plan are documents that are essential for identifying and managing disease on prawn farms and these plans should be written specifically for each farm, incorporating broad principles of biosecurity. The benefits from having these plans can be recognised at both regional and state-wide reporting levels.

An effective biosecurity plan should use the following approaches to reduce the risks of dangerous pathogens entering any farm above acceptable levels:

- Stock only post-larvae that have acceptable test results in terms of pathogen prevalence and load.
- Do not exceed optimal stocking densities.
- Eliminate or reduce risk from potential 'vectors' (infection-carrying agents) on the farm.
- Use water management practices that prevent or reduce contamination by the pathogen;
- Reduce the risk of spreading infection between ponds by restricting movements of people, equipment and other possible agents.
- Implement a health management program that aims to minimise stress to prawns by optimising the pond environment.
- Plan to deal with water-carrying disease vectors.
- Plan to deal with dead or moribund prawns.

However, it is important to know that not all diseases are infectious. Some can be caused by toxins and others by nutritional imbalances. In any pond, host characteristics (prawn age, nutritional status, stocking density), pathogen characteristics (ability to infect, cause disease in and kill the host) and environmental factors (water temperature or salinity) are constantly changing and interacting, usually without disease occurring. On the other hand, sometimes these three factors combine in such a way that a disease outbreak results.

The Australia Government has developed the *Aquavetplan* that ensures a coordinated and efficient approach is taken to assist in disease management and eradication. In WA, the Department of Fisheries' translocation policy provides the framework for ensuring disease certification for any movement of aquaculture stocks.

Using these protocols and considering the size of industry, the ability to identify and respond to disease outbreaks is good, so the consequences are considered to be 'moderate' ('2'). The likelihood of disease outbreaks occurring is 'rare' ('2').

Comments in Relation to Future Management

- Current protocols mean diseases can be contained - the use of the Department of Fisheries' translocation policy should be maintained.
- Use of Departmental Fish Kill program to investigate all fish kills in the wild if necessary.
- Licence conditions on applications should be set high to ensure management practices to minimize disease movement are high.
- The level of disease detection and the associated technology will improve in the next few years.
- An industry-wide process should be developed to assist in the creation of Biosecurity Plans to ensure consistent management of disease issues at an aquaculture facility level.
- Certifications should be required for any translocations (i.e. hatchery to grow-out).
- There should be a requirement for licensees to provide a comprehensive Disease Management Plan.

5.1.2.3 Animal welfare

Table 12 Animal welfare issues.

Description (Fletcher *et al*. 2004)	*Is there a need to assess whether the industry requires a protocol for dealing with the animal welfare issues associated with holding animals – particularly vertebrates?*			
Level of Impact	Whole of the industry			
Comment	• Industry needs to be aware of, and operate under, the provisions of the *FRMA*. • Ensure that any issues of site decommissioning are dealt with through licence conditions. • In best interests of the farmer to minimise any animal stress during farming operations, as it will impact on quality and value of product. • Future harvesting techniques and marketing requirements may impact in this area.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	1	1	1	Low

Justification for Risk Ranking

Understanding the biology of prawns and how they live in their natural environment will give any operator a stronger appreciation of what prawns need and how to care for them in the artificial environment of a prawn farm. Maximising prawn survival and growth depends greatly on minimising the stresses the animals encounter when pond conditions differ significantly from the conditions they are adapted to in the wild.

In a legislative sense, the *Animal Welfare Act 2002* outlines requirements to promote and protect the welfare, safety and health of animals, ensure the proper and humane care and management of all animals in accordance with generally accepted standards, and reflect the community's expectation that people who are in charge of animals will ensure that they are properly treated and cared for. Fish however are exempt from this act.

All matters relating to the welfare of fish in WA are prescribed under the *Fish Resources Management Act*. [Section 258 (va)].

At the national level (via Australian Animal Welfare Strategy) the Aquatic Animal Welfare Working Group has been established to progress the harmonisation of welfare legislation. Guidance will be provided to aquaculture operator through a code of practice based on exciting protocols.

The consequences of not adhering to animal welfare requirements will be felt mainly by the farm operator and these have the potential to be 'severe' for the farm in question. However, on a state level the consequences are considered 'minor' ('1'). The likelihood that state level consequences will occur is considered 'remote' ('1').

Comments in Relation to Future Management

- Ensure aquaculture operators are aware of their obligations under the Animal Welfare Act 2002.
- It is in the best interests of aquaculture operators to minimize stress on farm stock, as this may impact on the value of their 'product'.
- In the long-term future, there may be an animal welfare issue in regard to the processing of prawns if they are to be cooked whilst alive. However, at present mostly the prawns are chilled and hence killed before cooking, so this issue is relatively unlikely to occur.

5.1.3 Other species/communities processes

5.1.3.1 Disease escape and transmission

Table 13 Disease transmission.

Description (Fletcher *et al*. 2004)	*Could disease from the cultured species be passed on to other fauna in the region, either through passage of pathogens through water, intermediary hosts or from escapes?*
Level of Impact	Whole of the industry
Comment	• There is debate about the transfer of disease from wild stocks to farm stocks, but this would appear to be less of an issue with land-based facilities. • The farming of local wild stocks may increase the possibility of disease transfer.

Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	0	1	0	Negligible

Justification for Risk Ranking

As in all intensive animal production systems, disease outbreaks can occur on prawn farms following extreme weather conditions, over-feeding or poor quality of the incoming water (QEPA 2000). The agents that cause disease are opportunist pathogenic organisms taking advantage of the weakened (stressed) farmed prawns. These agents are present in the marine environment and in wild crustaceans but rarely expressed. This type of disease outbreak is considered to pose little threat to wild aquatic animals. On the contrary, wild aquatic animals are a common source of infectious agents for farmed prawns.

The Australian Government prohibits the use of exotic species and exotic foods in the aquaculture industry via regulations, and all prawns cultured in Australia are native species. The Australian Quarantine and Inspection Services (AQIS) enforce regulations that prevent the importation of live prawns and certain types of prawn product. Regulations are designed to prevent the introduction of exotic diseases that may affect wild and aquacultured prawn populations.

In WA, information indicates that the commercial wild stock of prawns are generally free of Gill Associated Virus (GAV) but are exposed to a Monodon Baculovirus (MBV)-like virus and Hepatopancreatic Parvovirus (HPV). The *Biosecurity and Agriculture Management Act 2007* provides state-based legislation to manage the importation and translocation of fish and other animals into and across WA, as well as manage the movement of frozen product destined for human consumption.

The *Fish Resources Management Act 1994* requires the notification of disease outbreaks, but presently there is no industry-wide monitoring component. Under current levels of prawn aquaculture in WA and new legislation, the consequences of disease being passed on to wild stocks is considered 'negligible' ('0') due to the prevalence of viral diseases in wild stocks. The likelihood of this occurring is considered 'remote' ('1').

Comments in Relation to Future Management

- Maintain current translocation and disease testing protocols.
- Ensure the importation of live product into WA is managed appropriately under any new legislation.

5.1.3.2 Food chain impacts

Table 14 Food chain impacts.

Description (Fletcher *et al*. 2004)	*If escapes occur, could these cause significant shifts in the food chain for large regions of the coast? This may also need to be answered at the regional level.*
Level of Impact	Whole of the industry
Comment	• The wild stocks of black tiger prawns are naturally low. • Commercial catch levels of other prawn species are being sustainably managed. • If they do occur, escapes of black tiger prawns will be low as a consequence of the small prawn aquaculture industry.

Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	2	1	2	Low

Justification for Risk Ranking

As outlined previously (Table 7) commercial fisheries reports from WA (*State of the Fisheries Report 2004/05*) identified black tiger prawns as a minor species in the Onslow and Nickol Bay Managed Prawn Fisheries. Black tiger prawns are present in the wild in low numbers, which is why they are not a target species. It is possible that black tiger prawns are found in the Kimberley region, but the populations are likely to be small.

In the event that individuals escape from a prawn farm, the likely impact on local black tiger prawn stocks will be dependent on the region in which the facility is located. Should the farm be situated adjacent to areas fished by the Onslow or Nickol Bay Managed Prawn Fishery, there is a good chance that they may form part of the commercial catch. If the facility is located in areas not adjacent to a Managed Prawn Fishery, escapes may increase the local stock numbers, but these increases should be small, assuming the escapees survive.

Located in land-based facilities, the likelihood of escapes reaching areas where black tiger prawns are found is ‘rare’. However, if we consider the impact on all prawn species, the impacts are considered to be ‘remote’ (‘1’) due to the low aquaculture production levels and spread of facilities.

Black tiger prawns associate with banana prawns and are likely to exploit a similar food resource. If a large-scale escape occurs (i.e. flood damage washes away a pond wall and, say, four tonnes of stock escape), then it is likely that the consequence at a catchment level will be ‘moderate’ (‘2’) until the prawns either die or are caught.

Comments in Relation to Future Management

- Maintain protocols to limit escapes in the first instance.
- Maintain the use of local broodstock so escapes will not impact on wild stocks.
- Permitting trawling in areas where escapes have occurred could be considered, but this would be dependent on the location – onshore areas are unlikely to be supported.

5.1.3.3 Behavioural changes and impacts (eg. migratory species)

Table 15 Changes or impacts on the behaviour of individual species.

Description (Fletcher *et al*. 2004)	*Is this type of industry (e.g. structures used to house farmed individuals) likely to cause 'large-scale' changes to behaviour of other species? Is a whole industry approach sensible (i.e. same type of impact likely to occur everywhere) or is a regional approach more appropriate?*
Level of Impact	Whole of the industry
Comment	• The discharge of high quantities of turbid water may change the breeding or migratory behaviour of fishes in creeks. • The extraction of water from creeks may modify current flows and affect localised behaviour of animals.

Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	2	1	2	Low

Justification for Risk Ranking

Previous studies in other parts of the world on bird interactions have focussed on land-based aquaculture, where small fish are often cultured, and sick and dying fish are taken by predatory or scavenging birds. There is no information specific to WA.

Crocodiles are a species likely to be attracted to prawn farms in the northern regions of WA, but there is very little to report in the way of interactions between the two to this point. Interactions are more likely to occur with open, earthen ponds than with any closed system.

Behavioural changes to species using local creek systems as habitat is a regional level issue and will be covered in more detail there (section 5.2.2.6). Results from these studies should be assessed against required state level policies.

Given the low level of aquaculture activity in the northern regions likely to have an impact on the behaviour of species, the consequences are considered to be 'moderate' ('2'). The likelihood of these consequences occurring is considered to be 'remote' ('1').

Comments in Relation to Future Management

- More research into the impacts on the behaviour of individual species is required. This is very much a Kimberley-specific issue that is unlikely to require consideration elsewhere.
- Develop protocols, together with industry, for managing and minimising any interactions with individual species.
- The reporting of interactions could be required through licence conditions, i.e. in the associated Environmental Monitoring and Management Plan.

5.1.3.4 Threatened and endangered species

Table 16 Threatened/endangered/protected species.

Description (Fletcher *et al*. 2004)	*Is this industry likely to cause impacts on these categories of species? Are 'whole of industry' approaches sensible (i.e. is the same type of impact likely to occur everywhere) or is a regional approach more appropriate?*
Level of Impact	Whole of the industry
Comment	• Self-assessment is required to be undertaken under the Commonwealth's *Environmental Protection and Biodiversity Conservation Act 1999*. • Criteria can be quite broad and difficult to define. • Threatened species are likely to be birds and reptiles (crocodiles).

Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	2	1	2	Low

Justification for Risk Ranking

Under the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act), migratory species protected under international agreements are considered to be 'matters of national environmental significance'. Referrals to the Commonwealth Minister for the Environment are required if an action (in this case, aquaculture) has, will have, or is likely to have, a significant impact on a matter of national environmental significance.

A 'significant impact' is an impact which is important, notable, or of consequence, having regard to its context or intensity. Whether or not an action is likely to have a significant impact depends upon the sensitivity, value, and quality of the environment which is impacted, and upon the intensity, direction, magnitude and geographic extent of the impacts.

An action is likely to have a significant impact on a critically endangered/endangered/vulnerable species if there is a chance or possibility that it will:

- lead to a long-term decrease in the size of a population;
- reduce the area of occupancy of the species;
- fragment an existing population into two or more populations;
- adversely affect habitat critical to the survival of a species;
- disrupt the breeding cycle of a population;
- modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline;
- result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species habitat;
- introduce disease that may cause the species to decline; or
- interfere with the recovery of the species.

The species likely to be impacted on by prawn aquaculture would be birds and reptiles. Areas where larger numbers of protected floral species are found have generally been identified through research and already form part of the conservation estate, managed by the Department for Environment and Conservation (DEC).

When an application for a new aquaculture facility is received, comment is sought from the DEC. Minimising interactions with bird species should be considered during the designing of the facility itself. Regional management regimes may not be the most appropriate way for dealing with individual species being threatened by various activities. This issue should form part of the Code of Practice to be developed to ensure vegetation removal is minimised or reinstated through rehabilitation programs.

Considering the current terrestrial management regime, the consequences of prawn aquaculture impacting on threatened species is considered to be 'moderate' ('2'). The likelihood of this occurring is considered to be 'remote' ('1'). It might be more appropriate to consider impacts on threatened species on a region level.

Comments in Relation to Future Management

- Maintain current protocols against the *Environment Protection and Biodiversity Conservation Act 1999*.
- Ensure the Department of Environment and Conservation continue to contribute to the assessment process.
- Continue the referral to the Environmental Protection Authority for assessment under the *Environmental Protection Act* Part IV for larger facilities.
- More research on impacts to these species is required.

5.1.3.5 Feeds composition (source and sustainability)

Table 17 Composition of Feeds.

Description (Fletcher *et al*. 2004)	*Does the industry use feeds? If so, is the source of these feeds sustainable?*
Level of Impact	Whole of the industry
Comment	• Some species use fish meal sourced from overseas (mainly South America). Are they using sustainable practices? If the process used is not sustainable, then the WA industry will eventually collapse when the feed source collapses. Farmers need to be selective about where the feed comes from. • Research is underway into replacing fishmeal (and fish oil). • Consider whether we want to produce fishmeal in WA, or try to get it from other states such as SA? There are environmental and economic drivers. • If other countries expand or commence aquaculture then there will be more competition for feed and prices will increase, therefore the industry needs a back-up strategy. • Most sources of fishmeal do not like to supply smaller operators. They prefer to supply larger amounts to the bigger industries. • Imported feed is important: is likely to be an issue dealt with by the new *Biosecurity and Agricultural Management Act 2007*. • There may be a public health issue and testing should be carried out on imported pellets to monitor toxin levels in fishmeal used.

Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	2	5	10	Moderate

Justification for Risk Ranking

Currently prawn aquaculture uses mainly pelletised feed at certain stages through the production cycle, which consists predominantly of fishmeal and fish oil that are obtained from overseas baitfish wild-capture fisheries. One of the major concerns for those opposed to the aquaculture of carnivorous fish is that more baitfish by weight is required for feed than what is produced by weight as the final product. For example, for every 2kg of baitfish used, only 1kg of prawns is produced.

The indirect use of baitfish is one of the weaknesses in the argument that aquaculture will help relieve the pressure on wild-capture fisheries. Most of the baitfish fisheries are already fully exploited, over-exploited or depleted and if aquaculture keeps expanding, then supply will fall short of demand. While these fisheries should be managed for sustainability by the relevant fisheries authorities, history shows that this is often not achieved and increased demand for product could lead to further problems with over-fishing (De Jong and Tanner 2004).

Baitfish are primarily small pelagic fish and the main wild capture species utilised for global supplies of fish meal are anchoveta, Chilean jack mackerel, chub mackerel, Japanese anchovy, round sardinella, Atlantic mackerel and European mackerel. Six of these species are found in the top-10 of capture fisheries in terms of production. Several management strategies and regulations have been put into place by government agencies around the world in order to improve the sustainability of these baitfish fisheries.

The main fishmeal-producing countries in order of decreasing output are Peru, Chile, China, Thailand, Japan, USA, Denmark, Iceland and Norway. Worldwide, one-third of the fish used to make fishmeal are used for aquaculture, while the remaining two-thirds are used for fishmeal to feed poultry, pigs and other animals.

The over-exploitation of these pelagic fish species may have severe consequences for the food chain by reducing the available food for larger predatory fish. For example, in the North Sea, over-fishing of sandeel, Norway pout and capelin has been associated with a decrease in stocks of certain fish such as cod, as well as changes in the distribution, population dynamics, and reproductive success of seal and seabird colonies. In the Peruvian up-welling system, a strong interaction between anchoveta and seabird and mammal populations has been observed. In Australia, pilchards (*Sardinops neoplichardus*) and jack mackerel (*Trachurus declivis*) are harvested for marine finfish food and both species are known 'keystone' prey for a number of vertebrates including penguins, gannets, Australian fur seals, shortbeaked common dolphins and Indo-Pacific dolphins.

The amount of baitfish captured varies greatly between years and there is some evidence that the global catch is declining, although some fisheries, such as for pilchards in WA, are still classified as underexploited. At present, Western Australian aquaculture is highly dependent on the import of fishmeal and fish oil for feed.

Fishmeal and oil prices have risen over the past few decades and will probably continue to rise as stocks become limited and demand increases. Due to the fluctuating food source, the industry has recognised the need for fishmeal and fish oil replacements in the diet. The major problem associated with replacing fishmeal and oil with plant-based products is that carnivorous fish do not utilize plant-based proteins and oils efficiently. Fishmeal and fish oil are used as ingredients because they supply the cultured fish with essential amino acids and fatty acids that are either deficient or not present in plant proteins and vegetable oil.

There is currently extensive research into fishmeal partial replacements for feeds both in

Australia and overseas. Worldwide, a wide variety of fish meal replacements have been evaluated, although very few of them show any potential for inclusion in a carnivorous fish diet. The main problem with the use of some of these products is their limited availability, varying quality and prices.

The replacement of fishmeal with meat meal has become highly controversial in recent years because major problems arose when livestock were fed meat meal contaminated with Bovine Spongiform Encephalopathy (BSE).

Within Australia, soybean and poultry offal meal have been tested for replacement of fishmeal in snapper feed, while soybean meal and protein concentrates made from narrow-leafed lupin and field peas have been evaluated for Atlantic salmon. Information suggests that up to 50 per cent of the fishmeal in snapper diets could be replaced by soybean meal and poultry meal without causing a reduction in growth rates. Soybean meal and pea protein concentrate showed the best potential for replacing at least 33 per cent of the fish meal in some feeds.

The other major risk associated with feed is contamination. While there is recent, although controversial, evidence that cultured fish have high contaminant levels due to contaminated feed, in Australia the National Residue Survey Group regularly tests for contamination to ensure there are no problems. However, there is currently no testing program for imported feed, so there is some risk of contamination occurring and leaving farmers with unmarketable product.

Prawns nutritional requirements change with their stages of development. During the hatchery phase, newly hatched nauplii do not feed but their next three zoeal stages feed on phytoplankton and/or fine suspended organic matter. Post-larvae stocked in well-prepared ponds can feed on a range of naturally occurring planktonic food organisms (such as copepods) and detritus, which remain important until artificial feeds can replace the majority of the stocks' nutritional requirements.

In 1997, 90 per cent of the feeds used by prawn farmers in Australia were imported mostly from Thailand and Taiwan. Currently, the Derby prawn farm imports feed from Queensland, using the "Ridley" brand.

Given the relatively small amount of prawns farmed in WA, the risk the State's industry imposes to baitfish stocks is low, but when we consider the aquaculture industry across Australia as a whole, the risk may be minor. Demand from aquaculture is likely to be contributing to over-fishing of a number of wildfish stocks. Of greater risk is the impact that relying on baitfish fisheries could have on the aquaculture industry, as prices are likely to increase as demand continues to increase.

The long-term viability and competitive edge of the industry in Australia is thus likely to depend on finding alternatives to fish meal and fish oil for producing feed. In light of these comments, the consequences could be 'moderate' ('2') with a likelihood of this occurring being 'occasional' ('5'). This could result in a moderate impact on the growth of a WA prawn aquaculture industry if feed composition is not researched and alternatives found.

Comments in Relation to Future Management

- Continue to undertake research to identify new feeds (Department of Fisheries, Seafood Cooperative Research Centre).
- Continue to utilise aquacultured ingredients where possible.
- Should we consider farming our own fish for use as fishmeal/fish oil?

- Ensure that species imported as an aquaculture feed are incorporated into species lists for *Biosecurity and Agricultural Management Regulations.*

5.1.3.6 Sensitive habitats

Table 18 Sensitive habitats.

Description (Fletcher *et al*. 2004)	*Are there certain habitats that all industry should avoid using and/or all of industry need to use a common approach to operate within? These issues are usually dealt with at a regional level, but there may be circumstances where the entire industry deals with the issue in a similar fashion.*
Level of Impact	Whole of the industry
Comment	• The Department of Fisheries does not support locating a facility over/in sensitive habitats without appropriate management techniques. • The Department of Environment and Conservation (DEC) assessment processes require the avoiding of mangrove habitats, minimising impacts on seagrasses, clearance of significant terrestrial vegetation, etc. • If industry grows significantly in one region, may need to consider maximum limits of habitat that can be compromised. • Major areas to be avoided will generally already be identified and form part of a DEC estate, Marine Protected Areas, RAMSAR wetland, etc. • Areas of national significance will need to be assessed against the *Environment Protection and Biodiversity Conservation Act 1999*.

Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	4	1	4	Low

Justification for Risk Ranking

The impacts from prawn aquaculture on sensitive habitats need to be considered for both marine and terrestrial areas. Habitats that are likely to be of concern to the WA government are seagrass, mangroves and coral ecosystems (in the marine environment) and wetlands and riparian vegetation (for terrestrial environments). Impacts on these habitats could be a consequence from ongoing discharges of nutrients and sediments, as well as the general placement of facilities.

Aquatic flora may be directly affected by clearing of vegetation and native habitats during the construction and subsequent operation of prawn aquaculture facilities. The clearing of native terrestrial flora has the potential to significantly impact on the biodiversity of a region, specifically in relation to the removal of habitats occupied by threatened or endangered species. The disturbance or removal of riparian vegetation also has the potential to affect stream ecology.

The DEC is unlikely to approve proposals in this situation. Any facilities that are located adjacent to these habitats will be monitored to ensure that impacts remain on site (as required by DEC) and are within critical trigger values for the specific nutrients of interest within determined buffer distances.

Guidance statements from the EPA for the protection of mangrove habitats and seagrass communities are providing a sound basis upon which to assess the consequences of prawn aquaculture. What needs to be determined however, is more detail on the impacts that can actually occur as a result of these types of facilities in WA and not continue to use assumptions based on inter-state operations and environments.

The consequences from prawn farming being located in sensitive habitats could be ‘major’ (‘4’),

but given the protocols currently in place in WA, the likelihood of this occurring is considered to be 'minor' ('1').

Comments in Relation to Future Management

- Maintain consideration by other determining bodies such as the DEC, Commonwealth Department of Environment, Water Resources, Heritage and the Arts (DEWRHA)
- Maintain a current Department of Fisheries assessment and licensing procedures.
- Maintain the DEC Native Vegetation Clearance approvals for terrestrial areas.
- Utilize EPA Guidance Statements No.1 – *Protection of Tropical Arid Zone Mangroves along the Pilbara coastline*, No. 29 – *Benthic Primary Producer Habitat Protection for WA's Marine Environment* and Position Statement No. 2 – *Environmental Protection of Native Vegetation in WA*.

5.1.3.7 Water quality

Table 19 Common standards for water quality.

Description (Fletcher *et al*. 2004)	*Are there common standards for all of industry to use with regards to water quality (e.g. to avoid poisoning customers who purchase the products grown)?*			
Level of Impact	Whole of the industry			
Comment	• There are numerous pieces of legislation and policy providing guidance across all facets of water quality, e.g. groundwater, rivers, estuaries, wetlands, and the marine environment. • Ensure licence conditions and code of practice supports the *State Water Quality Management Strategy*.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	2	3	6	Low

Justification for Risk Ranking

Australian prawn farmers have found that to maximise growth and minimise the risk of disease, it is best to exchange water in the ponds only when necessary and to provide it as slowly as possible. Most prawn farmers average less than three per cent a day over the entire crop. It is important to ensure that the timing and amount of exchange are related to the quality of the incoming water, the amount of aeration in the pond and the skill of the manager (QDPI&F 2006).

The major risk of environmental harm following the establishment of prawn farms is from the discharge of pond waters containing elevated levels of nutrients, organic matter, salinity, suspended solids, low dissolved oxygen concentrations or abnormal pH levels into tidal waterways, particularly where such waterways are poorly flushed by the tides and/or where the receiving environment is an important or sensitive coastal area (QEPA 2000).

Water discharge or effluent resulting from the prawn ponds has also been a contentious issue in regions around Australia. Essentially, prawn pond effluent has been perceived as a form of pollution. The NSW Government imposed levies based on discharge rates and this has been highly controversial. Prawn farmers argue that when nutrient levels in the watercourse are used as background, the level of nutrients in the prawn pond effluent is minimal.

In WA, water resources are managed via a vast array of legislation and supporting policy. The

State Water Quality Management Strategy (2004) (SWQMS) provides for the establishment of environmental values and environmental quality objectives as the goals for environmental quality management. This strategy has as its goal the protection of the environment from the effects of waste 'inputs' and pollution. Thorough public consultation must be undertaken prior to the development of suggested environmental values and environmental quality objectives prior to their submission to the Environmental Protection Authority (EPA). These suggested values then guide environmental impact assessment and natural resource management.

The DEC is currently progressing the implementation of the SWQMS through the drafting of regional environmental values and environmental quality objectives. These reports have been completed for Cockburn Sound and the Pilbara coast. As these reports are developed further, outputs will be taken on-board for determining water quality criteria as part of the Environmental Monitoring and Management Plan for aquaculture operations.

In the light of the protocols set-up through various administrative frameworks and the size of the industry, the consequences across the State are considered to be 'moderate' ('2') with a likelihood of moderate consequences occurring being 'unlikely' ('3').

Comments in Relation to Future Management

- Maintain the Department of Water's *Water Protection Notice* as guidance.
- Maintain the current protocols set out in State legislation, as outlined in the table below.
- Develop a code of practice for the industry, so it knows how and what criteria is needed to be adhered to in regard to water quality.
- Participate in discussions with the DEC during determination for environmental values and quality objectives in future, to ensure realistic criteria in respect to aquaculture operations.

Groundwater	Contamination of groundwater (microbes, chemicals & nutrients) Salinity Maintenance of drinking water quality	• New Legislation – *Contaminated Sites Bill* • National Action Plan for Salinity and Water Quality • State Salinity Strategy • Environmental Protection Policies • Statement of Planning Policies & land use planning mechanisms to manage water quality • Australian Drinking Water Guidelines
Rivers	Eutrophication Turbidity Loss of fringing vegetation Environmental Water Provisions Contamination Salinity Maintenance of drinking water	• Waterways WA Policy • National Action Plan for Salinity and Water Quality • Allocation Plans for surface water basins throughout the State that incorporate environmental water provisions • State Salinity Strategy • New Legislation – amendments to the *Environmental Protection Act 1986* • Australian Drinking Water Guidelines
Estuaries	Eutrophication Contamination Turbidity	• Waterways WA Policy • New Legislation – amendments to the *Environmental Protection Act 1986*
Wetlands	Environmental Water Provisions Contamination Eutrophication	• New Legislation – amendments to the *Environmental Protection Act 1986* • Allocation Plans for groundwater basins throughout the State that incorporate environmental water provisions • Environmental Protection Policies • Statement of Planning Policies & land use planning mechanisms to manage water quality
Marine Environment	Contamination Habitat degradation	• Environmental Protection Policies • New Legislation – amendments to the *Environmental Protection Act 1986* • Adoption of PIMC & NRMMC guidelines • Legislation – *Conservation and Land Management Act 1984* to create new marine reserves

5.1.3.8 Chemicals

Table 20 Use of chemicals.

Description (Fletcher *et al*. 2004)	*Are there chemicals being used in the industry that require 'whole of industry' approaches to their use?*			
Level of Impact	Whole of the industry			
Comment	• WA prawn farmers do not use chemicals in their ponds at present – they may use them in hatcheries to control bacteria.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	2	3	6	Low

Justification for Risk Ranking

Chemicals used in coastal aquaculture include those associated with structural materials, soils and water treatments, antibacterials, other therapeutants, pesticides, feed additives, anaesthetics and hormones. As the industry has grown, it has adopted chemicals originally developed for use by the other sectors, mainly agriculture (GESAMP 1997). Consequently, many chemicals now in common use have never been specifically evaluated from the perspective of their effects on the aquatic environment.

In 1997, the United Nations Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP) Working Group completed a study on the chemicals used in the aquaculture sector world-wide and considered various issues, such as environmental persistence, residues, toxicity in non-target species and drug resistance. They found that chemicals in use in aquaculture could be grouped into three categories. The first consisted of chemicals that pose an inherently high level of hazard and their use should be curtailed. The second category includes chemicals that can be used safely if standard precautions are followed but pose a threat to the environment and/or human health if misused. The third category includes those that may be environmentally benign under most situations but detrimental at specific sites because of those site's unique attributes.

Chemicals commonly used in prawn farming around the world include tea seed cake (*Camellia* sp.), lime, calcium/sodium hypochlorite, malachite green, formalin, copper sulphate, benzalkonium chloride, glutaraldehyde, zeolite and povidone chloride. Apart from lime, very small concentrations of the other chemicals are used, therefore their impacts on the environment are likely to be minimal. Although a considerable amount of lime is used (two to five tonnes applied per hectare of pond) for pond preparation, to neutralise acid sulphate conditions and also as a disinfectant, its impact on the environment is considered minimal (Black 2001).

In WA, prawn farmers do not use hormones or antibiotics in ponds and no chemicals are registered for use in prawn ponds containing stock destined for human consumption. However, antibiotics may be prescribed for use in hatcheries to reduce bacteria that can cause mortality in the larval-rearing tanks. Use of these types of drugs is strictly controlled in Australia by the AMVPA and they are only available via veterinary prescription.

There is a lack of data, especially in the tropics, concerning the impacts of antibiotics on human health and on the environment, and more data-driven relationships are needed to establish proven rather than perceived impacts. Impacts of antibiotic use on the aquatic environment are based mainly on work carried out in developed countries in temperate zones. Results of studies carried out in temperate countries may not necessarily apply to the tropics, since the pharmacokinetic behaviour of antibiotics varies with pH, salinity, temperature and light (Black 2001).

The consequences of chemical usage in WA are considered to be 'moderate' ('2') due to the size of the industry, as well as the lack of any research on the impact of chemicals in the WA environment. However, the current protocols in place regarding approval for use result in a likelihood value of 'unlikely' ('3'). If the prawn aquaculture industry increases in size over the next five to 10 years, these consequences may need to be reassessed.

Comments in Relation to Future Management

- Maintain the current chemical approval protocols.
- Monitoring should be required to determine environmental residues if the use of a chemical is approved.
- Develop a code of practice for hatcheries.
- Determine which chemical may be suitable for use in WA prawn aquaculture industry.
- Advise industry groups of protocols and research outcomes.

5.2 Impact of the Industry on the Catchment/Region (Cumulative Impacts)

This generic component tree covers issues that may need to be considered when assessing the combined impact of all aquaculture facilities operating (or planned to be operating) within a defined region/catchment/area. The main purpose of this tree is to try and assist in the examination of the potential cumulative impact of all these facilities in relation to regional circumstances such as geography and other industries already operating.

For example, if there are already objectives, or levels that have been established that all industry within a region (not just aquaculture industry) needs to comply with (e.g. a total amount of water extraction), this is the place to address these issues. Thus, this tree could be valuable for use by regional planning authorities.

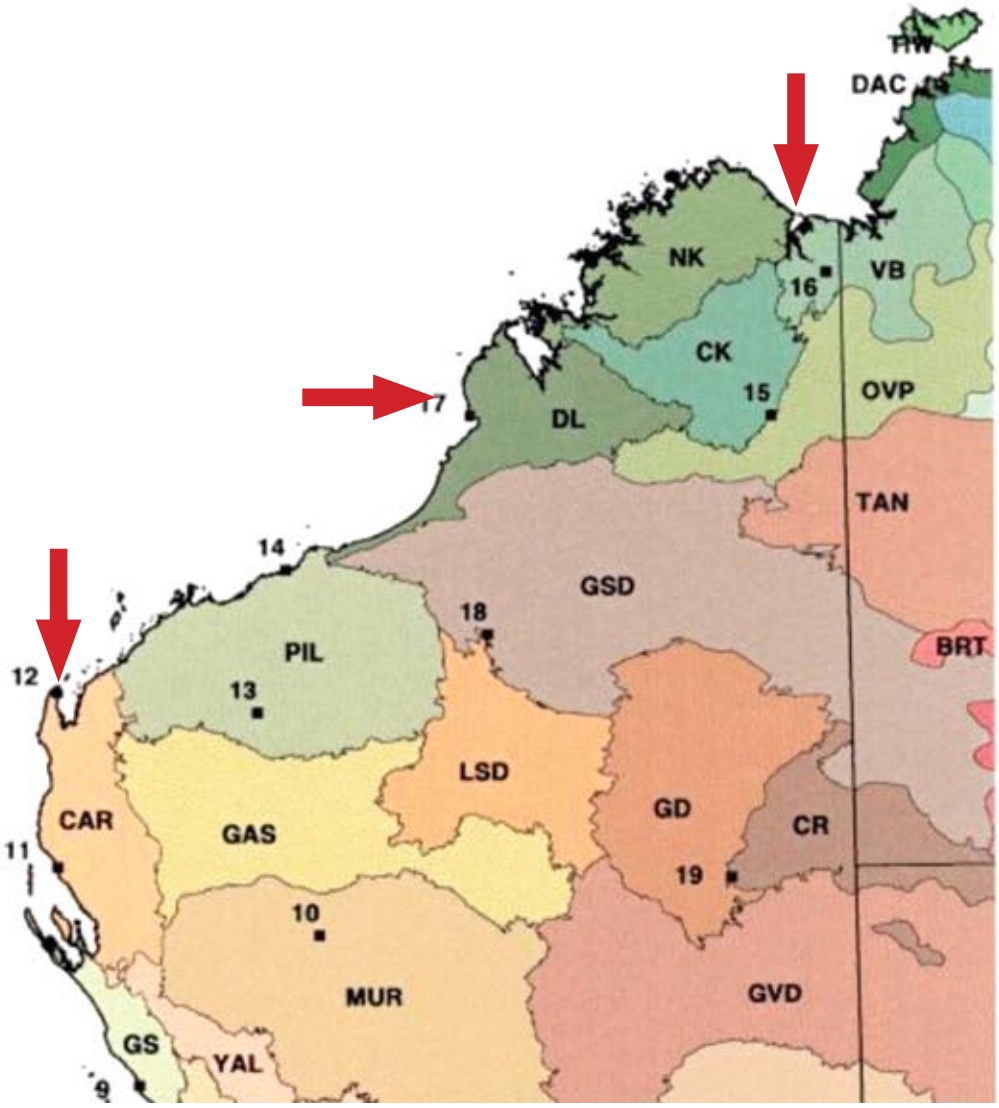
As outlined previously, licences authorising prawn aquaculture are located at Cone Bay, Exmouth Gulf, Derby, Broome and Carnarvon. Others are also licensed at Maddington, Fremantle and Bentley, but these are not considered to be potential commercial operations (being linked to tertiary institutions). Regions north of Geraldton are suitable for farming of black tiger prawns. A large prawn farm is being constructed near Exmouth, with a previously operational farm located at Derby and a 'pending proposal' for Wyndham.

IBRA Regions:

NK	Northern Kimberley
CK	Central Kimberley
DL	Dampierland
PIL	Pilbara
CAR	Carnarvon
GS	Geraldton Sandplains

IMCRA Regions:

KIM	Kimberley
KSD	King Sound
PIN	Pilbara (near-shore)
SBY	Shark Bay



5.2.1 Water use quality/quantity

This branch covers the potential impacts that all facilities within a catchment/region might have on water quality within that area. This includes impacts both on the incoming water body (such as from water extraction) and to any receiving water body (e.g. waste water release).

5.2.1.1 Plankton

Table 17 Plankton.

Description (Fletcher *et al*. 2004)	*If the facilities increase the nutrient load could this lead to an increased frequency/intensity/composition of plankton blooms (algal, zooplankton or both)? Is there a need to monitor this region for toxic species?*
Level of impact	Catchment/Region
Comment	• Impacts from discharges on plankton blooms will depend on the location, e.g. discharges within Shark Bay and around Exmouth being of more concern than within more open waters or less sensitive habitats. • The use of settlement ponds in the design of an aquaculture facility will lower water exchanges and lessen the chance of the release of plankton blooms. • Farmers wish to retain the plankton bloom for use within the aquaculture facility for feed purposes.

Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop				
NK	2	3	6	Low
CK	2	3	6	Low
DL	3	3	9	Moderate
PIL	2	3	6	Low
CAR	4	3	12	Moderate
GS	2	3	6	Low

Justification for Risk Ranking

In prawn farming, an important pond management practice is the establishment and maintenance of phytoplankton blooms in the ponds. This is done in order to shade the prawns, prevent the establishment of benthic algae, oxygenate the water, reduce ammonia levels and provide a natural source of food for the prawns. However, pond phytoplankton blooms are often unstable because of unpredictable variation in community composition and biomass.

In a prawn pond, the plankton community is comprised of phytoplankton, zooplankton, protozoa and bacteria. Phytoplankton, also known as microalgae, includes diatoms, dinoflagellates and other groups of unicellular algae species. Zooplankton will usually comprise copepods, amphipods, rotifers and other species groups. The establishment of a plankton bloom is a critical factor affecting health and growth of prawns in ponds (QDPI&F 2006).

Pond plankton communities go through a succession of changes in the types of natural feed species that are available. Algal bloom changes are often a result of fluctuating zooplankton populations grazing on the phytoplankton resource. It is imperative that the grazing pressure of the species that consume the algal bloom does not become dominant, as this can lead to the collapse of the algal bloom. If this were to occur, this would leave room for other species (some blue-green algae) to proliferate, that may not necessarily be consumed by the grazers.

The most common way of ensuring the bloom remains is to add fertilisers containing urea, ammonium or nitrate (as the nitrogen sources) and phosphate as the phosphorous source. Over fertilising should be avoided as it is a waste of money and will lead to an increase in the nutrient load in any discharge waters. Nutrients released from waste feeds and metabolic wastes from the prawns are usually enough to maintain the bloom when the prawns increase in size.

The use of settlement ponds for removing sediments and nutrient-stripping of discharge waters have been used in most cases, rather than direct discharge into creeks. Plankton consumers such as milkfish and mullet have been used in bioremediation ponds overseas; mullet have been trialled by the Queensland DPI Bribie Island Aquaculture Centre. Promising results suggest incorporating algal-supporting substrates in combination with sedimentation ponds containing finfish.

Filter-feeding bi-valves (e.g. oyster) have also been trialled in Queensland and shown to be effective in reducing suspended solids, total nitrogen and phosphorous, chlorophyll *a* and bacteria. Macro-algae can also be grown in ponds to reduce nutrients and suspended solids.

In WA, nutrient enrichment or algal blooms are managed under the *Environmental Protection Act's* 'environmental harm' provisions or Pollution of Unauthorised Discharge Regulations.

Within the IBRA regions of Dampierland, Carnarvon and Geraldton Sandplains are areas where plankton blooms could be discharged into bays with lower flushing rates. The associated IMCRA regions are King Sound, Pilbara and Shark Bay and for these regions, information is available on the ecosystems that could be impacted on by any increase in plankton blooms. These are, on the whole, sensitive habitats and information on these environments is covered under Section 2.2.9.

The industry at its present level would not discharge large quantities of plankton blooms into the broader environment due to the use of settlement ponds and zero levels of water discharge. The consequence of discharge waters resulting in increased algal blooms in a regional perspective range from 'major' ('4') in areas around Shark Bay, 'severe' at Exmouth ('3') to 'moderate' ('2'), but the likelihood of these consequences occurring is 'unlikely' ('3') due to current protocols.

Comments in Relation to Future Management

- Instigate the environmental monitoring of nitrogen and phosphorous ratios in discharge waters.
- Utilise the DEC environmental values and environmental objectives where they have been determined.
- In areas adjacent to sensitive habitats, higher standards of environmental management should be required.

5.2.1.2 Nutrients

Table 18 Ambient levels.

Description (Fletcher *et al*. 2004)	*There may be a need to relate nutrient inputs from this industry to ambient levels. What is the impact of background levels of nutrients in this region within both incoming and receiving waters on ecological processes?*
Level of impact	Catchment/Region
Comment	• We do not have any information on cumulative effects, i.e. for all inputs. • If there were 5,000 tonnes on west side of Exmouth Gulf, would it impact on the eastern side of Exmouth Gulf? • What is the nutrient loading per year and the characteristics of receiving environment? This would depend on the system. • If you decide to have a farm in an area where water quality criteria are high, then you need to have a recirculating system. • Some regions have other users that will be adding nutrients – the total maximum nutrient levels need to be determined. • More open flushed sites will assimilate nutrients more readily than closed sites such as Exmouth Gulf and Shark Bay. • Farm operators need to limit nutrient discharge and manage this through farm design.

Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
During workshop				
Scenario 1				Red
Scenario 2 (in Exmouth Gulf)				Orange
After workshop				
NK	2	2	4	Low
CK	2	2	4	Low
DL	2	2	4	Low
PIL	1	2	2	Low
CAR	2	2	4	Low
GS	3	2	6	Low

Justification for Risk Ranking

Nitrogen, phosphorous and suspended solids are arguably the parameters most critical to both the operation of a prawn farm and the environment in which waters are released. Significant research and monitoring effort has been put into studying these parameters, their effects and treatment options (QEPA 2000).

The draft *Australia Water Quality Guidelines* recommended the development of load-based guidelines for nutrients, biodegradable organic matter and suspended particulate matter.

The WA Department of Environment and Conservation (DEC) implements the *State Water Quality Management Framework* through a concentration approach to nutrients inappropriate in nutrient-poor waters. The measurement of concentration is useful in identifying contaminant levels that can cause acute effects, as compared to load determination, which provide a better understanding of total contaminants discharged.

Most parameters are affected by not only the on-site management performance but by the ambient levels in the intake waters. It is recognised that in order to determine the contribution

made by an aquaculture facility, both input and discharge waters are sampled at the same time, with the discharge levels related to input or 'background' level.

Nitrogen

This is one of the most important limiting nutrients in many estuarine and marine ecosystems. The principal source of nitrogen (other than intake waters) in prawn farm discharge is from feed introduced into ponds. Nitrogen in discharge waters is derived from uneaten feed, excreta, ammonia and algae.

Total nitrogen is made up of particulate nitrogen, ammonium, nitrate and dissolved organic nitrogen. The concentrations of these components can vary widely, but the total nitrogen levels are more consistent and therefore is the most appropriate parameter to measure. Ammonia concentrations are highly variable and difficult to sample and analyse (QEPA 2000).

Research by the Aquaculture Cooperative Research Centre has shown that 30 to 40 per cent of the total nitrogen in prawn pond effluent is in the form of dissolved organic nitrogen. The research has shown that most of the dissolved organic nitrogen in prawn pond effluent is high molecular weight compounds which biodegrade relatively slowly. The remaining 60 to 70 per cent of the total nitrogen is particulate nitrogen, ammonia/ammonium and nitrate/nitrite.

Phosphorous

Research indicates that estuaries and marine systems are not phosphorous limited and that prawn farms are not a major source of phosphorous. The sources of phosphorous within prawn farms are from uneaten food, solid excreta and soil particulates, the majority of which can be effectively controlled by settlement ponds/systems. Treatment systems developed for the control of nitrogen levels would also result in the reduction of phosphorous in discharge waters, as both have a significant proportion tied to particulate matter.

Suspended Solids

The suspended solids in prawn farm waste waters contain not only inorganic materials derived from inlet waters and erosion from channel walls, pond walls and floors, but also include nutrients in particulate form. The discharge of this material when mixed with marine waters generates 'marine snow' which can have major adverse impacts on marine organisms.

The majority of this material can be effectively removed from the waste stream by the incorporation of a settlement pond system. The efficiency of the design of such systems is based on the retention time and the settling characteristics of the influent stream.

Biochemical Oxygen Demand

From analyses carried out by the Queensland Environmental Protection Authority on pond water and effluent over several years, there is little correlation between biochemical oxygen demand and suspended solids. Prawn farm wastewater consists of a mix of algae, dissolved nutrients and suspended soil particles eroded from pond walls or due to turbid inlet water.

Chlorophyll a

Chlorophyll *a*, extracted from phytoplankton, is a common water quality parameter routinely used in characterising ambient water quality. It is often used to determine the productivity of the water body and as a surrogate for the biological availability of nutrients.

Research indicates that phytoplankton is a significant component of the total nitrogen in

discharge waters. However, the fate and effect of the phytoplankton from prawn ponds on adjacent waterways remains unknown, other than it can be the cause of a visible plume during discharge. Therefore, it has been considered more appropriate to refer to total nitrogen in prawn pond discharges rather than chlorophyll, until there is further information available specifically on the impacts of phytoplankton on receiving waters.

The S*tate Water Quality Management Strategy* (2004) provides for 'the establishment of environmental values and environmental quality objectives'. These are 'goals for environmental quality management to protect the environment from the effects of waste inputs and pollution'. In 2006, the DEC finalised the *Pilbara Coast Water Quality Consultation Outcomes* document, which recommended a set of Environmental Values and Environmental Quality Objects and where they should apply across the region between Exmouth Gulf and Cape Keraudren. This covers an area encompassed by the Pilbara and northern part of the Carnarvon Bioregion.

The spatial areas identified do not explicitly permit or prohibit uses, rather they set down goals for environmental quality. The DEC recognise that setting levels of environment protection may constrain discharges and disturbances from commercial and land-use activities and that it is unreasonable to propose a maximum level of ecological protection adjacent to large existing commercial/population centres. For this reason, maximum levels have not been identified for development in existing government-endorsed land-use plans.

The levels are considered to be interim and should be used to guide Environmental Impact Assessment, waste discharge regulation and natural resource management, until they are more formally established through government policy. The challenge will be in determining where areas suitable for aquaculture can and should be located in the future.

Western Australia's marine waters are generally low in nutrients and the discharge of significant levels of nutrients may have impacts on these environments. Little work has been done to determine what the level of impact may be for WA ecosystems, and this includes the other users currently discharging into waters where prawn aquaculture may be considered in future.

The low prawn aquaculture production at present, with the only operating farm in the Dampierland region not discharging at all, gives a consequence of 'severe' ('3') to 'moderate' ('2') depending on the region, with a likelihood of 'rare' ('2'), at present levels.

Comments in Relation to Future Management

- A large tidal flush-type facility could not be used in this instance.
- Tropical waters are nutrient-poor.
- This issue can be managed by the use of technology.
- The Department of Fisheries should undertake a site selection process where areas suitable for prawn farming are classified as red/orange/green – which is set by ambient nutrient levels.
- Set Environmental Management Plans including monitoring of control sites outside of impact areas to ensure nutrient levels are considered against the ambient levels of nutrients.
- Use the DEC *Pilbara Coast Water Quality Consultation Outcomes* (2006) report.
- Compare what WA can do with the data and methodology used by other states/countries.
- Conduct modelling to investigate the seasonal changes to the nutrient assimilative capacity of waters.

Table 19 Industry inputs.

Description (Fletcher *et al*. 2004)	*Is there already a problem due to pre-existing industries and is it possible that no or little further additions may be tolerated? Similarly, if the incoming water is very low in nutrients, this may also affect what output levels will be allowed.*
Level of impact	Catchment/Region
Comment	• Information on nutrient levels is only available for specific areas – similarly, ambient or baseline values are not available. • WA marine waters are generally naturally low in nutrients. • Existing prawn farms are located in remote areas away from other users.

Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop				
NK	2	1	2	Low
CK	2	1	2	Low
DL	2	2	4	Low
PIL	2	3	6	Low
CAR	2	2	4	Low
GS	2	3	6	Low

Justification for Risk Ranking

In regards to the north and central Kimberley as well as Dampierland regions, the main industries are mining, oil and gas exploration, horticulture, pastoral activities, fishing, tourism and pearling. Agricultural and horticultural activities take place primarily in the Ord River Irrigation Area (ORIA). Smaller operations occur in the areas around Broome and Derby. Products, ranging from sugar and maize to rockmelons and bananas, are produced predominantly in the ORIA. Cattle fattening, using irrigated leucaena pastures, also occurs in the ORIA.

The Pilbara region is undergoing rapid economic development across a range of marine-related industry sectors, including offshore oil and gas, ports, shipping, mining, minerals processing industries, solar salt production, commercial fishing and nature-based tourism.

Carnarvon and Geraldton Sandplain regions are facing localised increases in use, centred on Geraldton, Exmouth Gulf and Shark Bay. Most of these developments are marine-based but need to be considered when dealing with discharges from prawn aquaculture facilities.

Most farms will be built in areas with little industry that discharge waste water into the environment and, as such, the likelihood of being impacted on by other industrial users is low. There is little data for individual activities and none when considering cumulative effects in this region.

The consequence of having other users in the vicinity is ‘moderate’ (‘2’), if the Department of Fisheries/the Department of Environment and Conservation take the approach that licenses should be granted on the basis of the cumulative impact on the environment, not the point source impact. The likelihood of pre-existing industries limiting further aquaculture development is considered to be either ‘remote’ (‘1’) or ‘rare’ (‘2’).

Comments in Relation to Future Management

- Ensure planning for aquaculture takes into consideration the current and projected users and impacts in an area.

5.2.1.3 Other wastes / pollutants (e.g. chemicals)

Table 20 Regional impacts from the release or use of chemicals, dissolved oxygen & pH.

Description (Fletcher *et al*. 2004)	*Are there issues associated with the release or use of chemicals that need to be managed at the entire catchment/region scale? What is the impact of the release or use of chemicals at the entire catchment/region scale?*
Level of impact	Catchment/Region
Comment	• Existing prawn farms in WA do not use chemicals, so there should not be any chemical wastes entering the receiving environment. However, there is some use of antibiotics for bacterial control in hatcheries.

Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop				
NK	1	2	2	Low
CK	1	2	2	Low
DL	1	2	2	Low
PIL	1	2	2	Low
CAR	1	2	2	Low
GS	1	2	2	Low

Justification for Risk Ranking

The use of large amounts of chemicals in aquaculture is usually a sign of crisis or poor husbandry. Where such operations discharge significant amounts of hazardous chemicals to the aquatic environment, it is likely that the operation is unstable and may be unsustainable as stressed animals are more likely to succumb to disease.

Currently, the use of a variety of chemical agents to control sea lice is a major environmental concern in European salmon culture, although attitudes vary regionally, with much less emphasis being placed on the potential environmental effects of these chemical in Norway compared to the UK. Whether the use of such chemicals constitutes a major ecological threat at either regional or local levels, is currently being actively researched, as is the search for an effective immunological solution (Black 2001).

In WA, approval must be sought for the use of any chemicals on case-by-case basis from the Australian Pesticides and Veterinary Medicines Association (APVMA). There is no industry-wide protocol as to the actual use of chemicals, but the use of chemicals in land-based aquaculture is low at present. Consequences, across all regions, are considered to be 'minor' ('1') with the likelihood as 'rare' ('2').

Comments in Relation to Future Management

- The protocol should be maintained on the application, use and reporting of any chemical use.
- The design of a monitoring program should be considered for any site, including the surrounding area, where chemicals are approved. This should assist in providing guidance on any impacts that could eventuate from use of chemicals.
- 'Best practice' guidelines would assist industry for managing this environmental risk.
- The *Environment Protection Act* provides for 'environmental harm' and Pollution (Unauthorised Discharges) Regulations.

5.2.1.4 Water extraction

Table 21 Impacts of water extraction (ground or surface).

Description (Fletcher *et al*. 2004)	*If fresh water is used by the industry, does an upper limit for all removals from aquifers, rivers, etc, need to be set for the region?*			
Level of impact	Catchment / Region			
Comment	• Aquaculture applicants will need to gain a license from the Department of Water to get a water allocation. This covers water supplies from streams or the construction of structures on streams.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop				
NK	2	3	6	Low
CK	2	3	6	Low
DL	2	3	6	Low
PIL	2	3	6	Low
CAR	2	3	6	Low
GS	2	3	6	Low

Justification for Risk Ranking

Any site selected should have access to an unpolluted estuarine or marine water source, with an optimum salinity range of 15 to 25 parts per thousand (ppt). Seasonal effects of rainfall and evaporation can cause fluctuations, but salinity should not be less than 1 ppt or greater than 35 ppt. (QDPI&F 2006).

As for all forms of aquaculture, water is a principal determinant of productivity; the availability of large volumes of high quality water (with desirable water quality characteristics varying between culture species) providing the best results. Under ideal circumstances, depending on the region, maximum prawn pond productivity is most likely to be achieved when water exchange rates of six per cent per day are maintained (ASIC 1997).

Queensland prawn farmers have, on average, reduced water exchanges from eight to 10 per cent per day to less than four per cent per day (QEPA 2000). This is due to a shift to more flexible discharge regimes, i.e. on an ‘as needed’ basis rather than as a routine measure. The advantage to farmers of minimising the rate of water exchange is to maintain more stable pond conditions.

The quantity of water that is available for the farms is of importance, since volumes of around 12Ml are required to fill an average-size pond and volumes of up to 0.33Ml per day are required for a water exchange rate of three per cent for seven of the nine growing months.

Based on these figures, and consideration of season duration, evaporation, rainfall and seepage, it can be estimated that prawn farms (at least in NSW) use in the order of 9,000Ml of water per annum. However, maintaining pond levels during dry periods (due to evaporation) and wet periods (due to rainfall) would result in more or less water input or outflow during these production cycles. Using a flow-through reticulation system, most of the water pumped onto the farm would be returned to the original water source. This is estimated to be 28,000Ml.

The recirculating farm has a restricted availability of suitable quality water. Therefore, low water exchange rates must be employed and pond water recirculated. Whilst this results in a reduced production of water pollutants, it does so as a consequence of lower stocking densities and reduced feeding rates.

In WA, separate licences are required from the Department of Water for both groundwater (sourced from a bore or well) and surface water (sourced from rivers, streams or lakes). Approval needs to be obtained from relevant parties before a licence can be issued (i.e. if pipes need to be laid over Crown Land or across private property).

Applicants for all surface water licences and groundwater applications that require 100,000 kilolitres need to place an advertisement in the *West Australian* newspaper and the local regional newspaper asking for submissions within a 14-day period. Native Title Claimants are asked for comment within a 28-day period.

There is no fee to apply for the licence and no ongoing licence fees. The licences are issued for three to five years, when an application for renewal will then need to be submitted. If there are no changes to the proposed use, then the licence would be renewed without further assessment.

With current knowledge of the impacts that may be expected from land-based aquaculture, and the level of industry development, the consequences are considered to be 'moderate' ('2'). The likelihood of these consequences occurring is 'unlikely' ('3'). With the increase in knowledge from monitoring results, together with the improvement in industry technology, this issue could receive a lower risk value over time.

Comments in Relation to Future Management

- Consideration of the application of the new water use reform process for the Department of Water on the use of water.
- The requirement for reporting of groundwater quality and quantity should be included in any Environmental Monitoring and Management Plan.
- Consideration should be given to the Department of Water's *Water Protection Notice*.

5.2.2 Ecological/community structure and biodiversity

This branch addresses the potential impacts (both direct and indirect) from the operation of all the facilities on the ecosystems within the catchment / region.

5.2.2.1 Benthic communities (e.g. aquatic vegetation)

Table 22 Changes to benthic communities.

Description (Fletcher *et al*. 2004)	*Could all the activities result in catchment-wide changes to the benthic communities (including aquatic vegetation) such as from total levels of sedimentation (i.e. smothering benthic organisms) or from shading or turbidity (decreases in light intensity) or from increased nutrients and algae smothering seagrass?*
Level of impact	Catchment/Region
Comment	• The nutrient and sediment in discharge waters should be minimised by use of settlement ponds. • The correct choice of discharge site is the most important decision up-front. • Monitoring of receiving environment to be part of an Environmental Monitoring and Management Plan. • A baseline survey must be undertaken prior to any operations commencing, in order to determine if any change has taken place after the start of operations. • Some northern creeks are likely to have naturally high levels of turbidity. This should be considered in determining trigger levels for action. • Tidal creeks may have mangroves along their edges. These are able to assimilate some of the nutrients, but excessive growth of nuisance algae could lead to the smothering of pneumatophores.

Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop				
NK	3	1	3	Low
CK	3	1	3	Low
DL	3	2	6	Low
PIL	3	1	3	Low
CAR	3	1	3	Low
GS	3	1	3	Low

Justification for Risk Ranking

The use of fertilisers to stimulate plankton blooms during the first two months of culture, and artificial feeds, coupled with the faeces produced by the prawns, may cause the build-up of organic matter which result in hyper-nutrification as well as eutrophication. The high organic matter in the effluents will increase the suspended solids and nutrient levels, decrease the dissolved oxygen levels and increase the biochemical oxygen demand in coastal waters. This is turn, may cause the bottom sediments to become anoxic, leading to changes in the benthic community (Black 2001).

The indirect impacts to aquatic flora and fauna by prawn farms relate to the potential changes to water quality within the receiving environment. Potential impacts include changes to benthic faunal communities, in the level of epiphytic growth and speciation within mangrove communities, shading and smothering of seagrasses from phytoplankton and suspended solids, and increased population of macroalgae.

Although the volume of effluents discharged from prawn ponds used to be greater than those from other industries, recent advances in prawn farming have seen the development of the semi-enclosed or closed systems in the grow-out phase, with minimal water exchange. Therefore,

the impacts on benthic communities from sedimentation and nutrients have been considerably lowered.

Regulation of discharge quality can assist in reducing any potential impact. Receiving environments in WA are naturally low in nutrients and the impact is expected to be low. The most likely response is an increase in epiphyte growth on some benthic communities.

Currently in WA, there is no discharge of sediments and nutrients into the broader environment from the operational prawn farm. The farm in Exmouth will have a discharge pipe into the adjacent creek allowing for nutrient assimilation prior to reaching Exmouth Gulf waters. The consequences of prawn farm effluents on benthic communities is considered to be 'severe' ('3'), but over the next five years the likelihood rating is 'remote' ('1') in areas with no farms. The rating for the Dampierland region is 'rare' ('2').

Comments in Relation to Future Management

- Best practice guidelines for minimizing nutrient discharges should be developed.
- There is a preference for non-direct discharges.
- The DEC's *Pollution (Unauthorized Discharge) Regulations* must be considered.

5.2.2.2 Terrestrial vegetation

Table 23 Terrestrial vegetation.

Description (Fletcher *et al*. 2004)	*Could all the activities result in catchment-wide changes to the terrestrial vegetation such as from total levels of sedimentation (i.e. smothering vegetation communities) or from increased nutrients and smothering?*			
Level of impact	Catchment/Region			
Comment	• Native vegetation protection is to be achieved through the Department of Environment and Conservation's assessment of Clearance Applications.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop				
NK	3	1	3	Low
CK	3	1	3	Low
DL	3	1	3	Low
PIL	3	1	3	Low
CAR	3	1	3	Low
GS	3	1	3	Low

Justification for Risk Ranking

One of the most serious environmental concerns in relation to prawn farming is the loss of natural habitats, such as mangroves and other wetland ecosystems. In south-east Asian countries, the conversion of mangrove land into prawn ponds has also converted a common property and multi-use resource into a privately-owned single-use resource (Black 2001).

Mangrove habitats are known to be important spawning, breeding and nursery grounds for many species of fish and prawn. They play an important part in sustaining the fisheries resources through the tidal flushing of detritus and nutrients that form the food base for micro-organisms,

which is turn support the coastal and near-shore fisheries. Prawns, in particular, have been closely correlated to the presence of mangroves.

It is widely agreed that habitat loss is one of the major causes for decreases in biodiversity and, because of this, 'land clearance' is a listed key threatening process under the *Environment Protection and Biodiversity Conservation Act 1999*. Habitat destruction and fragmentation have had severe consequences for native terrestrial flora and fauna, while the removal of coastal vegetation has resulted in sand drift and erosion of dunes because there is no vegetation to anchor them (De Jong and Tanner 2004).

The removal of vegetation for any purpose, not just for prawn aquaculture, may have these consequences. Specific scientific research on the removal of vegetation for the prawn aquaculture industry is not required. Instead, this issue requires continual monitoring and management.

The moderate risk is probably more appropriate at the individual facility level. At the regional level, the impacts are localised, although the damage could still be long-term. Currently, all necessary systems are in place to manage this issue and the problem, if it exists, stems from a few individuals doing the wrong thing.

Consequences of removing terrestrial vegetation across a region could be 'severe' ('3'), but the likelihood of these impacts actually occurring is 'remote' ('1') due to current protocols and Native Vegetation Clearance approvals required from the DEC.

Comments in Relation to Future Management

- Utilize EPA Guidance Statements No. 1 – *Protection of Tropical Arid Zone Mangroves along the Pilbara Coastline*, No. 49 – *Development of Proposals in Shark Bay World Heritage Property*, Position Statement No. 2 – *Environmental Protection of Native Vegetation in WA*.
- If possible, seek interest from operators to share facilities and/or access where possible – check if this can be done during the planning phase.
- Identification of a clearing permit as part of a suite of regulatory approvals required for developing a site.
- Utilise the Native Vegetation Protection Regulations.
- Ensure the use of Draft EPA Guidance Statement No. 33 – *Planning and Development.*

5.2.2.3 Listed migratory species

Table 24 Listed migratory species.

Description (Fletcher *et al*. 2004)	*Are any migratory species listed that frequent this area? If so, what protocols need to be employed by all facilities within the area? Could the facilities impact on these species in a detectable and ecologically significant manner?*
Level of impact	Catchment/Region
Comment	• Proponents must check the internet for listed migratory species to determine whether these species will be affected by the aquaculture proposal. Indirect and offsite impacts must be considered. • Any interaction that occurs after the aquaculture facility construction would need to be reported to the Department of Environment, Water Resources, Heritage and the Arts.

Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop				
NK	2	3	6	Low
CK	2	1	2	Low
DL	4	3	12	Moderate
PIL	2	2	4	Low
CAR	2	2	4	Low
GS	3	4	12	Moderate

Justification for Risk Ranking

Under the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act), migratory species protected under international agreements are considered to be 'matters of national environmental significance'. Referrals to the Commonwealth Minister for the Environment are required if an action (in this case aquaculture) has, will have, or is likely to have, a significant impact on a matter of national environmental significance.

A 'significant impact' is an impact which is important, notable, or of consequence, having regard to its context or intensity. Whether or not an action is likely to have a significant impact depends upon the sensitivity, value, and quality of the environment which is impacted and upon the intensity, direction, magnitude and geographic extent of the impacts.

At the commencement of the EPBC Act, the National List of Migratory Species consisted of those species listed under the following International Conventions:

- Japan-Australia Migratory Bird Agreement (JAMBA)
- China-Australia Migratory Bird Agreement (CAMBA)
- Convention on the Conservation of Migratory Species of Wild Animals - (Bonn Convention)

It is important to consider the environmental impacts of the proposed facility early in the planning phase. These should be in relation to:

- site selection and the location of buildings or activities on the selected site;
- the timing of the action or its component activities; and
- the design of any buildings or other structures or infrastructure.

Proponents are required to consider all adverse impacts that may result from the action, including indirect and offsite impacts. In the case of prawn farms these would relate to impacts on wetlands or ocean reefs from sediment, fertilisers or chemicals which are washed or discharged into a river system.

Some listed migratory species are also listed as threatened species and different criteria for determining whether significant impacts will occur, apply for both. The criteria for migratory species include the following:

- substantially modify (including fragmenting, altering fore regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species;
- result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species; or

- seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically-significant proportion of the population of a migratory species.

The prawn farming industry in WA is in its infancy and any new proponent should be reminded of the need to undertake self-assessment against the EPBC Act. The consequence of the proponent not considering this issue in the planning phase and designing the facility to minimise or mitigate impacts could be 'major' ('4'), resulting in a substantial fine. The likelihood of this occurring is considered 'unlikely' ('3'). These ratings are dependant on the projected level of industry growth and whether the new facilities may be located close to sites known to encompass listed migratory species (e.g. Roebuck Bay).

Comments in Relation to Future Management

- Encourage proponents to use the Commonwealth's Department of the Environment, Water Resources, Heritage and the Arts *Significant Impact Guidelines (2006)* to determine whether an approval under the EPBC Act is required.
- Develop protocols for dealing with interactions that are relevant to the region and industry-specific.
- Maintain the DEC's reporting requirements of any interactions (i.e. with migratory species).

5.2.2.4 Threatened/endangered/protected species

Table 25 Interactions with certain species.

Description (Fletcher *et al*. 2004)	*Do any of these species interact with any facilities in the region? If they do, should protocols be employed by all facilities within the area to minimise these interactions or the effect of these interactions (e.g. is development a referable action under EPBC Act 1999)?*
Level of impact	Catchment/Region
Comment	• Protocols are set-up on a 'whole of industry' basis under the EPBC Act. • Proponents need to consider this issue in the planning phase and undertake self-assessment against EPBC Act for referral. • It is likely to be more of an issue in the north of the State, or in close proximity to wetlands or mudflats. • The number of facilities that are in close proximity is more the issue.

Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop				
NK	4	3	12	Moderate
CK	3	2	3	Low
DL	4	3	12	Moderate
PIL	3	1	3	Low
CAR	2	3	6	Low
GS	4	3	12	Moderate

Justification for Risk Ranking

As outlined in 5.1.3.4 and 5.2.2.3, the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act), protects species listed under international agreements that are considered to be 'matters of national environmental significance'. Referrals to the Commonwealth Minister for the Environment are required if an action (in this case, aquaculture) has, will have, or is

likely to have, a significant impact on a matter of national environmental significance.

An action is likely to have a significant impact on a critically endangered/endangered/vulnerable species if there is a chance or possibility that it will:

- lead to a long-term decrease in the size of a population;
- reduce the area of occupancy of the species;
- fragment an existing population into two or more populations;
- adversely affect habitat critical to the survival of a species;
- disrupt the breeding cycle of a population;
- modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline;
- result in invasive species that are harmful to a critically-endangered or endangered species becoming established in the endangered or critically-endangered species habitat;
- introduce disease that may cause the species to decline; or
- interfere with the recovery of the species.

The consequence of the proponent not considering this issue in the planning phase and designing the facility to minimise or mitigate impacts could be 'major' ('4'), resulting in a substantial fine. The likelihood of this occurring is 'unlikely' ('3'). These ratings differ across the regions, depending on the occurrence of threatened, endangered or protected species.

Comments in Relation to Future Management

- Maintain the current protocols against the *Environment Protection and Biodiversity Conservation Act 1999*.
- Ensure that the Department of Environment and Conservation continue to provide input into the assessment process, such as the referral to the Environmental Protection Authority for assessment under Part IV for larger facilities.

5.2.2.5 World Heritage/RAMSAR/MPAs

Table 26 Presence of certain zones.

Description (Fletcher *et al*. 2004)	*Are any of these types of zones present in the area? If there are, what special arrangements etc. are needed to meet their requirements (i.e. is development referable action under EPBC Act 1999)?*
Level of impact	Catchment/Region
Comment	• A requirement to obtain Native Vegetation Clearing Permits will ensure RAMSAR and other priority heritage areas are protected. • Aquaculture sites situated close to these areas require a rigorous Environmental Monitoring and Management Plan.

Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop				
NK	2	3	6	Low
CK	1	3	3	Low
DL	2	3	6	Low
PIL	1	2	2	Low
CAR	2	3	6	Low
GS	1	2	2	Low

Justification for Risk Ranking

Similar to 5.1.3.4, 5.2.2.3 and 5.2.2.4, RAMSAR sites are protected under the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act), and are considered to be 'matters of national environmental significance'. Referrals to the Commonwealth Minister for the Environment are required if an action (in this case, aquaculture) has, will have, or is likely to have, a significant impact on a matter of national environmental significance.

Shark Bay World Heritage Area

Shark Bay is located on the most western point of the coast of Australia and covers an area of 2.3 million hectares. The region is one of the few properties inscribed on the World Heritage List for all four outstanding natural universal values:

- as an outstanding example representing the major stages in the earth's evolutionary history;
- as an outstanding example representing significant ongoing ecological and biological processes;
- as an example of superlative natural phenomena; and
- containing important and significant habitats for *in situ* conservation of biological diversity.

The responsible administrative body is the Australian Government's Department for the Environment, Water Resources, Heritage and the Art's World Heritage Unit. An agreement exists between the Government of Australia and the State of Western Australia on legislative and administrative arrangements for the management of Shark Bay.

Collaborative bodies include the Department of Environment and Conservation, which has day-to-day administrative responsibility for Shark Bay. This is in accordance with existing Western Australian legislation, including the *Fish Resources Management Act 1994, Local Government Act, Land Act, Conservation and Land Management Act* and the *Environmental Protection Act*.

CALM Estates

There are a few large areas that form part of the DEC Conservation Estate of interest. These cover both marine and terrestrial areas, ranging from Dampier Archipelago, Ningaloo and Shark Bay. Within each of these reserves, areas have been set aside as Sanctuary Zones or General Use areas.

The assessment processes undertaken by the Department of Fisheries require all applications for sites on lands vested in other authorities, such as the Department of Environment and Conservation, be referred for comment. Any issues relating to the number of aquaculture sites operating within a conservation area or impacts from the adjacent operations are dealt with at this stage. These applications do not require a specific lease from the management authority in addition to the normal Aquaculture Licence although concurrent approval for the Minister for Environment is required.

The level of assessment has been consistent and open for all applications lodged within WA and there have not been any identified impacts to these sensitive areas. Having said this, the amount of monitoring and research into this issue is lower than optimal.

The Dampierland region has a previously operational prawn farm, but another farm in the Exmouth region is being constructed during 2008. Hatcheries are found in the Carnarvon region and Dampierland, but in general the industry is small, which has meant that impacts are thought to be correspondingly low. The protocols in place at present would limit the consequences ranging from 'moderate' ('2') to 'minor' ('1'), with a likelihood of 'unlikely' ('3') to 'rare' ('2').

Comments in Relation to Future Management

- Site selection guidelines should identify how to locate these heritage issues, on or adjacent to these areas, and how to avoid them.
- Undertake referrals under the EPBC Act as required.
- Maintain application referrals to the DEC.
- Maintain assessment through the *Native Vegetation Act* and the EPBC Act. An assessment is required in any aquaculture proposal that may impact on protected species.

5.2.2.6 Behavioural changes on species

Table 27 Significant changes to individual species behaviour.

Description (Fletcher *et al*. 2004)	*Could the facility in the area significantly alter the behaviour of individual animals – either attracting them or repelling them from the entire area so that it will cause them an ecologically significant problem (this may need to be assessed at individual facility level)?*
Level of impact	Catchment/Region
Comment	• This is difficult to determine for prawn aquaculture in WA as we do not know which species may interact with this type of operation. • We do not have data on what bird species are likely to be attracted to prawns. • Correct feed storage and management should limit the attraction of predators or scavengers during feeding times. • Removal and correct destruction of moribund individuals is recommended for all aquaculture facilities and will lower odour attractants in this area.

Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop				
NK	0	3	0	Negligible
CK	0	3	0	Negligible
DL	1	3	3	Low
PIL	0	3	0	Negligible
CAR	1	3	3	Low
GS	0	3	0	Negligible

Justification for Risk Ranking

Previous studies in other parts of the world on bird interactions with aquaculture have focused on land-based aquaculture, where often small fish are cultured, and sick or dying fish are taken by predatory or scavenging birds (De Jong and Tanner 2004). Information of this kind is unavailable for WA or this species.

Given the low level of aquaculture activity in the various regions likely to have an impact on the behaviour of species, the consequences are considered to be 'minor' ('1') for those areas where facilities are already located (Dampierland) and 'negligible' ('0') for other regions. The likelihood of these consequences occurring is 'unlikely' ('3').

Comments in Relation to Future Management

- Develop protocols, together with industry, for managing and minimizing any interactions between aquaculture facilities and individual species.
- Require the reporting of interactions through aquaculture license conditions.

5.2.2.7 Translocation between catchments

Table 28 Translocation policies.

Description (Fletcher *et al*. 2004)	*Are there any translocation policies or protocols that need to be considered by all facilities in the region which may be importing or exporting live product/seed stock/larvae, cages, etc, into or out of the region?*
Level of impact	Catchment/Region
Comment	• Any movement of stock between locations requires approval. • Controls already exist for farmers wishing to move stock from hatcheries to grow-out ponds - may not always be actioned.

Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop				
NK	2	1	2	Low
CK	2	1	2	Low
DL	3	1	3	Low
PIL	1	1	1	Low
CAR	3	1	3	Low
GS	2	1	2	Low

Justification for Risk Ranking

There are two main risks associated with the translocation of prawns from overseas, interstate and between regions for the purpose of aquaculture. These risks are the introduction of exotic disease, and introduction and establishment of exotic organisms.

The introduction of exotic organisms can be broken down further into two components – the establishment of feral population of exotic cultured animals and the introduction of exotic plants and animals that may have inadvertently been translocated with the cultured prawn. The possibility of the introduction of exotic plants and animals remains a risk to both the industry and the environment.

While there have been no documented introductions of exotic animals or plants due to aquaculture in WA, such introductions have been common elsewhere in the world. The majority of such introductions occurred prior to the implementation of today's stringent protocols to prevent such occurrences but there is still a risk of similar introductions happening today.

The Department of Fisheries' *Translocation Policy* set out the risk assessment process for dealing with the importation and translocation of fish in and around Western Australia, thereby reducing the risk of exotic disease introductions. Authorisations from the Department are required for the import or translocation of fish, and a veterinarian must certify the stock.

Under the current situation where translocation of native species for aquaculture purposes only occurs on a scale that is probably less than the scale of movement for commercially-caught prawns, the translocation of native species is likely to represent a low risk. If disease outbreaks occur in the areas that stock originates from, the risk could become high.

Comments in Relation to Future Management

- Maintain current protocols and approvals for all translocations.
- New *Biosecurity and Agriculture Management Act 2007* provides guidance in this area.

5.2.2.8 Scavengers

Table 29 Increases in regional level of scavengers.

Description (Fletcher *et al*. 2004)	*Will the facilities result in significant increases in the regional density or overall abundance of scavengers?*
Level of impact	Catchment/Region
Comment	• Intensive farms (i.e. hatcheries) operate indoors, so there is no issue. • There have been very few instances with inland aquaculture to date in regard to interactions with scavenger species. • Use of appropriate feeding regimes should minimise any waste feed. It is in the best interests of farmer to manage feed additions, as they cost money.

Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop				
NK	0	1	0	Negligible
CK	0	1	0	Negligible
DL	2	4	8	Moderate
PIL	0	1	0	Negligible
CAR	1	2	2	Low
GS	0	1	0	Negligible

Justification for Risk Ranking

The desire to control scavenger birds by various lethal methods can result in conflicts with members of the public wishing to conserve these birds as wildlife (Goldburg & Triplett 1997). It is necessary to control scavenger bird populations since the possibility of disease introductions via faecal matter from large numbers of scavengers is high.

Other scavengers around prawn farms in the northern regions of WA are crocodiles. It is difficult to know which methods to recommend to minimize this type of interaction, should it grow to become an issue.

Risk values for consequence are considered to be higher in the region where pond-based aquaculture currently operates, that being 'moderate' ('2') rather than 'negligible' ('0'). The likelihood of scavenger numbers being impacted is high in regions where aquaculture operates is 'possible' ('4'), but in other regions is 'remote' ('1'). This value is also based on the likely number of scavengers present due to other anthropogenic activities, i.e. the use of rubbish dumps.

Comments in Relation to Future Management

- Develop an Environmental Monitoring Management Plan that incorporates appropriate indicator species to measure any change in scavenger numbers around ponds.
- Ensure that aquaculture feeding regimes minimize feed wastage as much as possible.

5.2.2.9 Sensitive habitats

Table 30 Sensitive habitats.

Description (Fletcher *et al*. 2004)	*Are there any sensitive habitats in the area that would be significantly impacted on by presence of the facilities?*
Level of impact	Catchment/Region
Comment	• People who wish to carry out aquaculture should avoid impacting on sensitive habitats with their operations. • There is a need to determine the buffer distance required between aquaculture sites and any sensitive habitat – an initial industry monitoring program will assist in determining this. • There is a need to determine whether cumulative impacts result to sensitive habitats above a certain level of aquaculture production in a region, even if the production sites are not located directly over these habitats. Research is required into this matter.

Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop				
NK	1	2	2	Low
CK	1	2	2	Low
DL	1	2	2	Low
PIL	1	2	2	Low
CAR	1	2	2	Low
GS	1	2	2	Low

Justification for Risk Ranking

Terrestrial habitats

The Department of Environment and Conservation currently requires Native Vegetation Clearance approval be sought for any proposal located within a sensitive habitat which may require the removal of native vegetation. As a result, any consequences should be 'minor' ('1') with a likelihood of minor impacts occurring being 'rare' ('2').

Marine habitats

The three Interim Marine and Coastal Regionalisation (IMCRA) regions in questions are King Sound, Exmouth Gulf and Shark Bay, where sensitive habitats are located.

King Sound

King Sound is a large sound or gulf that is similar in many aspects to Cambridge Gulf. Its shores are characterised by broad tidal flats. The region is macro-tidal with relatively low wave energy. The gulf is the receiving basin for the Fitzroy, May and Meda Rivers. Mud flats, sand flats and gravel flats dominate the shore types, but to the north there is a local development of rocky shores. The dominance of mud and the extreme tidal range result in turbid waters in the area throughout the year.

Planning activities for aquaculture have identified the area as suitable for barramundi, coral trout or mullet, amongst others. Current research has indicated this region does not include any Marine Protected Areas or sensitive habitats. The seabed in King Sound is predominately sandy, with little likelihood of significant benthic habitat due to the natural turbidity of the water.

Due to the minimal sensitive habitats that could be affected by aquaculture development, the consequences are considered to be 'minor' ('1') with a likelihood of 'unlikely' ('3').

Pilbara (Nearshore)

The Pilbara coast has low relief with gently sloping beaches, numerous headlands and many offshore islands. The inner, near-shore marine waters of the region are relatively turbid, being subject to disturbance from strong tidal flows and to episodic run-off from adjacent rivers.

Exmouth Gulf is the largest embayment in the region, with the waters generally being turbid. Its eastern and southern shores are dominated by mangal and mudflat habitats of great importance for nature conservation and for sustaining local fisheries. A range of mangrove species and mangal assemblages are present in Exmouth Gulf. Extensive seagrass beds may be found in shallow waters of the gulf, which provide feeding habitat for turtles and dugongs. The shores and near-shore habitats of the western side of the gulf are quite different to those of the east.

The *Gascoyne Aquaculture Development Plan* (1996) identified Exmouth Gulf as a region where aquaculture could be considered. The areas around Points Murat and Lefroy, the Naval Communication Station and the other bays in the Gulf have potential for prawn aquaculture.

Due to the sensitive habitats that could be affected by discharges from aquaculture development, the consequences could be 'moderate' ('2') but with the size of the industry and current management policies and protocols, the likelihood of moderate consequences is 'rare' ('2').

Shark Bay

Shark Bay is a major, shallow embayment formed by the inundation of the coastal plain and protected by several offshore limestone islands. The water at the open end of Shark Bay is

considered oceanic and there is a marked transition towards the upper reaches of the eastern and western gulfs. Wave energy is low-to-moderate within Shark Bay and low within the more protected inlets. Tides are the major cause of water movement within the bay, where the maximum tidal range is about 1.2 metres.

A major feature of Shark Bay is the significant salinity gradients (or 'salinoclines'), which have a major impact on the local biota. The aquatic flora and fauna of the hyper-saline inlets, particularly Hamelin Pool, are relatively devoid of marine life. Towards the lower reaches of the bay, as the salinity decreases and approaches that of the open ocean, the diversity and abundance of species increases.

Approximately 4,000 km^2 of the Shark Bay marine environment consists of seagrass meadows, which is the largest reported area of this kind in the world. Seagrass is an important component in maintaining the structure and productivity of this unique area. *Amphibolis antartica* is the dominant species in an assemblage of 12 different seagrass species. The meadows are an essential link in the food web of Shark Bay, providing a high productivity biomass, as well as being a source of nutrients and a habitat and nursery for both fish and invertebrates.

Salinity was found to play an important role in the distribution of coral, with few species growing in the metasaline sections of the bay and no species inhabiting the hypersaline regions. The high flow of water about the Bernier, Dirk Hartog and Dorre Islands, with the resulting near-constant temperature and salinity regimes, provides the most favourable conditions for coral growth.

The Department of Water recommend that aquaculture facilities should not be constructed within natural lakes, swamps, wetlands with recognized conservation values, or affects their fringing vegetation buffer, unless approved by the Minister for the Environment on the advice of the Environmental Protection Authority.

The diverse range of ecosystems mean that the consequences could be 'severe' ('3') depending on the location of the facility, with a likelihood of this occurring is 'possible' ('4'). Hence, this issue requires considerably more management and stricter conditions on any aquaculture activities that operate in these waters. The current *Aquaculture Management Plan for Shark Bay* sets out the recommendations to appropriately manage aquaculture for this specific region.

Comments in Relation to Future Management

- Maintain requirement for Native Vegetation Clearance approval from the Department of Environment and Conservation.
- Maintain the current Department of Fisheries assessment procedures and management protocols.
- Recommend proponents read the Department of Water's *Water Quality Protection Notice* (2006).
- Research is needed into regional carrying capacity and potential impacts on sensitive habitats from the aquaculture of certain species.
- Sensitive environments should be excluded from aquaculture license areas as much as possible.
- Strategic assessments are needed of regions, in order to make an early identification of areas that are not suitable for prawn farming.

5.2.3 Physical structures and construction & tenure

This branch covers issues associated with the physical structures with aquaculture facilities and what impacts, collectively, these may cause.

5.2.3.1 Number of farms

Table 31 Number of farms in region.

Description (Fletcher *et al*. 2004)	*Are there any limitations/concerns regarding the total number of farms, the maximum size of any one farm or the total area occupied by all farms/ leases in the region? These may relate to concerns regarding the total amount of area lost via alienation for other activities or from the impact on visual amenity, or the number/type of structures used or the level of access still possible.*
Level of impact	Catchment/Region
Comment	• Nutrient mass loadings are a function of individual facility discharges, and the number/biomass of facilities. • These issues need to be considered in the planning phase. • Industry would need to develop significantly over next five years for this to be an issue.

Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop				
NK	3	1	3	Low
CK	3	1	3	Low
DL	3	1	3	Low
PIL	4	2	6	Moderate
CAR	4	1	4	Low
GS	4	2	8	Moderate

Justification for Risk Ranking

Though the assimilative capacity of the receiving environment has been identified in a number of areas where there is an intensification of land-use and urbanisation, very little research has been done on the assimilative capacity of system impacts by prawn farm waste water alone.

Studies were carried out of the flushing and processing of prawn pond effluent in Muddy Creek, Queensland, a six kilometre-long mangrove-fringed tidal creek. This creek received the discharge from 13.5 hectares of prawn farm. Flushing is slow, with a residence time varying between four days at spring tides and 10 to 15 days at neap tides. Since spring and neap tides alternate at seven day intervals, the system is never at equilibrium. As a result, occasional along-channel sampling of sediment and nutrients provided little information on the fate of the effluent.

Significant changes in discharges of nutrients occurred in the creek: chlorophyll *a* and total dissolved nitrogen increased in the creek, with dissolved organic nitrogen, particulate carbon, total dissolved nitrogen, total dissolved phosphorous and suspended sediments being removed from the creek waters.

Salinity, pH, biochemical oxygen demand and concentrations of dissolved oxygen and chlorophyll *a* were significantly higher in Muddy Creek than in two control estuaries over the period of intermittent discharge. There were no significant differences in water temperature, total suspended solids, and dissolved nutrient concentrations between impacted and non-impacted estuaries.

The results indicate that phytoplankton biomass was elevated and some water quality

characteristics were altered by effluent discharge into the upper reaches of the creek from the prawn farms. The large initial increase in chlorophyll *a* concentration was not surprising, considering the high chlorophyll *a* concentrations in the ponds and the large influx of dissolved and particulate nutrients into Muddy Creek during discharge periods.

Monitoring of the water quality in the lower reaches of Muddy Creek did not show any impact of the pond effluent in the lower estuary. Moreover, a comparison between these data and pre-impact data for the upper reaches indicate that conditions at the discharge site returned to ambient levels within one to two months after discharge ceased. The creek therefore, showed some capacity to assimilate or transform nutrients derived from periodic inputs from the prawn ponds. Periodic monitoring of the creek bottom did not indicate any obvious sedimentation of particulate material.

Pressures for development are different across the regions, but the Department of Fisheries has a role in ensuring aquaculture is considered as a justifiable user of resources during the consultation for development of any plan, as well as the number of farms that may be appropriate within a region. Consequences and likelihood are based on the assumed pressures being faced in the various regions and range from 'low' to 'moderate'.

Comments in Relation to Future Management

- Industry growth should be done in a framework of consultation with local government and the community, so as to resolve these issues in planning phase.
- 'Best practice' guidelines - and each facility meeting the relevant guidelines - will ensure regional impacts are not evident.

5..2.3.2 Habitat removal

Table 32 Removal of terrestrial vegetation due to aquaculture facilities.

Description (Fletcher *et al*. 2004)	*How much terrestrial vegetation can acceptably be removed/affected by the construction/operation of all facilities within the catchment? Will these affect sensitive habitats?*			
Level of impact	Catchment/Region			
Comment	• Native vegetation protection is to be achieved through the Department of Environment and Conservation's assessment of Clearance Applications.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop				
NK	3	1	3	Low
CK	3	1	3	Low
DL	3	1	3	Low
PIL	3	1	3	Low
CAR	3	1	3	Low
GS	3	1	3	Low

Justification for Risk Ranking

Prawn farming has the potential to cause habitat changes as a result of pond construction, farm development and through the discharge of waters. The direct impacts to aquatic flora and fauna generally relate to the clearing of mangroves and disturbance of wetland areas during the construction phase of development. Further potential impacts are related to changes to the tidal

prism and creek flow rates caused by the pumping or discharge of water, and the subsequent alienation of wetland areas or changes to stream morphology.

The moderate risk is probably more appropriate at the individual facility level. At the regional level, the impacts are localised, although the damage could still be long-term. Currently, all necessary systems are in place to manage this issue, and the problem, if it exists, stems from a few individuals doing the wrong thing (see section 5.2.2.2).

Comments in Relation to Future Management

- Utilize the EPA Guidance Statements No. 1 – *Protection of Tropical Arid Zone Mangroves along the Pilbara Coastline,* No. 49 – *Development of Proposals in Shark Bay World Heritage Property,* Draft EPA Guidance Statement No. 33 – *Planning and Development* and Position Statement No. 2 – *Environmental Protection of Native Vegetation in WA*.
- The identification of a clearing permit as part of a suite of regulatory approvals is required.
- Utilise the Department of Environment and Conservation's *Native Vegetation Protection Regulations* and approvals processes.

5.2.3.3 Alienation/visual amenity (e.g. access to areas)

Table 33 Alienation and visual amenity issues.

Description (Fletcher *et al*. 2004)	*Is the locating of aquaculture facilities across the region likely to have impacts on visual amenity or alienate coastal areas from other users?*
Level of impact	Catchment/Region
Comment	• These issues need to be considered in planning phase. • Industry is too small at present to have any issues in this area – if the industry were to develop in some regions over the next five years, then it may become important. • Prawn farms are generally located on private property or leasehold, i.e. on Crown Land or Aboriginal Land. • Pipes may require easement to gain access to a river or the coastline for water – this may impact on access.

Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop				
NK	1	2	2	Low
CK	1	2	2	Low
DL	2	2	4	Low
PIL	1	3	3	Low
CAR	2	3	6	Low
GS	2	3	6	Low

Justification for Risk Ranking

In WA, the *State Planning Strategy* is a plan that provides for growth across the State to the year 2029. The Western Australian Planning Commission develops regional planning strategies supporting this main strategy to provide guidance of the zoning and placement of specific activities within each region. Therefore, this issue is very much linked to the regional planning that occurs across each region.

Pressures for development are different across the regions, but the Department of Fisheries

has a role in ensuring aquaculture is considered as a justifiable user of resources during the consultation for development of any plans. Consequences and likelihood are based on the assumed pressures being faced in the various regions and range from 'low' to 'moderate'.

Comments in Relation to Future Management

- Industry growth should be done in a framework of consultation with local government and community, so as to resolve these issues in the planning phase.

5.2.3.4 Heritage Area effects

Table 34 Effects on Heritage Areas.

Description (Fletcher *et al*. 2004)	*Are there areas of heritage value that may be affected by the construction of any facilities – old buildings, historical sites, places of indigenous significance?*			
Level of impact	Catchment/Region			
Comment	• Gain all the necessary approvals to ensure Heritage Area protection. • If possible, undertake consultation with the Indigenous community during the preliminary planning phase.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop				
NK	5	2	10	Moderate
CK	5	2	10	Moderate
DL	5	2	10	Moderate
PIL	5	2	10	Moderate
CAR	3	2	6	Low
GS	3	2	6	Low

Justification for Risk Ranking

This issue does not require scientific research. Instead, it requires increased management during the planning process to ensure that Heritage Areas are not under threat from aquaculture farms, and increased monitoring to detect any breaches.

The *Aboriginal Heritage Act 1972* (AH Act) and the *Environmental Protection Act* both have legal capacity to consider aspects of Aboriginal heritage. Main focus of the AH Act is the protection of sites which are significant in social and heritage terms. The primary focus of the EP Act is to consider proposals which have the potential to have an environmental impact.

This issue is more likely to be a concern in the Kimberley and Pilbara regions, due to the higher number of significant heritage sites as well as the additional pressure being placed on these areas from tourism. The consequences could be 'catastrophic' ('5') in these two areas and 'severe' ('3') in others since the pressures are less. However, the likelihood of these sites being damaged is 'rare' ('2') since current legislative tools provide a suitable framework in which to identify and manage any impacts.

Comments in Relation to Future Management

- The Environmental Protection Authority and the Department of Indigenous Affairs have protocols to assess impact on, and limit potential damage to, heritage sites.
- The EPA's Guidance Statement No. 41 Draft – *Assessment of Aboriginal Heritage* should continue to be used.

- All relevant agencies and their required approvals should be listed in the Code of Practice.
- If possible, consultation should be undertaken with the Indigenous community during the preliminary planning phase for the region.

5.2.3.5 Soil quality

Table 35 Soil quality.

Description (Fletcher *et al*. 2004)	*Are there any issues associated with the quality of the soils in the area (such as acid sulphate soils)? Have they been mapped appropriately and are protocols needed to ensure they are not disturbed by the construction of any facilities in this region; or what areas need to be avoided?*
Level of impact	Catchment/Region
Comment	• Determine the location of any acid sulphate soils to avoid costly remedial action later. • Contaminated soils also need to be considered if any excavation is involved. • Best to identify areas to avoid when carrying out broad planning for aquaculture activities.

Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop				
NK	1	3	3	Low
CK	1	3	3	Low
DL	1	3	3	Low
PIL	1	3	3	Low
CAR	1	3	3	Low
GS	1	3	3	Low

Justification for Risk Ranking

Coastal Acid Sulphate Soils (CASS) have formed through natural processes and are generally overlain by other soils. When CASS are exposed to air by drainage or excavation and then rewetted, acid drainage water is produced. Obviously, the excavation required for the installation of prawn ponds has the potential to release CASS.

The *National Strategy for Acid Sulphate Soils* (2000) sets out the framework to improve understanding of CASS thereby avoiding and/or reducing the impact, ensuring an improvement in water quality. WA has a program to identify the location of CASS in the Perth metropolitan area and this is run through the Department of Environment and Conservation. It is unclear whether the program will extend across the state.

The Australian Prawn Farmers Association has developed sediment management guidelines through the *Environmental Code of Practice for Australian Prawn Farmers* (2001) on how to minimize the problems that could be faced by a farmer should they disturb CASS.

There are also inland forms of acid sulphate soils not associated with coastal soils and sediments, commonly occurring in agricultural areas well inland from the coast. These soils appear to form in response to rising water tables and land salinisation, predominantly in southern WA. They have the potential to cause significant down-stream environmental problems if these soils are drained.

Prawn pond soils, even those without CASS, need to be prepared prior to the pond being filled. Poor preparation can result in deterioration of the soils during the crop, with release of nutrients and toxic compounds to the water column, creating stress for the prawns and possible

environmental problems with the discharge of effluent (QDPI&F 2006).

Good pond preparation is also a pro-active measure for the control of diseases and should be a critical aspect of disease management strategies. Pond sludges that accumulate on the pond floor also need to be removed before the next crop – the on-farm disposal of sediments must be done responsibly.

The assessment of prawn farms in the northern areas of WA should include the requirement for information on the type of soil found on the site and whether alternate sites might be a better option. The industry at present does not appear to be having problems with CASS, so the consequences could be considered as 'minor' ('1') with a likelihood of 'unlikely' ('3').

Comments in Relation to Future Management

- Encourage applicants to access information from various government agencies regarding soil types and the location of any CASS.
- Support various soil testing options, from self-testing kits to the employing of a consultant.

5.2.3.6 Water table

Table 36 Water table impacts.

Description (Fletcher *et al*. 2004)	*What overall restrictions (if any) are there for the water table? Will it impact on what and where constructions can occur and what can be extracted or discharged?*			
Level of impact	Catchment/Region			
Comment	• Industry is small enough that any water extraction is minimal. • Many operators currently utilise rainwater to fill empty ponds. • The level of nutrients in water needs to meet water quality criteria if being discharged into an aquifer.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop				
NK	2	2	4	Low
CK	2	2	4	Low
DL	2	2	4	Low
PIL	2	2	4	Low
CAR	2	2	4	Low
GS	2	2	4	Low

Justification for Risk Ranking

This is considered to be more relevant at the facility level. Any actions that raise the water table (run-off or overtopping) could create water-logging and flow-on effects, such as vegetation loss. This issue can be managed under the 'environmental harm' provisions of the *Environmental Protection Act* and/or *Pollution and Unauthorised Discharge Regulations* if the issue involves contamination.

The Department of Water requires a licence be granted if storm water, over-topping, biofilters or the water-logging of soils is likely to be a concern.

The consequences of excessive water extraction could be 'moderate' ('2') due to the current level and knowledge on which management decisions are based. However there are assessment and licensing processes undertaken by the Department of Water, so the likelihood of a moderate impact occurring is considered 'rare' ('2'). When the level of knowledge and understanding of regional aquifers and the impacts due to allocation levels is increased, this may alter the ranking.

Comments in Relation to Future Management

- Maintain Department of Water and Department of Environment and Conservation assessment and regulation processes.
- Consider the Department of Water's *Water Protection Notice.*

5.2.3.6 Infrastructure

Table 37 Infrastructure constraints.

Description (Fletcher *et al*. 2004)	*What constraints will there be from the current infrastructure (e.g. are there enough roads, power, wharves, moorings etc)? What benefits/ impacts will there be if there is a need to construct any of these items?*
Level of impact	Catchment/Region
Comment	• There may be restrictions on the amount of land available due to vegetation loss, heritage issues or retention of wilderness areas. • Industry is small, so encouraging local or State government to provide additional infrastructure may be difficult. • Not having the infrastructure may limit the number of new players coming into industry, due to increased set-up costs. • Being located on private property makes the construction of additional infrastructure difficult.

Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop				
NK	3	4	12	Moderate
CK	3	4	12	Moderate
DL	3	4	12	Moderate
PIL	3	4	12	Moderate
CAR	3	2	6	Low
GS	2	2	4	Low

Justification for Risk Ranking

The location of any terrestrial facility will be heavily influenced by the availability of supporting infrastructure, such as roads, power and water. In remote regions of WA, such as King Sound, the provision of this infrastructure is dependent on cost, much of which will be borne by the proponent. Future State planning for infrastructure should include any future requirements for aquaculture.

The risk ranking is 'low' to 'moderate', depending on the region due to the currently small aquaculture industry. Any growth in aquaculture in the Pilbara and Kimberley regions will come at a significant cost to proponents and local government through the provision of roads, power, water and transport.

The consequences of not having infrastructure for the industry may not be as dramatic as if the industry were larger but it will impact on growth. The value is considered to be 'severe' ('3') in the Kimberley, Dampierland, Pilbara and Carnarvon regions and 'moderate' ('2') in Geraldton Sandplains. The likelihood of these consequences occurring is 'possible' ('4') for the northern regions and 'unlikely' ('3') in the more southern regions.

Comments in Relation to Future Management

- Work with local councils to ensure areas suitable for locating supporting infrastructure are considered in planning for coastal areas.
- Encourage aquaculture operators to utilize shared facilities wherever possible.

5.2.3.8 Noise/odour/dust/light

Table 38 Regional increases in noise, odour, dust and light.

Description (Fletcher *et al*. 2004)	*Are there any regional implications regarding noise, odour, dust or light that need to be considered?*			
Level of impact	Catchment / Region			
Comment	• Unlikely – noise, odour, dust and light are local issues.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop				
NK	0	1	0	Negligible
CK	0	1	0	Negligible
DL	0	1	0	Negligible
PIL	0	1	0	Negligible
CAR	0	1	0	Negligible
GS	0	1	0	Negligible

Justification for Risk Ranking

Prawn farm noise emissions are principally from aeration, feeding and pumping operations. There are a number of techniques available to minimise the impact of these types of noise that should be considered during regional planning processes. Determining the minimum distance between various emission sources and sensitive places is important and has been considered by the Department of Environment and Conservation and the Environment Protection Authority. A 'buffer' distance of 100 to 300 metres has been set for noise and odour impacts.

Alternative methods could be via the use of vegetated buffer zones or appropriate noise barriers or attenuators. Changing the number or type of aerators may be the only option in certain instances.

Odours are generally related to the draining of ponds and disturbance of damp or wet pond sediment. In managing the impact of odours, farmers must minimise the amount of sediment to be disturbed and allow pond sediment to dry sufficiently prior to any disturbance. Consultation with local government and developers should also be undertaken to ensure adequate buffers are provided for both noise and odour issues.

Prawn farms in WA are located in remote areas and considered unlikely to negatively impact on adjacent land users when it comes to noise, odour, dust or light issues.

Comments in Relation to Future Management

- Maintain the use of Guidance Statement No. 3 - *Separation Distances between Industrial and Sensitive Land Uses* (2005).
- Any Code of Practice should refer to the Noise Regulations under the *Environmental Protection Act.*

5.2.3.9 Site constraints

Table 39 Regional constraints to placement of facilities.

Description (Fletcher *et al*. 2004)	*Does the region have particular constraints that make it more or less suitable for the facilities proposed?*
Level of impact	Catchment/Region
Comment	• Facilities are on private property or leasehold land, so applicant would be selecting site within these constraints. • This not really a regional issue.

Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop				
NK	1	3	3	Low
CK	1	3	3	Low
DL	1	3	3	Low
PIL	1	3	3	Low
CAR	1	3	3	Low
GS	1	3	3	Low

Justification for Risk Ranking

A host of factors must be considered by prawn farmers when selecting sites for development. The following list is not exhaustive but identifies the major factors:

- water quality (both fresh and saline);
- the availability of both fresh and saline water;
- suitability of climate for selected species (i.e. tiger or Kuruma prawns);
- soil type (in terms of water-holding capacity for ponds);
- topography;
- accessibility to markets;
- availability of power; and
- site is not exposed to flooding or other potential natural disasters.

When potential environmental interactions also are addressed, other major factors would include:

- potential for the escape of exotic species;
- fauna and flora interactions;
- disease or parasite introductions into the environment;
- likely effluent quality and quantity;
- potential for erosion;
- conflicting activities; and
- benefits to the area.

The Queensland Department of Primary Industries and Fisheries state that the optimum topography for prawn farming is flat land that is less than one kilometre from access to estuarine or marine water, with elevations of more than one metre but not more than 10 metres above the highest astronomical tide level (QDPI&F 2006).

Correct site selection not only provides benefits to the environment and other users of the coastal zone, but also greatly enhances the prospects for profits to be made. There are many examples of poorly selected sites for aquaculture, not only overseas, but also in Australia. In nearly all cases, these farms are doomed to failure. This results in the loss of substantial investment dollars and a diminished reputation for all forms of aquaculture by the investment market and the public at large (ASIC 1997).

The ability to resolve some of these issues is limited, based on the fact that the site is generally freehold and the operation is unable to move to an alternative site. The sites suitability forms part of broader land use planning as well as the assessment process for each proposal.

The Department of Water, through the *Water Quality Protection Notice* (2006), recommend that where land-based aquaculture be situated on permeable soils (i.e. sand or gravel) that great care be taken at all stages to prevent water contamination. It is not recommended that prawn ponds be sited on these types of soils (see section 5.2.3.5) for reasons such as groundwater contamination and seepage.

Prawn farms should not be established over land that is seasonally flooded, needs to be artificially drained, requires natural watercourses to be diverted or construction will affect areas of waterway and wetland-dependant vegetation. These areas provide significant environmental water quality benefits through their ability to sustain aquatic ecosystems and filter run-off.

Buildings and ponds should be placed sufficiently high in the landscape to retain natural waterways, wetlands and their dependant vegetation, and allow for the effective operation of run-off filter zones and sediment control measures.

The Department of Water also recommends for land-based aquaculture, in order to protect any nearly waterway and its associated riparian area, that a foreshore area or waterway buffer be retained based on assessment of the biological and physical features associated with the water, its values and pressures.

Considering the current planning activities in WA, the consequences of having an inappropriately sited operation is ‘minor’ (‘1’) in respect to regional impacts, with the likelihood of it occurring being ‘unlikely’ (‘3’).

Comments in Relation to Future Management

- Broader planning activities should be considered and, where possible, the Department of Fisheries should participate in consultation processes for zoning of land (so as to ensure suitable sites are identified and zoned for aquaculture activities).
- Recommend applicants read the recommendations contained in the Department of Water’s *Water Quality Protection Notice (2006).*

5.2.4 Production

This branch covers the issues that may assist production of the cultured species at optimal levels for the catchment by minimizing the collective impacts of the individual operations.

5.2.4.1 Disease transmission risks (e.g. through proximity of facilities, translocation)

Table 41 Disease protocols for region.

Description (Fletcher *et al*. 2004)	*What protocols (if any) are needed within the region to minimise the risk of disease transmission, either in terms of where sites are located and their proximity to each other, the movement of stock within the regions and the introduction of stock from outside the region?*
Level of impact	Catchment/Region
Comment	• Transmission of disease between farms is unlikely to be an issue since all translocations must be assessed and approved by the Department of Fisheries. • There is a need to consider disease transmission by sharing of equipment. • This issue should be determined in conjunction with the regional carrying capacity – the proximity between sites. • Disease management should be developed for the 'whole of industry' for application by license holders within agreed regions. • The use of chemicals needs to be under close scrutiny, since discharge of contaminated waters may impact downstream users.

Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop				
NK	3	2	6	Low
CK	3	2	6	Low
DL	3	2	6	Low
PIL	3	2	6	Low
CAR	3	2	6	Low
GS	3	2	6	Low

Justification for Risk Ranking

In most cases, external signs of disease are non-specific and even if a particular disease is identified, this is unlikely to provide any direct information about the environmental conditions that led to this disease outbreak.

Pathogens can be introduced to, or transmitted between, ponds/farms in several ways. These include the introduction of disease by apparently normal but infected 'carrier' prawns, entry of wild carrier animals such as shrimp or crabs, improper disposal of dead prawns, contact with contaminated objects, contaminated water such as drainage water from other farms, contaminated feeds or aerosols from infected ponds (QDPI&F 2006).

The most common diseases observed in Australian prawn farms are Mid-Crop Mortality Syndrome (MCMS), Bacterial Septicaemia and Haemocytic Enteritis. The most significant viral disease is MCMS - a disease associated with a varying combination of viral pathogens. Animals can be infected with Gill Associated Virus (GAV), Spawner Mortality Virus (SMV), Infectious Hypodermal and Haematopoietic Necrosis Virus (IHHNV) and Mourilyan Virus (MoV).

Most of the prawn health research in Australia has been conducted on GAV in MCMS, so it can be used as the indicator virus where the majority of therapies that control it would be effective against other viruses as well (QDPI&F 2006).

Typically, 50 percent of all black tiger prawns will be infected with GAV within one month of being stocked into ponds. It is only when the prevalence or intensity increases by 20 or 30 per cent respectively, that the likelihood of an outbreak would be high.

The majority of diseases occurring in ponds are probably due to bacterial infection such as Vibriosis or problems related to Septacaemia. Poor pond preparation, poor food control and inefficient sweeping of the bottom with paddlewheels can all contribute to harmful bacteria getting out of control.

It is also important to know that not all potential causes of disease on prawn farms can be excluded by the application of a biosecurity program. Many *Vibrio* species can occur naturally on farms as part of the prawn's normal microbial fauna and in the pond environment. Under certain conditions these bacteria can proliferate, causing serious disease problems.

The Department of Fisheries' *Translocation Policy* ensures any potential disease transmission between sites and regions is assessed on a case-by-case basis using a risk assessment process, in order to minimize any likely disease outbreaks occurring. Stock movements are closely managed, with health certification required prior to these activities.

Under the *Fish Resources Management Act 1994*, there are requirements for the notification of any disease outbreaks within 24-hours of the farmer becoming aware of such an outbreak.

With current protocols and policies, the consequences could be 'severe' ('3'), but the likelihood of severe impacts on a regional scale would be 'rare' ('2').

Comments in Relation to Future Management

- Maintain the current translocation and health certification protocols.
- Encourage effective biosecurity through secure farm design, hygiene and quarantine, regular health testing, record keeping, and the control of disease vectors.

5.2.4.2 Water availability

Table 42 Water availability.

Description (Fletcher *et al*. 2004)	*Is there enough groundwater available for prawn farming activities at a regional level or is it restricted by quality, salinity, ionic composition etc?*
Level of impact	Catchment/Region
Comment	• The prawn aquaculture industry is small enough that any water extraction is minimal. • The operator in Kununurra fills ponds via rainwater.

Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop				
NK	2	2	4	Low
CK	2	2	4	Low
DL	2	2	4	Low
PIL	2	2	4	Low
CAR	2	2	4	Low
GS	2	2	4	Low

Justification for Risk Ranking

The classification of various water resources around Australia and its suitability for prawn farming has been investigated. Low salinity prawn culture refers to waters of 10 ppt or less (16,000 µS/cm). Water above 3.8 ppt would be classed as generally too saline for agriculture (once water passes 1.8 ppt, it could only be used on salt tolerant crops).

Water that falls within the range 0.4 to 1.8 ppt would be classed as low-to-medium salinity and it is this water that has most potential for direct integration of black tiger prawn production and terrestrial farming. To use higher salinity waters requires the use of stand-alone or 'zero-discharge' systems.

Groundwater may also differ significantly in terms of its relative ionic composition compared to seawater. There must be a similar cation to anion ratio to that found in seawater to be suitable for prawn aquaculture.

Most saline groundwater is deficient in potassium, although other key ions such as sodium, chloride, calcium and magnesium can also vary considerably depending on the aquifer. Australian groundwater is typically deficient in potassium and as this ion plays an essential role in regulating sodium, will influence fluid balance within crustaceans. Adding potassium has been shown to assist in the survival of post-larval black tiger prawns.

This demonstrates that not all groundwater will be suitable for prawn farming. The Department of Water has completed mapping of the size of groundwater reserves and extraction rates from these aquifers are determined on a case-by-case basis during any water licence application assessment. This work has not considered the appropriateness of prawn farming.

Based on the current farming activities, where the facility relies solely on rainwater, the availability of groundwater reserves are unlikely to be of concern. If the proposed facility is approved over the next five years, it may require bore water and some analysis of groundwater composition. On these rates of growth, the consequences of availability of groundwater being an issue for prawn farms is 'moderate' ('2') with a likelihood of this occurring being 'rare' ('2').

Comments in Relation to Future Management

- Maintain current Department of Water allocation assessment processes.

5.2.4.3 Disposal of processing waste

Table 43 Disposal of processing wastes.

Description (Fletcher *et al*. 2004)	*Does the processing of product occur in the water and, if so, what is the impact of this?*			
Level of impact	Catchment/Region			
Comment	• Onsite disposal of wastes needs to be managed appropriately and process waste removed offsite to an appropriate facility. • There are license conditions prohibiting any dumping of viscera and offal in water – all waste has to be disposed of in land-based facilities. • This question is more relevant within an aquaculture facility.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop				
NK	3	1	3	Low
CK	2	1	2	Low
DL	3	1	3	Low
PIL	1	1	1	Low
CAR	1	1	1	Low
GS	3	1	3	Low

Justification for Risk Ranking

Western Australia manages the disposal of fish processing waste through the *Fish Resources Management Regulations 1995* which prohibits 'the deposition of any refuse or waste in any waters where fish are likely to be'. Due to the current legislative requirements, the likelihood of any processing waste being disposed of inappropriately is 'remote' ('1') but if it were to occur, the consequences would range between 'minor' ('1') to 'severe' ('3') depending on the region (i.e. the flushing rates in the particular region and whether sensitive habitats occur there).

Comments in Relation to Future Management

- The license condition should be maintained that prohibits any dumping of viscera and offal in water – all waste has to be disposed of in land-based facilities.
- Guidelines for processing and offal disposal need to be developed and included in a 'Code of Practice'.
- There should be no disposal of viscera and offal in water close to recreational-use areas.
- Managed in accordance with the *Environment Protection Act* and/or *Pollution and Unauthorised Discharge Regulations.*

5.2.4.4 Disposal of unusable product

Table 44 Disposal of unusable product.

Description (Fletcher *et al*. 2004)	*Could the need to dispose of significant quantities of unmarketable product (from disease or other cause) be handled within the area (i.e. are there suitable waste disposal facilities)?*			
Level of impact	Catchment/Region			
Comment	• Such disposal should be arranged in advance of any need. • Usually local government facilities are adequate, but in some cases disposal may be difficult or expensive to resolve.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop				
NK	2	3	6	Low
CK	1	3	3	Low
DL	2	3	6	Low
PIL	1	3	3	Low
CAR	1	2	2	Low
GS	2	2	4	Low

Justification for Risk Ranking

The size of the prawn aquaculture industry and the low level of production restrict the amount of wastes being produced. All mortalities should be collected from the ponds on a daily or weekly basis, and disposed of in land-based facilities, in a similar manner to processing wastes.

Some regions will have facilities to handle operational waste but others will not. More remote locations are likely to have difficulty finding a suitable disposal facility and will need to develop ways to handle their waste themselves. The likelihood of not being able to dispose of wastes appropriately ranges from 'unlikely' ('3') to 'rare' ('2').

Comments in Relation to Future Management

- Maintain the current protocols for disposal in land-based facilities that are managed by councils.
- Arrangements with local government for normal and 'worst-case' disposal requirements should be agreed in advance of being required, i.e. each aquaculture facility should be required to have an agreed worst-case disposal arrangement. As each facility is properly provided for, regional issues will not arise.

5.2.4.5 Disposal of production product

Table 45 Disposal of production wastes.

Description (Fletcher *et al*. 2004)	*Does the processing of product occur in the water and, if so, what is the impact of this?*			
Level of impact	Catchment / Region			
Comment	• Harvesting occurs from land-based ponds and no viscera are produced during this activity. • There is minimal processing of this species [prawns] anyway.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop				
NK	0	3	0	Negligible
CK	0	3	0	Negligible
DL	0	3	0	Negligible
PIL	0	3	0	Negligible
CAR	0	3	0	Negligible
GS	0	3	0	Negligible

Justification for Risk Ranking

There is no processing of product in the pond water since all prawns are harvested and sold whole.

Comments in Relation to Future Management

- This situation may change, depending on future marketing demands for processed product.

5.3 Impacts of Individual Facilities on Environmental Wellbeing

These are the potential topics that may relate to what an operator (and any consent authority) needs to consider for assessing the issues related to a specific aquaculture facility. This includes both the construction phase/site selection aspects and the issues associated with the operation of the facility once it is in production.

Where relevant, topics which are possibly affected by objectives/levels developed at higher-level trees (catchment and/or 'whole of industry') should be dealt with in more detail by the proponent during any application process. **Justifications may not have been developed due to the difference between individual facilities and the difficulty in assessing issues in this context.**

5.3.1 Site selection/construction/infrastructure

This branch is designed to cover the issues related to the initial building, construction and development of an aquaculture facility – i.e. before the facility becomes operational.

5.3.1.1 Habitat effects and removals

Table 46 Effects on surrounding habitat due to development.

Description (Fletcher *et al*. 2004)	*What habitat will have to be removed or affected by the construction; development; expansion of the facilities (e.g. digging of ponds, cage construction and other infrastructure such as roads, workshops)? Does the proposed level of removal for the facility fit within the total amount allowed to be affected for the catchment/region?*			
Level of impact	Individual facility			
Comment	• Native Vegetation Clearance approval required from the Department of Environment and Conservation.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	3	3	9	Moderate

Justification for Risk Ranking

If sites are located on private property, Native Vegetation Clearance approval will still be required from the Department of Environment and Conservation, and the cumulative effects of excessive habitat removal will be considered through this process.

The Department of Fisheries can place a condition on the licence requiring revegetation and rehabilitation activities on the site to act as a noise barrier and screening for visual amenity issues. If possible, the condition should recommend that local endemic species be used for this barrier/screening.

Regional levels of habitat removal are considered in sections 5.2.2.2 and 5.2.3.2.

Consequences from habitat removal on site could be 'severe' ('3') but with current protocols and assessment processes, severe impacts should be 'unlikely' ('3').

Comments in Relation to Future Management

- There should be guidelines that identify habitat removal requirements and processes for approval.

5.3.1.2 Erosion

Table 47 Impacts due to erosion.

Description (Fletcher *et al*. 2004)	*Will construction cause any short or long-term erosion problems for the area?*			
Level of impact	Individual facility			
Comment	• Construction impacts are possible and need specific consideration in the design of an aquaculture facility and, in some cases, require active management.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	3	4	12	Moderate

Justification for Risk Ranking

The construction plan for any new aquaculture facility must show that the issue of erosion management has been considered and dealt with. Earthworks should therefore be minimised during any recognised wet season, with any area that is disturbed being limited to the immediate construction site.

Appropriate methods, such as the use of perimeter bunds, must be used to prevent overland flow from entering the construction site. Reducing the erosion of top soil should be a priority and this links closely to reducing saltation of waterways (by using straw bales, silt fences or sediment traps).

Research by the Aquaculture Cooperative Research Council has found that approximately 80 per cent of sediment accumulated on a pond floor had come from erosion of the pond walls. In order to mitigate this erosion, it has been recommended that pond walls should be grassed above the waterline to protect the walls and make them durable. A layer of topsoil should be deposited on the walls during construction and irrigation provided in the initial phase, so as to allow grass to grow quickly when the ponds are new.

Below the waterline, plastic lining or the correct placement of aerators are useful control methods (QEPA 2000).

There is also a need to minimise erosion in discharge channels and at farm discharge points. Discharge channels structure should be designed to minimise the level of erosions, with the emphasis on protecting the drain walls from direct water impact and associated erosion. This includes the incorporating of a suitable batten angle and methods to minimise discharge water velocity.

Farm discharge points should be sited and used in such a way that unacceptable erosion of creek or stream banks/walls will not occur. These points should also be protected from scouring.

Depending on the individual site and the design characteristics, the consequences could be 'severe' ('3') with a likelihood of 'severe' consequences being possible ('4').

Comments in Relation to Future Management

- Guidelines for managing erosion and sedimentation are required.

5.3.1.3 Seepage

Table 48 Seepage of material during construction.

Description (Fletcher *et al*. 2004)	*Will the type of construction allow seepage of materials, e.g. saltwater from ponds into neighbouring areas?*			
Level of impact	Individual facility			
Comment	• Ponds should be designed/constructed for minimal seepage so as to conserve water and prevent contamination of surface and groundwater bodies.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	2	3	6	Low

Justification for Risk Ranking

It is important to ensure that there is no pond seepage, as this will increase pumping costs and can affect groundwater in local aquifers. Resealing also ensures that the final finish on the pond floor is smooth and that the pond drains well towards the outlet for the future harvest (QDPI&F 2006).

If suitable remediation processes are used, the seepage from a pond will be minimised. Soil types should allow for water-holding and load-carrying capacity with a post-construction seepage rating of less than 1×10^{-8} metres/second. The clay content should be adequate to eliminate or reduce the loss of water. If suitable soil testing is undertaken during site selection, this should minimize future problems with pond seepage.

Environmental monitoring to be implemented for the prawn aquaculture industry could incorporate monitoring groundwater quality to ensure any seepage is detected and rectified, by proper pond sealing. Current operations have not detected any seepage and continuing to use the protocols in place should minimise potential impacts on groundwater. The consequences of seepage occurring could be 'moderate' ('2') on the local groundwater reserves, but the likelihood of these consequences occurring is 'unlikely' ('3').

Comments in Relation to Future Management

- Guidelines on construction techniques are required by industry.
- This may be an ongoing issue needing management.

5.3.1.4 Rehabilitation

Table 49 Site rehabilitation.

Description (Fletcher *et al*. 2004)	*Do processes have to be planned to rehabilitate the aquaculture site if production is ended?*			
Level of impact	Individual facility			
Comment	• Structures need to be stabilised, water flows managed, sludge removed from ponds and disposed of appropriately. • There is a need to consider the removal of stock during decommissioning. • There is a need to consider the rehabilitation of vegetation that was removed during the construction phase.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	2	4	8	Moderate

Comments in Relation to Future Management

- Guidelines for decommissioning are required and should form part of the Code of Practice.
- Department of Environment and Conservation guidelines of pond de-sludging and disposal are required.
- Department of Environment and Conservation guidelines for incorporating stormwater flows over the site are required.

5.3.1.5 Soil quality

Table 50 Soil quality.

Description (Fletcher *et al*. 2004)	*Is the area prone to acid sulphate soils or other such problems? If it is, are processes needed to ensure that this does not get activated when construction occurs?*			
Level of impact	Individual facility			
Comment	• The existence of soils of this kind is very dependent on the site chosen. • The site-testing of soils against acid sulphate criteria should be encouraged.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	4	2	8	Moderate

Justification for Risk Ranking

Some prawn farms have faced difficult environmental management issues due to the selection of a site with poor soil characteristics. Soils suitable for pond construction and the farming of prawns must possess properties that allow for:

- economic construction of pond embankments;
- growth of beneficial algal blooms;
- water-holding and load carrying capacity with a post-construction seepage rating of less than 1 x 10^{-8} metres/second; and
- favourable chemical growing conditions.

In general, soils for earthen pond construction should have a low organic matter content and a pH of 5.5 to 8.5. Problematic soils with the potential to interfere with the construction and operation of pond systems or be toxic to cultured organisms include acid sulphate soils, dispersive soils, expansive clays, organic soils, structured (aggregated) soils or be soft or compressible (QDPI&F 2006).

It is recommended that a soil test be undertaken during the site-selection phase to assess whether the soil is suitable or not, depending on its percentage of clay content (>70% clay) and elasticity.

Consequences of not taking into account soil quality could be 'major' ('4'). The likelihood of this occurring should be 'rare' ('2'), taking into account the testing required and assessment processes.

Comments in Relation to Future Management

- Construction and site-selection guidelines should be developed.
- A Code of Practice needs to identify where proponents can go for information and advice
- Simple test kits are available that can be used to identify if acid sulphate soils are present on-site.

5.3.1.6 Noise/dust

Table 51 Noise resulting from facility.

Description (Fletcher *et al*. 2004)	*Will construction of the aquaculture facility result in an unacceptable increase in noise and dust to surrounding areas?*			
Level of impact	Individual facility			
Comment	• A localised impact is highly likely. • Management techniques are simple, as noise regulations apply. • Dust nuisance may be an offence under the *Environmental Protection Act* and controlled by local government during construction. • Local government may manage this via planning development approval processing.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	2	5	10	Moderate

Comments in Relation to Future Management

- There needs to be guidelines to manage noise and dust – local government should develop them.
- There should be a separation of the issues of noise and dust, as they are quite different to manage.

5.3.1.7 Infrastructure

Table 52 Infrastructure requirements.

Description (Fletcher *et al*. 2004)	*Is the necessary infrastructure (e.g. roads, electricity, etc) available in the area where the proposed site is located?*			
Level of impact	Individual facility			
Comment	• Discussions with local government should be held to determine whether the activity is compatible for the land zoning. • Link to regional planning for future infrastructure provision.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	3	2	6	Low

Comments in Relation to Future Management

- Applicants should be provided with copies of Department of Fisheries assessment processes as advice (i.e. if local government consultation is required).
- The State Government should work with local government to identify areas where aquaculture could be sited and the associated future infrastructure provisions.

5.3.1.8 Waste (e.g. dredge spoilage)

Table 53 Disposal of dredge spoilage from ponds.

Description (Fletcher *et al*. 2004)	*Do there need to be processes developed to plan for the disposal of dredge spoilage?*			
Level of impact	Individual facility			
Comment	• The Department of Environment and Conservation have guidelines to manage the disposal of spoilage into adjacent land. • Discussions should take place with local government regarding locations where sludge can be suitably dumped – there may be a need to change land-use zoning.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	2	4	8	Moderate

Comments in Relation to Future Management

- A Code of Practice should outline methods for disposing of sludge.

5.3.1.9 Flood plain/storm flows

Table 54 Regional water flows.

Description (Fletcher *et al*. 2004)	*Will the construction of this aquaculture facility interrupt water flow within the region (a reference may be needed to the 'whole of catchment' level assessment)?*
Level of impact	Individual facility
Comment	• Applicant should indicate the position of the proposed aquaculture facility in relation to surrounding water courses. • The regional water/river/stream flows should be identified, including levels and extent of any flooding. • It should be specified how the facility will be managed to minimise impacts on water courses and flooding. • Incorrect placement could have drastic consequences for the farm.

Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	4	2	8	Moderate

Comments in Relation Future Management

- Maintain Department of Water assessment processes and protocols.

5.3.1.10 Alienation

Table 55 Alienation of other groups.

Description (Fletcher *et al*. 2004)	*Will the construction of the aquaculture facilities alienate other groups (e.g. indigenous, recreational and commercial fishers, boating) from using an area that they previously had access to?*
Level of impact	Individual facility
Comment	• This situation is unlikely to arise if the proposed facility is to be on private land, but if it on Crown (public) land this may be an issue. • It should be indicated whether the removing/discharging of water from/ to a river by the proposed facility will impact on other river users.

Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	1	3	3	Low

Justification for Risk Ranking

Over the years, discussions regarding the prawn farms operating in NSW revealed that the only industry which has serious concerns regarding the impact of prawn farming activities in the area is the fishing industry. Several issues have been cited as being of particular significance, most being associated with the effects of prawn farming on the natural environment:

- potential for disease which may affect natural populations of prawns and the issue of quarantine;
- impacts of 'poor' site selection where farms may be sited on existing or past wetlands;
- potential for the escape of exotic strains of prawns; and
- release of excessive nutrients in pond effluent.

Prawn farmers perceive the situation differently. They contest that they are replacing a declining fishery - which has had the opportunity to become involved in prawn farming for a number of years.

Since the prawn farms in WA are located on leased land and other applications are likely to be sited on similarly tenured land, there should be minimal concern in this regard. However, the placement of water extraction and discharge pipes across Crown Land may result in alienation of areas if incorrectly sited. Therefore, it is recommended that consultation with relevant stakeholders take place during the project development phase.

Current Ministerial Policy Guideline No. 8 processes undertake this consultation as part of the agreed licence application assessment, so any potential alienation will be considered.

Comments in Relation Future Management

- The current Department of Fisheries assessment processes using Ministerial Policy Guideline No. 8 should be maintained.
- Discussions on this matter between the proponent and local government in the early stages of planning the proposed facility should be encouraged.

5.3.1.12 Proximity to sensitive fauna/regions

Table 56 Proximity to sensitive fauna/regions.

Description (Fletcher *et al*. 2004)	*Is the proposed aquaculture facility close to an area where there are sensitive fauna, habitat or other regions of particular value?*			
Level of impact	Individual facility			
Comment	• This issue would be considered by referral during the assessment process and include appropriate management as licence conditions.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	1	2	2	Low

Justification for Risk Ranking

The Fisheries Research and Development Corporation (FRDC) funded research into the fate, processing and assimilation of prawn farm effluent in 1993 - 96. Results from this work, demonstrated that mangrove environments are capable of assimilating a substantial load of prawn farm nutrients and sediment, but the capacity of these systems to remove or assimilate effluent for the longer term remained unclear.

More research, including computer modelling, was undertaken in 2001, this time using a slow-flushing tidal creek, having a residence time varying between 4 to 10 - 15 days (Davidson *et al*. 2001).

Most tidal creeks with mangroves forests on their banks have a stronger ebb tide than flood tide. These tidal currents can scour the channels and drains, and resuspend lighter sediments, thereby leading to a reduction in concentrations of most nutrient and sediment parameters.

Studies showed that nutrients and sediment that remain in the creek appear to cause little immediate damage to the mangrove, pelagic or benthic ecosystems, as most easily-accessible carbon and nitrogen is transformed or used by food chains within the creek system. The cumulative impact from the bank of nutrients that moves downstream remains unknown. The bulk of nutrients emanating from prawn farms are in particulate form and are generally fully assimilated within the study area and moved seaward. Using settlement ponds and bio-filtration would lessen the amount of particulate matter discharged to the creek in the first instance.

Therefore, if we consider the impact on threatened species such as mangroves, a sensible

approach is to encourage the use of settlement ponds to minimise the amount of sediment discharged into these sensitive environments.

In WA, the Department of Environment and Conservation have two Guidance Statements requiring the consideration of impacts to benthic primary-producer habitats and mangrove communities. Continuing to utilise these position papers will minimize impacts on these habitats to an acceptable level. Applicants should consider this issue during the application development phase to mitigate impacts as much as possible. Consequences are considered to be 'minor' ('1') with a likelihood of 'rare' ('2').

Comments in Relation Future Management

- Discussions should be encouraged with government agencies during the application development phase of an aquaculture facility.
- The EPA Guidance Statements No. 1 – *Protection of Tropical Arid Zone Mangroves along the Pilbara Coastline,* No. 49 – *Development of Proposals in Shark Bay World Heritage Property,* Draft EPA Guidance Statement No. 33 – *Planning and Development* and Position Statement No. 2 – *Environmental Protection of Native Vegetation in WA* should be used.

5.3.1.12 Proximity to users

Table 57 Proximity to users.

Description (Fletcher *et al*. 2004)	*How close is the aquaculture facility to markets?*			
Level of impact	Individual facility			
Comment	• This is more of an economic consideration and unlikely to have environmental repercussions.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	0	1	0	Negligible

Comments in Relation to Future Management

- This issue should be considered when selecting a site – i.e. how it links into transport corridors.

5.3.1.13 Water table

Table 58 Impacts on water tables.

Description (Fletcher *et al*. 2004)	*Will the construction of the aquaculture facility have an impact on the water table (other than associated with soil quality issues dealt with above)? This may need to be referred to 'whole of catchment' issues.*			
Level of impact	Individual facility			
Comment	• An applicant will still require approval from the Department of Water for any water use and access. • An applicant needs to demonstrate this approval and licence when lodging aquaculture licence application.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	2	4	8	Moderate

Justification for Risk Ranking

Prawn farm development has the potential to provide a conduit for salt water to enter groundwater supplies and the possible degradation of groundwater suitable for irrigation and other established uses.

The Department of Water and the Department of Environment and Conservation assessments consider the impact of farms on region water flows. They also consider the extraction levels being proposed and what impacts this may have, if any, on regional water tables. Proponents need to provide this information within their application, but assessments of each farm will take into consideration the regional impacts from the facility.

Comments in Relation to Future Management

- Proponents should be advised of the requirement for a Department of Water licence for water extraction.

5.3.1.14 Engineering for climate

Table 59 Engineering for climate.

Description (Fletcher *et al*. 2004)	*Does the location of the aquaculture facility require specific engineering techniques to protect it from climatic, topographic or other impacts?*			
Level of impact	Individual facility			
Comment	• It is necessary to consider temperatures, rainfall, flooding and cyclones during the design of facilities in the northern regions of the State. • Facilities need to be able to withstand these conditions without releasing stock or exacerbating flooding through pond-wall breaches. • Historic records should be considered to determine the placement of the facility. • It could have severe consequences for the facility if these issues are not dealt with adequately.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	3	4	12	Moderate

Justification for Risk Ranking

Prior to the construction of any new facility, a comprehensive site evaluation and facility design test should be conducted to determine if the proposed site's characteristics are suitable for the construction and sustainable operation of a prawn farm. This evaluation should include:

- determination of availability and quality water, including requirements for reuse/ recycling;
- tidal patterns;
- climatic conditions;
- freshwater flows (including flood levels and frequency); and
- soil characteristics.

Any proponent who fails to undertake this data collection faces the prospects of severe facility and operational failure, since the facility may fail from an engineering perspective.

Comments in Relation to Future Management

- A proponent should be advised of the data requirements during the site selection and facility design phases of an aquaculture facility.

5.3.1.15 Creek systems

Table 60 Creek systems.

Description (Fletcher *et al*. 2004)	*Will the local creek system impact on the functioning of the aquaculture facility or its placement? Will the facility's placement on the creek system affect its integrity?*			
Level of impact	Individual facility			
Comment	• It is necessary to consider creek flow lines, flood levels and length of inundation. • Considerable damage can be caused to a facility through breaking pond walls, stock losses and disease introductions.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	2	3	6	Low

Justification for Risk Ranking

Placement of the aquaculture facility in the landscape is a fundamental criteria requiring consideration during site selection. Obviously, the impact of the facility on the creek system is of major importance to the environment, but the impact the creek system may have on the operational facility is a longer-term concern.

As for site selection, it is imperative that the proponent determines the position of seasonal creek flow lines, maximum and minimum flood levels and the length of inundation. The impact that floods and intermittent creek flows can have on a facility has the potential to be considerable and result in loss of stock, disease transfers and damage to pond walls.

This is a major issue at the facility level but can result in regional level impacts if it is not dealt with properly.

Comments in Relation to Future Management

- Advise proponent of need for a Department of Water licence regarding water extraction.
- The Department of Environment and Conservation referral will provide guidance on any impacts to creek systems.

5.3.1.16 Water quality

Table 61 Water quality.

Description (Fletcher *et al*. 2004)	*Does the quality of wastewater released from pipes/overflows or the water that passes from ponds include increased/decreased levels of nutrients, waste feed or faeces? Are these within agreed limits of the lease regulations and are these compatible with the total levels allowed for the catchment?*
Level of impact	Individual facility
Comment	• A proponent should calculate nutrient levels for each facility, based on the stock biomass proposed, design and technology to be used, water availability and feed rates. • Environmental Monitoring and Management Plans (EMMP) will assist the industry develop nutrient guidelines. • Reporting of EMMP results can assist in design of future upgrades to an aquaculture facility.

Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	4	3	12	Moderate

Justification for Risk Ranking

The Australian Prawn Farmers Association has undertaken a study to quantify whole farm budgets for total suspended solids, total nitrogen and total phosphorous. The results have demonstrated a high level of variation in effluent loads depending on several factors including: location, rainfall, species farmed, phase of the production season and the farm management practices. This variability adds considerable complexity to the task of setting water quality standards and in designing waste management systems to meet those standards (QEPA 2000).

Dissolved oxygen concentrations vary with salinity and temperature. To provide direction on acceptable discharge standards for dissolved oxygen and pH, use of the WA *State Water Quality Framework* is recommended as a reference. These guidelines contain water quality information derived from largely unimpacted waters to develop certain reference values.

The Aquaculture Cooperative Research Centre has shown that there is substantial variation in both dissolved oxygen and pH, for both intake and discharge waters. This is caused by photosynthetic activity. During daylight hours the phytoplankton produce oxygen (increasing dissolved oxygen) and remove CO_2 from the water (increasing pH).

During the night, respiration of phytoplankton and bacteria use oxygen and produce CO_2. The diurnal pH variation is usually more extreme in discharge water compared to the receiving environment - daytime peaks are usually higher and night-time minima are usually lower. The CRC also found that night-time sag is always more pronounced in the discharge water, because it has a higher biomass (principally phytoplankton).

The critical criteria is to identify significant variations from the natural variation of the receiving waters, which could be an environmental management issue caused when an algal bloom dies off, resulting in a low dissolved oxygen discharge during the day.

Comments in Relation to Future Management

- Calculation should be required of nutrient production and release levels during the application development stage.

- Environmental Monitoring and Management Plans should be established for each facility for water quality criteria.

5.3.2 Operations

This set of sub-branches is designed to identify the issues that may occur, or be needed, during the operation of the facility once it is in production.

5.3.2.1 Effects on cultured species

This sub-branch covers issues related to the impacts on the stocks being cultivated that may need to be addressed within each facility

Table 62 Disease management (surveillance, quarantine).

Description (Fletcher *et al*. 2004)	*Is a health surveillance or quarantine management system in place or does one need to be developed?*			
Level of impact	Individual facility			
Comment	• Farmers are required to report disease outbreaks under the *Fish Resources Management Regulations 1995* and must therefore maintain close watch on the health of stock. • It is in farmers' best interests to ensure disease outbreaks are detected quickly.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	3	3	9	Moderate

Justification for Risk Ranking

Industry-wide protocols should be set up to ensure health surveillance is undertaken on a consistent basis – this could also link in with the new *Biosecurity and Agricultural Management Act*. This is better dealt with in detail under section 5.1.2.2.

A Disease Emergency Plan should be developed for each site which outlines actions and steps to be taken by all farm staff in the event of a disease outbreak. The plan should include specific written protocols to be followed by staff and incorporate planning and implementation procedures.

Operators should be made aware of the Australian Government's *Aquavetplan*. The plan will ensure that a coordinated and efficient approach is taken to assist in disease management and eradication. Manuals are available on the internet and are working documents, in that they will be updated with research findings as and when these become available.

Consequences at the facility level for not having a health or disease surveillance system in place to detect health or disease issues could be 'severe' ('3'), but the likelihood of this happening is 'unlikely' ('3').

Comments in Relation to Future Management

- Where possible, guidelines should be provided for species being considered for an aquaculture facility (i.e. the diseases to watch for with the species).
- Applicants should be provided with some concept of the likely disease monitoring required under the *Fish Resources Management Regulations 1995* – a Code of Practice could assist.

Table 63 Stocking density/biomass.

Description (Fletcher *et al*. 2004)	*Is there a sensible limit to the stocking density (or biomass levels) of individuals within the aquaculture facility to minimise impacts on growth/ survival etc?*			
Level of impact	Individual facility			
Comment	• The stock biomass should be linked to pond size, maximum stocking densities, feeding regimes and required nutrient discharge levels.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	3	2	6	Low

Justification for Risk Ranking

In comparison to prawn aquaculture in other parts of the world, Australian prawn farms are far less intensive and better described as being semi-intensive. Stocking rates of 60PL/m^2 (twice that used in Australia) are typical in the major producing countries such as Thailand, Indonesia and Ecuador, which results in a far greater potential for disease and excessive nutrient loading in pond effluent, as well as a greater demand for water, aeration and food.

Tiger prawns are generally stocked at approximately 30PL/m^2 (of pond floor area) although this depends upon the individual management practices and techniques. Lower stocking densities are necessary in circumstances where access to water is limited by site selection and river water quality.

There is always a commercial desire to attain higher stocking densities since stocking rates are a direct determinant of pond yields and lower pond yields reflect lower profitability and returns on capital investment. However, given the capacity of a pond system to support a particular prawn biomass, a biological limit to stocking densities always exists. Prawn culture management is essentially the science of balancing biomass production with the pond environment. (ASIC 1997).

Monitoring the biomass of the crop regularly is important to ensure the health of the stock, to improve food conversion ratios, maximising growth rates, survival rates and yield. Some farmers partially harvest to maintain a specific biomass, while others may commence harvests depending on water temperatures, dissolved oxygen levels and general health of the pond.

Farmers should therefore consider the aeration capacity of the pond, water exchange capacity, feed quality, impacts of increased metabolic wastes and disease implications when determining the most suitable stocking density.

Consequences of incorrect stocking densities will remain on the farm, but the repercussions can be ‘severe’ (‘3’). The likelihood of these occurring is considered to be ‘rare’ (‘2’).

Comments in Relation to Future Management

- Applications for an aquaculture facility must incorporate some understanding of the repercussions of stocking biomass and densities on farm management and operations.

Table 64 Animal welfare.

Description (Fletcher *et al*. 2004)	*Is there any relevant animal welfare legislation that needs to be incorporated into the husbandry techniques used within the aquaculture facility?*			
Level of impact	Individual facility			
Comment	• There is a need to comply with the *FRMA*.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	1	3	3	Low

Comments in Relation to Future Management

- Make applicants aware of their obligations under the *FRMA*.
- Advise applicants of the licence conditions that may be attached to any approval in regards to stock management, site rehabilitation and decommissioning

Table 65 Predation.

Description (Fletcher *et al*. 2004)	*Are predators (e.g. birds) a problem around this aquaculture facility? If these predators are protected species, this may result in different actions being necessary.*			
Level of impact	Individual facility			
Comment	• The methods to be employed to minimize predation of stock should be outlined.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	1	4	4	Low

Justification for Risk Ranking

A range of predators have the potential to impact on prawn farming operations. The management of predators will vary depending on the species, region and operator preference. The appropriate management of predators is likely to increase profitability and minimise the potential environmental impacts to predator species such as birds, some finfish and/or crocodiles.

In order to appropriately manage predators, farmers must utilise one or more of the following practices:

- screening of pond intake and discharge structures with appropriately-sized mesh;
- appropriate channel treatment of pond water;
- overhead netting of ponds;
- installation of waterline nets;
- installation of overhead wires;
- use of repellent sound or light emissions;
- increased personnel around ponds during feeding for birds;
- installation of predatory images or models; and
- culling of target species under an appropriate permit as issued by the administering authority.

Comments in Relation to Future Management

- Guidance should be provided with information on suitable methods to minimize predator interactions.
- Biological information should be available on predator species to increase understanding.

Table 66 Competition for food.

Description (Fletcher *et al*. 2004)	*Will this species compete for food in the pond environment resulting in more aggressive prawns dominating the feeding activity?*			
Level of impact	Individual facility			
Comment	• Larger prawns are known to be more dominant and can aggressively out-compete smaller prawns. • It should be ensured that adequate feed is provided so that all sizes of prawns have access to food.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	2	2	4	Low

Justification for Risk Ranking

Prawns need regular feeding because they have small stomachs and rapid digestions. Although the manufactured feeds are designed to remain stable for a few hours, some soluble compounds do leach out of the pellets. Feeding smaller amounts more regularly is a more effective strategy to maximise the Feed Conversion Ratio (FCR) over the entire crop. Spreading the feeding program over four or five times a day also minimises the effects of high stocking densities on growth caused by prawns fighting for food.

Prawns generally feed and then rest periodically before returning to the water column in search of more food. This behaviour can enable the farmer to segregate feeding strategies for different size classes in the same crop by applying feeds for the larger and more aggressive prawns first, and 20 minutes later feeding for smaller stock with a smaller pellet.

The consequences of prawns competing for food can be ‘moderate’ (‘2’) if feed is not applied at the required rates. The likelihood of this occurring should be ‘rare’ (‘2’) if the farmer is undertaking adequate feed monitoring

Comments in Relation to Future Management

- The feeding activity of the different size classes should be monitored and the amount of feed required subsequently calculated.
- The monitoring of Feed Conversion Ratios should be maintained throughout the growth cycles for effective feed consumption.

Table 67 Food safety and standards.

Description (Fletcher *et al*. 2004)	*Will the product being sold from the aquaculture facility require food safety testing against national/state standards? Does this protocol exist?*
Level of impact	Individual facility
Comment	• The proposed *Food Act* will outline the minimum requirements for any licensed aquaculturist undertaking processing of product on site. • Regulations will provide specific guidance, along with supporting Codes of Conduct.

Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	3	1	3	Low

Justification for Risk Ranking

Food Standards Australia New Zealand (FSANZ) is a bilateral authority that develops standards for all food produced or imported into Australia for sale. These standards should:

- Protect public health and safety by maintaining a safe food supply;
- Provide consumers with information about food to enable informed choices; and
- Prevent misleading and deceptive conduct by food businesses.

FSANZ has developed the *Model Food Act* (MFA) and revised the Food Standards Code to provide the legislative framework integral to a nationally consistent approach to the production of safe food in Australia. Regulatory control of the MFA falls under the relevant State legislation.

In Western Australia, food safety for the domestic market and for imported goods is the responsibility of the Health Department of Western Australia (DOHWA) and currently is dealt with under the *Health Act 1911*. However, following stakeholder consultation, there has been agreement to progress the majority of the MFA as the *WA Food and Related Matters Bill*. This Bill has been drafted by the DOHWA and was introduced into State Parliament in 2005. The Bill, once enacted, will replace the food component section contained in the *Health Act 1911.*

The Food Standards Code sits under the MFA, and provides general standards which apply to all foods, as well as standards affecting particular classes of foods. Included in these sections will be standards for levels of chemical and microbiological contaminants and residuals in foods, standards for labelling, food additives, etc.

The Food Standards Code describes standards for food hygiene issues, including food safety programs and practices, staff training and hygiene, premises and equipment. This information relates only to "food businesses" and excludes "primary producers" unless selling directly to the public.

To fill this gap, the FSANZ has commenced the development of the *Primary Production and Processing Standards* for food production standards for the primary production sector in Australia. These standards, once completed, will form part of the Food Standards Code.

The Food Standards Code applies to every business involved in the handling of food for sale, or the sale of food, in Australia, with the exception of businesses involved solely in primary production, provided they do not process their products or sell them directly to the public.

Comments in Relation to Future Management

- It should be ensured that any applicant/licence holder is aware of their obligations under the *Food Act* and any associated code.

Table 68 Feed quality.

Description (Fletcher *et al*. 2004)	*Are there standards of the feed quality required by the industry that may impact on the ability to purchase or import feeds?*			
Level of impact	Individual facility			
Comment	• Aquaculturists should only use certified feeds from registered companies. • Australian farmers are encouraged to use only feeds made in Australia.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	4	1	4	Low

Justification for Risk Ranking

Feeding methods and products vary considerably according to the species cultured, prawn weight, operating environment and operator preference. However, feeding strategies should be planned and managed to optimise Food Conversion Ratios, productivity and minimise the associated nutrient levels in discharge waters.

Operators should only source artificial feed derived from a certified source. This will assist in minimising the importation of diseases or use of an inferior quality feed, such as one with high levels of dust or fines. Feed should also have appropriate water stability, to ensure pellets do not disintegrate when placed in the water, and a high percentage of digestible ingredients. A level below two percent of phosphorous is recommended, to minimise the addition of this nutrient into the pond.

Feed should be stored in a way that does not attract pest species, such as mice and rats. Recognising these types of measures will improve feed management and increases the potential to significantly contribute to waste minimisation and farm profitability.

Developing a Code of Practice for this industry will ensure farmers are aware and attempt to abide by these recommendations. The consequences of not following these statements will be felt by the farmer alone and could be ‘major’ (‘4’), but the likelihood of them not operating of the most profitable way is considered ‘remote’ (‘1’)

Comments in Relation to Future Management

- Outline the feed suppliers in the Code of Practice.
- The *Biosecurity and Agriculture Management Ac 2007* manages the importation of feeds from overseas and may require strict certification.

5.3.2.2 Use

This sub-branch covers issues associated with the use of resources whilst the facility is operational.

Table 69 Water use.

Description (Fletcher *et al*. 2004)	*Does the aquaculture facility need to use water (e.g. fresh water/ river/ground water) that is in limited supply? May need to refer to any catchment level limits.*
Level of impact	Individual facility
Comment	• The proponent should apply for, and maintain, the appropriate water licence. • Applicant to provide information on water sources, the amounts required, treatment processes and disposal to be used on-site.

Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	3	4	12	Moderate

Comments in Relation to Future Management

- The Department of Water licence should be maintained.

Table 70 Visual impact.

Description (Fletcher *et al*. 2004)	*Does the aquaculture facility need to meet any visual impact limitations?*
Level of impact	Individual facility
Comment	• Recommend use of vegetation screens as an appropriate visual barrier. • Select sheds of a colour to blend in with surroundings. • Being on private or leased land should have minimal risk in this case.

Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	0	1	0	Negligible

Comments in Relation to Future Management

- Applicants should be advised of the requirement to contact local government if any restrictions are in place regarding the land in question, i.e. zoning issues.

Table 71 Air quality and odour.

Description (Fletcher *et al*. 2004)	*Does the aquaculture operation produce greenhouse gases, other air pollutants and smells?*
Level of impact	Individual facility
Comment	• Encourage the use of alternative power sources where possible. • Is solar/tidal/wind power a possible alternative?

Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	1	2	2	Low

Comments in Relation to Future Management

- Advise applicants of the *Environmental Protection Act* guidelines for air emissions.
- Work with local government during planning stages for future power infrastructure provisions.
- Use of alternative power sources may be the only way for facilities in the remote northern regions of WA to obtain electricity – proponents in this situation need to be made aware of running costs in the longer term.

Table 72 Energy.

Description (Fletcher *et al*. 2004)	*What is the energy consumption for the aquaculture facility and what is the energy efficiency rating?*			
Level of impact	Individual facility			
Comment	• Is solar/tidal/wind power a possible alternative? • Are there ways to lower power usage?			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	2	4	8	Moderate

Justification for Risk Ranking

As a commercial entity, the use of large amount of energy during the production cycle is contrary to financial management objectives. Improved energy usage will benefit the individual farmer directly through reduced operating expenses.

As a result, most prawn farms in Australia are designed to allow for the distribution of water through the facility using gravity. The use of underground pipes is considered to be cheaper and require less space than an aquaduct, but they have been found to be constrictive and use more energy (QDPI&F 2006).

Use of solar power for heating water can assist in lowering energy usage. As other alternative energy sources come online, the industry operating in remote regions should be encouraged to investigate any potential opportunities.

As could be expected, the consequences are very much based on each individual facility and could range from negligible to major depending on the size of operations. The consequences are considered to be 'moderate' ('2'), as a result of limited financial and investment backing and the cost of installing power supplies. The likelihood of these consequences occurring is 'possible' ('4').

Comments in Relation to Future Management

- Aquaculture facility operators should monitor power usage and initiate actions to minimize wastage.

Table 73 Noise.

Description (Fletcher *et al*. 2004)	*Does the aquaculture operation produce noise likely to cause a disturbance to adjacent users?*
Level of impact	Individual facility
Comment	• If the aquaculture facility is on private land, the noise risk needs consideration. • Noise is managed by the Department of Environment and Conservation under Noise Regulations.

Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	0	1	0	Negligible

Justification for Risk Ranking

Where prawn farms are constructed near other rural users and they experience residential development encroaching on previously un-utilised lands, there is the potential for operational noise to create a nuisance. Impacts are likely to result principally from aeration devices, pump operation and feeding operations. The level of impacts will vary depending on background noise levels, the type of noise, distances to sensitive places and buffers.

In WA, prawn farms are currently located, or likely to be located, in remote areas, far removed from any adjacent users. As a result, the consequences of operational noise are considered to be 'negligible' ('0') with a likelihood of these consequences occurring considered to be 'remote' ('1').

Comments in Relation to Future Management

- Monitor noise levels at the start-up of an aquaculture facility and then at intervals during its operation.
- Department of Environment and Conservation guidelines are required in regard to buffer distances and management options for noise-generating activities.

Table 74 Escapement.

Description (Fletcher *et al*. 2004)	*Is escapement of individuals an issue (may require reference to 'whole of industry' protocols)?*
Level of impact	Individual facility
Comment	• Outlines methods to minimise escapes should be provided – in line with *Translocation Policy* and the *Fish Resources Management Regulations 1995*. • This could happen during equipment transportation between locations – sterilisation of individuals may help if there are any escapes.

Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	2	2	4	Low

Justification for Risk Ranking

There are various methods employed by Australian prawn farmers to ensure that cultured animals are not released in to the environment. These stock containment practices include:

- screening of pond discharge structures in accordance with prawn size;

- exchanging pond water at times when animals are known to be inactive; and
- screening farm discharge structures with an appropriate-sized mesh.

Comments in Relation to Future Management

- A plan should be developed that identifies potential escapes and the associated mitigation methods.

Table 75 Habitat effects.

Description (Fletcher *et al*. 2004)	*Will operations of the aquaculture facility continue to impact on habitat (e.g. trampling around leases, smothering of habitat, impacts on sensitive habitat)? Reference may be needed to 'whole of catchment' objectives.*			
Level of impact	Individual facility			
Comment	• This is highly unlikely to be an issue if the facility is on private land.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	1	2	2	Low

Comments in Relation to Future Management

- Guidelines on the protection of environmentally-sensitive areas that are in proximity to aquaculture facilities could raise awareness of operators on this issue.
- This should not be an issue on the site itself, if it has been assessed adequately in the planning stages.

Table 76 Chemical therapeutants.

Description (Fletcher *et al*. 2004)	*Are chemical therapeutants used? If so, what protocols are needed? Reference may be needed to 'whole of industry' protocols.*			
Level of impact	Individual facility			
Comment	• Environmental implications of chemical and medicinal usage. • Data on type, amount, frequency and toxicity of any chemicals used is needed to complete this element. • Concentrations or any known or likely impacts must be contained within the lease areas (mixing zone).			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	2	3	6	Low

Comments in Relation to Future Management

- Further data - and refinement - is required.
- Techniques for isolated parasitic dosing should be developed.
- An aquaculture facility should have no impacts outside its license area (e.g. into waterways) – this is a condition of Department of Fisheries licensing.

Table 77 Entanglement interactions.

Description (Fletcher *et al*. 2004)	*Could the structures result in entanglement of large/protected species? Reference may be needed to 'whole of catchment' of industry protocols.*			
Level of impact	Individual facility			
Comment	• This is unlikely to be an issue.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	0	1	0	Negligible

Comments in Relation to Future Management

- Applicants should be advised to consider discussing their proposal with the Department of Environment and Conservation if birds are of concern.

Table 78 Decommissioning.

Description (Fletcher *et al*. 2004)	*Are processes in place to decommission the aquaculture site, should it no longer remain functional?*			
Level of impact	Individual facility			
Comment	• Bonds can be used to cover the cost of infrastructure removal. • The Department of Fisheries can remove infrastructure and charge proponent under the *Fish Resources Management Act 1994* and existing policies. • Most farms are located on leasehold or private land, so this is not so much of an issue.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	1	2	2	Low

Justification for Risk Ranking

Prawn farmers should consider a Rehabilitation Plan in the event that operations cease. Site rehabilitation must include restoration of the local topography, burying of pond sediments, revegetation of the site, closure of farm intakes and discharge channels, and restoration of any Crown Land used for access. Information along these lines should be given to proponents during the application phase

Conditions of all Aquaculture Licences require farmers operating on Crown Land to cover the cost of decommissioning. However, most of the land-based operations are located on freehold land or land held under a Pastoral Lease and this requirement will likely be dealt with under the Crown Lease.

Comments in Relation to Future Management

- Set-up protocols to cover cost of infrastructure removal.

Table 79 Security.

Description (Fletcher *et al*. 2004)	*Is there a need for security at the aquaculture facility to minimise stock losses?*			
Level of impact	Individual facility			
Comment	• This is a farm management issue and it is in the best interest of the operator to undertake this activity.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	2	1	2	Low

Comments in Relation to Future Management

- Sites should be monitored for unauthorized entry by their licensees, who would make changes to security as required.

5.3.2.3 Waste

This sub-branch refers to issues that arise from any waste products generated by the facility. Is the quality of the water used by the facility acceptable for release into the environment, is it freshwater or marine? The required limits on levels of waste products should relate to 'whole of industry' levels.

Table 80 Turbidity.

Description (Fletcher *et al*. 2004)	*Does the aquaculture operation result in turbid outputs to the environment? What ability does the facility have to minimise the level of turbidity?*			
Level of impact	Individual facility			
Comment	• This issue is specific to the particular site and its receiving waters and is dependant on discharge volumes of water and any treatments incorporated into it.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	3	3	9	Moderate

Justification for Risk Ranking

Monitoring of prawn pond effluent has shown that, irrespective of location, suspended solids are the main constituent and that most of this material (70 to 90 per cent) is inorganic. The main sources of this inorganic matter are the influent water and erosion of the pond floor and banks.

Farms that are located on major rivers frequently have high levels of suspended sediment (>100 mg/L) in their intake water. Sources of the suspended sediment include upstream soil erosion due to agriculture and other land-clearing activities. During the early part of the production cycle, farm ponds can act as sediment sinks, resulting in effluent with lower concentrations of suspended solids than in the influent. However, as the production season progresses, the action of pond aerators can cause sediment re-suspension and bank erosion. This can result in a net export of suspended solids when water is discharged from ponds (QEPA 2000).

Licensees will be required to undertake an Environmental Monitoring and Management Plan including various criteria for suspended solids. Depending on the readings, changes to aquaculture facility design may be required to lower amounts discharged (if the amounts of suspended solids are above acceptable thresholds).

Consequences will be site-specific at this present time due to the small industry and could be 'severe' ('3'). However the likelihood of this occurring is considered to be 'unlikely' ('3'), due to the management frameworks in place and the proposed monitoring programs.

Comments in Relation to Future Management

- The suspended solids in discharge waters should be monitored and compared to *State Water Quality Framework* for trigger values.

Table 81 Waste feed and faeces.

Description (Fletcher *et al*. 2004)	*What methods will be employed to minimise the level of waste feed and faeces being released into the environment through wastewater? Will the level require specific treatment?*
Level of impact	Individual facility
Comment	• Operators will be trying to minimise waste for economic reasons. • It is suggested that farmers maintain a feed register to determine feed rate against biomass. • The treatment of discharges should demonstrate how the farm has been designed to ensure minimal waste feed and faeces.

Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	2	2	4	Low

Justification for Risk Ranking

Prawns eat by grinding up their feed with mouth mandibles and, if their feed is of a pelletised form, some can be lost to the pond as detritus. In intensive prawn farming systems it is inevitable that residues of feed, faeces, organic matter and toxic inorganic nitrogen will be accumulated. Excretions released into the water become incorporated into the water chemistry, resulting in excessive levels of dissolved and particulate nitrogen and phosphorous. This can exacerbate algal and bacterial blooms and lead to unstable water chemistry, with subsequent stress on the prawns.

The ability to recapture waste nutrients varies considerably according to several factors, including effluent composition and the design and management of the settlement ponds. Research into prawn pond effluent treatment is at an early stage and the nutrient processes in settlement ponds are poorly understood.

However, field studies and tank trials have already demonstrated that effluent nutrients can be successfully recaptured using secondary cash crops such as seaweeds and bivalves. The Queensland Government is assessing the effectiveness of using constructed mangrove wetlands and finfish in settlement ponds to improve effluent water quality (QEPA 2000).

In parallel with the development and use of settlement ponds, efforts are now being made to develop pond production systems that can absorb high nutrient loading with minimal release of water from the ponds during the whole production system.

The proponent should be able to demonstrate how they intend to minimise the waste production and remove any solids prior to discharge. The consequences will be localised and are considered to be 'moderate' ('2'). This is a result of the zero discharge at present, but allows for growth over the next five years. The likelihood of these consequences happening should be 'rare' ('2') due to the adaptive management regime, where monitoring results will lead to changes in farm operation.

Comments in Relation to Future Management

- Feed rates should be monitored to minimise any overfeeding.
- An Environmental Monitoring and Management Plan should be undertaken to detect unacceptable levels of waste feeds in discharge waters.

Table 82 Salinity.

Description (Fletcher *et al*. 2004)	*Will the aquaculture facility result in an increase in salinity in the region? How will this be managed and/or minimised?*			
Level of impact	Individual facility			
Comment	• An understanding of prawn biology and requirements for survival should be demonstrated in the application. • The applicant/proponent will need to maintain and monitor the salinity of incoming and pond waters for suitability for prawns.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	1	1	1	Low

Justification for Risk Ranking

In the wild, juvenile and adult prawns seek higher salinities necessary for spawning and larval development, which may explain their reduced low-salinity tolerance at larger sizes. During normal farming practices, where prawns are grown from advanced post-larvae or juveniles through to sub-adults, they are tolerant of a wide range of salinities. Having said that, any rapid changes to salinity should be avoided, as it can exert osmotic stresses.

Consistently high salinities caused by dry-season evaporation cause prawns to increase the amount of energy used to control osmo-regulation and this can result in poor food conversion ratios and slower growth (QDPI&F 2006).

Water taken from bores and/or rivers will inevitably have varying salinity levels during the course of the year. This is a natural phenomenon and should be tolerated to a large degree due to the prawns ability to osmo-regulate its internal salt levels. The prawn farmer will need to monitor these levels to ensure they do not rise beyond the critical tolerance level of the prawns, before exchanging water in the ponds. The salinity levels in these discharge waters are unlikely to be much higher than ambient levels found in adjacent creeks.

It would be advisable to monitor the salinity levels in discharge waters as part of the overall facility Environmental Monitoring and Management Plan. Any cumulative impacts, due to multiple farms being located in a single river, could then be assessed.

The level of prawn farming in Western Australia is very small and the likelihood of multiple farms being situated in a single creek is considered 'remote' ('1'). Any consequences from current levels of farming are considered to be 'minor' ('1').

Comments in Relation to Future Management

- The salinity of incoming/outgoing and pond waters should be monitored, both from a water quality and prawn survival perspective.

Table 83 Pollutants (e.g. chemicals, dissolved oxygen, pH).

Description (Fletcher *et al*. 2004)	*What pollutants will be released from the aquaculture facility? Will they have any broader impacts on the region and how will these impacts be managed?*			
Level of impact	Individual facility			
Comment	• An aquaculture facility should be able to report on the amount of emissions released through discharge waters – this will be done through an Environmental Monitoring and Management Plan. • Many of the issues for the general environmental impacts will also relate to prawn health and require monitoring and action.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	1	1	1	Low

Justification for Risk Ranking

Aerators and other water movers play a vital role in the maintenance of desirable culture environments in large ponds. The use of these apparatus lowers the requirement to add chemicals, as well as to ensure suitable dissolved oxygen levels in discharge waters. Oxygen levels naturally fluctuate twice daily due to:

- algae producing oxygen through photosynthesis and consuming carbon dioxide during the day, which causes an increase in pH; and
- algae and all other organisms (such as bacteria, prawns, etc) consuming oxygen through respiration during the night and producing carbon dioxide, which causes a decrease in pH.

Black tiger prawns are known to respond to available feed more quickly if the dissolved oxygen levels are above 3.5 ppm. Although they are known to survive at lower levels, repeated lowered oxygen events than can occur in the early morning should be pre-empted and proactive management taken such as reduction in feed input and an increase in pond water exchange (QDPI&F 2006).

Low dissolved oxygen events can occur as a result of different weather conditions. Overcast weather can slow down the rate of photosynthesis during the day, which results in a lower overall dissolved oxygen level during the night. Warmer saline waters also have lower oxygen-holding capabilities.

Fundamentally, if the dissolved oxygen levels are maintained at a level suitable for the prawns, then it will likely be suitable for the broader environment, taking into account the natural variability found in creeks and the marine environment.

Some farmers add lime before and during crops, which is effective in:

- increasing pH (alkalinity) and hardness in the water column;
- guarding against extreme water pH fluctuations (acting as a buffer);
- improving the pH of pond sediments during dry-out periods to reduce disease in the next crop;
- flocculating suspended or soluble organic materials in the water column to improve light penetration;
- accelerating the decomposition of accumulated organic matter; and
- improving fertiliser response.

The liming agents applied generally are calcium and/or magnesium oxides or carbonates and vary between high to moderate solubility in fresh water. In seawater, there is a potential for insoluble coatings to form around lime particles due to the slow dissolving rate. These substances may therefore continue to be in solution within discharge waters if used in large enough amounts. In order to ensure correct amounts are applied, it is beneficial to have soil samples analysed for liming rates.

Farmers must monitoring the dissolved oxygen, nutrient and pH levels in waters being discharged from the facility. The consequences of having raised levels could be 'major' ('4') from the facility perspective but 'minor' ('1') at a regional level. The likelihood of consequences at a facility level could be 'severe' ('3') but at a regional level, 'minor' ('1'). The Environmental Monitoring and Management Plan will incorporate discharge criteria so as to minimise any likelihood of pollutants being released at unacceptable levels.

Comments in Relation to Future Management

- The Environmental Monitoring and Management Plan should be maintained and its results fed-back into ongoing management of the aquaculture facility.

Table 84 Disposal of unsaleable product.

Description (Fletcher *et al*. 2004)	*For any deaths of the cultured species, are there adequate facilities for their disposal at the aquaculture facility (e.g. in local dumps)?*			
Level of impact	Individual facility			
Comment	• Wide-scale deaths of prawns at an aquaculture facility may overload local waste disposal facilities in remote areas. • A worst-case scenario contingency plan should be arranged.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	1	2	2	Low

Comments in Relation to Future Management

- Guidelines on waste disposal are required from local government.

Table 85 Processing waste.

Description (Fletcher *et al*. 2004)	*Is there processing of product (particularly filleting, etc.) done on the aquaculture facility? Is there any disposal of this waste on site?*			
Level of impact	Individual facility			
Comment	• If an aquaculture facility was to undertake processing, it would require a separate Department of Fisheries licence to do this since prawn are a prescribed class of fish and processing is not covered under an Aquaculture License. • Local government and the Department of Health have roles in regulating health safety issues.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	1	3	3	Low

Comments in Relation to Future Management

- Guidelines on waste disposal planning are required.

- Current protocols and authorisations should be maintained. When the new *Food Act* is enacted, proponents should be advised of its requirements and obligations.

Table 86 Sewage.

Description (Fletcher *et al*. 2004)	*Does the aquaculture facility have appropriate sewage treatment?*			
Level of impact	Individual facility			
Comment	• This is unlikely to be an issue unless the facility is very large (i.e. has a large workforce). • Even if the facility is large, septic tank systems may be appropriate.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	0	2	0	Negligible

Comments in Relation to Future Management

- The current protocols for local government approval should be maintained.

Table 87 General rubbish.

Description (Fletcher *et al*. 2004)	*Are there protocols for the management of general rubbish within the aquaculture facility?*			
Level of impact	Individual facility			
Comment	• Good site management would suggest that the removal of rubbish is important for maintaining appropriate health and safety levels.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	1	4	4	Low

Justification for Risk Ranking

This waste stream is generally minor in its nature and is limited to office wastes and prawn feed packaging. Currently, the feed used in prawn farming is transported in paper or plastic bags. A reduction in the level of feed packaging will reduce the costs associated with the storage and disposal of this packaging.

It is probably unrealistic to expect a large reduction in this packaging, as the amount of feed used is linked to the amount of prawns being fed. As prawn farmers achieve better Feed Conversion Ratios the use of feed will be lower, but there is a lower limit.

Negotiations could be undertaken on a state-wide or industry-wide level to encourage manufacturers to use recyclable packaging.

Impacts are likely to remain on-site and be directly linked to the stocking levels. This figure will be dependant on each facility and the consequences may be 'minor' ('1') with a likelihood of 'possible' ('4').

Comments in Relation to Future Management

- A Code of Practice should suggest that the removal of rubbish is a general farm operational requirement.

Table 88 Biofouling on intake/outlets.

Description (Fletcher *et al*. 2004)	*Is biofouling removed from structures used in the aquaculture facility? If so, what happens to this material when it is cleaned off?*			
Level of impact	Individual facility			
Comment	• Use industry-wide protocols to manage this activity. • Farmers would not wish for the blockage of inlet/outlets pipes from an operational viewpoint. • There is a need to manage sedimentation and the deposition of land areas with excessive wastes.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	1	4	4	Low

Comments in Relation to Future Management

- A Code of Practice should be used to provide protocols for biofouling removal and waste disposal.

Table 89 Fuels and chemical storage.

Description (Fletcher *et al*. 2004)	*How are any fuels and chemical used in the aquaculture facility stored?*			
Level of impact	Individual facility			
Comment	• This is an occupational health and safety issue – fuels and chemicals should be stored in accordance with manufacturers' recommendations.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	3	1	3	Low

Comments in Relation to Future Management

- A Code of Practice should outline recommendations for fuel and chemical storage.

Table 90 Sludge disposal.

Description (Fletcher *et al*. 2004)	*Does the aquaculture operation result in the production of pond sludge? If so, how often and what amount is produced? How is this material disposed of?*			
Level of impact	Individual facility			
Comment	• Code of Practice to provide details.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	1	2	2	Low

Justification for Risk Ranking

Removal of pond sludge may be necessary if deposition has been excessive in a previous crop. A high organic load can tend to keep soils waterlogged and slow to dry out, as well as encourage the proliferation of harmful anaerobic bacteria during the next crop.

The decision to remove sludge should be based on the previous crop's performance, as well as the size of the mound. A small mound can easily be spread-out using tilling so that the soil can be oxidised, whereas a large mound (higher than 10cm with a diameter > 40m) needs to be

removed entirely from the pond surface. Sludge that has been removed and cured for a couple of seasons may be returned to the pond walls as topsoil to encourage grass growth and reduce erosion.

The accumulation of sludge which has been under water for four to six months can cause an imbalance of the beneficial microbial populations in the soil, change the soil chemistry and leave a nutrient load that will interact with pond water in the next crop. If a significant amount has built-up, it may affect the performance of internal slopes and spoon drains, affect water movement patterns and result in a wide area of sediment in the next crop.

Tilling the pond bottom exposes more surface area of the soil, increases the effect of oxidation and encourages more aerobic bacteria. Sunlight and dryness kill algal spores, benthic algal mats, fish eggs and any predators potentially remaining in the soil. The tilling process also assists in the breakdown of organic residues and nutrients that are locked up in the soil, making them more biologically available for the next crop.

Areas used to stockpile sludge should have the following properties:

- must be compacted sufficiently to minimise nutrients leaching into groundwater;
- methods must be used to prevent overland flow from entering and resulting in unacceptable levels of sediment/top soil erosion; and
- methods must be used to reduce erosion of the sediment from within the storage area and subsequent saltation of waterways.

Use of these techniques will lessen the amount of sludge produced each year, as will proper feed management lessen waste production in the first instance. Levels of production have been minimal to date, resulting in low levels of sludge production. Until the industry increases in size, the consequences of sludge production are considered to be ‘minor’ (‘1’) with the likelihood being ‘rare’ (‘2’)

Comments in Relation to Future Management

- A Code of Practice is needed to outline suggested methods for removal and disposal of sludge.
- Contact should be maintained with local government regarding location and methods for sludge disposal.

6.0 APPENDIX 1 – WORKSHOP PARTICIPANTS

Dr	Rick	Fletcher	Dept. of Fisheries - Facilitator	✓
Ms	Jo	McCrea	Dept. of Fisheries	✓
Ms	Fiona	vom Berg	Dept of Fisheries	✓
Dr	Fran	Stephens	Dept of Fisheries	✓
Dr	Sagiv	Kolkovski	Dept. of Fisheries	✓
Dr	Mervi	Kangas	Dept of Fisheries	✓
Dr	Brett	Glencross	Dept. of Fisheries	✓
Mr	Rob	Tregonning	Dept. of Fisheries	✓
Mr	John	Looby	Dept. of Fisheries	–
Ms	Tina	Thorne	Dept. of Fisheries	✓
Ms	Heather	Brayford	Dept. of Fisheries	–
Mr	Paul	Fitzpatrick	Dept of Fisheries	–
Mr	Tim	Nicholas	Dept of Fisheries	–
Ms	Lyn	Hobbs	Dept. of Fisheries	✓
Mr	Dexter	Davies	Aquaculture Development Council	–
Mr	Peter	Millington	Dept. of Fisheries	✓
Mr	Craig	Astbury	Dept. of Fisheries	–
Ms	Barbara	Sheridan	Dept. of Fisheries	✓
Mr	Justin	Bellanger	Dept of Fisheries	✓
Dr	Cameron	Sim	Dept of Environment and Conservation	–
Mr	Peter	Skitmore	Dept. of Environment and Conservation	✓
Mr	Peter	Ryan	Dept. of Water	–
Ms	Jade	Hankin	Dept. of Environment and Conservation	–
Ms	Emma	Glencross	Dept. of Environment and Conservation	✓
Dr	Chris	Simpson	Dept. of Environment and Conservation	✓
Dr	Nic	Dunlop	Conservation Council of WA	✓
Mr	Dan	Machin	Aquaculture Council of WA	✓
Mr	Greg	Jenkins	Challenger TAFE	✓
Mr	Peter	Fraser	Marine Produce Australia	–
Mr	Steven	Hood	MG Kailis Group	✓
Mr	Ian	Crimp	Kimberley Prawn Company	✓
Ms	Bronwyn	Harries	Cape Seafarms Pty Ltd	✓
Mr	Warwick	Michalk	Southern Cross Aquaculture	–
Dr	Greg	Maguire	Consultant	–
Mr	Ian	Yarroll	Qld Dept of Primary Industries & Fisheries	–

7.0 REFERENCES

Aquaculture Certification Council (2002) *"Guidelines for Best Aquaculture Practice Standards"*. Global Aquaculture Alliance.

Australian Seafood Industry Council (1997) *"An Environmental Framework for Coastal Aquaculture in Australia. Part 2 – Case Studies"*. Prepared by Pacific Seafood Management Consulting Group Pty Ltd with funding provided by the Commonwealth Department of the Environment, Sport and Territories. 146pp.

Black K. (2001) *"Environmental Impacts of Aquaculture"*. Sheffield Academic Press. 211pp.

Collins A., Russel B., Walls A. and Hoang T. (2005) *"Inland Prawn Farming. Studies into the Potential for Inland Marine Prawn farming in Queensland"*. Queensland Department of Primary Industries and Fisheries. 79pp.

Davidson A., McKinnon D., Moore K., Spagnol S. and Wolanski E. (2001) *"Quantifying and Predicting the Impact of Prawn Effluent on the Assimilative Capacity of Coastal Waterways"* and *"Pond and Effluent Management"*. Produced at the request of Fisheries Research and Development Corporation and Aquaculture CRC Limited. FRDC Project No. 97/212 & Aquaculture CRC Project No. E1. 87pp.

Department of Fisheries (2004) *"Draft Aquaculture Plan for Shark Bay"*. Fisheries Management Paper 171. Government of Western Australia. 130pp.

Department of Fisheries (2004) *"Draft Aquaculture Plan for Exmouth Gulf"*. Fisheries Management Paper 172. Government of Western Australia. 117pp.

Department of Water (2006) *"Water Quality Protection Notice"*. Government of Western Australia. 12pp.

Donovan D.J. (1999). *"Environmental Code of Practice for Australian Prawn Farmers"*. Prepared by the Australian Prawn Farmers Association with funding provided by the Environmental Protection Agency. 38pp.

Environmental Protection Authority (1998) *"Prawn Farm, Doctors Creek, Derby"*. Report and recommendations of the Environmental Protection Authority. Bulletin No. 918.

Fisheries Western Australia (1998) *" Kimberley Aquaculture Development Strategy"*. Prepared on behalf of the Kimberley Aquaculture Development Group. 46pp.

Fisheries Western Australia (1999) *"Proceedings of the WA Conference on Tropical Aquaculture in the Kimberley"*. Edited by C.L. Lee and D.C. Harvey. May 27-29, 1999, Broome WA. 175pp.

Fisheries Department of Western Australia (1996) *"Kimberley Aquaculture Development Plan"*. Prepared by S. Nel on behalf of the Fisheries Department of Western Australia and Kimberley Development Commission. 106pp.

Fisheries Department of Western Australia (1996) *"Gascoyne Aquaculture Development Plan"*. Prepared by N. Fowler on behalf of the Fisheries Department of Western Australia and Gascoyne Development Commission. 174pp.

Global Aquaculture Alliance (undated) *"Guiding Principles for Responsible Aquaculture"*. GAA website 29-9-2006. (http://www.gaalliance.org/prin.html)

Global Aquaculture Alliance (undated) *"Individual Codes of Practice"*. GAA website 26/9/2006. (http://www.gaalliance.org/code0.html)

Group of Experts on the Scientific Aspects of Marine Environmental Protection (1997) *"Towards safe and effective use of chemicals in coastal aquaculture"*. Food and Agriculture Organisation of the United Nations, Rome.

Jones B. and Stephens F. (2005) *"Aquatic Animal health Subprogram: development of a national translocation policy using abalone and prawns ads templates for other aquatic species"*. Funded by the Fisheries Research and Development Corporation, Project No. 2004/080. 90pp.

Jones B.J. (2003) *"Determination of the Disease Status of Western Australian Commercial Prawn Stocks"*. Funded by the Fisheries Research and Development Corporation, Project No. 98/212. 88pp.

Queensland Department of Primary Industries and Fisheries (2006) *"Australian Prawn Farming Manual. Health Management for Profit"*. 157pp.

Queensland Environmental Protection Agency (2000) *"Discussion Paper on Review of Queensland Marine Prawn Aquaculture Licensing under the Environmental Protection Act"*. Environmental Planning Division, Brisbane. 50pp.