FINFISH AQUACULTURE IN WESTERN AUSTRALIA:
FINAL ESD RISK ASSESSMENT REPORT FOR SEA-CAGE AND LAND-BASED FINFISH AQUACULTURE

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Finfish Aquaculture in Western Australia:
Final ESD Risk Assessment Report
for Sea-cage and Land-based
Finfish Aquaculture

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DISCLAIMER

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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 realised 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 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 (AFMF) and the National Aquaculture Council (NAC), the marine and land-based finfish aquaculture sector is the first to be run through this process.

1.1 Finfish Aquaculture in WA

Aquaculture in WA has steadily grown in both value and volume since 1998 with finfish worth $2.4 million in 2003/04, for which barramundi made up $1.9 million (302 tonnes). To put this into some perspective, the total WA aquaculture industry produced over 1,300 tonnes in 2003/04 with a value of around $6.8 million (excluding marine algae, edible oysters and pearls).

There were 146 Department of Fisheries licences in 2004/05 authorizing finfish aquaculture in WA. This was made up of:

- 134 land-based
- 8 sea-based
- 4 combination of land-based and sea-based

Of these, 24 are Mariculture Licences, which are located in coastal water and/or are large-scale land-based operations. They are classified as 'IDCA Licences', which were assessed by the now defunct Inter Departmental Committee on Aquaculture and reflect a more complex and in-depth consultation processes during their assessment. The 24 licences consist of the following:

- 12 land-based

- 8 sea-based
- 4 combination of land-based and sea-based

These licences authorize the aquaculture of:

- barramundi – 10 licences (2)
- Sparidae species (including pink snapper and black bream) - 10 licences (2)
- ornamental fish – 5 licences (1)
- silver perch – one licence (0)

(The figure in brackets represents those licences where aquaculture product is being generated.)

Other freehold land licences, of which there are 122, are made up of Non-Marron, Restricted Marron and Unrestricted Marron Licences. These Licences authorize the aquaculture of:

- barramundi – 36 licences (14)
- Sparidae species (including pink snapper & black bream) - 29 licences (1)
- ornamental fish – 34 licences (14)
- silver perch – 72 licences (10)
- rainbow trout – 49 licences (12)

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 a 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 amongst 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 marine and land-based finfish aquaculture industry on 5 April 2006 with the purpose of evaluating the perceived risks of finfish aquaculture rather than the documented risks, since there is very little information available on this aspect for Western Australia.

At the time of the workshop, the main fish species being farmed in either marine or land-based facilities were barramundi, silver perch, ornamental fish species, pink snapper, black bream and rainbow trout.

The risk assessment workshop used the National ESD reporting framework for aquaculture (Fletcher *et al.* 2004), often referred to as the "How to" Guide. This guide was developed to provide a framework that could be used across all aquaculture species in Australia for consistency.

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 the performance of management.

Throughout the workshop, the generic 'component trees' outlined in the guide were modified to produce trees specific to marine and land-based finfish 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 undertaken 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, representing industry, government and conservation interests. (Appendix 1)

A general introduction to the day's activities was presented along with a brief overview of finfish aquaculture in WA. Dr Fletcher provided an explanation of the risk assessment process to the participants. Two scenarios were used to assist participants to work through the various component trees:

Scenario 1: Kimberley endemic sea-cage finfish farm: 50 – 100 tonnes and 100 – 1,000 tonnes

Scenario 2: West coast non-endemic land-based finfish farm: <10 tonnes and >10 tonnes.

The generic component trees outlined in the framework were modified so that they were specific for the sea-cage finfish 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. This was repeated for land-based finfish aquaculture industry (Figures 4 - 6)

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, 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 an assessment was being made on the likelihood of that consequence occurring and *not* the likelihood of that particular 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.

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 indicators recommended for the measurement of management.

The summaries were sent back to the delegates at the workshop for further comments. The risk ranking have been re-assessed by the Department of Fisheries based on both the comments made during the workshop and the submissions made on this report. This report provides the agreed risk assessment position for each issue identified.

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 altered measurably and some function or components are locally missing/declining/increasing outside of historical range &/ 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 occur 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). Note that the risk level is calculated by multiplying the likelihood value by the consequence value.

		Consequence					
		Negligible	Minor	Moderate	Severe	Major	Catastrophic
Likelihood		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	Full performance report
Extreme	> 19	Likely additional management activities	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 that have been developed through the IMCRA and IBRA processes is convenient and provides an already established base.

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 - "Interim Biogeographical Regionalisation for Australia" or IBRA.

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*."

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

3.1 IMCRA Regionalization

The scale and extent to which different human activities affect either biodiversity and/or ecological processes, and the extent to which these human activities or impacts can be managed, determines both the scale and nature of management and monitoring required, and hence defines the framework for ecosystem management.

As such, biogeographical regions or 'bioregions' provide the boundaries and framework for biodiversity or conservation management and the integrated, multiple-use management of other specific human activities or uses, such as fisheries, mining and tourism. For WA, 17 meso-scale regions were identified, these being:

ABR	Abrolhos Islands	NIN	Ningaloo
CAB	Cambridge – Bonaparte	NWS	North West Shelf
CAN	Canning	OSS	Oceanic Shoals

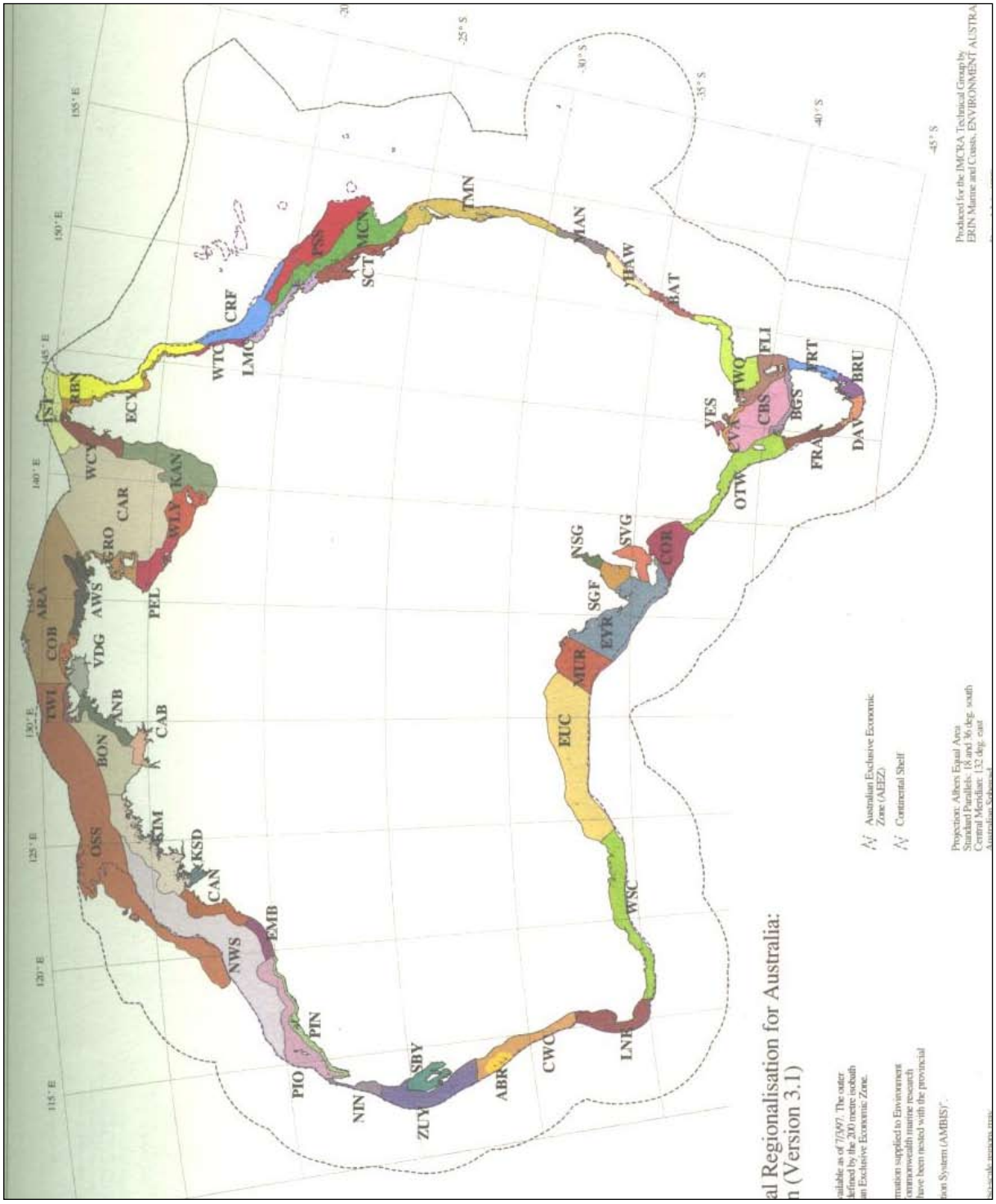
CWC	Central West Coast	PIN	Pilbara (nearshore)
EMB	Eighty Mile Beach	PIO	Pilbara (offshore)
EUC	Eucla	SBY	Shark Bay
KIM	Kimberley	WSC	WA South Coast
KSD	King Sound	ZUY	Zuytdorp
LNE	Leeuwin – Naturaliste		

IMCRA sets the scale of regions to between hundreds to thousands of kilometres. These are suitable for a regional perspective or level 2 assessments in this ESD process.

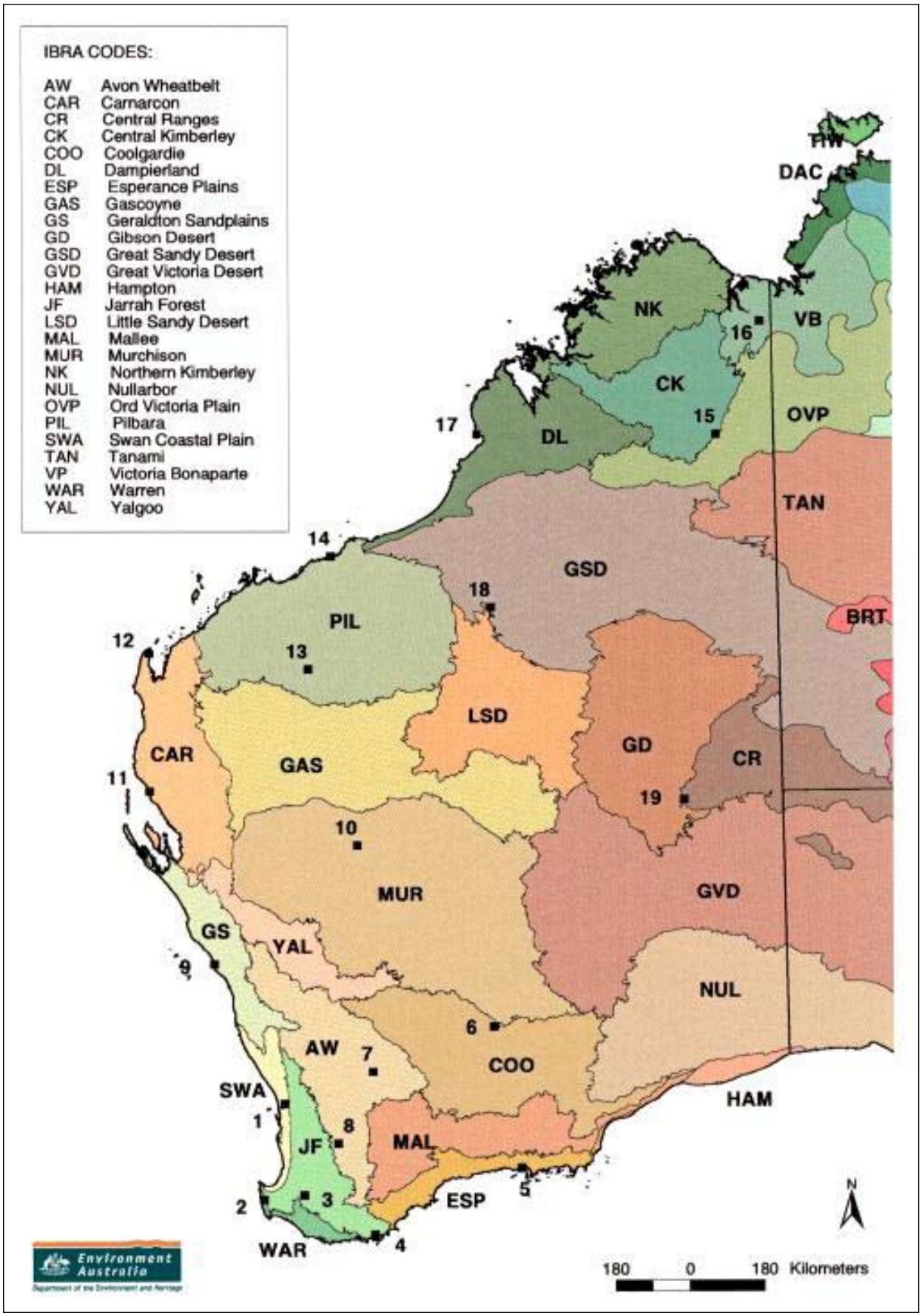
3.2 IBRA Regionalization

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. For WA, there are 26 bioregions identified, these being:

AW	Avon Wheatbelt	JF	Jarrah Forrest
CAR	Carnarvon	LSD	Little Sandy Desert
CR	Central Ranges	MAL	Mallee
CK	Central Kimberley	MUR	Murchison
COO	Coolgardie	NK	Northern Kimberley
DL	Dampierland	NUL	Nullarbor
ESP	Esperance Plains	OVP	Ord Victoria Plain
GAS	Gascoyne	PIL	Pilbara
GS	Geraldton Sandplains	SWA	Swan Coastal Plain
GD	Gibson Desert	TAN	Tanami
GSD	Great Sandy Desert	VP	Victoria Bonaparte
GVD	Great Victoria Plain	WAR	Warren
HAM	Hampton	YAL	Yalgoo



Interim Marine and Coastal Regionalization for Australia Version 3.3 (1998) – Meso-scale regions



Interim Biogeographical Regionalization for Australia (Version 5.1)

4.0 RESULTS – SEA-CAGE FINFISH

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

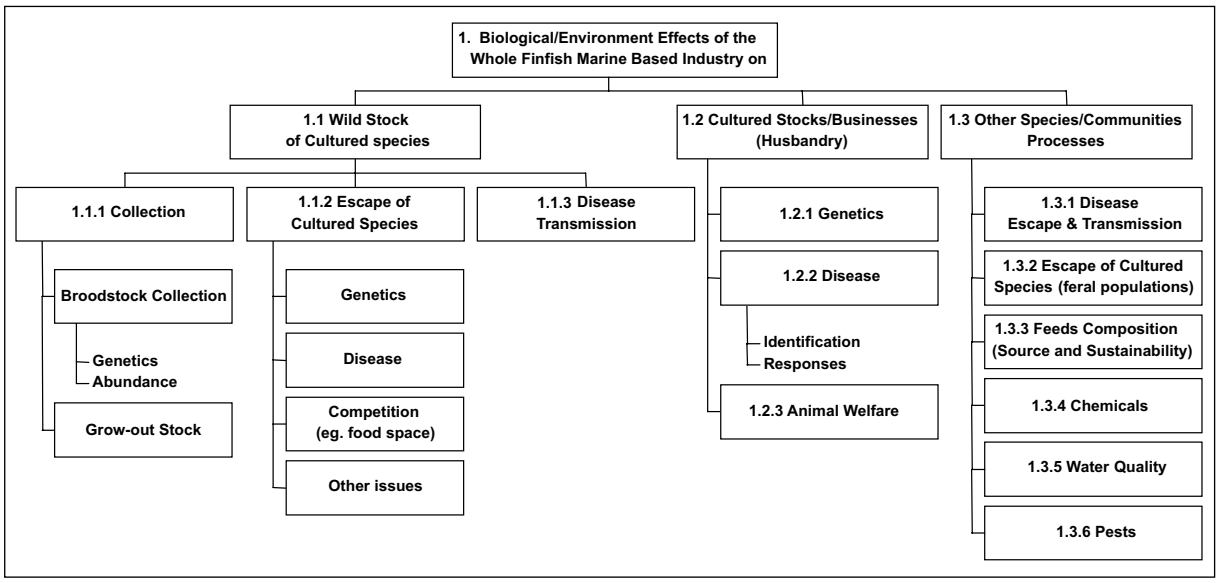


Figure 1 Component Tree 1 - Biological/Environmental Effects of the Whole Finfish Sea-cage Based Industry (modified from Fletcher *et al*. 2004)

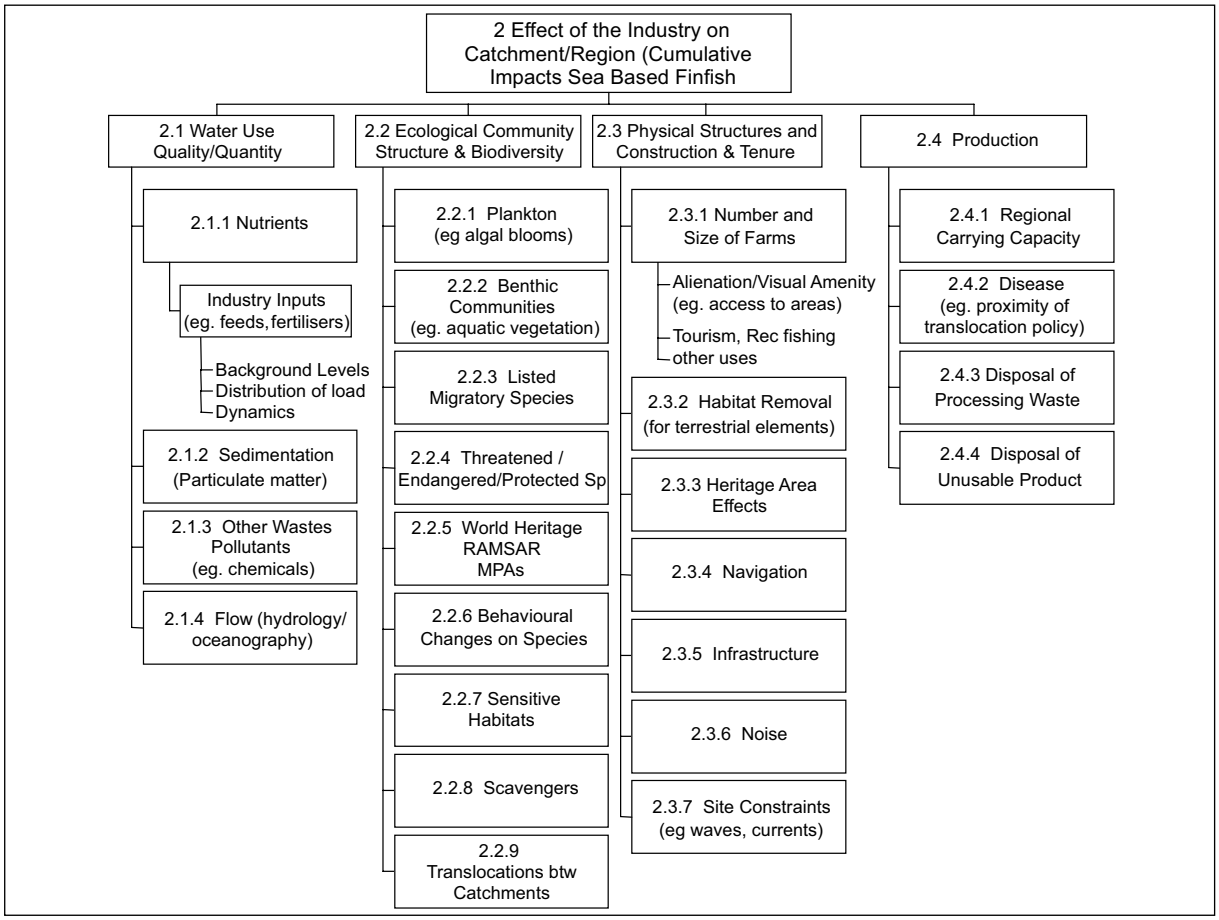


Figure 2 Component Tree 2 - Environmental Impacts of the Sea-cage Finfish Aquaculture Industry on the Catchment/Region (modified from Fletcher *et al.* 2004).

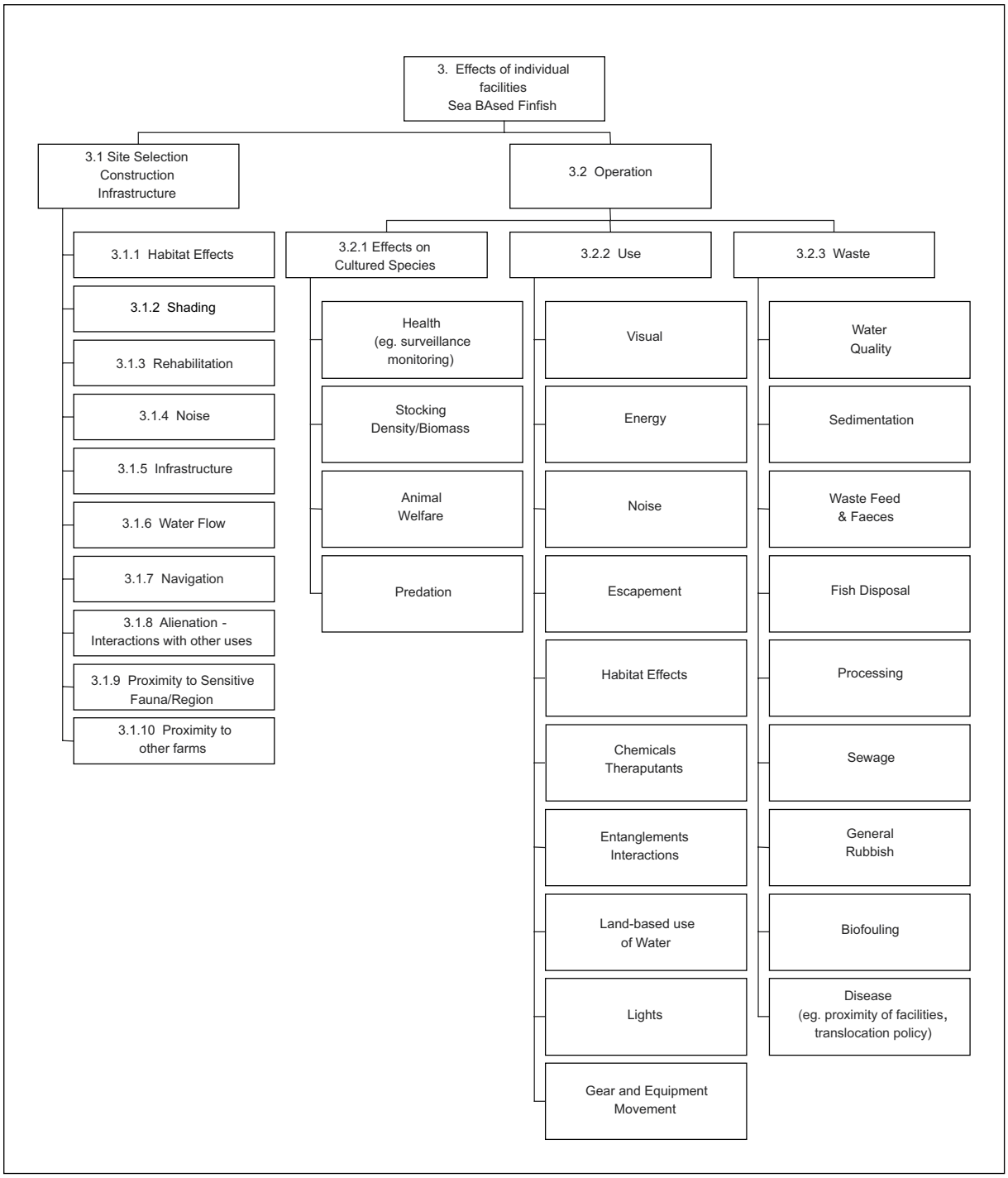


Figure 3 Component Tree 3 - Environmental Impacts of Individual Sea-cage Finfish Aquaculture Facilities (modified from Fletcher *et al*. 2004).

4.1 Summary of Issues & Risk Rankings

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 the collection of broodstock on spawning stock size (1.1.1)	1	2	1	2	Low
Effects of over-collection of broodstock (1.1.1)	1	3	2	6	Low
Minimise risk of genetic impacts on wild-stock (1.1.2)	1	2	2	4	Low
Effects of disease transmission to wild-stocks (1.1.2)	1	3	1	3	Low
Effects of increasing competition for food with wild-stock due to escapes of cultured stock (1.1.2)	1	1	3	3	Low
Effects of release of cultured individual on disease introductions to remnant stocks (1.1.3)	1	3	1	3	Low
Effects of genetically-modified cultured stocks (1.2.1)	1	3	1	3	Low
Effects of diseases on cultured stocks (1.2.2)	1	2	3	6	Low
Animal welfare issues (1.2.3)	1	1	3	3	Low
Effects of diseases from cultured stocks passing to wild-stocks (1.3.1)	1	3	3	9	Moderate (page 32)
Effects on environment due to the establishment of feral populations (1.3.2)	1	3	1	3	Low
Impacts on feed composition and their sustainability (1.3.3)	1	2	4	8	Moderate (page 35)
Effects of chemical use and use of protocols (1.3.4)	1	3	2	6	Low
Impacts of applying common standards for water quality (1.3.5)	1	1	2	2	Low
Effects of transportation of equipment (1.3.6)	1	2	4	8	Moderate (page 40)

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:

KSD	King Sound	ABR	Abrolhos Islands	LNE	Leeuwin – Naturaliste
SBY	Shark Bay	CWC	Central West Coast	WSC	WA South Coast

Issue	Comp Tree	Consequence						Likelihood						Risk ranking (regional)						Authors rankings
		KSD	SBY	ABR	CWC	LNE	WSC	KSD	SBY	ABR	CWC	LNE	WSC	KSD	SBY	ABR	CWC	LNE	WSC	
Effects on region due to release of nutrients (2.1.1)	2	0	2	2	1	1	2	1	2	2	1	1	1	1	4	4	1	1	2	Low
Impact of sedimentation across the regions caused by release of material (2.1.2)	2	1	0	0	1	0	0	1	1	1	1	1	1	1	0	0	1	0	0	Neg - Low
Effects of chemical use and release on region (2.1.3)	2	2	3	3	1	1	3	1	1	1	1	1	1	2	3	3	1	1	3	Low
Impact of facilities on water flow across region (2.1.4)	2	0	1	0	0	0	0	2	4	2	1	1	1	0	4	0	0	0	0	Neg - Low
Increased frequency/ intensity/ composition of plankton blooms (2.2.1)	2	0	3	2	0	1	2	1	4	2	1	4	2	0	12	4	0	4	4	Neg – Mod (page 51)
Changes to benthic communities due to sedimentation/ shading (2.2.2)	2	0	2	1	1	1	2	1	2	2	1	1	1	0	4	2	1	1	2	Neg - Low
Changes to migratory species in area (2.2.3)	2	4	4	3	3	3	4	4	4	4	3	3	2	16	16	12	9	9	8	Mod (page 54)
Interactions between threatened species and facilities (2.2.4)	2	0	2	1	1	1	3	1	4	3	3	4	3	0	8	3	3	4	9	Neg – Mod (page 56)
Effects of aquaculture on RAMSAR/MPA/ World Heritage Areas (2.2.5)	2	0	2	1	0	0	1	1	3	3	1	1	1	0	6	3	0	0	1	Neg - Low
Effects of aquaculture on individual species behaviour (2.2.6)	2	1	2	1	1	1	1	1	4	3	4	4	2	1	8	3	4	4	2	Low – Mod (page 61)

Issue	Comp Tree	Consequence						Likelihood						Risk ranking (regional)						Authors rankings
		KSD	SBY	ABR	CWC	LNE	WSC	KSD	SBY	ABR	CWC	LNE	WSC	KSD	SBY	ABR	CWC	LNE	WSC	
Effects on sensitive habitats by aquaculture (2.2.7)	2	1	3	3	2	1	3	3	4	4	2	1	2	3	12	12	4	1	6	Low – Mod (page 62)
Effects on level of scavenger abundance (2.2.8)	2	1	1	1	1	2	1	1	2	1	1	3	2	1	2	1	1	6	2	Low
Translocation policies for stock movements (2.2.9)	2	2	3	2	1	1	3	2	3	2	2	2	3	4	9	4	2	2	9	Low – Mod (page 66)
Total number and size of farms across region (2.3.1)	2	1	2	2	1	1	1	2	4	4	3	2	1	2	8	8	3	2	1	Low – Mod (page 68)
Impact on regional amount of native vegetation acceptably removed (2.3.2)	2	2	2	2	1	0	2	3	2	2	4	2	2	6	4	4	4	0	4	Low
Effects of aquaculture on heritage areas (2.3.3)	2	2	2	1	1	0	1	4	4	2	2	1	1	8	8	2	2	0	1	Neg – Mod (page 70)
Effects of aquaculture on navigational hazards (2.3.4)	2	1	1	1	1	1	1	1	2	1	2	1	2	1	2	1	2	1	2	Low
Constraints on aquaculture from current infrastructure levels (2.3.5)	2	1	2	2	1	1	2	4	2	3	2	1	3	4	4	6	2	1	6	Low
Effects on regional noise levels from aquaculture (2.3.6)	2	0	0	0	0	0	0	1	3	2	1	1	1	0	0	0	0	0	0	Negli-gible
Regional constraints to placement of aquaculture facilities (2.3.7)	2	2	3	2	1	1	3	4	4	3	3	2	4	8	12	6	3	2	12	Low – Mod (page 74)
Regional carrying capacity (2.4.1)	2	1	2	2	1	3	1	3	4	2	2	4	2	3	8	4	2	12	2	Low – Mod (page 75)
Regional effects due to disease transmission (2.4.2)	2	0	1	0	0	1	1	1	2	1	1	3	2	0	2	0	0	3	2	Neg - Low
Effects of processing product in water (2.4.3)	2	2	3	2	1	3	1	1	1	1	1	1	1	2	3	2	1	3	1	Low
Ability to dispose of unmarketable product in the region (2.4.4)	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Low

5.0 DISCUSSION – SEA-CAGE FINFISH AQUACULTURE

The only species being farmed in the marine environment currently in WA is barramundi, although more are authorized through various aquaculture licenses.

There are a number of general reviews on the environmental impacts of sea-cage finfish aquaculture and although these reviews draw upon experience from countries other than Australia, many of the issues discussed in these papers are relevant to Western Australian aquaculture.

For each issue, the comments and risk assessment values determined during the workshop are firstly summarised (Tables 5 - 77). It should be noted that the comments in these tables marked as 'During workshop' come directly from workshop participants (listed in Appendix 1). Other comments have been inserted after the workshop and are identified as such.

In the National ESD Framework aquaculture guide supplement (Fletcher *et al*. 2004) a brief description of the issue to be discussed is given and this description has been included in the summary of each issue. Everyone who was invited to attend the workshop was invited to comment on this workshop summary report.

Additional comments made, or alternative risk values given, have been reconsidered and, where relevant, incorporated by the Department of Fisheries in the summary table for each issue. This report sets out the agreed risk assessment values for each issue. These issues will be expanded upon in the Management 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 Collection

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

Table 5 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
Comments during workshop	• Access to commercial fisheries is not an issue. • Direct collection is carried out under 'exemption' – total numbers of individuals is limited to a small number (set by policy). • Compliance levels vary, depending on the issue. In the case of the Kimberley TAFE, the Department of Fisheries go and watch them take the stock. • There is no risk in catching broodstock, as proportion is so small. This should not be confused with illegal fishing. • Why do we have to pay $1,500 and it takes six weeks to assess risk if it is a low risk or no risk? • Same for scenario 1 and 2 (i.e. 100 tonnes and 1,000 tonnes).

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

Justification for Risk Ranking

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

A Ministerial Exemption for collecting broodstock is provided through Section 7 of the *Fish Resources Management Act* 1994. A draft policy statement was developed by the Department of Fisheries to set 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 method by which they are taken.

The number of individuals that may be taken for broodstock of marine finfish is determined on a case-by-case basis. Given the size of the WA aquaculture industry, the consequence of collecting broodstock is considered to be 'moderate' ('2') however the likelihood of this happening is 'remote' ('1'). As things stand, no additional management response is needed.

Comments in Relation to Future Management

- Maintain the current limits on broodstock collection.
- Finalise draft policy on *"Access to Broodstock and Hatchery production if Endemic and Non-endemic Species for Aquaculture Purposes"* (2005).

Table 6 Grow-out stock

Description (Fletcher *et al*. 2004)	*If the industry relies on collecting stock for grow out, are the protocols in place (or needed) to ensure stocks are not over harvested or unduly affecting other fisheries reliant on these species?*
Level of impact	Whole of the industry
Comments	• Would likely be dealing with southern bluefin tuna only, as all others are grown out from hatchery stock/broodstock. • Pink snapper should be prohibited from this sort of aquaculture since the wild stocks are in decline – due to commercial and recreational fishing pressures.

Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	3	2	6	Low

Justification for Risk Ranking

In WA, most fish are either grown out from hatchery stock or broodstock. South Australia is the only state currently growing out wild-caught southern bluefin tuna and, with the quota system in place for this species, grow-out is unlikely to occur in WA within the next five years.

There are issues regarding the stocks of this species in the wild. The Australian government is a member of the Convention for the Conservation of Southern Bluefin Tuna (CCSBT) and participates in discussions setting quotas to CCSBT member nations. Whether this quota will be lowered from its current level in future years is unclear.

Pink snapper could be a species suitable for grow-out, however given existing commercial and recreational fishing pressure, the Department of Fisheries is not considering authorizing its grow-out for aquaculture purposes. The Department is committed to implementing the principles of Integrated Fisheries Management (IFM). This process requires that all sectors be part of the considerations towards determining catch quotas for the species as a whole.

As mentioned for the previous issue, the Department of Fisheries operates a system whereby aquaculture farmers can apply to collect broodstock via a Ministerial Exemption. Numbers of individuals that can be collected are outlined in this policy.

A consequence ranking of ‘severe’ (‘3’) has been selected if considering a grow-out of pink snapper under the current circumstances. In future, it would need to be demonstrated that the stock levels of any species considered to be suitable for the grow-out of wild-caught stock could sustain this activity, i.e. be in line with the principles of IFM. Authorization to grow out wild-caught species is not being considered currently by the Department of Fisheries, however this may change in future years - hence, the likelihood rating of ‘rare’ (‘2’) at this point in time.

Comments in Relation to Future Management

- Limits on collection in line with the IFM level set across sectors.
- Consider the need to apply restrictions on granting of exemptions if collecting certain species for grow-out – e.g. southern bluefin tuna, pink snapper.
- Anyone interested in the collection of southern bluefin tuna stocks for grow-out would need to demonstrate they have bought quota in the wild-caught fishery.
- Maintain current policy regarding Ministerial Exemptions for aquaculture broodstock collection.

5.1.1.2 Escape of cultured species

This 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 what are the possibilities of escapes actually occurring?

Table 7 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 wild-stock population from the escape of any cultured individuals?*
Level of impact	Whole of the industry
Comments during workshop	• In next five years, only first generations will be grown (F1). Translocation policy operates for all movement of fingerlings. Can barramundi be sourced from any stock across northern Australia, as stocks are considered by some to be one genetic stock? Exception may be the stock from Exmouth. Broodstock for the Kimberley being sourced from Exmouth is unlikely. There could be a higher risk of barramundi moving from Exmouth south. • It is very likely that fish will escape – but the issue is what will be the effect on the genetics of the wild stock? • It is still not known what the threshold is, i.e. what numbers of 'outsider' fish in a population will lead to genetic change. • This isn't going to happen in the next five years. • If escapes occur, this is considered a 'minor' to 'moderate' consequence, but only a 'remote' risk.

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

Justification for Risk Ranking

Under an Aquaculture Licence, conditions require the Department of Fisheries to be notified of any large fish escapes within 24-hours. Other conditions require:

- the net to be of a certain mesh size and quality to provide a complete barrier in order to retain 100 per cent of fish stocked;
- the mesh to be of a specified size depending on the size of the fish to be contained; and
- the mesh does not contain holes or openings greater than 1.5 times the size of the mesh.

These conditions are not applied to all sea-cage finfish aquaculture, but the Department of Fisheries is currently reviewing all licence condition on a species-by-species basis. Once this review is complete, there will be a consistent approach to the application of conditions such as these.

The size of the WA finfish aquaculture industry is relatively small, with most farm stock purchased from approved hatcheries from wild-caught broodstock. Some operators still purchase fingerlings from South Australia or the Northern Territory, increasing the risk of escapees intermixing with wild stocks and resulting in changes to genetic strains.

There is an opportunity for WA to develop a larger barramundi hatchery industry to minimise risks due to importation of genetically-different stock.

The Department of Fisheries developed the *"Emergency/Incident Management Plan"* in July 2002, which 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. It includes 'fish kills', disease outbreaks, feral pest incursions, pollution, algal blooms and other emergencies.

In addition to this, future legislative changes leading to the enacting of the *Biosecurity and Agricultural Management Act 2007* will provide more stringent controls on the importation of certain fish species. It provides the impetus for the Department to encourage the production of WA hatchery-based fish for more finfish species.

The consequence value has been set at 'moderate' ('2') in light of the current application of licence conditions and level of importation of interstate stocks. The likelihood of any changes occurring to the genetic structure of wild stocks is considered to be 'rare' ('2') due to the current size of the industry in WA and the plans in place to respond to any fish escape events.

Comments in Relation to Future Management

- Maintain the current protocols
- Currently there is no plan in WA if an escape occurred, such as that which took place in the Northern Territory recently.
- Recognise that Exmouth Gulf is a special case and set the management response accordingly.
- Need to develop protocols for movement of species between regions and how to deal with any escapes that may occur - across the whole industry.
- *Biosecurity and Agricultural Management Act 2007* will impact on management of this issue.

Table 8 Escape of cultured species causing disease in wild-stock

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			
Comments	• It would be in best interest of industry to develop protocols. • There has not been a need to date to deal with disease outbreaks – would not envisage an incident over next five years, since farms are small and stock are not held in high densities. • Some barramundi fingerlings are sourced from South Australia, which could bring in disease – but all imports require certification. • Farm management practices should attempt to minimise any disease outbreaks and escapes.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	3	1	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 disease are endemic or exotic. In addition, Australia has international obligations, including reporting to the global organisation for animal health *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).

Mainly due to its isolation, Australia has maintained freedom from imported, infectious diseases. The surveillance and reporting program focuses on the fact that Australia will increasingly be called upon to substantiate freedom from major diseases in order to support export certification and quarantine import policy.

In regards to legislative tools, the *Fish Resources Management Regulations* (FRMR) 1995 (Regulation 69) requires all aquaculture operators notify the Department of Fisheries within 24 hours of becoming aware, or suspecting, that any fish at the place where aquaculture is carried out may be affected by diseases as specified. This allows for the treatment or euthanizing of infected stock to minimize any further spread of the disease to wild-stock.

The Australian Pesticides and Veterinary Medicines Authority (APVMA) has regulatory responsibility for veterinary medicine use in Australia, including the registration of vaccines, under the *Agricultural and Veterinary Chemicals Code Act 1994*. Chemicals registered suitable for aquaculture purposes are limited, which means that should any disease outbreak occur, it would take time to respond. As a result, the consequence value is considered to be 'severe' ('3'), since time to identify the disease and gain approval could be significant. The likelihood of this occurring however is 'remote' ('1'), since stocking levels are low, importation of fingerlings requires health certification and any translocation must be approved.

Comments in Relation to Future Management

- Require regular testing of industry for disease occurrence (audit or part of EMMP)
- Require appropriate structures to minimise escape possibility.
- *Biosecurity and Agricultural Management Act* will deal with this issue.

Table 9 Escape of cultured species increasing competition with wild-stock

Description (Fletcher *et al*. 2004)	*Would the escape of cultured animals cause problems to the wild-stock due to increased competition for resources (this could be food, shelter, space, etc)?*			
Level of impact	Whole of the industry			
Comments	• Do not know the impacts. It is possible that escapees will have an impact on the food chain. • Industry needs to continue to minimise the chance of escape, particularly at levels that might impact on the food chain. • The level of aquaculture over next five years is likely to remain small. • Species that escape will have different consequences on wild stocks, as will the location of the farm. • The issue requires research and management. • An increase in certain cultured stocks may be a benefit to the equivalent wild stocks, as numbers have been low in certain species. • Utilization of appropriate cage structures are a suitable management tool. • Ability of escapees to survive may be low, as cultured stock are 'domesticated' on pellet food and may be unable to hunt and catch wild prey. • Research undertaken in South Australia shows that escaped yellowtail kingfish have a low risk in regards to impacting on wild stocks.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	1	3	3	Low

Justification for Risk Ranking

Studies on the interactions between wild and cultured fish have been carried out on salmon populations in the northern hemisphere. In the north-east Atlantic, gut analyses were performed on salmon and it was found that there was no difference in condition, number and weight proportions of prey in the diet of wild and escaped cultured salmon.

This suggested that an increase in the numbers of escaped salmon may result in increased competition for food for the wild stock in that region. Previous overfishing of wild stocks may be offset by this increased competition, so food availability for the wild stock may still be high, depending on whether total population size is low or high, compared to original stock levels (De Jong and Tanner 2004).

Direct comparisons between the two hemispheres are difficult to make, due to differing husbandry practices. In the northern hemisphere, several generations of Atlantic salmon are bred and cultured, whereas in Australia, for all native sea-cage finfish species, only the first generation is cultured and therefore no artificial selection is occurring nor is there any use of genetically modified organisms (GMOs).

There would be little risk of 'genetically superior' escaped fish that are better at competing for resources than the wild stock. Given this, competition would only be a concern if behavioural differences between wild and cultured fish lead to a cultured stock that competed with the wild stock.

Given the apparently poor feeding ability of escaped fish, it is considered that the current consequence of escapees for competition on the wild stock is likely to be 'minor' ('1'), and that over the next five years might be 'moderate' ('2') rather than 'severe'.

If the absolute number of escapees increases substantially, then a 'severe' ('3') ranking would be appropriate. The likelihood of a minor consequence would be 'unlikely' ('3'), resulting in a risk value of '3'.

Comments in Relation to Future Management

- Minimise any escapes by agreed farm management protocols.
- If escapes do occur, measure any impacts on commercial species catch levels within their home range.
- Maintain regulation that industry must notify the Department of Fisheries when a fish escape occurs.
- *Biosecurity and Agricultural Management Act 2007* may deal with this issue.

5.1.1.3 Disease transmission

Table 10 Disease transmission to wildstocks

Description (Fletcher *et al*. 2004)	*Will the release of cultured individuals increase the risk of disease introduction to the remnant stock?*
Level of impact	Whole of the industry
Comments during workshop	• Disease certification is required for translocation of fingerlings, etc, to minimize risk if any of them should escape during transport. • When comparing captured individuals and wildstock, they appear to have similar disease profiles. • Captured species can be vaccinated to reduce risk. This is written up in the current FRDC draft report - Brian Jones *et al*; 'Maintaining and quarantining barramundi stocks to prevent the spread of *Streptoccocus iniae*'. • National disease status protocols are in place. • Requirement that aquaculture operators report any large numbers of fish killed should reduce risk to wild-stock. • There is a difference when dealing with pests and parasites (see section 5.1.3). • It is uncommon for disease to occur this way, i.e. to move from captured fish to wild-stock. There is one possible example of this in Scandinavia (but not proven). • If there was an impact it may be severe, but there was a remote 'likelihood' of this happening.

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

Justification for Risk Ranking

There have been no documented cases of the direct transfer of native or exotic diseases from sea-cage cultured fish to wild stock in Australia. However, that is not to say there have been no disease issues, more that research has yet to be undertaken into this issue.

Throughout the rest of the world, there have been incidents where exotic diseases have been introduced to wild fish from translocated farmed fish, which have had serious consequences for local fish populations. In contrast, there have been no documented cases of direct disease transfer from farmed fish to wild fish of pathogens that are native to the region.

Indirect correlations suggest that there is a link between the increase of the incidence of disease in wild stock and the occurrence of aquaculture, but correlations of this type do not provide evidence of a causal link. The difficulty of identifying direct pathogen transfer between the cultured stock and wild-stock is a consequence of the difficulty in determining the origin of the pathogen in wild stock and determining whether any links with disease in cultured fish exist (De Jong and Tanner 2005).

The introduction of exotic diseases into areas where animals may not have an innate immune response is a major concern. There have been wild fish 'kills' or declines in other parts of the world due to exotic diseases and parasites, which are thought to be introduced from cultured fish that have been translocated. The introduction of the monogenean parasite, *Gyrodactylus salaris*, was most likely from the import of animals for culture and has had a major impact on the wild salmon stocks in Norway resulting in a dramatic decline in numbers.

Similarly, infectious hematopoietic necrosis (IHN), a salmonid viral pathogen, was introduced to Japan from infected sockeye salmon eggs that were imported from Alaska and caused significant

mortalities in three species of salmon (De Jong and Tanner 2005). There are restrictions and regulations in place that limit the import and translocation of fish in and around WA, thereby reducing the risk of exotic disease introductions.

Department of Fisheries policy prohibits the intentional release of fish and any accidental escapes are managed through the *Emergency / Incident Management Plan.* Since these protocols are in place, it is considered that consequence values could be 'severe' ('3') however the likelihood of this occurring at present levels of production is 'remote' ('1').

Comments in Relation to Future Management

- Disease certification should be required for importation or translocation of fingerlings, etc.
- Current protocols and response procedures should be maintained.

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 11 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			
Comments	• Unlikely that the use of GMOs will be considered. • Adequate levels of broodstock taken from wild stocks could be used to negate requirement for use of GMO. • There is no need to provide reasons for disease management – better options are to minimise disease outbreaks in the first place. • Information from overseas would suggest that use of GMO salmon still has unknown consequences, both for food safety and escapee introductions to wild stocks.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	3	1	3	Low

Justification for Risk Ranking

The Australian government 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. It does this 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).

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 (Ward 2002).

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 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 traits desired by consumers. Selection programs work with existing genetic variation, selecting those combinations that give improved results. Hence the wild population will have the same genetic variation.

In Australia, for all native marine finfish species, there is no artificial selection occurring, nor is there any use of genetically-modified organisms (GMOs) at this point in time.

For many aquaculture operations, full physical containment of farmed stock is often difficult and there may be some escapes. When WA is considered, the likelihood of escapes may be 'rare'. The consequences of a native NGAO or GIO escaping are likely to be 'low' to 'negligible', in regard to effects on the existing wild gene-pool or environmental impacts.

For GMOs with similar likelihood of escapes, consequences are unknown but precautionary principles would suggest they might be considered as 'severe' ('3'), giving an overall inherent risk as 'moderate'. There has been preliminary discussion held regarding the use of GMOs within the WA aquaculture industry and this 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

- Prohibit the use of GMOs in the light of the current gap in research and knowledge of impacts.
- Maintain protocols.
- Consider research into the consequences of escapes if policy position changes.

5.1.2.2 Disease

Table 12 Disease monitoring of 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 severe disease event)?*			
Level of impact	Whole of the industry			
Comments	• There are no sector-wide programs operating to ensure any disease outbreaks are identified and monitored – to date this has not been necessary due to the size of industry. • Should ensure that disease outbreaks are identified as soon as possible to minimise the need for broad-scale use of chemicals. • Farm species in waters according to their biology – the culture of temperate fish within temperate waters is one way of minimizing chemical use.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	2	3	6	Low

Justification for Risk Ranking

In Western Australia there is no industry-wide disease monitoring program, but any importation or translocation of fingerlings does require health certification. The Department of Fisheries has a fish pathology unit that deals with any disease outbreaks or research into fish diseases.

The FRMR requires that all aquaculture operators notify the Department of Fisheries as soon as they are aware that disease may be affecting stock. At present, this is the only mechanism for detecting and reporting disease outbreaks. There are no sector-wide surveillance programs applied by the Department and, due to this lack of any consistent protocol, a slightly higher risk value would be expected. The Department does have an Emergency Response Plan that operates effectively.

The consequence of not having a surveillance program could be 'moderate' ('2') if the industry were to grow at its current rate over the next five years. The likelihood of continuing to have no surveillance program is 'unlikely' ('3') once the Code of Practice is finalised.

Comments in Relation to Future Management

- Develop protocols and implement through an industry-wide Code of Practice.
- Require certifications for any translocations (i.e. hatchery to grow-out).
- Continue to operate Emergency/Incident Response Plan.

5.1.2.3 Animal welfare

Table 13 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			
Comments	• Species are generally held at a stocking density that minimises stress to the animals, but optimises economic return. • Industry needs to operate in line with the *Animal Welfare Act.* • Current low stocking rates will help to avoid any risk. • Need to ensure any issues with site decommissioning are dealt with through licence conditions.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	1	3	3	Low

Justification for Risk Ranking

In WA, 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.

Through the FRMA (sections 191A & 258), fisheries officers can exercise powers as a general inspector conferred by the *Animal Welfare Act 2002.* New guidance was provided through the Code of Practice for Aquaculture developed by the Aquaculture Council of Western Australia.

There are moves at an international level to ensure any slaughtering of aquaculture products is done in the quickest and most humane way. Australia is providing comment into these international level discussions and WA will be obligated to implement any outcomes adopted.

The consequences of not having a protocol are 'minor' ('1') as management is still provided through other mechanisms, albeit not sector specific. The likelihood of not having a protocol is 'unlikely' (3).

Comments in Relation to Future Management

- Ensure operators are aware of their obligations under the Animal Welfare Act.
- It is in best interests of an aquaculture operator to minimize stress on farm stock, as this impacts on value of their product.

5.1.3 Other species/communities processes

5.1.3.1 Disease escape and transmission

Table 14 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
Comments	• There is debate as to the transfer of disease from wild to farm stock. • It is possible, but industry is small enough to make any likelihood of disease transmission negligible at present. • Farming of local stocks may increase any risk of disease transferral. • South Australia is undertaking research on the parasite ecology of escaped yellowtail kingfish and potential parasite transmission between escapees and wild stock. A review of risk should be undertaken once the results are received. • There is a need to distinguish between pests and parasites. • Do fish have to escape to pass on disease, since the cultured stock is still interacting with other species while in the cage? Still unknown.

Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	3	3	9	Moderate

Overview of Disease in Sea-cage Aquaculture of Finfish

When large numbers of fish are confined to a relatively small area, as occurs in sea-cage farming, factors such as overcrowding, increased stress and reduced water quality can produce conditions suitable for the spread of disease and parasites in the cultured fish. It is possible for the wild stock and other species of fish to interact with the cultured stock, either through the sea-cages or when fish escape, and this could potentially lead to the transfer of disease between them.

The transmission of disease from cultured stock to wild stock and/or to other species could have potentially significant consequences. To date, there have been no investigations into disease transmission between wild and cultured fish in Australia.

A great deal of research has been conducted in the northern hemisphere and, although there is much debate in the literature, there is insufficient evidence to conclude whether or not observed increases in disease in the wild stocks are due to disease transfer from escaped cultured fish (De Jong & Tanner 2005).

There are numerous groups of disease-causing organisms found in farmed fish worldwide. There are very few pathogens identified for yellowtail kingfish in Australia. A lot more information is known about the salmonid pathogens in Australia, as these species have been cultured for several decades in Tasmania.

Several more pathogens have been identified throughout the world, especially in Japan where close relatives of the yellowtail kingfish are cultured, and in countries such as Canada and Norway, where Atlantic salmon are cultured. To date, there is no documented evidence that these pathogens have been transmitted to, or spread by cultured fish to wild fish, or have caused an increase in disease in wild fish.

Diseases could potentially be transmitted to other animals by escaped fish, either through direct interaction with the cultured fish in the sea-cages, or indirectly through the water column. Disease transmission may occur between the cultured stock and either the wild stock of that species or other species in the environment. In this section, disease will be taken to include parasites.

Justification for Risk Ranking

Throughout the rest of the world, there have been incidents where exotic diseases have been introduced to wild fish from translocated farmed fish, which have resulted in serious consequences for local fish populations. In contrast, there have been no documented cases of direct disease transfer from farmed fish to wild fish of pathogens that are native to the region.

Indirect correlations suggest that there is a link between the increase of the incidence of disease in wild-stock and the occurrence of aquaculture, but correlations of this type do not provide evidence of a causal link (De Jong and Tanner 2004). The difficulty of identifying direct pathogen transfer between the cultured stock and wild-stock stems from the difficulty in determining the origin of the pathogen in wild-stock and establishing any links with disease in cultured fish.

For pathogens already present in an area, there is no definitive evidence that marine aquaculture has caused an increase of those diseases that are "native" in the wild-stocks. Several studies in the northern hemisphere have correlated high sea lice infection rates in wild-stock with areas of intense aquaculture.

For example, Norwegian researchers found that a population of Arctic char and sea trout, in an area where aquaculture of the closely-related Atlantic salmon occurs, had higher salmon lice infestations compared to populations that were located in an aquaculture-free area. However, this type of correlative relationship does not take into account that disease or parasite 'load' can be dependant on the local environmental conditions and therefore does not provide evidence of causal linkage between aquaculture and disease prevalence in wild fish.

Another study used a more appropriate method by comparing parasite 'loads' in the wild fish in the same area during times of fallowing and times of aquaculture production. They found a weak relationship between lice abundance on wild salmonids and the stage of production of fish farms.

Infestations of sea lice in the wild fish were higher during periods of farming compared to the fallowing period. However, there was no statistically-significant correlation between the lice abundance on the wild and farmed fish, indicating that other factors may have a greater influence on lice abundance.

Several models have been developed to estimate and quantify the parasite populations in cultured and wild fish. However, they do not estimate or infer anything about transmission between the two stocks.

The difficulty with developing such a model stems from the large number of variables that influence transmission and a lack of accurate data. These variables include wild and cultured host ecology, parasite infection dynamics, larvae, hydrodynamics, temperature and salinity.

The behaviour of escaped fish could potentially play an important role in the transmission of disease to wild-stock. There is very little known about the behaviour of escaped fish, except that yellowtail kingfish escapees often stay close to farms for several days, which enables the recapture of many of them. It is not known whether escaped fish form self-sustaining populations or integrate with wild schools, thereby increasing the chances of disease transfer.

A PhD student from the University of Adelaide is currently researching parasite transmission between wild and cultured yellowtail kingfish in South Australia. The transmission of other diseases between the wild and cultured stocks needs further research, as does the behaviour and ecology of the escaped fish.

Given the contentious nature of this issue in the northern hemisphere, where it is possible that the salmon aquaculture industry is having detrimental effects on wild salmon stocks due to disease, the moderate risk ranking is based on an 'unlikely' ('3') likelihood but 'severe' ('3') consequence.

However, it should be realised that any effect of aquaculture is just one of a long list of possible causes for the decline of wild salmon stocks in the northern hemisphere, and the negative effects of aquaculture probably occur because stocks are already stressed from other forms of disturbance and pollution.

The 'moderate' risk ranking reflects the fact that we simply do not know, and it is entirely possible that aquaculture has little if any effect. Under current policies, the risk of introducing new diseases is probably 'low', but it is essential that current practises relating to import and translocation of stock continue, otherwise this ranking could increase.

Comments in Relation to Future Management

- Maintain the protocol regarding translocation of stocks between regions.
- Require that suitable farm management practices be used.
- Develop a monitoring program to allow for detection of any disease outbreaks – links to within facility operations.

5.1.3.2 Escape of cultured species (feral populations)

Table 15 Establishment of feral populations

Description (Fletcher *et al*. 2004)	*If the species/population being cultured is not native to the country or even the region (i.e. outside their natural range), could they establish feral populations if they escaped?*			
Level of impact	Whole of the industry			
Comments	• Currently any aquaculture of exotic species in marine waters is not being approved – require the use of contained land-based sites for exotics. • This may be an issue if farming endemic stocks but outside of their genetic range. Impacts are unknown.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	3	1	3	Low

Justification for Risk Ranking

The Department of Fisheries has a policy which prohibits sea-cage aquaculture of non-native marine finfish and states this must be undertaken within a closed, land-based system. This policy is designed to minimise any likely introduction through escapes, of exotic species into the WA marine environment. The engineering requirements, containment and water filtering

protocols required for land-based aquaculture facilities for these species, are designed to limit the possibility of any larvae or fingerlings escaping.

In light of this current policy, the consequence would still be 'severe' ('3') however the likelihood of any non-native species getting out into the marine environment would be 'remote' (1).

Comments in Relation to Future Management

- Maintain the current restrictions and protocols.
- Continue to allow only endemic species to be farmed in open sea-cages.

5.1.3.3 Feeds composition (source and sustainability)

Table 16 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			
Comments	• Some species use fishmeal 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 required into replacing fishmeal (and fish oil). • Consider whether we want to produce fishmeal in WA or get it from other states such as South Australia? 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 sellers of fishmeal do not like to supply smaller operators. They prefer to supply larger amounts to the bigger industries. • Since the feed is imported, there are likely to be issues when the new *Biosecurity and Agriculture Management Act* comes into play. • There may be a public health issue - testing should be carried out on imported pellets to monitor toxin levels in the fishmeal used. • The use of feeds with added chemicals should be considered – what are the impacts on the broader environment?			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	2	4	8	Moderate

Justification for Risk Ranking

Currently sea-cage finfish aquaculture (except for tuna) uses mainly pelletized feed, which consists predominantly of fishmeal and fish oil that are obtained from overseas baitfish from wild capture fisheries. Some farmers also use baitfish on occasion for aquaculture feed.

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 3.16 kilograms of baitfish used, only 1kg of Atlantic salmon is produced.

These feed conversion ratios are improving, but a lot is dependent on specific farm management practices. 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, overexploited or depleted and, if aquaculture keeps expanding, 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. Increased demand for product from these fisheries could lead to further problems with overfishing (De Jong and Tanner 2004).

Baitfish are primarily small pelagic fish and the main wild capture species of them that are 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 world 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, overfishing of sand eel, 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 upwelling 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, short-beaked common dolphins and Indo-Pacific dolphins.

The amount of baitfish captured varies greatly from year-to-year and there is some evidence that the global catch is declining, although some fisheries, such as for pilchards in Western Australia, 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 fish 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 fish population fluctuations of this food source, the industry has recognised the need for fishmeal and fish oil replacements in the diet. Carnivorous fish can use plant-based protein and oils just as well as fish-based proteins and oils. There are some product quality issues with the use of alternatives to fish oils, but the fish's health and growth are not affected (B. Glencross pers. comm. 2006).

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 Western Australia the Department of Fisheries has been undertaking research into replacements for over eight years. Most of the assessment has been focussed on meat meals and

lupin meals. Researchers have been able to replace 66 per cent of the fishmeal in trout diets with lupin protein concentrates and 100 per cent of the added oils in snapper diets with canola oil. Commercially, most diets now use less than 30 per cent of fishmeal, but going any lower has caused issues with palatability of the diet to the fish and also is generally not cost-effective in terms of the formulation cost. Even with the fishmeal prices doubling over the past six months, lupin replacements are a cost-effective protein source for use in feeds, but this still drives the feed prices up (B. Glencross pers. comm. 2006).

The other major risk associated with feed is contamination. While there is recent, although controversial, evidence that cultured fish can 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.

Given the low amount of fish farmed in Western Australia, the risk from the State's aquaculture industry to baitfish stocks is 'low'. However, when we consider the aquaculture industry across Australia as a whole, the risk may be 'moderate'. Demand from aquaculture is likely to be contributing to overfishing 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 issue of fishmeal processing affecting feed prices which, in turn, could affect aquaculture profitability needs to be addressed. By improving resource base availability for feed companies to use alternatives, it will help reduce feed price pressure and therefore improve profitability for the industry.

There are not many aquacultured ingredients used in feeds and certainly nothing that is likely to make any inroads into addressing the protein supply issue. A more prudent approach is to rely on the production of agricultural products/by-products for use in feeds.

Other issues that the industry needs to consider are:

- the use of fishery waste products and aquaculture by-product processing products in feeds;
- the use of GMOs in the food chain;
- product quality issues, such as maintaining the omega-3 levels that there they need to be in the product; and
- environmental impacts associated with feed design and management

It should be realised that these fish species are targeted by sectors apart from aquaculture and, should aquaculture discontinue the use of fish for supplying fish meal/fish oil, there would still be considerable demand for these species.

Comments in Relation to Future Management

- Continue to undertake research to identify new feeds (Department of Fisheries, Aquafin CRC).
- Continue to utilise agricultured/aquacultured ingredients where possible.
- Should we consider farming our own fish for use as fishmeal/fishoil?
- Ensure that species imported as an aquaculture feed are incorporated into species lists for *Biosecurity and Agricultural Management Regulations*.

5.1.3.4 Chemicals

Table 17 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
Comments	• Use of therapeutants and hormones will require the development of protocols to ensure any use is managed and regulated. • Use of veterinary chemicals need to be considered differently than those for growth improvements. • Some of these chemicals are incorporated into fish feeds – need to determine whether this is the best way to manage their dosages. • Research is required to determine impacts that are known and understood for WA species and environments. • Environmental implications of chemical and medicine usage need to be assessed. • Data on type, amount, frequency and toxicity of chemicals is needed to complete this element. • Concentrations or any known or likely impacts must be contained within the lease area (mixing zone). • If use is required in future years, need to consider research on the impacts on, other species and the broader ecosystem, as well as any long-term retention in sediments, etc.

Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	3	2	6	Low

Justification for Risk Ranking

A lot of work has been done in Scotland into the use of chemicals and the resultant impacts to the environment. Intensive production of farmed salmon has been associated with both disease and parasite problems that have caused major losses to the industry. The use of antibiotics and chemotherapeutants used to be widespread (Ross 1997).

Extreme disease problems in the early 1990s led to very high levels of antibiotic use in fish feed, causing increasing levels of antibiotic resistance in bacteria. Once in the marine environment, the antibiotics are still active and can cause resistance on other non-target bacteria species, with implications for human health. Antibiotics are also persistent, with little or no degradation occurring in sediments where they may persist for months or even years.

Antibiotics also suppress the decay of organic matter, thus affecting seabed recovery under cages. The development of increasingly effective vaccines has now reduced the levels of antibiotic use.

Sea lice can also present major problems for the industry. These parasites are treated mainly using chemotherapeutants, which are either poured into the enclosed fish cage and then released after the treatment, or incorporated into the salmon feed.

Sea lice treatments are, by their very nature, biocidal and have raised considerable concern over their impacts on other non-target species and the ecology of the marine environment. Resistance to treatments has also been encountered in sea lice.

As mentioned previously, the Australian Pesticides and Veterinary Medicines Authority (APVMA) manages the registering and use of chemicals, and use is not permitted without its prior approval. This protocol manages the industry as a whole, so there is some level of industry-wide approach already in operation. However, the use of chemicals is still determined

on an individual basis, rather than having some predetermined response to known or expected disease outbreaks.

The consequences of any inappropriate use of chemicals due to the lack of any industry-wide protocols could be 'severe' ('3') due to the lack of any relevant research and understanding of local impacts, but with the current protocols and approvals processes, the likelihood of anything happening is considered to be 'rare' ('2').

Comments in Relation to Future Management

- Requires further data and refinement.
- Develop protocols, in consultation with industry, for use of chemicals.
- Determine which chemicals will be permitted for use in WA and under what circumstances.
- Advise industry groups of protocols and research outcomes.
- Techniques for isolated parasitic dosing should be developed, rather than in-pen dosing.
- No impacts outside of aquaculture licence areas will be a requirement of any future management actions.

5.1.3.5 Water quality

Table 18 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			
Comments	• Industry utilizes open marine waters and water quality criteria have been developed – form the basis for regional water quality standards. • Environmental water quality parameter guidelines are known and should be achieved the edge of any mixing zone (e.g license area). • Monitoring water quality could be a criteria for any environmental monitoring program in areas where concern is raised or flushing around cages is less than optimal.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	1	2	2	Low

Justification for Risk Ranking

In Western Australia, the *State Water Quality Management Strategy* (2004) provides for the establishment of environmental values and environmental quality objectives as goals for environmental quality management. This strategy has as an objective the protection of the environment from the effects of waste 'inputs' and pollution.

Thorough public consultation must be undertaken prior to the development of environmental values and environmental quality objectives prior to their submission to the Environmental Protection Authority (EPA) for review and endorsement. These values then guide environmental impact assessment and natural resources management.

The legislative force behind the strategy outlined above is the *Environmental Protection Act 1986* and associated Regulations. These set down standards that facilities discharging in to the marine environment must meet. There are a range of regulatory enforcement tools, which

include a list of materials that cannot be discharged into the environment. Animal waste is one of these - which could be applicable to aquaculture facilities.

The Department of Environment and Conservation and the Department of Water are contributing to the development of these plans, which are managed by the various natural resource management groups. Reports have been completed for Cockburn Sound and the Pilbara Coast. As these reports are developed further, the 'outputs' will be taken on-board in respect to aquaculture operations for determining water quality criteria as part of the Environmental Monitoring Program. In light of these operational protocols and policies, the consequences are considered to be 'minor' ('1') with a likelihood of anything of consequence happening, being 'rare' ('2').

Comments in Relation to Future Management

- Utilize state-wide water quality criteria developed by relevant authorities in environmental monitoring programs.
- Sites sensitive to nutrients (and other waste products) should not be used for pen locations, i.e. sites should be non-sensitive or high-flushing.

5.1.3.6 Pests

Table 19 Introduction of marine pests

Description (Fletcher *et al*. 2004)	*Does there need to be protocols developed regarding the transportation of equipment and the possible introduction of marine pests?*			
Level of impact	Whole of the industry			
Comments	• Transportation of equipment should operate under agreed guidelines to minimise any occurrence or possibility of transfer of marine pests. • Unlikely to occur between regions since translocation policy in place. • Unknown what the impacts might be – whether to on-farm stocks or the broader environment. • Costs of rectifying any marine pest incursions – who bears it if impacts go regional or come from outside of industry?			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	2	4	8	Moderate

Justification for Risk Ranking

Marine pests have the potential to cause significant long-term economic, ecological and health consequences for the sea and the creatures who live in it. They can have a harmful effect on the biodiversity and health of marine ecosystems, and the industries and amenities that depend on them. There are currently about 250 introduced marine species in Australia. Already 92 of these can be found in WA.

Aquaculture activities in some Australian states have resulted in the deliberate introduction of non-native aquatic plants and animals, so that they can be cultured for food. When an aquaculture species is being transported from one place to another, other animals and plants may be introduced unintentionally in the transport water or packaging, or may attach themselves to the aquaculture species. These unintended introductions are classified as marine pests, rather than as an aquacultured species.

The management of introduced marine pests has two components – controlling existing invasions and preventing the introduction of new exotic species. State, Territory and Commonwealth agencies are working with industry and the community to prevent further pest introductions,

reduce the impacts and further spread of existing introduced marine pests, and to develop options for their eradication.

The Department of Fisheries has an *Emergency/Incident Management Plan,* which provides the administration of the framework for responding to a marine pest incursion. Under the current management arrangements, the consequences would be 'moderate' ('2') however the likelihood of an incursion occurring is 'possible' ('4').

Comments in Relation to Future Management

- Maintain current protocols regarding marine pests.
- Consider national guidelines and legislation.
- Determine research program if required.

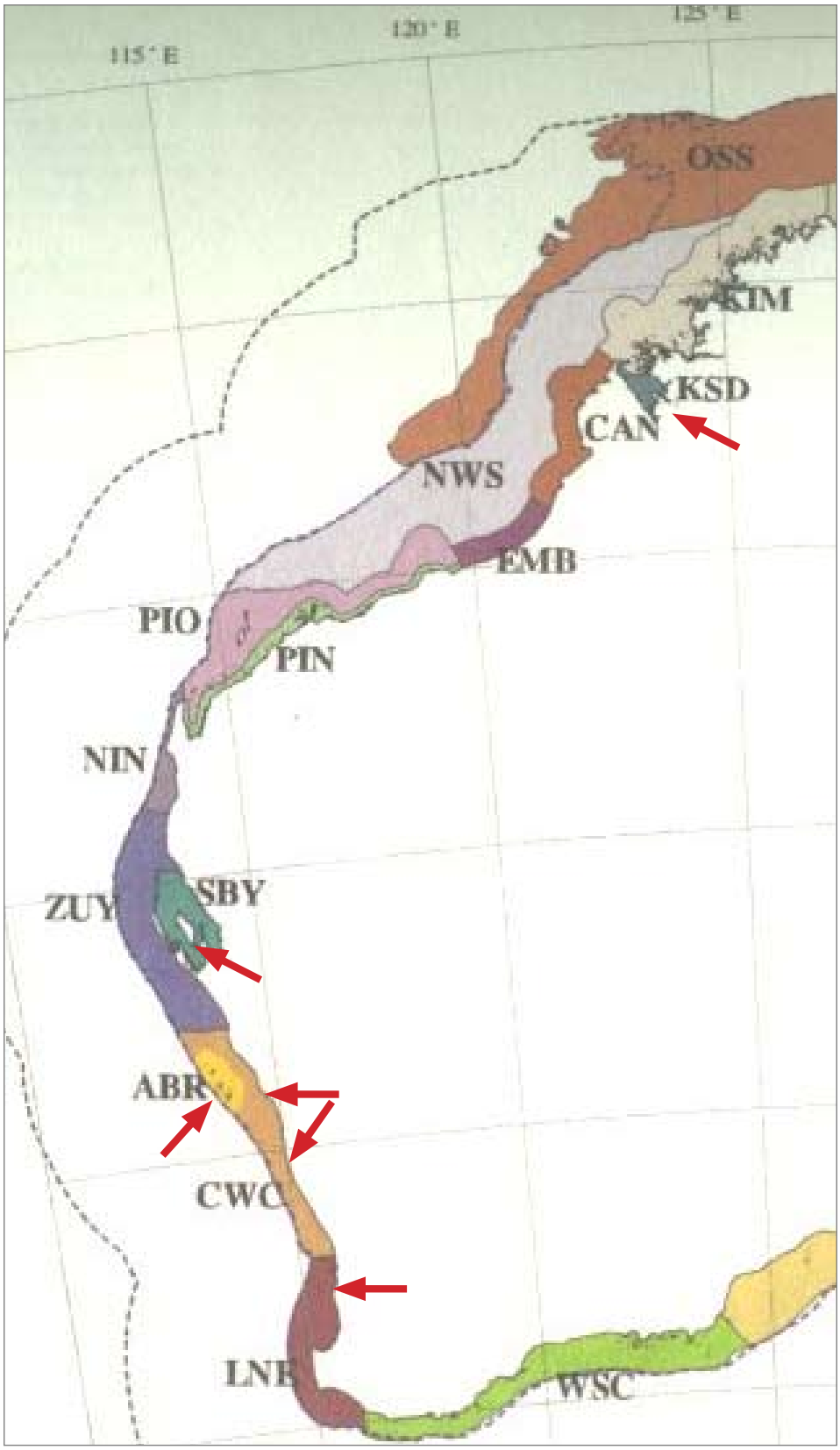
5.2 Impact of the Industry on the Catchment/Region (Cumulative Impacts)

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. the 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.

The regions where aquaculture operators are currently licensed for finfish production are:

KSD	King Sound (Cone Bay)	1
SBY	Shark Bay	2 (+ 1 non-productive)
ABR	Abrolhos Islands	1 (+ 1 tentative trial project)
CWC	Central West Coast (Jurien Bay, Geraldton)	2 (+ 1 non-productive)
LNE	Leeuwin – Naturaliste (Fremantle)	1



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 Nutrients

Table 20 Quantity and quality of water use

Description (Fletcher *et al*. 2004)	*If production by facilities in the region results in the release of nutrients, should a maximum/total amount allowable (e.g. total dissolved solids per day/week/year) for the whole regions be set?*
Level of impact	Catchment / Region
Comments during workshop	
Fitzroy	• Objective would be to have an acceptable level of impact on the ecosystem. • No measurable change outside the lease area. • Should be an objective at the regional level. • Can't really put as a regional objective as don't know the output level. • Regional objectives are required. • As most of the areas are 'wild', no detectable change is a good thing. • Fitzroy has such an enormous run-off that even putting in a considerable amount of nutrients would be insignificant in a flood event. • The water environment in the Fitzroy is so dynamic that it would be hard to detect change. Even though dynamic – still require some monitoring in place to see what is happening. • Overall objective: No detectable change within this region outside of natural variations, which could be attributed to the aquaculture project (because of the Kimberly's dynamic water environment.) • There was total agreement that at a 100 tonne cage culture, you would have no way of detecting anything. • Also total agreement that at 1,000 tonnes cage culture, there could be numerous farms in the one area, but this would still not change the risk profile.
Abrolhos Islands	• Should deal with two categories; 1) shallow low-flushed embayment. 2) deeper well-flushed environments. • Believe that if aquaculture goes ahead in WA, it will be in deeper water – should do this as a category also – 'offshore submersible'. • Regionally, with a 100 tonne fish production, still wouldn't detect change [in nutrient level]. This would only discharge about 8 tonnes (7,641 kg) of nitrogen, 41 tonnes (41,380 kg) of carbon and one tonne (1,426 kg) of phosphorus over a 12-month period. • There would be no perceptible change [in nutrient levels] with 1,000 tonne fish production. • Where are the nutrients going – although they are being assimilated, we want to know where they are going? • No point in assessing/measuring water quality.

Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
During workshop				
Fitzroy:				
100 tonne cage	0	0	0	Low
1,000 tone cage	0	0	0	Low
Abrolhos Islands:				
<20m depth	1	2	2	Low
<100 tonne	2	2	4	Low
deep water	0	0	0	Low

After workshop				
KSD	0	1	1	Low
SBY	2	2	4	Low
ABR	2	2	4	Low
CWC	1	1	1	Low
LNE	1	1	1	Low
WSC	2	1	2	Low

Justification for Risk Ranking

The release of effluents and pollution from the aquaculture industry into the marine environment is one of the most contentious issues associated with sea-cage finfish aquaculture. The main industry 'inputs' from sea-cage finfish aquaculture are uneaten feed and fish faeces that enter directly into the surrounding marine environment.

Worldwide, there is an extensive literature on the impacts, modelling, monitoring and management of sea-cage finfish aquaculture discharges into the marine environment. In Australia, sea-cage finfish aquaculture is relatively new in comparison to countries in Europe, North America and South America, and therefore there is less information regarding the impacts of industry inputs on the environment (De Jong and Tanner 2004).

The publications regarding the impacts of sea-cage finfish industry 'inputs' in the Western Australia marine environments are limited to a few environmental monitoring reports, site surveys and impact assessments by consultants and government agencies.

Impacts

Industry 'inputs' (i.e. feeds) from sea-cage finfish aquaculture into the marine environment can increase sedimentation and nutrient loads, which, in turn, can impact on this environment in a number of ways. For example, an increase in sedimentation can smother benthic organisms.

The main impacts of nutrient enrichment in the marine environment are eutrophication, excessive epiphytic growth on seagrasses that smothers the plants, increased growth of macroalgae, and harmful algal blooms. Eutrophication is an increase in nutrients that normally limits primary productivity, resulting in an increase in algal growth, which in turn results in the depletion of oxygen in the water column. Eutrophication of the water column and sediments can lead to increased biological oxygen demand, hypoxia and altered benthic community structure (De Jong and Tanner 2004).

Around the world, the severity of impacts of wastes from sea-cage finfish aquaculture has varied from 'negligible' to 'serious'. Some studies did not find any difference in community structure along a transect that ran from under a salmonid sea-cage to a distance of 50 metres in England. In contrast, others have found distinct changes in the benthic community in the area around a fish farm in a sea lock in Scotland, with the greatest impact occurring underneath the sea-cage where no benthic fauna were found.

Work done in Spain found that since the onset of fish farming in an embayment in south-eastern Spain, 53 per cent of *Posidona oceanica* seagrass meadows have been either lost completely or significantly degraded. In Japan, it was calculated that nutrients released from aquaculture sites affect an area three to nine times the size of the aquaculture zone.

In South Australia, the degree to which sea-cage finfish aquaculture wastes impact the environment is also varied. For tuna, studies found that epibenthic communities (on the seabed) were impacted up to a distance of 150 m and benthic infauna (in the sediments) were impacted up to 20 m from sea-cages in Boston Bay.

The greatest impact of nutrient enrichment on benthic communities occurs underneath and in the near vicinity, of the sea-cages, where the surface sediments can become anoxic. The degree of impact decreases with increasing distance away from the sea-cages. The level of impact is thought to be dependant on a combination of factors including the species being cultured, husbandry practices, feed type, level of 'inputs', hydrology and the nature of the receiving environment, in terms of physics, chemistry and biology.

Modelling

There are numerous models that have been developed to predict various aspects of wastes in the environment such as production of fish waste, nutrient enrichment in the water column and sediments, deposition of particulate and organic matter, and impacts on the benthos (De Jong and Tanner 2004). Even though these models have been developed in other parts of the world, the theories behind them are likely to be relevant for Australian sea-cage finfish aquaculture. These models may provide a useful starting point for developing models specific to Western Australia.

There are two major problems associated with the development and use of models to predict the impacts of sea-cage finfish aquaculture. The first problem is the lack of baseline information available to parameterise the models. Without accurate data on factors like water currents, generation of waste, flushing dynamics and carbon accumulation for each aquaculture site, it is difficult to make any accurate predictions.

The second problem is that these models are often over-simplified, due to knowledge gaps in our understanding of the behaviour of wastes in the environment and their impacts on biological communities. Where knowledge gaps exist, a precautionary approach has been taken and a number of assumptions have been made that produce the highest amount of nutrient deposition and enrichment.

Although a precautionary approach is ideal for reducing the risk of environmental impacts, an underestimate of carrying capacities could unnecessarily hinder the growth of this industry and significant investment opportunities could be lost. These factors therefore need to be investigated and quantified in order to develop more accurate models.

Currently, stocking limits and densities of farms in South Australia are limited by carrying capacities calculated using these simplistic models. In its simplest definition, the carrying capacity is the maximum level of fish production that does not cause significant changes in the ecosystem.

The models in use provide a conservative estimate of carrying capacity, due to a number of assumptions made. Work is currently being done in developing models for carbon deposition to the seafloor and levels of dissolved, inorganic nutrients for sea-cage finfish aquaculture in South Australia, based on models from other parts of the world. Once these models have been validated and tested in the field, they may be useful in predicting the impacts of aquaculture in WA marine environments.

Monitoring and Management

Work undertaken in Victoria has reviewed appropriate methods for environmental monitoring of marine aquaculture and these methods may be applicable to other Australian waters. They separated the possible indicators of environmental change into three main categories:

1) impacts on sediment quality;

2) impacts on water quality; and

3) biological impacts.

It is usually the biological variables that are of interest because changes in the chemical variables may not be enough to cause biological changes, due to the varying assimilation of different sites. So, although a change in the chemical variable may be detected, due to the high assimilation of nutrients in that particular area, a biological change may not be detected.

Many studies have shown that benthic infauna is a reliable indicator of near-field environmental change caused by increases in nutrients and sedimentation and, as such, infauna sampling has become a common tool in environmental monitoring programs worldwide.

In South Australia, all license holders are required to submit an environmental monitoring program (EMP) report annually, in accordance with the monitoring protocol outline by PIRSA Aquaculture. This EMP is based on the statistically-rigorous EMP required for the tuna farming industry. It quantitatively addresses changes to the benthic infauna at potentially-impacted lease sites relative to replicated control sites.

In addition, a qualitative assessment of the epibenthic flora and fauna is made using underwater video. Similar programs are now being considered for WA.

Due to the relatively recent introduction of finfish farming in sea-cages in South Australia (licences for kingfish farming were issued for Arno Bay only four years ago) few EMP reports have been submitted to PIRSA Aquaculture (apart from those for tuna), of which two were part of the same monitoring program. The report suggests that there is negligible impact of a yellowtail kingfish aquaculture farm on the environment in comparison to control sites.

The results from the EMP were reviewed for salmonid aquaculture at Cape Jaffa conducted between 2001 to June 2003. Results from the survey suggest that there was negligible impact on the seagrasses and seabed, including sediments and benthic communities. However, no analytical procedures were used on the video transects, so the results obtained are highly subjective. These investigations should also be repeated with improved methodology and statistical analyses.

These types of monitoring programs will only detect local impacts caused by individual facilities. There is a need to design and implement monitoring for impacts on the catchments/regions, due to increased industry 'inputs'. Designing such a program is the focus of a current Aquafin CRC project being undertaken by the South Australian Research and Development Institute (SARDI).

In WA, regional water quality criteria will be developed through the *SWQMS* which provides the implementation framework for determining 'environmental values' for water quality, broad environmental quality objectives for each 'environmental value' and environmental quality criteria or benchmarks to allow determination if a standard has been breached. At current stocking levels, and at likely levels over the next few years, this issue is likely to be a 'low' risk at the region level, but would be 'moderate' at the individual facility level.

While there is argument over the regional impact of tuna farming, there is probably little regional impact of other forms of sea-cage finfish farming at this stage. The risk would be 'low' but with expansion it could become 'moderate'.

Comments in Relation to Future Management

- Utilise triggers identified in various report and strategies to determine when management actions are required. – these may be available from various reports and strategies already completed.

- Make sure the Abrolhos Islands gets into the management plan as a separate region, as identified.
- There should be no impacts outside license area.
- Water quality guidelines should be met at license boundary.
- Environmentally-sensitive sites (e.g. coral reefs and seagrass areas) should not be part of license area.

5.2.1.2 Sedimentation (particulate matter)

Table 21 Sedimentation impacts

Description (Fletcher *et al*. 2004)	*Can the collective amount of material released/escaping/dropping from the structures, including biological material or sediments from erosion, cause a problem for the region / catchment from sedimentation?*
Level of impact	Catchment / Region
Comments	• The current level of operations is minimal, so no regionally-significant amounts of sediment would be expected. This could be verified through environmental monitoring programs for sites that are operational within regions. • Farm management practices to restrict the removal of cage fouling while in water: should be part of licence conditions (or will be). • Any rubbish from feeding operations is required to be removed from the site and not released into the environment. • Try to get hold of research reports from SA (Aquafin CRC) which look at impacts from sea-cages on sediment. • Site selection, stocking rates and feeding rates determine nutrient loading and environmental acceptability. This is a cumulative issue, relevant within regional context. • At a regional level no issues are likely, especially as each facility will be managed to relevant standards/criteria.

Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop				
KSD	1	1	1	Low
SBY	0	1	0	Negligible
ABR	0	1	0	Negligible
CWC	1	1	1	Low
LNE	0	1	0	Negligible
WSC	0	1	0	Negligible

Justification for Risk Ranking

Sediments are diverse environments, supporting a range of flora and fauna existing in a complex matrix, whose defining parameters include particle size, carbon (food) availability, oxygen concentration and redox potential. Biogeographical chemical processes in marine sediments are dominated by ambient hydrography (deposition, erosion and oxygen supply) and by the net input of carbon, which determines sedimentary oxygen demand and thus redox chemistry. (Black 2001).

Aquaculture wastes consist of uneaten fish feed and faecal and other excretory wastes. The characteristics and impacts of wastes from aquaculture operations vary according to the type and siting of the aquaculture system (Goldburg & Triplett, 1997).

The fraction of fish feed that becomes waste varies considerably - between one to 15 per cent of dry-pelleted aquaculture feed, the most frequently-used type of feed in the US, typically is not

consumed by fish. However, if 'trash fish' is to be used, the percentage of feed not eaten can be as high as 40 per cent because fish feed made from trash fish easily breaks apart in the water. In addition, a substantial amount of feed that is eaten is subsequently released to the environment as faeces.

The gross effects of wastes from intensive cage culture on marine benthic habitats and processes are fairly well understood in northern Europe and other cool-temperate regions. Essentially, these follow the pattern of impacts from other organic pollutant sources, but on a more reduced spatial scale. Recorded effects include reducing sediments, hypoxia in the water overlying the sediment, increased sulphate reduction, and marked changes in benthic faunal and meiofaunal assemblages in terms of species numbers, diversity, abundance and biomass (Black 2001).

The Aquafin CRC is finalising a project for the "development of regional environmental sustainability assessments for tuna sea-cage aquaculture". The findings from this project may provide more detail useful for understanding and detecting sedimentation impacts under marine finfish cages.

Management procedures that should be practiced are the cleaning of cages on land to minimise any occurrence of deposition of biological material as well as site fallowing after the farm cycle. These practices will assist in minimising the amount of waste material falling to the seabed and give the material that does fall, the time to be assimilated. The environmental monitoring program to be developed will ensure that any impacts found on-site will be determined and an attempt to give a regional perspective of any changes can follow.

Major impacts are generally found within a localised area and are unlikely to pose a significant threat to the regional environment at current levels of use. As a result, the consequence of the current level of farming would be expected to be 'negligible' ('0') or 'minor' ('1') depending on the region being considered. The likelihood of these impacts occurring is 'remote' ('1').

Comments in Relation to Future Management

- Maintain the protocols and licence conditions to management farm practices.
- Monitor the seabed through EMP and annual reporting requirements.

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

Table 22 Regional impacts from the release or use of chemicals

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?*
Level of impact	Catchment/Region
Comments	• Need to develop industry-wide protocols for chemical use. • Need to consider available chemicals and which ones may be appropriate for use in WA. • Limited amount of aquaculture currently in the various regions. • No reported use of chemicals has been recorded to-date. • At regional level, no issues are likely, especially as each facility will be managed to relevant standards/criteria.

Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop				
KSD	2	1	2	Low
SBY	3	1	3	Low
ABR	3	1	3	Low
CWC	1	1	1	Low
LNE	1	1	1	Low
WSC	3	1	3	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 chemicals in Norway in comparison 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 a case-by-case basis. There is no industry-wide protocol guiding the use of chemicals but the actual levels of chemical usage are low at present. Consequences, depending on the region, could range from 'severe' ('3') to 'minor' ('1') depending on the environment in which it is used (sandy bottom or highly diverse coral communities) but the likelihood is 'remote' ('1').

Comments in Relation to Future Management

- Maintain protocol on application, use and reporting of any chemical use.
- Design a monitoring program for sites, including surrounding area, where chemicals are approved and provide guidance on any impacts that could eventuate from use of chemicals.
- Consider who will be responsible for any cleanup should it be required – and who covers costs.

5.2.1.4 Flow (hydrology/oceanography)

Table 23 Effect of facilities on circulation

Description (Fletcher *et al*. 2004)	*Could the collective impact of the facilities affect the flow of water within the embayment (e.g. too many cages close together could impede water flushing rates)?*
Level of impact	Catchment / Region
Comments	• Number of cages in use is minimal, as are the tonnages being farmed. • This should be considered in regard to the placement of sites prior to any approval being granted. • Larger bays that have suitable flushing rates could be unrestricted. • It is in farmer's best interest to ensure maximum flushing rates – in order to get a better quality product. • If any lowering of flushing rates is detected by the level of deposition underneath cages, there is a need to take appropriate management responses –to move the site, spread cages out over the site and decrease stocking rates within cages.

Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop				
KSD	0	2	0	Negligible
SBY	1	4	4	Low
ABR	0	2	0	Negligible
CWC	0	1	0	Negligible
LNE	0	1	0	Negligible
WSC	0	1	0	Negligible

Justification for Risk Ranking

Siting aquaculture facilities in appropriate locations can mitigate or prevent many of the environmental impacts of aquaculture. Siting is crucial in sea-cage farming which relies on natural tides or currents to flush wastes that settle below farms. High rates of erosion of bottom sediments, as well as high water flows, are most desirable.

Farms must be well-spaced to reduce the potential for the spread of disease between farms, as well as reduce any cumulative effects of waste production (Goldburg and Triplett 1997). Having a minimum distance between farms will also ensure tidal flows and currents are not interrupted significantly.

The Department of Fisheries has a policy requiring a buffer distance of 5 km between pearl oyster sites. This allows for the consideration of a new site in the area between 5 and 2 nautical miles distant from the existing farm, if agreement is received from the latter. On the basis of this policy (if considered to be relevant for finfish aquaculture), the consequences would be 'negligible' ('0') or 'minor' ('1) in Shark Bay, due to the sensitive environmental habitats in the latter. The likelihood is considered to be 'remote' ('1') to 'possible' ('4'). More research on oceanographic conditions would assist in clarifying this issue.

Comments in Relation to Future Management

- Maintain rigorous assessment processes to minimize likelihood of any occurrence of potential problems with flushing rates.
- If lowering of flushing rates is detected, instigate an appropriate farm management response.

- Incorporate monitoring of surrounding areas during any EMP – will need to link to a regional assessment of impacts once more farms open-up.

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. This could be the ecological manifestations of the effects identified in branch 2.1.

5.2.2.1 Plankton (e.g. algal bloom)

Table 24 Impact of plankton on the region

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
Comments	• Blooms do occur naturally, but is aquaculture likely to increase the likelihood of blooms? • Background levels of plankton prior to farming are needed. • There is a need to monitor the frequency/intensity/composition of blooms. • Risk should be recognised and farmers should be monitoring [for plankton blooms/toxic species]. • It is unknown whether finfish aquaculture could increase the intensity or frequency of blooms. • Farmers wouldn't want blooms – they could result in loss of stock. • Carrying-capacity models are required for regions where finfish aquaculture may increase. • Research in South Australia has shown a localised increase in chlorophyll around finfish farms. • Soluble nutrients from activities at finfish farms may change the ratio of nutrients in the marine environment, thereby favouring or changing the species composition of phytoplankton. This may favour toxic species, given the reduction of silica in the wastes.

Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop				
KSD	0	1	0	Low
SBY	3	4	12	Moderate
ABR	2	2	4	Low
CWC	0	1	0	Negligible
LNE	1	4	4	Low
WSC	2	2	4	Low

Justification for Risk Ranking

An increase in nutrients, which normally limits primary productivity in the aquatic environment, can cause an increase in algal growth. Increased algal growth due to increased nutrient loading can lead to eutrophication or increases in frequencies and magnitudes of toxic and non-toxic algal blooms (De Jong and Tanner 2004).

Harmful algal blooms can cause fish kills and contaminate filter-feeding shellfish and are a major concern for both sea-cage finfish and marine shellfish aquaculture sectors. There are several environmental factors that can be altered by sea-cage finfish aquaculture which are also considered to be factors that may promote harmful algal blooms. These factors include

circulation, turbulence (intensity of vertical mixing), nutrients, light, temperature, and salinity, although nutrient enrichment remains the factor most often associated with algal blooms (De Jong and Tanner 2004).

Sea-cage finfish aquaculture does increase nutrients, which can lead to increased phytoplankton production. It has been suggested that the occurrence and impacts of harmful algal blooms is dependent on whether harmful species are present, the relative abundance of the nutrients, the mixing and hydrographic characteristic of the area, and other factors such as grazing intensity or light availability.

Conversely, a recent report to the Scottish EPA concluded that 'the present level of fish farming is having a small effect on the amount and growth rate of Scottish coastal phytoplankton, but that this should not be a cause for concern except in a few heavily-loaded sea-lochs.' Given the high biomass of fish farmed in Scotland in comparison to that farmed in Western Australia, and the relatively enclosed nature of the areas used for aquaculture in Scotland, this suggests that there should be even less concern in Western Australia - where farmed biomass is low, and farming occurs in relatively-open areas.

To date, no harmful algal blooms have been directly attributed to aquaculture in WA or the rest of the world. However, indirect evidence suggests that sea-cage finfish aquaculture may have promoted toxic algal blooms in a Norwegian fjord, which resulted in extensive mortalities in the fish farms.

Interestingly, laboratory experiments in Chile suggest that excreta from farmed Atlantic salmon do not affect the growth of the alga *Alexandrium catenella* and actually inhibits growth of *Heterosigma akashiwo*. These two species of algae are known to produce red tides in areas of Chile where sea-cage finfish aquaculture occurs.

There has also been a suggestion that mass mortalities of farmed tuna in Boston Bay in 1996 were due to microalgae, most likely related to nutrient 'inputs', although the general consensus is that other factors were responsible.

Phytoplankton composition used to be monitored as a part of the broader Tuna Environmental Monitoring Program (TEMP). However, it was found to be difficult to distinguish changes in phytoplankton due to aquaculture from other sources of nutrient input, such as pollution from urban development, industry and shipping. That being said, the TEMP showed higher total algal counts and chlorophyll *a* around sea-cages compared to controls, which does suggest that sea-cage finfish aquaculture may increase phytoplankton levels (De Jong and Tanner 2004).

The phytoplankton monitoring program conducted by the Tuna Boat Owners Association of South Australia (TBOASA), which took one to two samples a week (sometimes more) for a period of 18 months at Boston Island and surrounds, provides more detail on the occurrence and temporal patterns of several algal species of concern to sea-cage finfish farmers. A few algal blooms occurred during this period, but they were not toxic to marine finfish. The cysts of species toxic to marine finfish were found in some sediment samples.

Other studies investigating the phytoplankton dynamics of Boston Bay found that chlorophyll *a* levels varied greatly on a daily basis, particularly around tuna sea-cages.

Further investigation is needed to determine if sea-cage finfish aquaculture may have a direct impact on phytoplankton composition and abundance in Western Australia. Given that there are suggestions that severe problems have occurred elsewhere, the consequence could be 'severe' ('3') and the likelihood 'rare' ('2'), or 'possible' ('4') if there is substantial expansion of aquaculture in enclosed areas such as Shark Bay. This would result in a risk value of '4' to '12' ('low' to 'moderate').

Comments in Relation to Future Management

- Incorporate monitoring of phytoplankton in EMP, so that base levels are determined.
- Ensure region-wide monitoring is undertaken to allow for determination of carrying capacity and possible increase in bloom frequency/intensity.

5.2.2.2 Benthic communities (e.g. aquatic vegetation)

Table 25 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
Comments	• Have DEC 'benthic producer policies' so are assuming that cages wouldn't be put over these complex areas. • Farmers wouldn't want benthic sediment to become anaerobic. • No change in the license area to produce anaerobic sediments. • Standard approach to licensing that cages can't be over seagrass or coral. • No detectable changes in benthos or buffer zone.

Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
During workshop	1	1	1	Low
After workshop				
KSD	0	1	0	Negligible
SBY	2	2	4	Low
ABR	1	2	2	Low
CWC	1	1	1	Low
LNE	1	1	1	Low
WSC	2	1	2	Low

Justification for Risk Ranking

It has only rarely been possible to demonstrate any linkage between the nutrients produced from farming and a biological response, although many such linkages have been claimed. Beyond looking at purely local enrichments, it is normally not feasible to attribute wider-scale effects to nutrients from farms (Black 2001).

Around Australia, little work has been done to determine the regional impacts of aquaculture, but the Aquafin CRC is developing a project to consider the regional assessment of tuna aquaculture in South Australia. In WA, no data is available, so studying the results from the CRC will assist in putting in place mechanisms to monitor any regional impacts on benthic habitats.

At current farming levels, where only one site is operating in each region, the expected consequences range from 'negligible' ('0') to 'moderate' ('2'). The likelihood of these consequences actually occurring is 'remote' ('1') or 'rare' ('2').

Comments in Relation to Future Management

- Utilize EPA Guidance Statements No. 22 – *"Seagrass Habitat Protection"* and No. 29 – *"Benthic Primary Producer Habitat Protection for WA's Marine Environment"*.
- Maintain current protocol regarding placement of aquaculture over seagrass/coral communities.

5.2.2.3 Listed migratory species

Table 26 Listed migratory species

Description (Fletcher *et al*. 2004)	*Are there listed migratory species 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
Comments	• Need to develop protocols for dealing with the issue across whole of industry that feed into regional level protocols. • Issue is considered during assessment phase – the site location and number of cages may reduce impact with respect to whales. • Interactions need to be reported and monitored – this could be done through a licence condition requirement. • Acoustic harassment devices are not currently used – they have been trialled by southern bluefin tuna licensees in SA. • If the aquaculture industry causes changes to numbers of rare species (e.g. sea lions) then the consequence level may be higher. • Use of certain feeds may alter the number of interactions – pellet feeds are not taken by birds. • Most shorebirds found around cages are not migratory.

Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop				
KSD	4	4	16	Moderate
SBY	4	4	16	Moderate
ABR	3	4	12	Moderate
CWC	3	3	9	Moderate
LNE	3	3	9	Moderate
WSC	4	2	8	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 on July 16 2000, 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 impact from supplemental feeding, waste material or chemicals that fall, are washed or discharged into the marine environment.

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 major impact in WA is considered to be the entanglement of whales on ropes and floats. Management responses require ropes to be as taut as possible, without restricting movements due to tidal fluctuations. In instances where this has occurred, the Department of Environment and Conservation was notified and responded as necessary. The requirement for notification of this agency will form part of the Department of Fisheries' Environmental Monitoring Program once finalized.

The finfish farming industry in WA is still rather small and any new proponent should be reminded of the need to undertake the self-assessment against the EPBC Act. The consequence of the proponent not considering this issue in the planning phase and designing the facility to minimize or mitigate impacts could be 'major' ('4'), resulting in a substantial fine. The likelihood of this occurring is 'unlikely' ('3').

These ratings will be different, depending on the region in which the proposal is becoming mooted, as some regions have higher levels of visitation by listed migratory species.

Comments in Relation to Future Management

- Develop protocols for dealing with marine animal interactions that are relevant to the region and are industry-specific.
- Maintain reporting requirements with the Department of Environment and Conservation for any interactions that occur.
- Include the reporting through the Department of Fisheries' Environmental Monitoring Program of any interactions that occurred during the previous year.
- Undertake referrals to the Commonwealth's Department of Environment,Water, Heritage and the Arts under the EPBC Act if required.

5.2.2.4 Threatened/endangered/protected species

Table 27 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
Comments	This deals with whales, dolphins, dugongs, sea lions and great white sharks. The size of the industry and the low feeding rates have not resulted in any interactions to-date (at least ones that have been reported). If stocking densities and hence feeding rates were to increase, these might increase the interactions with great white sharks. There have been no entanglements with sea-cages in WA.

Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop				
KSD	0	1	0	Negligible
SBY	2	4	8	Moderate
ABR	1	3	3	Low
CWC	1	3	3	Low
LNE	1	4	4	Low
WSC	3	3	9	Moderate

Justification for Risk Ranking

Under the EPBC Act, 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.

Dolphins

A number of dolphin species are found in WA. There are some anecdotal observations of behavioural changes in dolphins around farms in South Australia, but these have not been quantified. The potential impacts of aquaculture on dolphins can be either direct (by intentional killing and incidental capture), or indirect (through competition for food and changes in the habitat).

Dolphins can be attracted to farms due to the increase of fish around the farms that are feeding on excess feed. Dolphins can also become entangled in the sea-cage nets or anti-predator nets, although it is unknown why they become entangled, even though they are aware of the nets. It is thought that they become distracted while feeding (De Jong and Tanner 2004).

A study was conducted in South Australia during 1994 - 1999 by Kemper & Gibbs (1997, 2001) on dolphins entangled in tuna farm nets near Port Lincoln. During this period, 15 bottlenose dolphins (*Tursiops aduncus*) and nine common dolphins (*Delphinus delphis*) died from entanglements with the nets and their carcases were examined and compared to dolphin carcases washed up or floating in Port Lincoln and other parts of South Australia.

An additional 13 dolphin entanglements were reported, but not collected. There is evidence that at least another eight dolphins died due to entanglements, but were not reported. Of the 37 entangled animals, 24 of them were juveniles or young, sexually-mature females. Most of the sexually-mature dolphins were pregnant or lactating. Three of the entangled animals were calves.

The remains of fish species that are common around tuna sea-cages were found in the stomach of entangled dolphins. However, there is not enough information on the behaviour, ecology and population dynamics of dolphins in South Australia to properly assess if sea-cage finfish aquaculture is affecting dolphin populations.

From the results of that study, several recommendations were made, including the removal of anti-predator nets. Anti-predator nets are no longer used in South Australia. These recommendations also included appropriate net design (semi-rigid or well-tensioned net material, mesh size of 6 cm); minimize food wastage; use of pellet feed; appropriate siting of farms; prompt removal of dead fish; gear maintenance; and constant vigilance.

Several methods that are not recommended were also listed, including the use of acoustic devices, trapping and relocation, and chasing. Dolphins are a protected species and therefore it is illegal to kill them. Farmers must attempt to safely release any trapped or entangled animals and guidance through a Code of Practice on this issue may be appropriate.

Sharks

Four shark species are protected in Western Australian waters. These are the whale shark (*Rhincodon typus*), an important focus of the marine tourism industry in the Exmouth area; the great white shark (*Carcharodon carcharias*); the grey nurse shark (*Carcharias taurus*) and the northern river shark (*Glyphis sp.c*).

The great white shark is found in almost all the aquaculture regions. There is currently no published information on the interactions between sharks and aquaculture in Australia or worldwide. In South Australia, most of the interactions between sharks and sea-cages are with bronze whaler sharks. Bronze whaler sharks are not a protected species and are usually killed if they enter the sea-cages. Farmers are not permitted to kill great white sharks and must attempt their safe release.

A review on the status of great white sharks was conducted in Australian waters and noted there were several reported incidents where these sharks were inadvertently caught, either in tuna tow cages or inshore farm sea-cages. In 1999 there were three confirmed captures and one unconfirmed capture in tuna sea-cages.

Over a period of about five years, there was a total of nine captures by the tuna industry. Six of these captured sharks were killed, usually by power-head, and the other three were already dead when found. Both sexes of the great white shark have been captured in tuna sea-cages and their lengths have ranged between three to five metres.

There are also unsubstantiated reports of up to 10 to 20 great white shark captures by, and interactions with, the tuna industry each year. It is anticipated that similar interactions are likely to occur with the aquaculture of other sea-cage finfish species, such as yellowtail kingfish and snapper.

There have been three reported attempts to release sharks that were captured in tuna sea-cages. During 1999 in South Australia, a diver tied a rope to the tail of a shark that was found in poor condition but still alive at the bottom of a tuna tow cage. The shark was then lifted out of the sea-cage and released back over the side of the sea-cage where it then sank. There was no information available on the release attempt in 2000.

In 2003 a great white shark entered a SARDI Aquatic Science experimental tuna sea-cage. This event provided the SARDI staff with an opportunity to trial a number of different methods for removing the shark safely (for both shark and human) while preventing the tuna from escaping. After trying several different methods over a period of seven days, the shark was successfully released by using a part of the net as a "corridor" for it to swim out.

Only two tuna were observed to escape in the process, although more were found to be missing at harvest. This method of release shows some potential for the safe release of sharks with minimal fish loss, and has since been used successfully for the release of two sharks from commercial pontoons.

A shark interaction workshop funded by the Fisheries and Development Corporation (FRDC) was conducted by the Commonwealth's Department of Environment and Heritage in 2003 in Adelaide. The workshop was attended by a variety of stakeholders and the outcomes of the workshop were published in 2004.

Bronze whaler sharks usually enter the sea-cage by biting a hole in the nets in order to eat any dead fish in the sea-cage. To reduce the occurrence of this type of interaction, the industry promptly removes, usually daily, mortalities from the sea-cages. Nets made of steel mesh, instead of polypropylene, have been developed and preliminary results show that they reduce predator interactions, as well as decreasing entanglements with marine mammals. Currently, the costs of setting up the steel nets are very high.

Farmers are also working with companies that produce electronic shark repellent pods for divers to make ones that can be attached to sea-cages to repel sharks. The pods work by releasing electric pulses into the water to deter the sharks. Before these devices are used, they need to be tested for any negative effects on the cultured fish and on other animals such as dolphins, whales and birds.

In order to gain a better understanding of the impacts of aquaculture on great white sharks there needs to be a monitoring and mandatory reporting program. The license conditions for sea-cage finfish farms require any interactions with large marine vertebrates (including sharks) to be reported as they occur, as well as in the annual environmental monitoring reports.

However, due to the young age of the industry, it is not yet clear if these procedures are effective, or what the results of this monitoring are. More information on the ecology, biology and population status of the great white shark is also required in order to assess and manage the impacts of sea-cage finfish aquaculture.

The 'low' risk ranking for this issue is probably more appropriate than 'moderate', but the lack of data on interactions with finfish farms other than tuna makes the level of risk difficult to assess. The 'moderate' ranking is based on the region and the likely interactions that could be expected.

Given that predator nets have been abandoned by the tuna industry, and are not to our knowledge being actively considered for other species, it is felt that the low risk ranking is appropriate in certain locations. This ranking should be revised if predator nets or other deterrents are introduced.

Cetaceans

Fish farming represents an opportunistic source of food for seals and sea lions and the potential for interactions exists wherever seals encounter fish farms. These interactions continue to cause substantial losses to salmon farmers and governments have been called upon to mitigate the problem in various states of Australia and countries around the globe.

The WA Department of Fisheries states (1998) that both the Australian sea lion (*Neophoca cinerea*) and New Zealand fur seal (*Arctocephalus forsteri*) are known to occur along the south coast of WA. Breeding and haul-out sites exist on several islands of the Recherche Archipelago. The New Zealand fur seal is a more proficient 'scrambler' than the Australian species and may pose a greater risk of interactions if they have an opportunity for above-water access to the fish being cultured.

There is currently no sea-cage aquaculture along WA's south coast, butr there exists significant potential for future aquaculture, assuming suitable farming technology is used to mitigate any impacts due to interactions with threatened species.

Comments in Relation to Future Management

- Assess likelihood of interactions during assessment processes – if necessary forward to the Commonwealth's Department for the Environment, Water, Heritage and the Arts for an assessment under the EPBC Act.
- Seek advice from WA's Department of Environment and Conservation when required.
- Develop, with industry, management protocols to deal with any marine animal interactions and implement them, when and if necessary.

5.2.2.5 World Heritage/RAMSAR/MPAs

Table 28 Presence of certain zones

Description (Fletcher *et al*. 2004)	*Are any of these types of zones present in the area? If there are, what species arrangements, etc, are needed to meet their requirements (i.e. is development referable action under the EPBC Act 1999?)?*
Level of impact	Catchment / Region
Comments	• There would be problems if certain escapees eat species of importance within Marine Protected Areas. • Issue needs monitoring and investigations – depending on whether species of interest in Shark Bay WHA and Jurien Marine Park are being impacted on by aquaculture. • Ministerial Policy Guidelines No. 8 process requires assessment by management authorities. • Any aquaculture licenses approved in these areas are likely to have stricter conditions and an environmental monitoring requirement attached to them.

Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop				
KSD	0	1	0	Negligible
SBY	2	3	6	Low
ABR	1	3	3	Low
CWC	0	1	0	Negligible
LNE	0	1	0	Negligible
WSC	1	1	1	Low

Justification for Risk Ranking

Similar to issues 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.

The assessment process used by the Department of Fisheries requires all applications for sites in waters 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 marine managed area or impacts from the 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.

The level of monitoring being done at present has been minimal and lower than optimal, but the level of farming operations has meant that impacts are corresponding low. The protocols in place at present would limit the consequences to 'negligible' ('0') to 'moderate' ('2'), with a likelihood of 'remote' ('1') to 'unlikely' ('3').

Comments in Relation to Future Management

- Maintain Ministerial Policy Guideline No. 8 assessment and management protocols.
- Any requirements for referral under the EPBC Act to occur as required.
- For sites approved within areas of interest, implement a strict environmental monitoring program to detect any impacts.

5.2.2.6 Behavioural changes on species

Table 29 Significant changes to individual species

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
Comments	• There are protocols for reporting interactions with certain species for the whole of the industry, but these are likely to be more relevant at regional level. • This issue is included in the planning stage – site location and number of cages may reduce the impact with regards to whales. • Use of 'acoustic harassment devices' could be considered if the interactions [with cetaceans] were of concern. • Noting interactions however will not assist in understanding any changes to behaviour of cetaceans/rare species. • Any changes to behaviour of rare species that are caused by aquaculture facilities in Shark Bay or other areas of high tourism potential could impact on tourism and other related industries. • Use of certain types of feed could change the behavioural activity of bird species – the use of pellets should lower any behavioural changes of this nature. • Minimising any wastage of the use of baitfish in aquaculture should lower any attraction to sea lions and/or sharks. • It is in the best interest of farmers to minimise any wastage of feed. They must take all reasonable and practical measures to minimise adverse interactions.

Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop				
KSD	1	1	1	Low
SBY	2	4	8	Moderate
ABR	1	3	3	Low
CWC	1	4	4	Low
LNE	1	4	4	Low
WSC	1	2	2	Low

Justification for Risk Ranking

Work has been undertaken to investigate the interactions between seabirds and southern bluefin tuna aquaculture farms in Port Lincoln. Short-tailed shearwaters (*Puffinus tenuirostris*) were observed to eat a very small proportion of the total feed taken by seabirds at farms that use either baitfish or pellets, and were observed in very low numbers within the sea-cages (average two) compared to the larger number observed outside the sea-cages (average 60 to 70).

The southern giant petrel (*Macronectes giganteus*) was found to visit aquaculture leases but not observed to eat the feed (De Jong and Tanner 2004).

Seabirds present on tuna farms showed a general preference for baitfish over pellets when both types of feed were available at the same time. In addition, it was found that seabirds did not consume any feed when it was distributed in the sea-cage as frozen blocks. The seabirds ate a high proportion of feed when baitfish were dispensed pneumatically or by shovelling.

Behavioural changes were seen in the seagulls that foraged at the farms. Although the gulls are

not migratory, this suggests that behavioural changes may occur in migratory birds also.

In South Australia, the main sea-cage finfish species cultured are southern bluefin tuna, yellowtail kingfish and Atlantic salmon. These species are large predatory fish that are unlikely to be preyed or scavenged upon by the seabirds, in which case the most common source of interaction between the two is the consumption of feed. In addition, cages are covered by bird netting to prevent access by scavengers and predators, further reducing potential problems.

It could be argued that studies in other parts of the world on bird interactions with aquaculture are irrelevant in attempting to assess the potential interactions in WA because these studies have focused on land-based aquaculture, where often small fish are cultured and sick or dying fish are taken by predatory or scavenging birds.

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') or 'moderate' ('2') in Shark Bay, where a higher number of protected species occur. The likelihood of these consequences occurring ranges from 'remote' ('1') to 'possible' ('4'), again in Shark Bay.

Comments in Relation to Future Management

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

5.2.2.7 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 the presence of the facilities?*
Level of impact	Catchment/Region
Comments	• Aquaculture sites should be located so as to avoid sensitive habitats. • The buffer distance required between aquaculture sites and any sensitive habitat should be determined – an initial industry monitoring program will assist in determining this. • It should be determined whether cumulative impacts to sensitive habitats occur above a certain level of aquaculture production in a region, even if the associated farms are not located directly over these habitats – research into this matter is required.

Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop				
KSD	1	3	3	Low
SBY	3	4	12	Moderate
ABR	3	4	12	Moderate
CWC	2	2	4	Low
LNE	1	1	1	Low
WSC	3	2	6	Low

Justification for Risk Ranking

This issue will be discussed on a region-by-region basis.

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 and is the receiving basin for the Fitzroy, May and Meda Rivers. The region is macro-tidal with relatively low wave energy. 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'). The Kimberley Aquaculture Plan sets out the zones considered as suitable for aquaculture and King Sound has been identified as one of those where finfish aquaculture could occur.

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 gulf. 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 hypersaline 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 flows of water about Bernier, Dirk Hartog and Dorre Islands, with the resulting near-constant temperature and salinity regimes, provide the most favourable conditions for coral growth.

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

Abrolhos Islands

The Abrolhos Islands are located near the northern end of the west coast overlap zone, where tropical marine species dominate but significant numbers of temperate species occur. The marine system contains a considerable development of high latitude coral reefs - the southernmost in the Indian Ocean - but also has extensive growths of temperate macroalgae such as kelp. The combination of tropical, temperate and WA marine species makes the Abrolhos Islands a unique area, with considerable scientific value.

Marine macroalgae – the seaweeds – occur extensively in the Abrolhos Islands. These plants require a hard substrate for attachment. The Abrolhos Islands are unusual due to a large temperate species of kelp (*Ecklonia radiata*) found growing among tropical species of corals.

Ten species of seagrasses have been recorded from the Abrolhos Islands. The most obvious are species of *Posidonia* and *Amphibolis* which occur in shallow water and form dense meadows. Other seagrasses, such as *Halodule,* are small, delicate species which do not form large beds.

Extensive coral development occurs in the Abrolhos Islands, particularly on reef slopes, shallow reef perimeters and the sheltered northern and eastern sides of the three island groups. The corals can be overgrown by macroalgae, but populations of the latter are controlled by herbivorous fish.

This area has been researched and studies continue to identify and categorise the various habitats. The consequences of inappropriate aquaculture could be 'severe' ('3') with a likelihood of 'possible' ('4'), due to the information still required regarding long-term impacts on these species. The Department of Fisheries research facility in the Abrolhos may provide facilities to understand this region to a greater degree in the future, depending on the level of research funding available.

Central West Coast

This region runs from Kalbarri to Perth and incorporates a diverse, moderate energy coastline. The marine fauna is diverse and plentiful. The single, most profound effect on this fauna is the Leeuwin Current.

Usually, western shore of continents have a cold, northward flowing current, yet along the Gascoyne coast there is a warm, southerly flowing current which carries tropical seed for fish and coral from the Indian – Indonesian Archipelago.

Interest in aquaculture in this area is low at present, which means that consequences are considered to the less than if the industry were larger. As a result, the consequences are 'moderate' ('2') with a likelihood of any impacts being 'rare' ('2'). These figures will need to be reconsidered should there be a pick-up of industry development in this area.

Leeuwin – Naturaliste

This region extends from Perth to Black Head on the south coast. This is a high energy, heavy swell coastal area, with cold inshore currents running counter to the warm offshore Leeuwin Current.

The marine fauna and flora species are diverse with strongly affinities to the southern Australian regions, sharing similar habitats to WA's south coast. There continues to be a stronger Indo-West Pacific element, believed to be through the influence of the Leeuwin Current, but some species fail to penetrate around Cape Leeuwin.

Current interest in aquaculture in this region is minimal, with most activity being run by tertiary institutions. Accordingly, the consequences are 'minor' ('1') with a likelihood of any impacts being 'remote' ('1').

WA South Coast

The affinities of the coastal marine and estuarine flora and fauna of WA's south coast lie strongly with the South Australian region, but with a significant local endemic element. Extensive seagrass meadows are a feature of sheltered bays and inlets.

Kelps dominate rocky substrates in the sub-littoral zone. There is a rich rocky shore inter-tidal fauna. Many near-shore islands are haul-out and breeding sites for Australian sea lions and New Zealand fur seals. Southern right whales make extensive use of sheltered bays.

There is potential for aquaculture in this region in the future. Accordingly, the consequences could be 'severe' ('3') with the likelihood of any impacts being 'rare' ('2').

Comments in Relation to Future Management

- Maintain the current assessment procedures and management protocols.
- Research is needed into regional carrying capacity and impacts on sensitive habitats from aquaculture of certain species, using certain feeds, etc.
- Exclude sensitive environments from aquaculture lease areas as much as possible.
- A strategic assessment is needed of regions, along with early identification of areas that are not suitable for pens.

5.2.2.8 Scavengers

Table 31 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			
Comments	• Use of certain types of feed can result in increases in scavenger numbers – most likely to be certain bird species, i.e. silver gulls. • Work in South Australia has shown that the use of pellets lowers this possibility. • Scavengers of waste or uneaten feed underneath cages can also result. It is in farmers' best interest to minimise waste of this kind food this as much as possible (for economic reasons). • Some increase in the number of invertebrate scavengers can occur underneath cages, even with good farm practises (e.g. ascidians, polychaetes and gastropods). Fallowing regimes can manage this impact from a longer-term perspective. • A monitoring program should measure any increases in these invertebrate species.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop				
KSD	1	1	1	Low
SBY	1	2	2	Low
ABR	1	1	1	Low
CWC	1	1	1	Low
LNE	2	3	6	Low
WSC	1	2	2	Low

Justification for Risk Ranking

Published reports of interactions between birds and sea-cage finfish culture are relatively few,

although several species are known to take fish from ponds and cages (Black 2001). The desire to control scavenger birds by various lethal means conflicts with the desire of many members of the public to conserve these birds as wildlife (Goldburg & Triplett 1997).

The method used in South Australia to control sea gull numbers on Louth Island is by 'pricking' eggs to limit their viability. This method does not require particular scientific expertise and is done on a yearly basis, using staff from the aquaculture operation. It is a cheap and efficient way to lower seagull numbers.

In conjunction with different feeds and feeding techniques, the aquaculture industry is assisting in controlling bird numbers. This activity was viewed as necessary due to the possibility of disease introduction via faecal matter from large numbers of scavengers (F. vom Berg pers. comm.).

In WA, the risk values for consequence are generally consistent across regions - that of 'minor' ('1') or 'moderate' ('2'). The likelihood of scavenger numbers being impacted ranges from 'remote' ('1') to 'unlikely' ('3'). This is based on the presence of scavengers due to other anthropogenic activities.

Comments in Relation to Future Management

- Develop EMP incorporating indicator species to measure increase in scavenger numbers under cages.
- Ensure any feeding regimes minimize any feed wastage as much as possible.

5.2.2.9 Translocation between catchments

Table 32 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			
Comments	The Department of Fisheries has policies in place to deal with the translocation of fish between regions and those fish that are considered exotic. Strict controls already exist for farmers wishing to move stock from hatcheries to grow-out cages.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop				
KSD	2	2	4	Low
SBY	3	3	9	Moderate
ABR	2	2	4	Low
CWC	1	2	2	Low
LNE	1	2	2	Low
WSC	3	3	9	Moderate

Justification for Risk Ranking

There are two main risks associated with the translocation of fish 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 fish. The possibility of the introduction of exotic plants and animals remains a risk to both the industry and the environment (De Jong and Tanner 2004).

In the 1970s, the importation into Victoria of Japanese goldfish infected with the bacteria *Aeromonas salmonicida* introduced 'goldfish ulcer disease' to cultured and wild Australian goldfish and koi carp populations. Although these species of fish are not native to Australia or farmed in sea-cages off shore, this exotic disease introduction highlights the risks associated with the translocation of animals.

Further studies revealed that this pathogen was able to infect salmonids, which could have serious consequences for the aquaculture industry.

It has been suggested that the risk of translocating native fish within their distributional range poses a greater threat than translocating exotic species because the disease would then spread to native populations that are known to be susceptible to the disease but may not have been exposed to the pathogen before. This is in comparison with the risk associated with translocating exotic fish that may be carrying an exotic disease that requires specific hosts and hence would be unable to infect the native fish.

While there have been no documented introductions of exotic animals or plants due to aquaculture in Western Australia, such introductions have been common elsewhere in the world. While the majority of such introductions occurred prior to the implementation of today's stringent protocols to prevent such occurrences, there is still a risk of similar introductions happening today. These historical introductions emphasise the importance of taking extreme care when translocating stock long distances.

Department of Fisheries translocation policies manage the importation and translocation of fish in and around Western Australia, thereby reducing the risk of exotic disease introductions. Authorizations from the Department are required for the import or translocation of fish, and a veterinarian must certify the stock. There are also national regulations restricting the translocation of animals.

Under the current policy in WA, translocation of native species is likely to represent a 'low' to 'moderate' risk depending on the region. A slightly higher risk would be associated with the inter-state translocation of barramundi for example, and it is important to maintain careful control over this process. If disease outbreaks occur in the areas these originate from, the risk could become 'high'.

Comments in Relation to Future Management

- Maintain the current protocols and approvals for all translocations.

5.2.3 Physical structures and construction, and tenure

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

5.2.3.1 Number of farms

Table 33 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? May relate to concerns regarding the total amount of area lost via alienation for other activities or from the impact on visual amenity. May require limits of the total area lost, or the number/type of structures used, the level of access still possible.*
Level of impact	Catchment / Region
Comments	• Issues need to be considered in the planning phase for farms within an area. • It is important to determine carrying capacity of a region prior to any aquaculture sites being located in it. This includes dealing with social issues (i.e. potential loss of access by recreational fishers to an area, due to the number of farms and/or perceived impact on amenity). • Industry is too small at present to provide any issues in this area – if the industry were to develop in some regions over the next few years, the matter of limitations on the number of farms in a particular area may become important.

Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop				
KSD	1	2	2	Low
SBY	2	4	8	Moderate
ABR	2	4	8	Moderate
CWC	1	3	3	Low
LNE	1	2	2	Low
WSC	1	1	1	Low

Justification for Risk Ranking

Pressures for development are different across the various 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 marine/aquatic plans for the regions.

The Abrolhos Islands Management Advisory Committee provides advice to the Minister for Fisheries on the management of the islands and requested a moratorium on any further expansion of the aquaculture industry, due to environmental concerns. A Draft Policy was put in place and this is now due for review. Consideration will be given to how the existing arrangements are working and whether there is a need to maintain the moratorium.

Shark Bay is a Marine Park managed by WA's Department of Environment and Conservation. The Management Plan may be reviewed in 2008 incorporating a reassessment of aquaculture development.

Comments in Relation to Future Management

- Aquaculture industry growth will be undertaken in consultation with government and community.

5.2.3.2 Habitat removal (for terrestrial elements)

Table 34 Removal of terrestrial vegetation due to 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
Comments	• The Department of Environment and Conservation's assessment of the extent of native vegetation loss should be considered during an assessment phase. • How much vegetation can be removed is managed under a Native Vegetation Clearance Permit by the Environmental Protection Authority (EPA). • If the removal of vegetation is over and above that approved, the EPA can act [against the construction company/aquaculture operator?] under its regulations for causing environmental harm. • Vegetation loss that occurs during construction/operation of an aquaculture site can be an issue where there is no defined access and driving/dragging of nets over dunes, etc, occurs. • Accessibility of an aquaculture site is considered when an application to carry out aquaculture is assessed. • A number of farms operating in a region could decrease the habitat removed if they shared facilities and/or access.

Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop				
KSD	2	3	6	Low
SBY	2	2	4	Low
ABR	2	2	4	Low
CWC	1	4	4	Low
LNE	0	2	0	Low
WSC	2	2	4	Low

Justification for Risk Ranking

It is widely agreed that habitat loss is one of the major causes of decreases in biodiversity. Because of this situation, 'land clearance' is a listed key threatening process under the Commonwealth's EPBC Act.

Habitat destruction and fragmentation have had severe consequences for native terrestrial flora and fauna, while removal of coastal vegetation has resulted in sand drift and erosion of dunes, due to the loss of vegetation acting as wind barriers. The removal of vegetation for any purpose, not just for sea-cage finfish aquaculture, may have dire consequences and is thus assessed by WA's Department of Environment and Conservation.

Specific scientific research on the removal of vegetation for the sea-cage finfish aquaculture industry is not required. Instead, this issue requires continual monitoring and management (De Jong and Tanner 2004).

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.

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 aquaculture facilities and/or access where possible. This possibility should be considered/done at the planning phase.

5.2.3.3 Heritage Area effects

Table 35 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
Comments	• This will be different for each region. • Many important sites are already identified in Regional Coastal Management Plans. There is a problem with people driving over the dunes to access the beach. • This issue is part of the impacts on coastal vegetation. • Many areas have been surveyed, however in remote locations the Department of Indigenous Affairs will require a Heritage Survey to be undertaken prior to construction. • To prevent wasting time, operators should research databases listing areas of heritage value prior to lodging application for the construction of facilities to determine if the proposed construction site is located in an inappropriate area. • Some of this work could be done under a broader assessment process, (community consultation), when determining areas suitable for aquaculture. • It may be difficult to get access to some potential farm sites if they are situated near national parks, even though farms are allowed offshore.

Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop				
KSD	2	4	8	Moderate
SBY	2	4	8	Moderate
ABR	1	2	2	Low
CWC	1	2	2	Low
LNE	0	1	0	Negligible
WSC	1	1	1	Low

Justification for Risk Ranking

This issue requires increased management during the planning process to ensure that heritage areas are not under threat from nearby aquaculture farms, and increased monitoring to detect any breaches. 'Moderate' risks are based on the greater existence of indigenous heritage in these areas.

The *Aboriginal Heritage Act 1972* (AH Act) and *Environmental Protection Act 1986* (EP Act) both have legal capacity to consider aspects of Aboriginal heritage. The main focus of AH Act is the protection of sites with social and heritage significant. The primary focus of the EP Act is to consider proposals that have the potential to have an environmental impact.

Comments in Relation to Future Management

- The EPA and Department of Indigenous Affairs have protocols to assess impact on heritage sites.

- Undertake consultation with indigenous communities during preliminary planning phase.
- Continue to use EPA Guidance Statement No. 41 Draft – *"Assessment of Aboriginal Heritage"*.

5.2.3.4 Navigation

Table 36 Navigational hazards within region

Description (Fletcher *et al*. 2004)	*Will the structures constructed for all facilities pose a navigational hazard or benefit for the region? Are there any requirements for all facilities to comply with in this region?*
Level of impact	Catchment/Region
Comments	All aquaculture licences are required to have marking and lighting positioned once infrastructures is placed in the water – this is stated in license conditions. Compliance officers run regular checks to ensure navigational hazards caused by non-functional lighting is avoided. Department of Planning and Infrastructure (Marine Safety) maps the locations of all navigational aids and all aquaculture operators must notify the department when lights or markers are installed. In areas of heavy shipping or boating traffic, permanent markers will be required. Positioning of aquaculture sites will require consultation by the Department of Planning and Infrastructure during Ministerial Policy Guideline No. 8 assessment to minimise creating new navigational hazards for ships and placement of infrastructure in channels.

Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop				
KSD	1	1	1	Low
SBY	1	2	2	Low
ABR	1	1	1	Low
CWC	1	2	2	Low
LNE	1	1	1	Low
WSC	1	2	2	Low

Justification for Risk Ranking

The Department of Fisheries works closely with the Department of Planning and Infrastructure (Marine Safety) to ensure that as each aquaculture application is received, it is assessed against known navigational channel, boating and shipping movements. If approved, all sites are required to install appropriate lighting and marking, and maintain it in a good working order as recommended by the DPI.

This protocol works well and has ensured that there have been no issues regarding interruptions to navigation. Therefore, the consequences will be 'minor' ('1'), with likelihoods either 'remote' ('1') or 'rare' ('2') depending on the level of any users within the region. As aquaculture increases, along with other activities, this figure will need to be reconsidered.

Comments in Relation to Future Management

- Maintain the license conditions which require installation of appropriate marking and lighting.
- Ensure all lights are maintained in a good working order.
- Consider any impacts from inappropriate location of larger sites in areas of heavy traffic.

- Ensure use of appropriate and suitable anchorages.
- Apparatus for species and site must be chosen taking into consideration the oceanographic conditions.

5.2.3.5 Infrastructure

Table 37 Constraints from current infrastructure

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
Comments	• In areas such as Shark Bay and King Sound there may be restrictions on the amount of land available to construct further infrastructure, due to loss of vegetation, heritage areas or retention of wilderness areas. • Industry is so small that encouraging local or state government to provide additional roads, power, etc, may be difficult. • If industry were to grow to the extent that the provision of infrastructure was economic, the main constraint would be removed. • Not having additional infrastructure may limit growth of individual players, as they need to commit more funds into providing wharves, access roads, etc, rather than buying hatchlings or apparatus. • Benefit also to managing where roads are located – this leads to shared facilities rather than separate and uncoordinated facilities.

Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop				
KSD	1	4	4	Low
SBY	2	2	4	Low
ABR	2	3	6	Low
CWC	1	2	2	Low
LNE	1	1	1	Low
WSC	2	3	6	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 regions such as King Sound and the Abrolhos Islands, the provision of this infrastructure is dependant on cost, much of which will be borne by the proponent. Future planning for infrastructure should include any requirements for aquaculture.

The risk ranking is 'low' due to the currently small aquaculture industry, but any growth in areas such as the Pilbara, Kimberley and South Coast may increase this to 'moderate'.

Comments in Relation to Future Management

- Work together with local government 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.
- Continue to use EPA Guidance Statement No. 3 *"Separation Distance between Industrial and Sensitive Land Uses"* (2005). This deals with the seafood processing activities that are associated with marine-based finfish aquaculture.

5.2.3.6 Noise

Table 38 Regional increases in noise

Description (Fletcher *et al*. 2004)	*Are there any regional implications regarding noise that need to be considered?*
Level of impact	Catchment/Region
Comments	Noise would not be an issue for the marine component but there may be some issues resulting from land-based operations. This is more a local level issue. There would be some noise from boats accessing cages during feeding, etc, – whether this will impact on migration or movement of certain marine species is unknown. The use of generators, forklifts, air conditioners, truck movements, etc, may be an issue for terrestrial facilities, more so if one is located close to residential development. Industry is small enough to consider this not an issue at present.

Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop				
KSD	0	1	0	Negligible
SBY	0	3	0	Negligible
ABR	0	2	0	Negligible
CWC	0	1	0	Negligible
LNE	0	1	0	Negligible
WSC	0	1	0	Negligible

Justification for Risk Ranking

Sea-cages are marine-based and any noise is likely to be caused by boating activities during feeding and harvesting or net changeover. These sounds may be detected by various mammals, such as dugongs (Shark Bay) and whales (Abrolhos Islands) but any impacts will be short-term and far less than the level of potential disturbance which could be caused by seismic activity, for example.

As a result, the consequences will be ‘negligible’, with the likelihood ranging from ‘remote’ (‘1’) to ‘unlikely’ (‘3’) depending on the region.

Comments in Relation to Future Management

- Consider any noise issues when planning a location for jointly-used facilities.
- Monitor the impacts on marine species in regard to noise if it becomes apparent that interference is occurring.

5.2.3.7 Site constraints (e.g. waves, current)

Table 23 Regional constraints to placement of facilities

Description (Fletcher *et al*. 2004)	*Does the region have particular constraints (e.g. wave height, strength etc) that make it more or less suitable for the facilities proposed?*
Level of impact	Catchment/Region
Comments	This issue is fundamental to the selection of the site. It is an initial consideration to be dealt with during site selection. Most finfish species require a current of between one to two knots to maintain flushing through cages and ensure healthy fish. This can limit the location chosen. This also ensures suitable flushing of any detritus that may fall to the seabed – and assists in assimilating this into the environment by dispersion. More offshore sites can be utilised, but this would require the use of more robust cage structures – and anchors. It is necessary to consider the usual wave and wind direction of the majority of storms. Most cages are sited in bays or in the lee of islands for protection.

Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop				
KSD	2	4	8	Moderate
SBY	3	4	12	Moderate
ABR	2	3	6	Low
CWC	1	3	3	Low
LNE	1	2	2	Low
WSC	3	4	12	Moderate

Justification for Risk Ranking

In WA there are many agencies that have undertaken marine research for policy and planning activities. Some regionally-specific studies have been undertaken during the drafting of the Department of Fisheries' aquaculture development plans. Studies carried out by the former WA Department of Conservation and Land Management (CALM) for marine planning processes are also available.

The Department of Environment and Conservation has completed regional assessments for areas such as Cockburn Sound and the Pilbara coast. The Department of Industry and Resources, as well as numerous industry bodies, have considered oceanographic studies as part of the planning processes for large-scale proposals.

Using these data - and others as they become available - will assist proponents in understanding the constraints to development in the marine environment. The National Oceans Office will have commenced Regional Marine Planning in WA shortly, which will provide additional expertise and funding for research.

In light of this work, but understanding the knowledge gaps for some of the regions, the consequences are 'minor' ('1') to 'severe' ('3'), with likelihoods of 'possible' ('4') to 'rare' ('2').

Comments in Relation to Future Management

- Ensure site selection processes are completed during the application process and backed-up by data to show oceanographic conditions are suitable for cage aquaculture.
- Maintain current protocols for application assessment.

- Monitoring of the site will determine whether currents are adequate to provide flushing through and under aquaculture structures.

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 individual operations.

5.2.4.1 Regional carrying capacity

Table 40 Regional carrying capacity

Description (Fletcher *et al*. 2004)	*Is a maximum level of stocking for all individuals within the catchment/ region needed – e.g. to avoid any stunting of growth, increased disease risk etc?*
Level of impact	Catchment/Region
Comments	• No work has been done to determine carrying capacities in WA. • In South Australia, models are used to determine stocking limits, depending on the carrying capacity and expected 'inputs' of sites. • Nutrients, sedimentation and wastes are a potential issue when high stocking rates occur. • Need to consider all finfish aquaculture that occurs within a bay, not just those of a single species. • Tonnages produced by aquaculture in a particular area could be capped in the future when industry grows. • A review of the risk will be required when the current farms increase production. • Current production levels are low, so no impact from aquaculture is expected. However some areas used for aquaculture have other [industrial/environmental] 'inputs' into the region that need to be considered when calculating total inputs into the system. • Link site environmental monitoring programs to regional reporting. • A maximum stocking density should be set on a licensed site – i.e. 30 kilograms per cubic metre. • It must be ensured that the maximum biomass of a permitted species does not exceed the maximum allowed tonnage across all species.

Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop				
KSD	1	3	3	Low
SBY	2	4	8	Moderate
ABR	2	2	4	Low
CWC	1	2	2	Low
LNE	3	4	12	Moderate
WSC	1	2	2	Low

Justification for Risk Ranking

The productivity and state of a site or region may be affected if sea-cages are overstocked or if there are too many sea-cages in an area. If fish production levels are too high, then excessive amounts of nutrients, in the form of waste and uneaten feed, will enter the surrounding environment. This may result in an increase in primary production, eventually leading to eutrophication and algal blooms.

In its simplest definition, the carrying capacity is the maximum level of fish production that is sustainable for a given region or site, which depends on the environment's capacity to assimilate

increased nutrient inputs.

With the increasing emphasis on ecologically sustainable development, the carrying capacity of a region is more commonly defined in terms of the maximum level of fish production that does not cause significant changes in the ecosystem. The most widely accepted indicator of ecosystem change used to calculate carrying capacities is water quality. In South Australia, carrying capacities are calculated by determining the maximum level of fish production possible without exceeding the recommended water quality guidelines for a region (De Jong and Tanner 2004).

The carrying capacity for the production of sea-cage finfish can be estimated using a mass balance model. This model is based on the assumption that the concentration of a nutrient in an area is determined by the nutrient loading. The carrying capacity of a region is calculated from the difference between the initial nutrient values of the body of water prior to use (by aquaculture) and the final nutrient levels after use.

A maximum allowable nutrient level (dissolved inorganic nitrogen) is set for the model based on the 1992 Australian and New Zealand Environment and Conservation Council water quality guidelines for embayments and coastal regions. In addition, the model can be run a second time using maximum phytoplankton (as chlorophyll *a*) levels recommended by the ANZECC (1992) guidelines. The model is conservative in that when calculating the carrying capacity based on either species of nitrogen, it has been assumed that all waste nitrogen was released as that species.

Several factors including nutrient loading, the volume of the region, the nitrogen content of the fish food, the feed conversion rate (FCR), the flushing rate and the fraction of nutrients lost to the sediments are taken into consideration in the mass balance model. Using these factors the final nutrient levels in the water column after aquaculture production can be estimated from the nutrient loadings entering the system. From this, the tonnage of fish that would produce the maximum allowable nutrient levels can be calculated.

The limiting factor with the use of these models is that they are calculated using either generic values or values for only one species of fish for the FCR and feed nitrogen content. If a wet diet consisting of baitfish is used then they suggest that the carrying capacity would be substantially lower.

The differences in these values may result in different carrying capacity values. In addition, the problem with this model is that it does not account for different species of fish, with different FCR and feed content, being cultured in the same region. The carrying capacity needs to be constantly reassessed with the changing composition of farmed species and as new information and data becomes available.

A FRDC / PIRSA Aquaculture project will refine and validate the carrying capacity models.

The model may prove useful in WA for determining carrying capacities once the industry indicates preferred locations for growth. The ‘moderate’ ranking for the risk associated with carrying capacity is reasonable, based on a likelihood of ‘rare’ (‘2’) and the consequence of ‘moderate’ (‘2’). This risk can be mitigated by taking a staged approach to increasing stocking levels, and using the carrying capacity models discussed above in an adaptive management framework to first predict the likely change in the environment with any given increase, and then to validate and refine the model.

Comments in Relation to Future Management

- Those involved in regional planning should consider all users that 'input' into waters.
- Assessments should determine the expected nutrient 'input' from aquaculture operations into the marine environment.
- Before aquaculture industry is allowed to grow in a particular region, a maximum tonnage and maximum nutrient 'inputs' for this region should have first been determined.
- The measurement of nutrient 'inputs' should be made part of the environmental monitoring program for an aquaculture site and its outputs linked to regional reporting for Ecosystem-based Fisheries Management Plans.
- Water quality guidelines should be met at an aquaculture license boundary. This will prevent any cumulative regional impacts.

5.2.4.2 Disease (e.g. proximity of facilities, translocation policy)

Table 41 Disease protocols for region

Description (Fletcher *et al*. 2004)	*What protocols (if any) are needed within the region to minimize 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
Comments	• Transmission of disease between farms can be limited by maintaining the 5 km buffer between sites – a bigger buffer would be preferable. • It is necessary to consider that diseases could be transmitted between cages and sites by wild stock. • Using sites with suitable currents for flushing should limit the occurrence of diseases in the first place. • Translocation of stock between regions is managed through policies. • The use of chemicals needs to be closely managed through authorization to ensure use on one site does not impact on others.

Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop				
KSD	0	1	0	Negligible
SBY	1	2	2	Low
ABR	0	1	0	Negligible
CWC	0	1	0	Negligible
LNE	1	3	3	Low
WSC	1	1	1	Low

Justification for Risk Ranking

This issue is covered in more detail in 1.2.2 and 1.3.1. The current protocols regarding siting and assessment should minimize the risk here.

Comments in Relation to Future Management

- Maintain the current translocation policies.
- Develop policies regarding distances between sites to allow for disease management, amongst other things such as use of chemicals.

5.2.4.3 Disposal of processing waste

Table 42 Disposal of processing/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
Comments	Some processing may occur in the water, depending on each sites' operations. Dumping of any viscera and offal in the water is prohibited under the *Fish Resources Management Regulations 1995* (FRMR) and managed by licence conditions. All waste materials are brought back to shore and disposed of in approved facilities. This is a requirement of local government health regulations. A heavy dumping rate of offal can have local impacts such as aesthetics and attract the attention of scavengers, which in the case of sharks and crocodiles may be a significant risk.

Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop				
KSD	2	1	2	Low
SBY	3	1	3	Low
ABR	2	1	2	Low
CWC	1	1	1	Low
LNE	3	1	3	Low
WSC	1	1	1	Low

Justification for Risk Ranking

The Department of Fisheries manages the disposal of fish processing waste through the FRMR 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 be 'minor' ('1') to 'severe' ('3') depending on the region.

The consequences in Shark Bay are higher, due to the limited flushing that occurs within the bay. The consequences in the Leeuwin – Naturaliste region are higher because of other users already discharging wastes into the water and the likelihood of exceeding any regional carrying capacity. The other regions have much greater flushing rates and any discharges would be dispersed relatively quickly.

Comments in Relation to Future Management

- Maintain license condition prohibiting any dumping of viscera and offal in water – all waste to be disposed of in land-based facilities.
- Guidelines for any processing of sea and offal disposal need to be developed – include this in a Code of Practice.
- There should be no disposal of waste close to areas used for recreational purposes.

5.2.4.4 Disposal of unusable product

Table 43 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			
Comments	No wastes are to be dumped in the sea – all unmarketable product is currently disposed of in land-based facilities. This is a requirement of local government health regulations. Usually local government facilities are adequate, but in some cases disposal may be difficult or expensive to resolve. The example of the local problem at Lake Argyle is well-known.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop				
KSD	1	1	1	Low
SBY	1	1	1	Low
ABR	1	1	1	Low
CWC	1	1	1	Low
LNE	1	1	1	Low
WSC	1	1	1	Low

Justification for Risk Ranking

The WA finfish aquaculture sector is small at present and produces low levels of unusable product. Any unusable product is likely to be as a result of disease. Good management practices should ensure that any dead fish are collected from the cages on a daily or weekly basis. These dead fish are required under Local Government health regulations to be disposed of in land-based facilities, in a similar manner to processing wastes.

Abiding by current regulations and conditions means the risk from this issue is 'low'.

Comments in Relation to Future Management

- Maintain current protocols on disposal in land-based facilities that are managed by local government councils.
- Arrangements with local government for normal and worst-case disposal requirements should be agreed in advance of them being required, i.e. each facility should be required to have an agreed worst-case disposal arrangement. If waste disposal at each facility is properly provided for, regional issues in this operational area should not arise.

5.3 Impacts of Individual Facilities on Environmental Wellbeing

These are the potential topics that relate to what an operator (and any consenting authority) needs to consider for assessing the environmental issues related to the development of a specific 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 have not been developed due to the nature of individual facilities and the difficulty in assessing risk in this context. More detail will be provided in the Management Report.

5.3.1 Site Selection/Construction/Infrastructure

This branch covers 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

Table 44 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. 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			
Comments	• Marine aquaculture still needs to utilize land-based sites for storage of feeds, cage construction and any processing sheds. • The best way would be to consider the provision of "Aquaculture Parks" to minimize impact on terrestrial habitats by the sharing of facilities. • If operations require separate land-based facilities, they should be located in areas where the least damage results. • There should be a determination of whether the number of facilities in the region has reached the upper limit of allowable loss of habitat (if this habitat is 'sensitive'). • Environmentally-sensitive areas such as corals, seagrass, and mangroves should not be part of lease areas and therefore the issue will be insignificant.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	1	2	2	Low

Comments in Relation to Future Management

- Site selection guidelines should exclude sensitive areas.
- Areas available for lease should be strategically determined (excluding sensitive areas).
- Guidance Statement No. 29 *"Benthic Primary Producer Habitat Protection for WA Marine Environments"* should continue to be used.

5.3.1.2 Shading

Table 45 Effects of any shading due to facility

Description (Fletcher *et al*. 2004)	*Will the construction of the facilities result in the shading of some areas (e.g. seagrass from cages/racks etc)?*			
Level of impact	Individual facility			
Comments	• This is not an issue if sensitive areas are excluded from possible aquaculture. • Department of Fisheries policy is to avoid seagrass/coral habitats for the placement of any aquaculture structures. • In regions where it is agreed that finfish cages can be placed over these habitats, more rigorous Environmental Monitoring Programs will be developed.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	1	2	2	Low

Comments in Relation to Future Management

- This will be an ongoing issue.
- Sensitive areas should be excluded from available license/lease areas.
- More rigorous EMP will be required in locations where the shading of sensitive habitats may occur.
- The use of Guidance Statement No. 29 – *"Benthic Primary Producer Habitat Protection for WA Marine Environment"* should be continued.

5.3.1.3 Rehabilitation

Table 46 Site rehabilitation

Description (Fletcher *et al*. 2004)	*Do processes have to be planned to rehabilitate the site if production is ended?*			
Level of impact	Individual facility			
Comments	• The Department of Fisheries is re-assessing its policy to allow for the calling of a 'bond' to cover cost of rehabilitation – linked to a 'lease'. • A bond has previously been imposed but this may not be the most appropriate (or legal) way. • This bond has been applied inconsistently across finfish aquaculture licences at present.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	1	3	3	Low

Comments in Relation to Future Management

- Finalize the process and method for requiring and managing a fee to cover the cost of site rehabilitation. Legal opinion is required.

5.3.1.4 Noise

Table 47 Noise resulting from facility

Description (Fletcher et al. 2004)	*Will construction of the facility result in an unacceptable increase in noise and dust to surrounding areas?*			
Level of impact	Individual facility			
Comments	This is unlikely to be a concern.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	1	2	2	Low

Comments in Relation to Future Management

- License locations in close proximity to noise sensitive areas should be prevented from occurring.
- Noise Regulations apply under the *Environmental Protection Act 1986*.

5.3.1.5 Infrastructure

Table 48 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			
Comments	• If possible, promote the areas for aquaculture that provide suitable infrastructure that can be utilized by more than one operator. • Areas where aquaculture could be sited are very few despite the size of WA. The ability to provide these services 'as and when required' will be difficult. Local government will need assistance in this regard. • The Department of Fisheries is encouraging the use of 'aquaculture parks' which will assist in resolving this issue.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	1	6	6	Low

Comments in Relation to Future Management

- Continue to consider the need for new aquaculture parks, when new areas are opened for aquaculture.
- Discuss the potential aquaculture options with local government during regional planning activities – where the most appropriate future locations for aquaculture are located.

5.3.1.6 Water Flow

Table 49 Regional water flows

Description (Fletcher *et al*. 2004)	*Will the construction of this facility interrupt water flow within the region (may need reference to the whole of catchment level assessment)?*			
Level of impact	Individual facility			
Comments	Unlikely to be an issue for sea-cage finfish – land-based activities will be small and can be located to avoid these types of impacts.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	0	1	0	Negligible

Comments in Relation to Future Management

- Continue to undertake application assessment involving local and state government.
- Department of Water legislation *Rights in Water and Irrigation Act 1914.*
- Facilities at aquaculture sites should avoid water courses.

5.3.1.7 Navigation

Table 50 Navigational hazards

Description (Fletcher *et al*. 2004)	*Will the structures pose a navigational hazard or benefit (may need reference to the whole of catchment level assessment)?*			
Level of impact	Individual facility			
Comments	• Department of Planning and Infrastructure (Marine Safety) should comment on any application for new aquaculture facilities, to ensure placement does not interrupt use of navigable waters. • All aquaculture sites have a licence condition that requires placement of marking and lighting (to a required standard) once infrastructure is placed in the water – and to advise the DPI about this placement. • Discussions are held during Ministerial Policy Guideline No. 8 assessment on the broader implications of future increases of development in the region. • In remote areas, the lighting could be a benefit to recreational boat users during a storm.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	4	3	12	Moderate

Comments in Relation to Future Management

- This could be an ongoing issue.
- Maintain current protocols and processes requiring the placement of navigational aids.

5.3.1.8 Alienation – interaction with other uses

Table 51 Alienation of other groups

Description (Fletcher *et al*. 2004)	*Will the construction of the facilities alienate other groups (e.g. indigenous, recreational and commercial fishers, boat owners) from using an area that they previously had access to?*			
Level of impact	Individual facility			
Comments	• Ministerial Policy Guideline No. 8 assessment process identifies other users of the area and ensures consultation takes place with them – seeks to avoid conflicts. • Regional planning activities should identify any potential future uses of areas for aquaculture.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	1	3	3	Low

Comments in Relation to Future Management

- Maintain assessment and consultation processes as stated in Ministerial Policy Guideline No. 8.
- Undertake socio-economic assessments of areas once aquaculture industry increases in size, or if issues arise.
- Continue to participate in the development of local government planning strategies, where possible.
- The Environmental Protection Authority will continue to have assessment role if proposal is large.

5.3.1.9 Proximity to sensitive fauna / habitat

Table 52 Proximity to sensitive habitats

Description (Fletcher *et al*. 2004)	*Is the proposed facility close to an area where there are sensitive fauna, habitat or other regions of particular value?*			
Level of impact	Individual facility			
Comments	• Buffer distances should be set according to type of habitat, oceanographic conditions, species being farmed, and maximum stocking densities. • A consistent distance between seagrass and coral communities and finfish aquaculture is required. • When setting buffer distances, the data coming out of the Environmental Monitoring Programs should be considered and the distances altered if required.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	2	4	8	Moderate

Comments in Relation to Future Management

- Maintain the current protocols.
- Determine suitable future buffer distances, in accordance with EMP results.

5.3.1.10 Proximity to other farms

Table 53 Proximity to other farms

Description (Fletcher *et al*. 2004)	*How close is the facility to other aquaculture farms?*			
Level of impact	Individual facility			
Comments	• This should be assessed during application processing. • A compromise is required between limiting any alienation of waters with ensuring that any disease transferral or environmental impacts are minimised. • This would be more critical if stocking densities were high. • Farms that are too close together may impact on migration of certain marine species.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	2	2	4	Low

Comments in Relation to Future Management

- Maintain the current assessment processes and protocols.

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 54 Health of cultivated stock

Description (Fletcher *et al*. 2004)	*Is a health surveillance monitoring system needed?*			
Level of impact	Individual facility			
Comments	• This is a management activity that it would be in the best interests of farmers to operate under. • It is a requirement of the *Fish Resources Management Act 1994* (FRMA) for aquaculture licensees to notify the Department of Fisheries of any fish health issues – a surveillance system is needed to ensure that this happens. • Industry could assist operators by developing an agreed, common system for detecting any breaches.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	1	2	2	Low

Comments in Relation to Future Management

- Maintain the current protocols under FRMA and the *Fish Resources Management Regulations 1995* (s69) requiring notification and action by a license holder of any disease.

Table 55 Stocking density / biomass

Description (Fletcher *et al*. 2004)	*Are there are issues regarding the proposed stocking densities for the farm? Could they result in discharge concerns?*			
Level of impact	Individual facility			
Comments	This relates to waste discharge levels, e.g. nutrients and sediments.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	1	2	2	Low

Comments in Relation to Future Management

- Stocking rate/waste generation guidelines are needed to enable a decision on acceptable nutrient loads to be made, so as to ensure water quality criteria are met at the boundary of the license area.

Table 56 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 facility?*			
Level of impact	Individual facility			
Comments	• The Minister has not authorised any regulations with respect to fish welfare, so essentially there are no standards or enforceable laws. • It should be ensured that all licence holders are aware of their obligations under this legislation.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	0	1	0	Negligible

Comments in Relation to Future Management

- Maintain the current protocols and legislation.
- It should be ensured that compliance officers check this as part of their ongoing activities.

Table 57 Predation

Description (Fletcher *et al*. 2004)	*Are predators (e.g. birds, seals, sharks) a problem around this facility? If these predators are protected species, this may result in different actions being necessary.*
Level of impact	Individual facility
Comments	• This issue relates very closely to the feed management practices that are being used in each facility. • Pellet feeds do not attract predator species as much as the use of pilchards does. • Farm practices should require the removal of any dead fish each day. • Acoustic Deterrent Devices are not currently utilised in WA – these could assist in limiting interactions with predators.

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

Comments in Relation to Future Management

- Industry Code of Practice should set guidelines for feed provision to minimize any attraction of predators.
- The Code of Practice to outline measures to limit interactions between predators and farm stocks.

5.3.2.2 Use

Table 58 Visual impact

Description (Fletcher *et al*. 2004)	*Does the facility need to meet any visual impact limitations?*
Level of impact	Individual facility
Comments	• The dominant issue may be the management and disposal of wastes, including plastics, paper and equipment. • The use of an appropriate colour for the infrastructure should be investigated.

Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	0	3	0	Negligible

Comments in Relation to Future Management

- Continue to rely on local government by-laws for waste management.
- Maintain the current licensing conditions in regard to waste management, i.e. general rubbish.

Table 59 Energy

Description (Fletcher *et al*. 2004)	*What is the energy consumption for the facility and what is the energy efficiency rating?*
Level of impact	Individual facility
Comments	• The use of alternative power sources in remote locations could be encouraged by the Department of Fisheries. This would minimize the need for additional power infrastructure. • Power is used for water pumps, lighting, cooling. • Operators utilising a barge will use a generator. It is imperative that water flow is maintained.

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

Comments in Relation to Future Management

- Encourage the use of alternative power sources through a Code of Practice.

Table 60 Noise

Description (Fletcher *et al*. 2004)	*Does the operation of the facility include noisy machinery (e.g. pumps) or devices (e.g. bird scarers)? Would such activities affect neighbours or sensitive fauna?*			
Level of impact	Individual facility			
Comments	Compliance with noise regulations is required during construction and ongoing operation (for the terrestrial component). The criteria for site location near noise-sensitive areas should prevent this from being a problem (for the marine component).			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	2	3	6	Low

Comments in Relation to Future Management

- Site selection guidelines should ensure that areas in close proximity to noise-sensitive areas are excluded from usage.
- Noise regulations under the Environment Protection Act should be observed.

Table 61 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			
Comments	Should be dealt with at a 'whole of industry' level – then only need to ensure that each operator maintains/implements the required standards. These should be set out in the Code of Practice.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	1	4	4	Low

Comments in Relation to Future Management

- Develop a Code of Practice to provide guidelines on an appropriate farm design and operational practices to minimize any risks.

Table 62 Habitat Effects

Description (Fletcher *et al*. 2004)	*Will operations of the facility continue to impact on habitat (e.g. trampling around leases, smothering of habitat, impacts on sensitive habitat)? May need reference to whole of catchment objectives.*			
Level of impact	Individual facility			
Comments during workshop	• No change outside 'lease area'. • Accept some change inside the lease area, but change should be reversible. The Department of Environment and Conservation will assess the potential for these impacts at the application stage. • No change outside of the 'buffer' area. • Any impacts to surrounding habitats (including habitat under cages) will be monitored under a Environmental Monitoring Program. • A fallowing regime should be instigated to ensure any impacts (deposits) on the seabed directly underneath the cages are being assimilated.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
During workshop	2	2	4	Low

Comments in Relation to Future Management

Site selection guidelines will prevent these problems occurring.

- The Department of Environment and Conservation (DEC) will continue to assess each proposal when sites over significant sensitive habitats, or in Marine Parks.
- The DEC should ensure an industry-wide Environmental Monitoring Program deals with the monitoring of habitat in and around site.

Table 63 Chemical theraputants

Description (Fletcher *et al*. 2004)	*Are these used? If so what protocols are needed? Reference may be needed to 'whole of industry' protocols.*			
Level of impact	Individual facility			
Comments	• Environmental implications of chemical and medicine usage need to be assessed. • Data on type, amount, frequency and toxicity of chemicals is needed to complete this element. • Concentrations or any known or likely impacts must be contained within the lease area (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

- Requires further data and refinement.
- Techniques for isolated parasitic dosing should be developed, rather than in-pen dosing.
- No impacts outside lease area are a requirement outcome of management actions.

Table 64 Entanglement interactions

Description (Fletcher *et al*. 2004)	*Could the structures result in entanglement of whales or other large/ protected species? Reference may be needed to refer to 'whole of industry' protocols.*			
Level of impact	Individual facility			
Comments	• Information of the routes used by migratory whales is being constantly improved, as research continues. • 'Pingers' are available to 'identify' aquaculture structures, should the occurrences increase as the industry grows. • Damage caused by these creatures can be substantial, so it is in best interest of the industry to minimize these interactions. • Entanglements of whales and other large/protected species may be linked to the number of farms within an area if the formers' migration routes traverse through this area.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	3	1	3	Low

Comments in Relation to Future Management

- Maintain the current protocols.
- Ensure all aquaculture license holders notify the Department of Fisheries and the Department of Environment and Conservation of any interactions between aquaculture infrastructure and marine species.

Table 65 Land-based use of water

Description (Fletcher *et al*. 2004)	*Does the facility need to use water that is in limited supply? Reference may be needed to catchment level limits.*
Level of impact	Individual facility
Comments	• Certain regions may have stricter controls of use of water – needs to be considered on a case-by-case basis. • Land-based facilities for marine-based aquaculture would be mainly for storage of feeds and equipment, equipment wash-down, etc. • The Department of Water may have some requirement for determining maximum allowable water use. • Use of bore water could be more appropriate in certain locations – would then need to consider the draw-down on any bores used and impacts on groundwater tables. • Facilities need to be licensed to extract water from bores.

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

Comments in Relation to Future Management

- Check for any protocols the Department of Water may require in future.
- Maintain the current assessment protocols.
- The Department of Water's *Rights in Water and Irrigation Act 1914.*

Table 66 Lights

Description (Fletcher *et al*. 2004)	*Will the use of lights impact on sensitive species? Reference may be needed to 'whole of industry' protocols.*
Level of impact	Individual facility
Comments	• This is unlikely to be an issue for a marine-based facility. • Sites are required by legislation to show marking and lighting to ensure marine safety (navigation). • Lights are mainly flashing.

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

Comments in Relation to Future Management

- Maintain assessment of facility operations on adjacent users and sensitive species.
- Light can be regulated via Section 49 of the *Environmental Protection Act* as an 'unreasonable emission' of electromagnetic radiation if required.

Table 67 Gear and equipment movement

Description (Fletcher *et al*. 2004)	*Will the movement of equipment between farms result in the need for translocation protocols? Reference may be needed to 'whole of industry' protocols.*
Level of impact	Individual facility
Comments	• Movement of equipment between regions should be dealt with through a Code of Practice with an industry-wide perspective. • All equipment should be washed and disinfected prior to any movement. • Farmers may have aquaculture licenses in different regions and wish to move equipment between them on a regular basis. It is necessary to set-up protocols to enable this activity and manage any translocation of pests/parasites, etc.

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

Comments in Relation to Future Management

- Develop protocols to manage equipment movements while minimizing translocation issues.
- Develop industry-wide Code of Practice for the movement of equipment between each region.

5.3.2.3 Waste

Table 68 Water quality

Description (Fletcher *et al*. 2004)	*Is the quality of the water used by the facility acceptable for release into the environment, freshwater or marine? Required levels should relate to 'whole of industry' levels.*			
Level of impact	Individual facility			
Comments	• Water quality guidelines must be met outside mixing zone or lease boundary. • No water 'discharged' in marine facilities. • Discharge from land-based facility needs to be appropriately managed.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	2	3	6	Low

Comments in Relation to Future Management

- Water quality guidelines/criteria must be met outside the license boundary or the edge of mixing zone.
- Guidelines for appropriate waste disposal should apply to whole industry. Direct discharges of high nutrient and particulate wastes should be discouraged.
- Avoid discharges close to sensitive habitats or recreational areas.

Table 69 Sedimentation

Description (Fletcher *et al*. 2004)	*Does the operation result in the sedimentation of habitat or physical environment (e.g. under the cage, near an outfall)? If yes, refer to appropriate levels for the catchment.*			
Level of impact	Individual facility			
Comments	• Site selection, stocking rates and feeding rates determine nutrient loading and environmental acceptability. • Some sedimentation of pellets, etc, will occur, but must be managed on-site.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	2	3	6	Low

Comments in Relation to Future Management

- Water quality guidelines/criteria must be met outside the license boundary or the edge of mixing zone.

Table 70 Waste feed and faeces

Description (Fletcher *et al*. 2004)	*Does the quality of wastewater released from pipes/overflows or the water that passes from cages/rafts include increased/decreased levels of nutrients, waste feed or faeces? Are these within the agreed limits of the lease regulations and are these compatible with the total levels allowed for the catchment?*			
Level of impact	Individual facility			
Comments	• Water quality guidelines must be met outside mixing zone or lease boundary. • There is a need for projected figures on stocking levels, feed rates and predicted nitrogen and phosphate levels from applicants for aquaculture licences.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	2	3	6	Low

Comments in Relation to Future Management

- Water quality guidelines/criteria must be met outside license boundary or edge of mixing zone.
- Guidelines for appropriate waste treatment disposal should apply to the whole industry. Direct discharges of high nutrient and particulate wastes should be discouraged.
- Discharges should avoided being carried out close to habitats or recreational use areas.

Table 71 Fish disposal

Description (Fletcher *et al*. 2004)	*For any deaths of the cultured species, are there adequate facilities for their disposal (e.g. local dumps)?*			
Level of impact	Individual facility			
Comments	• Such disposal should be onshore and arranged in advance of any need. • Usually local government facilities are adequate, but in some cases disposal may be difficult or expensive to carry out.			
Risk assessment values				
Organisation/Person	Consequence	Likelihood	Risk Value	Risk Ranking
After workshop	1	3	3	Low

Comments in Relation to Future Management

- 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 should not arise.

Table 72 Processing

Description (Fletcher *et al*. 2004)	*Is there processing of product (particularly filleting etc) done on the facility? Is there any disposal of this waste on site?*			
Level of impact	Individual facility			
Comments	Any disposal of waste should be carried out off-site, using a licensed landfill. There is a need to have disposal protocols worked out with industry. Processing sites are individually licensed – each has separate food and health issues.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	2	3	6	Low

Comments in Relation to Future Management

- Department of Fisheries licensing manages sea-based processing for commercial fisheries.
- Guidelines for processing and disposal of waste need to be developed and incorporated into a Code of Practice.

Table 73 Sewage

Description (Fletcher *et al*. 2004)	*Does the facility have appropriate sewage treatment?*			
Level of impact	Individual facility			
Comments	• The issue will depend a lot on the activities authorized at the land-based facility. • If using joint facilities in remote locations, this could be used to provide suitable water treatment for each operator. • Many sea-cage finfish farmers only use the site for storage and may not be able to fund the provision of full water treatment – in this instance septic tanks may be the only option. These would need to comply with local government and Health Department direction.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	1	2	2	Low

Comments in Relation to Future Management

- The Department of Health deals with the regulation of septic tanks.
- Ensure the assessment of aquaculture applications deals with the management of any sewage, if appropriate.

Table 74 General rubbish

Description (Fletcher *et al*. 2004)	*Are there protocols for the management of general rubbish within the facility?*			
Level of impact	Individual facility			
Comments	• Guidelines on general rubbish disposal are required, but are essentially no different to other industries. • The *Fish Resources Management Regulations 1995* (FRMR) prohibit the deposition of any refuse or waste in any waters where fish are likely to be. • Ensure off-marine activities (i.e. feeding of pellets of frozen fish) do not result in any rubbish into the marine environment – enforce the FRMR through compliance if necessary.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	1	2	2	Low

Comments in Relation to Future Management

- The Code of Practice provides guidance on suitable methods for disposal of rubbish.

Table 75 Biofouling

Description (Fletcher *et al*. 2004)	*Is biofouling removed from structures used in the facility? If so, what happens to this material when it is cleaned off?*
Level of impact	Individual facility
Comments	• The Code of Practice should require nets are cleaned on land. In cases where marine pests are found to be biofouling organisms, this should be mandatory. • Some sea-cages are located in areas where it would be very difficult or impossible to remove them onto land to clean off any algae due to coastal geomorphology or adjacent terrestrial parks. There is a need to develop a strategy to provide an alternative arrangement. • There is a need to consider the disposal of this material in the same way as other waste material.

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

Comments in Relation to Future Management

- Develop a Code of Practice that deals with biofouling.
- Agree on appropriate methods of cleaning cages and the locations for this activity.

Table 76 Disease (e.g. proximity of facilities, translocation policy)

Description (Fletcher *et al*. 2004)	*Is there a need to consider the transmission of diseases due to the proximity of neighbouring farms? Regard may be needed for 'whole of catchment' requirements.*
Level of impact	Individual facility
Comments	• Part of an assessment consultation should consider the distance to other users. • Issues should be considered on a regional and/or 'whole of industry' level. • There is a need to determine appropriate buffers between farm sites (taking into account differing species or types) to minimise possibility of disease transmission. • Use of chemicals and residual chemicals in the water column will also influence any treatment of disease.

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

Comments in Relation to Future Management

- The Code of Practice must refer to the policies and protocols to be complied with.
- Current consultation on aquaculture applications should be maintained.

6.0 RESULTS – LAND-BASED FINFISH

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

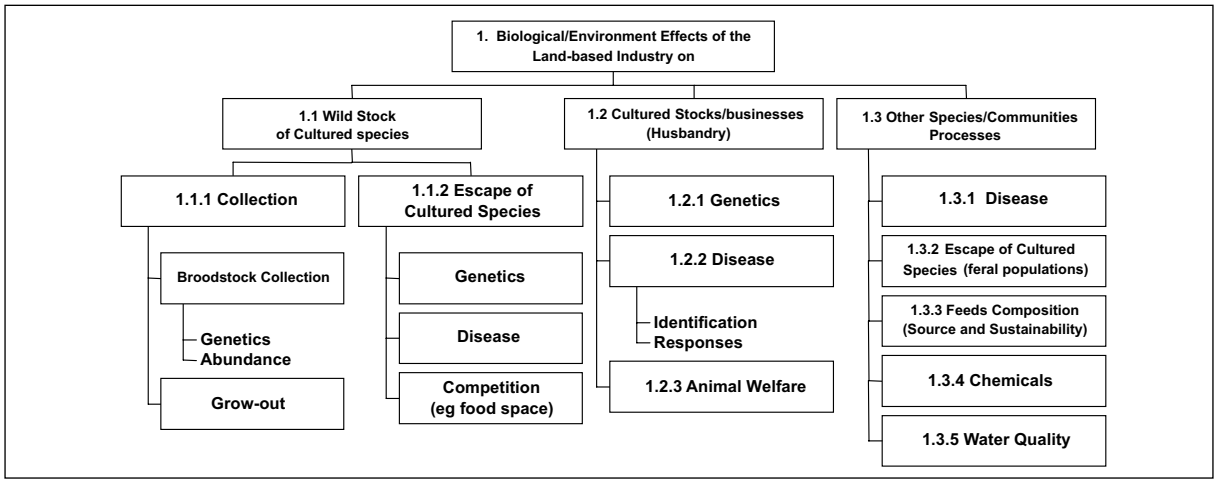


Figure 4 Component Tree 1 - Biological/Environmental Effects of the Whole Land-Based Finfish Industry (modified from Fletcher *et al*. 2004)

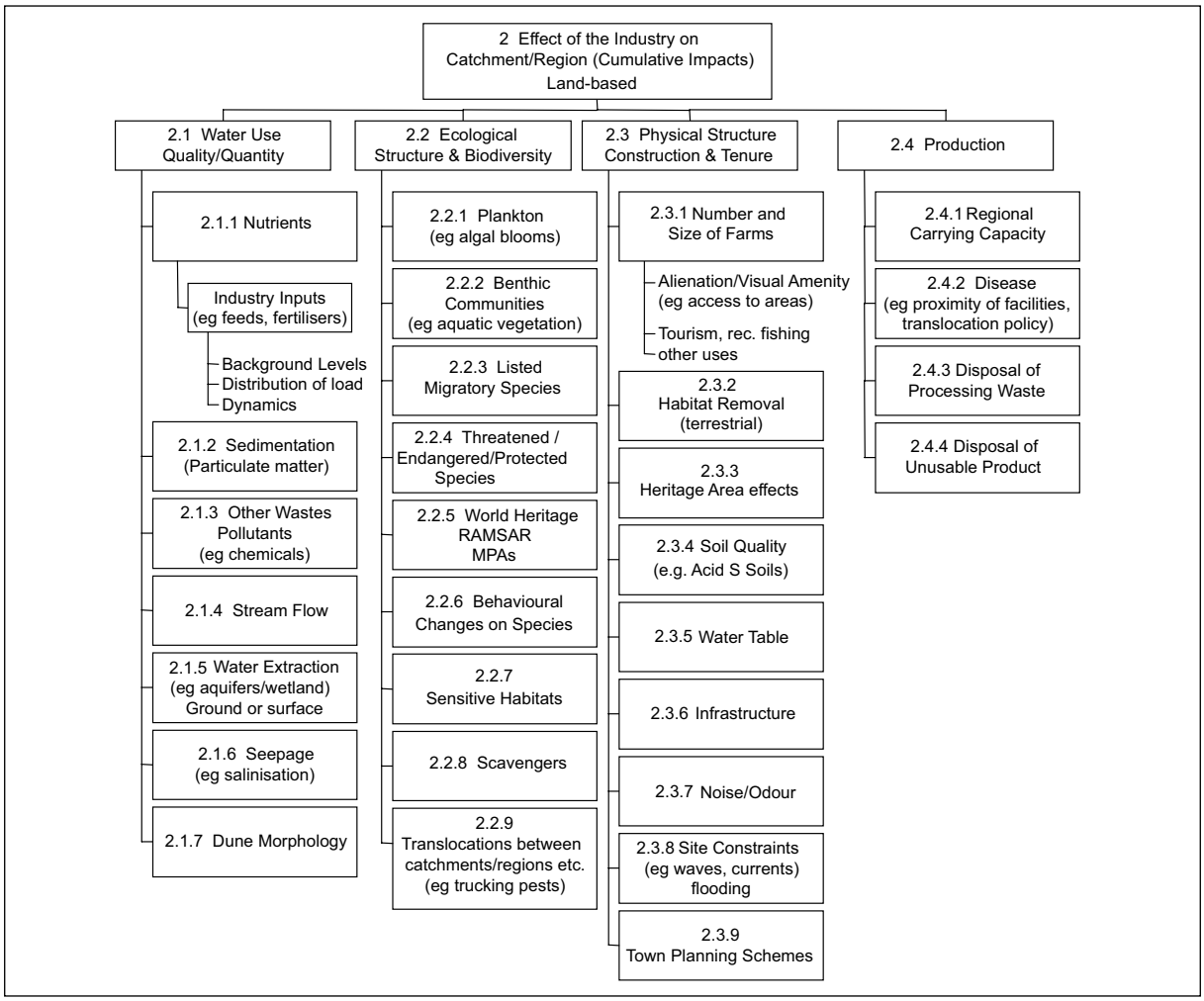


Figure 5 Component Tree 2 - Environmental Impacts of the Land-based Finfish Aquaculture Industry on the Catchment/Region (modified from Fletcher *et al.* 2004).

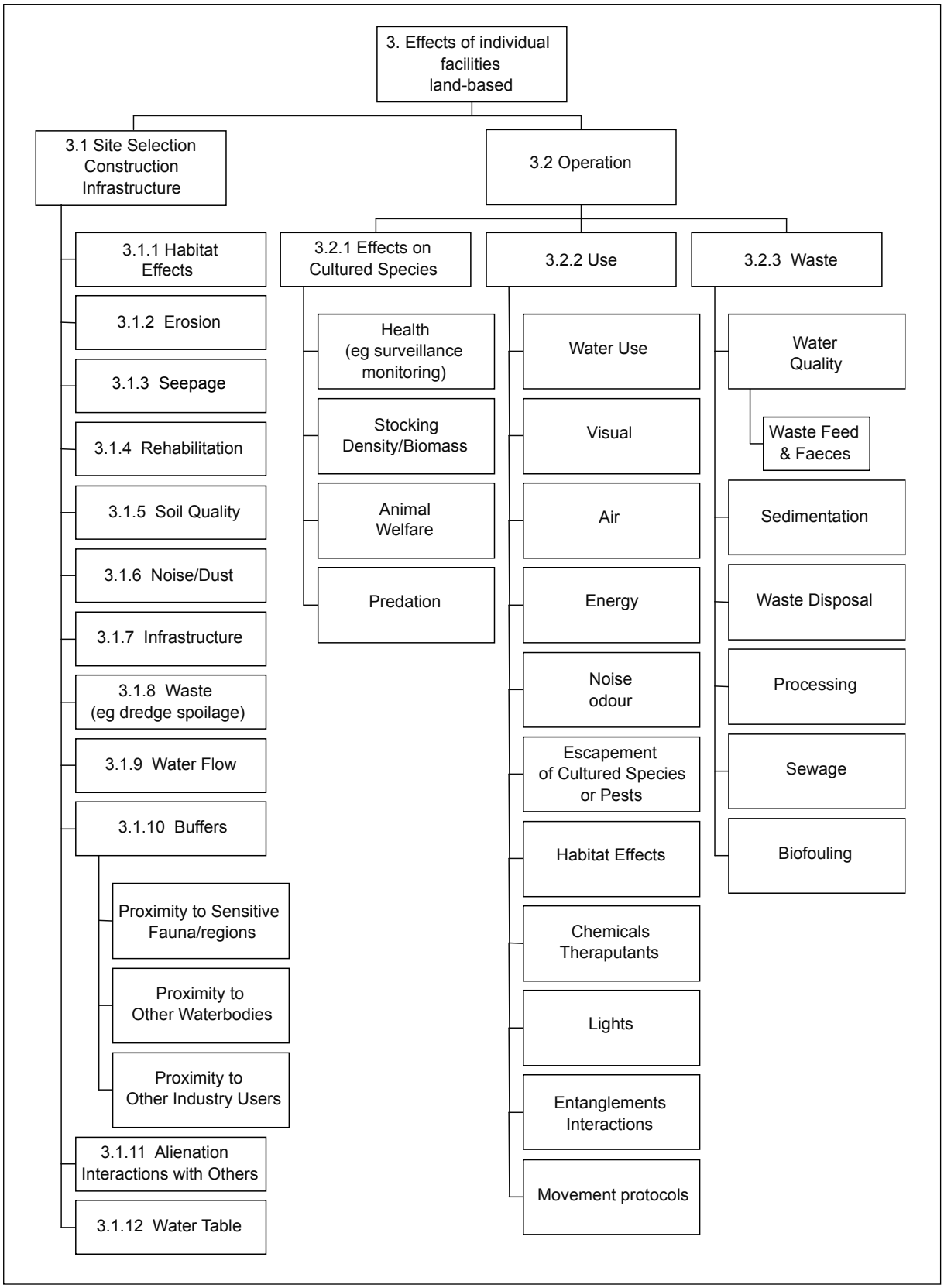


Figure 6 Component Tree 3 - Environmental Impacts of Individual Land-based Finfish Aquaculture Facilities (modified from Fletcher *et al*. 2004).

6.1 Summary of Issues and Risk Ranking

List of environmental issues for Component Trees 1 & 2. The consequence, likelihood and risk value are given.

Issue	Component Tree	Consequence	Likelihood	Risk ranking	Authors ranking
Effects of the collection of broodstock on spawning stock size (1.1.1)	1	2	1	2	Low
Effects of over-collection for grow-out (1.1.1)	1	0	0	0	Negligible
Minimise risk of genetic impacts on wildstock (1.1.2)	1	3	1	3	Low
Effects of disease transmission to wildstocks (1.1.2)	1	2	2	4	Low
Effects of increasing competition for food with wildstock due to escapes of cultured stock (1.1.2)	1	2	2	4	Low
Impacts on genetic composition of wildstocks (1.2.1)	1	4	1	4	Low
Effects of diseases on cultured stocks (1.2.2)	1	2	3	6	Low
Animal welfare issues (1.2.3)	1	1	3	3	Low
Effects of diseases from cultured stocks passing to wildstocks (1.3.1)	1	3	1	3	Low
Effects on environment due to the establishment of feral populations (1.3.2)	1	2	1	2	Low
Impacts on feed composition and their sustainability (1.3.3)	1	2	4	8	Moderate (page 110)
Effects of chemical use and use of protocols (1.3.4)	1	2	3	6	Low
Impacts of applying common standards for water quality (1.3.5)	1	2	2	4	Low
Effects on region due to release of nutrients (2.1.1)	2	1	2	2	Low
Impact of sedimentation across the regions caused by release of material (2.1.2)	2	0	1	0	Negligible
Effects of chemical use and release on region(2.1.3)	2	0	1	0	Negligible
Effect of facilities on regional stream flow (2.1.4)	2	1	4	4	Low
Impact of water extraction across region (2.1.5)	2	2	3	6	Low
Impacts on surrounding water table due to seepage (2.1.6)	2	0	1	0	Neg
Impacts on dune morphology due to water use (2.1.7)	2	3	2	6	Low
Increased frequency / intensity / composition of plankton blooms (2.2.1)	2	2	1	2	Low

Changes to benthic communities due to sedimentation /shading (2.2.2)	2	2	1	2	Low
Changes to migratory species in area (2.2.3)	2	4	3	12	Moderate (page 126)
Interactions between species and facilities (2.2.4)	2	4	3	12	Moderate (page 127)
Effects of aquaculture on RAMSAR/MPA/World Heritage Areas (2.2.5)	2	1	2	2	Low
Effects of aquaculture on individual species behaviour (2.2.6)	2	1	2	2	Low
Effects on sensitive habitats by aquaculture (2.2.7)	2	1	2	2	Low
Effects on level of scavenger abundance (2.2.8)	2	1	2	2	Low
Translocation policies for stock movements (2.2.9)	2	3	1	3	Low
Total number and size of farms across region (2.3.1)	2	1	2	2	Low
Impact on regional amount of native vegetation acceptably removed (2.3.2)	2	1	2	2	Low
Effects of aquaculture on heritage areas ((2.3.3)	2	1	2	2	Low
Effects of aquaculture on soil quality (2.3.4)	2	1	3	3	Low
Effects on water table from extractions or discharges (2.3.5)	2	2	3	6	Low
Constraints on aquaculture from current infrastructure levels (2.3.6)	2	2	3	6	Low
Effects on regional noise and odour levels from aquaculture (2.3.7)	2	0	2	0	Negligible
Regional constraints to placement of aquaculture facilities (2.3.8)	2	0	3	0	Negligible
Impact on aquaculture due to Town Planning Schemes (2.3.9)	2	0	4	0	Negligible
Regional carrying capacity (2.4.1)	2	1	2	2	Low
Regional effects due to disease transmission (2.4.2)	2	1	2	2	Low
Effects of processing product in region (2.4.3)	2	0	2	0	Negligible
Ability to dispose of unmarketable product in the region (2.4.4)	2	1	2	2	Low

7.0 DISCUSSION – LAND-BASED FINFISH AQUACULTURE

In Western Australia, the main species aquacultured in land-based ponds or tanks are barramundi, black bream, silver perch, pink snapper, ornamental fish and rainbow trout.

In order to provide information on various culture techniques, an assessment of the culture systems currently used in Australia for producing barramundi fingerlings is provided below. These types are:

- clear-water tank culture (considered intensive larval rearing);
- green-water tank culture (semi-intensive larval rearing); and
- pond culture (extensive larval rearing).

Clear water tank culture involves the culture of larvae in a controlled environment, such as an indoor hatchery, where the fish larvae are supplied with zooplankton, which are also cultured under controlled conditions.

Green water tank culture maintenance is significantly lower compared with clear water tank culture, with growth comparable in both methods. Larval survival in green water tank culture is often up to 50 per cent higher than clear water culture.

Pond culture involves extensive larval rearing, which is carried out in earthen ponds ranging from 0.1 to 1 hectare surface area. Ponds that are designed with a maximum depth of 1.8 metres, and a central concrete raceway into which the entire pond drains, enable easy harvesting. Inlet water should be pre-filtered to 300µm to filter out potential predators and eggs of other fish species.

Each system has its own merits, with site characteristics usually dictating the type of system used. In South-East Asia, barramundi larvae are mainly reared intensively, whereas in Australia only a few hatcheries use this technique, usually in situations where environmental control is required because of geographical location (i.e. the hatchery is situated in an area where barramundi are not normally found). The majority of barramundi farms in northern Australia use extensive larval rearing procedures.

Pond Culture

The most common growout system is pond culture, in either brackish or fresh water. Fish are usually maintained in cages within the pond, although cage culture of fish less than 120 to 150 mm total length and free-ranging of larger fish, are sometimes combined.

The cages are usually four to 50m^2 water surface area and two to four metres deep. They may hold 15 - 40 kg/m^3, provided the cages are cleaned of bio-fouling regularly, as poor water flow will stress the fish. Typically, the ponds are aerated and receive water exchange of five to 10 per cent of pond volume per day.

Cage Culture

Another grow-out method is cage culture in estuarine waters. Relatively few companies are using this technique.

Cage culture in estuarine or marine waters has advantages over other systems, particularly where large-scale production is envisaged. However, there are problems with bio-fouling of cages and, to a lesser extent, predators, which can cause holes in the cage and hence the escape of stock. Predator nets around the cages are recommended.

Tank Culture

The third method of on-growing barramundi is intensive production in an indoor, controlled environment building, using underground water (i.e. pathogen free) and a high level of recirculation through biological filters. Because of the controlled environment, it allows for year-round production virtually anywhere in Australia where underground water is available.

This method of production also avoids the environmental concern associated with release of nutrients to open waterways from pond or cage culture operations. However, capital and operating costs may be higher than for outdoor cage systems.

Diet

In Australia, farmed barramundi are reared on dry, pelleted diets, in contrast to South-East Asia where they are usually reared on 'trash' fish or in association with a foraging species such as *tilapia* spp. Weaning fry from live feed to dry crumbles can be commenced with fry as small as 10 mm total length, but much better survival and quicker adaptation onto the dry diets is obtained if weaning is delayed until the fry are at least 15 to 20 mm total length.

Barramundi are reared on progressively larger pellets as they grow from fingerling to market-size. Barramundi are happy to feed from the water surface or the pond or tank bottom. Diets produced by Australian fish feed manufacturers give good food conversion ratios (FCR) of 1.0 to 1.8:1, depending on the feed type and size of fish harvested.

Although this information is provided for barramundi, the types of culture methods and diets are comparable across the other species.

Discussion

For each issue, the comments and risk assessment values determined during the workshop are firstly summarised (Tables 78 - 151). It should be noted that the comments in these tables marked as 'During workshop' come directly from workshop participants (listed in Appendix 1). Other comments have been inserted after the workshop and are identified as such.

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

7.1 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.

7.1.1 Wildstock of cultured species

7.1.1.1 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 77 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			
Comments	• Access from commercial fisheries or hatcheries to broodstock is not an issue. • Direct collection is carried under 'Ministerial Exemption' – the total numbers of individuals collected is limited to a small number, set by policy. • Compliance levels vary, depending on the issue. At the Kimberley TAFE, the Department of Fisheries go and watch them take stock for aquaculture purposes. • There is no risk in catching broodstock, as proportion taken is so small. The taking of broodstock shouldn't be confused with illegal fishing.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	2	1	2	Low

Justification for Risk Ranking

In Western Australia, the current legislative framework allows for the granting of an Aquaculture Licence, which provides 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.

A Ministerial Exemption is provided for through Section 7 of the *Fish Resources Management Act 1994*. A draft policy statement was developed by the Department of Fisheries to set 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 method by which they are taken.

The number of individuals that may be taken for broodstock of land-based finfish is determined on a case-by-case basis. Given the size of the WA aquaculture industry, the consequence of collecting broodstock is considered to be 'moderate' ('2') however the likelihood of this happening is 'remote' ('1'). As things stand, no additional management response is needed.

Comments in Relation to Future Management

- The current limits on broodstock collection should be maintained.

Table 78 Grow-out stock

Description (Fletcher *et al*. 2004)	*If the industry relies on collecting stock for grow-out, are the protocols in place (or needed) to ensure stocks are not over harvested or unduly affect other fisheries reliant on these species?*			
Level of impact	Whole of the industry			
Comments	Currently, there is no consideration of policies for this area.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	0	0	0	Negligible

Justification for Risk Ranking

In WA, there are no policies that consider the grow-out of wild stocks for land-based aquaculture production.

Comments in Relation to Future Management

- There is no consideration being given to any species for this type of aquaculture.

7.1.1.2 Escape of cultured species

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.

Table 79 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			
Comments	• Translocation policies manage interactions between farm stock and wild stock. • Farm management practices should minimize any possibility of escapes – farms can be placed away from flood-prone areas where 'over-topping' may occur. • Impacts from any escapes will be a lot less likely if the brood stock is from local stocks. • The requirements for stock disposal must be complied with.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	3	1	3	Low

Justification for Risk Ranking

Under an Aquaculture Licence, conditions are sometimes attached requiring notification of any large fish escapes to the Department of Fisheries within 24 hours. Other conditions require:

- the net to be of a certain mesh size and quality to provide a complete barrier in order to retain 100 per cent of fish stocked;
- the mesh to be of a specified size depending on the size of the fish to be contained; and
- the mesh does not contain holes or openings greater than 1.5 times the size of the mesh.

These conditions are not applied to all land-based finfish aquaculture, but the Department of Fisheries is currently reviewing all licence condition on a species-by-species basis. Once this review is complete, there will be a consistent approach to the application of conditions such as these. Non-compliance can result in licence suspensions, prosecutions or cancellations.

The size of the WA finfish aquaculture industry is relatively small, with most farm stock purchased from approved hatcheries with wild caught broodstock. Some operators still purchase fingerlings from South Australia or the Northern Territory, increasing the risk of escapes intermixing with wild stocks and resulting in changes to genetic strains. There is an opportunity for WA to develop a larger barramundi hatchery industry to minimise any risks due to the importation of genetically-different stock.

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.

Future legislative changes that of the enacting of the *Biosecurity and Agricultural Management Act* will provide more stringent controls on the importation of certain fish species. It provides the impetus for the Department to encourage WA hatchery product for more finfish species.

The consequence value has been set at 'severe' ('3') in light of the current application of licence conditions and 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 plans in place to respond to any fish escape events.

Comments in Relation to Future Management

- The current protocols should be maintained.
- Currently there is no formal response plan in WA if escapes happen in similar manner to that which recently occurred in the Northern Territory.
- It should be recognised that regions are different and set the management response to escapes accordingly.
- There is a need to develop protocols across the whole industry for the movement of species between regions and how to deal with any escapes that may occur.
- The *Biosecurity and Agricultural Management Act* and its subsidiary legislation may provide more detail on management responses once finalised.

Table 80 Escape of cultured species causing disease in wildstock

Description (Fletcher *et al*. 2004)	*Are protocols needed at the whole of industry level to minimize the risk of disease transmission to the wildstock from the escape of cultured individuals?*			
Level of impact	Whole of the industry			
Comments	• It would be in the best interest of industry to develop protocols to minimize disease in the first place, rather than deal with managing outbreaks. • Industry is small enough that disease outbreaks have not been an issue within farm stock. • Management practices should be used to minimize any disease outbreaks and transferals. • There is a need to consider actions for ornamental fish breeders as human health requirements may not be as relevant but environmental management still requires strict controls.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	2	2	4	Low

Justification for Risk Ranking

The spread of diseases through introduced species is a serious concern. Disease agents introduced

with exotic species or strains may be more pathogenic in their new environment, where they may spread to atypical hosts or encounter more favourable conditions (Black 2001).

Aquaculture Licences have conditions attached that require the notification of any large fish escapes to the Department of Fisheries within 24 hours. This condition may not be applied to all land-based based finfish aquaculture, but the Department is reviewing all licence conditions on a species-by-species basis. Once this review is complete, there will be a consistent approach to the application of conditions such as these. Non-compliance with licence conditions can result in licence suspensions, prosecutions or cancellations.

The *Fish Resources Management Regulations 1995* regulation 69 requires all aquaculture operators notify the Department of Fisheries within 24 hours of becoming aware, or suspecting, that any fish at the place where aquaculture is carried out may be affected by diseases as specified.

Comments in Relation to Future Management

- Maintain current protocols – these must be consistent with national requirements.
- Maintain health certification for all fingerlings brought into WA.
- Regular on-farm testing may be required if the incidence of disease increases.
- Farm design should be required to consider the placement of ponds outside of flood-prone areas, thus minimizing the possibility of escapes.
- Consider the need for hatcheries and other facilities to becoming biosecure.
- Work with other states to increase the ability of testing procedures to pick-up disease outbreaks.

Table 81 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			
Comments	• We would not know of any impacts if this were to occur. • Industry needs to continue to minimise the chance of escapes, particularly at levels that may impact on the food chain. • The 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 there may be low catches in the regions of certain species. • Utilise local stocks [for aquaculture] so genetic differences in activity are minimised. • Barramundi is the primary species at present - fingerlings are sourced from interstate – mainly South Australia. Black bream also farmed. • It is impossible to manage the 'beyond farm-gate' impacts of any escapes of ornamental fishes on wild stocks.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	2	2	4	Low

Justification for Risk Ranking

Aquaculturists can reduce the competition with wildstock from escaped cultured fish by a few methods (Goldburg & Triplett 1997). The simplest way is to not raise non-native aquaculture

species, unless compelling evidence can be established that escaped fish cannot establish in the wild. Instead, native species or domesticated strains of non-native species that cannot survive and reproduce in the wild should be farmed. Secondly, farmers can incorporate designs that minimise fish escapes, such as the use of suitable screens for outlet water or by the use of closed recirculating systems.

In Western Australia, policies allow for the aquaculturing of non-native fish species under specific management plans. Silver perch, golden perch, Murray cod, Australian bass, brown trout and rainbow trout have Fisheries Management Papers, at various stages of development, written for them which set out the protocols and processes that must be adhered to in order to bring these species into the State for aquaculture purposes.

Given the placement of aquaculture facilities and the likelihood that escapees will be able to interact with and/or locate wild species, together with the protocols currently in place, it is felt that the current consequence of escapees competing with the wild stock will be 'moderate' ('2'). The likelihood of a 'moderate' consequence would be 'rare' ('2'), resulting in a risk value of '4'.

Comments in Relation to Future Management

- Any escapes should be minimised by an agreed farm management/design protocol.
- Maintain the requirement for industry to notify the Department of Fisheries should any escapes occur.
- Finalize the Fisheries Management Paper for golden perch, Murray cod and Australia bass.

7.1.2 Cultured stocks/businesses (husbandry)

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

7.1.2.1 Genetic composition

Table 82 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, selective breeding)?*			
Level of impact	Whole of the industry			
Comments	• It is unlikely that the use of GMOs will be considered in WA in the near future. • Adequate levels of broodstock from the wild are necessary to negate a requirement for use of GMOs.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	4	1	4	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).

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 (Ward 2002).

In Australia, for all native finfish species, there is no artificial selection occurring nor is there any use of genetically modified organisms (GMOs) at this point in time.

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 traits desired by consumers. Selection programs work with existing genetic variation, selecting those combinations that give improved results. Hence, the wild population will have the same genetic variation.

For many aquaculture operations, full physical containment of farmed stock is often difficult and gametes and/or larvae may escape. When WA is considered, the likelihood of escapes may be rare. The consequences of a 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 'major' ('4'), giving an overall inherent risk as 'moderate'.

There has been minor discussion held regarding the use of GMOs within the WA aquaculture industry but this 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 the light of the current gap in research and knowledge of potential impacts.
- Research should be considered prior to any change in policy regarding the use of GMOs,.

7.1.2.2 Disease

Table 83 Disease monitoring of 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			
Comments	• There are no sector-wide programs operating to ensure any disease outbreaks are detected as soon as possible. • This 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 use of chemicals. • Species should be farmed in areas that are suited to their biology.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	2	3	6	Low

Justification for Risk Ranking

In Western Australia there is no industry-wide disease monitoring, but any importation or translocation of fingerlings does require health certification. The Department of Fisheries has a Fish Pathology Unit that deals with any disease outbreaks or research into fish diseases.

The *Fish Resources Management Regulations 1995* (FRMR) requires that all aquaculture operators notify the Department of Fisheries as soon as they are aware that disease may be affecting their stock. At present, this is the only mechanism for detecting and reporting disease outbreaks. There are no sector-wide surveillance programs applied by the Department of Fisheries and, due to this lack of any consistent protocol, a slightly higher risk value would be expected. The Department does have an Emergency Response Plan that operates effectively.

The consequence of not having a surveillance program could be 'moderate' ('2') if the industry were to grow at its current rate over the next five years. The likelihood of continuing to have a moderate consequence is 'unlikely' ('3') once the Code of Practice for finfish aquaculture is finalized.

Comments in Relation to Future Management

- Develop protocols and implement through the industry-wide Code of Practice.
- Require certifications for any translocations (i.e. from hatchery to grow-out).
- Continue to operate the Department of Fisheries' *Emergency/Incident Response Plan*.

7.1.2.3 Animal welfare

Table 84 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			
Comments	• Industry needs to be aware of - and operate under - the provisions of the *Animal Welfare Act 2002*. • It should be ensured that any issues of site decommissioning are dealt with through licence conditions. • It is in the best interests of the farmer to minimize any animal stress during farming operations, as it will impact on quality and value of product.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	1	3	3	Low

Justification for Risk Ranking

In WA, 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.

Through the *Fish Resources Management Act 1995* (FRMA) (sections 191A & 258), Fisheries Officers can exercise powers as a general inspector conferred by the *Animal Welfare Act 2002*. New guidance will be provided through the Code of Practice for finfish aquaculture that is being developed.

There are moves on an international level to ensure any slaughtering of aquaculture products is done in the quickest and most humane way. Australia is providing comment into these international level discussions and WA will be obligated to implement any outcomes adopted.

The consequences of not having a protocol are 'minor' ('1') as management is still provided through other mechanisms, albeit not sector-specific. The likelihood of not having a protocol is 'unlikely' ('3').

Comments in Relation to Future Management

- Ensure operators are aware of their obligations under the *Animal Welfare Act 2002*.
- It is in best interests of aquaculture operators to minimize stress on farm stock, as this potentially impacts on the value of the product.

7.1.3 Other species/communities processes

7.1.3.1 Disease escape and transmission

Table 85 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			
Comments	• There is debate about the transfer of disease from wild stocks to farm stocks, but this would appear to be less of an issue for land-based finfish. • Farming of local stocks may increase any risk of disease transferral. • Stocks are self-contained so it is unlikely that any wild stocks will interact with the farm stocks. • Ensure any disposal of fish carcasses is through the agreed facilities.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	3	1	3	Low

Justification for Risk Ranking

The spread of disease by introduced species is a concern. Disease agents introduced with exotic species or strains may be more pathogenic in their new environment, where they may spread to atypical hosts or encounter more favourable conditions (Black 2001). For example, whirling disease in rainbow trout is caused by a myxosporidean that is non-pathogenic in brown trout.

The *Fish Resources Management Regulations 1995* requires that all aquaculture operators notify the Department of Fisheries as soon as they are aware that a disease outbreak may be affecting

stock. At present, this is the only mechanism for detecting and reporting disease outbreaks. There are no sector-wide surveillance programs applied by the Department of Fisheries and, due to this current lack of any formal protocols, a slightly higher risk value would be expected. The Department does have an Emergency Response Plan that operates effectively.

The consequence of not having a surveillance program could be 'severe' ('3') if the industry were to grow at its current rate over the next five years. The likelihood of continuing to have a 'severe' consequence is 'remote' ('1') once a Code of Practice is drafted.

Comments in Relation to Future Management

- Develop protocols and implement through the industry-wide Code of Practice.
- Require protocols and certifications for any translocations (i.e. hatchery to grow-out).
- Continue to operate the Department of Fisheries' *Emergency/Incident Response Plan*.
- Maintain protocols of requiring any exotic fish to be farmed in recirculating systems.
- Develop industry-wide monitoring programs to detect and monitor any disease outbreaks.

7.1.3.2 Escape of cultured species (feral populations)

Table 86 Establishment of feral populations

Description (Fletcher *et al*. 2004)	*If the species/population being cultured is not native to the country or even the region (i.e. outside their natural range), could they establish feral populations of they escaped?*			
Level of impact	Whole of the industry			
Comments	• This may be an issue if silver perch or other exotic species are being farmed. • There is a need to consider the aquaculture of exotic ornamental species – this is generally done in sheds under recirculating systems. • The filtration of waste water minimises the risk of escape of any eggs. • The impact from any escapes is unknown and will depend on the species and the location involved.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	2	1	2	Low

Justification for Risk Ranking

The Department of Fisheries implements a policy whereby the aquaculture of non-native marine finfish must be undertaken within land-based closed systems. This policy is designed to minimise any likely introduction, through escapes, of exotic species into the WA marine environment. The engineering requirements, containment and water filtering protocols required for land-based aquaculture facilities for exotic species are designed to limit the possibility of any larvae or fingerlings escaping.

Aquaculture of various non-native species in WA is managed under policies outlined in a number of Fisheries Management Papers.

In light of this current policy, the consequence would still be 'moderate' ('2'), but the likelihood of any non-native species going feral in freshwater environments would be 'remote' ('1').

Comments in Relation to Future Management

- Maintain the protocols on the translocation of exotic species and the associated requirements for careful farm design.

- As required, finalise the writing/production of Fisheries Management Papers for other non-native species.

7.1.3.3 Feeds composition (source and sustainability)

Table 87 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
Comments	• 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 required into replacing fishmeal (and fish oil). • It should be considered whether we want to produce fishmeal in WA or to buy this from other state, such as South Australia? There are environmental and economic drivers [behind this decision]. • 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 sellers of fishmeal do not like to supply smaller operators. They prefer to supply larger amounts to the bigger ones. • Since feed is important, there are likely to be issues when the new *Biosecurity and Agricultural Management Act* comes into play. • The source of feeds may be a public health issue and testing should be carried out on imported pellets to monitor toxin levels in the fishmeal used. • The use of feeds with added chemicals should be considered – what are the impacts of this on the broader environment?

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

Justification for Risk Ranking

Currently land-based finfish aquaculture uses mainly pelletized feed, which consists predominantly of fishmeal and fish oil that are obtained from baitfish caught in overseas 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 3.16 kilograms of baitfish used, only 1kg of Atlantic salmon is produced. Although feed conversion ratios are improving, a lot is dependent on specific farm management practices.

The use of baitfish in feeds 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, overexploited or depleted. If aquaculture keeps expanding, then supply will fall short of demand.

While these baitfish 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 overfishing (De Jong and Tanner 2004).

Baitfish are primarily small pelagic fish. 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, overfishing 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 upwelling 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, short-beaked common dolphins and Indo-Pacific dolphins.

The amount of baitfish captured varies greatly from year-to-year. There is some evidence that the global catch is declining, although some baitfish fisheries, such as for pilchards in Western Australia, 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.

Carnivorous fish can use plant-based protein and oils just as well as fish -ased proteins and oils. There are some product quality issues with the use of alternatives to fish oils, but the fish's health and growth are not affected (B. Glencross pers. comm.).

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 of the major problems that arose in Europe when livestock were fed meat-meal contaminated with Bovine Spongiform Encephalopathy (BSE).

Within Western Australia, the Department of Fisheries has been undertaking research into replacements for over eight years. Most of the assessment has been focussed on meat-meals and lupin meals. Researchers have been able to replace 66 per cent of the fishmeal in trout diets with lupin protein concentrates and 100 per cent of the added oils in snapper diets with canola oil.

Commercially, most diets now use less than three per cent of fishmeal, but reducing this further has resulted in issues with the palatability of the diet to fish and is also generally not cost-effective in terms of the formulation cost. With fishmeal prices doubling over the past six months, lupin replacements are a particularly cost-effective protein source for use in feeds but this still drives the feed prices up (B. Glencross pers. comm.).

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.

Given the low amount of fish farmed in Western Australia, the risk the State's aquaculture industry imposes to baitfish stocks is 'low', but when we consider the aquaculture industry across Australia as a whole, the risk may be 'moderate'.

Demand from aquaculture is likely to be contributing to the overfishing of a number of wild fish 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 issue of fishmeal process affecting feed prices which, in turn, affects aquaculture profitability is still a key issue that needs addressing. By improving resource base availability for feed companies to use alternatives to fishmeal, it will help reduce feed price pressure and therefore improve profitability for the industry.

There are not many feed ingredients produced by aquaculture and certainly nothing that is making any inroads into addressing the protein supply issue. A more prudent approach is to rely on the production of agricultural products/by-products for use in feeds.

Other issues that the industry needs to consider are:

- the use of fishery waste products and aquaculture by-product processing products in feeds;
- the use of genetically modified organisms (GMOs) in the food chain;
- product quality issues, such as maintaining omega-3 at the necessary level in feeds; and
- environmental impacts associated with feed design and management

It should be realised that these fish species are targeted by sectors apart from aquaculture. If aquaculture should discontinue the use of baitfish in fishmeal/fish oil, there would still be considerable demand for these species.

Comments in Relation to Future Management

- Continue to undertake research to identify new feeds (Department of Fisheries, Seafood CRC).
- Continue to utilise aquacultured ingredients where possible.
- Consider the farming of our own fish for use in fishmeal/fish oil.
- Ensure species imported as an aquaculture feed are incorporated into species lists for the *Biosecurity and Agricultural Management Regulations*.

7.1.3.4 Chemicals

Table 88 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
Comments	• The use of therapeutants and hormones require the development of protocols to ensure their use is managed and regulated. • The use of veterinary chemicals should be considered differently than those for growth improvements. • Some of these chemicals are incorporated into fish feeds – determine whether this is the best way to manage dosages. • Research is required to ensure that the impacts for WA species and environments are known and understood. • If use is required in future years, it is necessary to consider carrying out research on the impacts of chemicals on target species, other species and the broader ecosystem, as well as any potential long-term retention in sediments, etc. • Data on the type, amount, frequency and toxicity of chemicals is needed to complete the investigation of this potential issue. • Chemical concentrations or any known/likely impacts of chemicals on nearby water sources must be contained within the lease area ('mixing zone').

Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	2	3	6	Low

Justification for Risk Ranking

A lot of work has been done in Scotland into the use of chemicals and the resultant impacts on the environment. Intensive production of farmed Atlantic salmon has been associated with both disease and parasite problems that have caused major losses to the industry. The use of antibiotics and chemotherapeutants [in this situation] was widespread (Ross 1997).

Extreme disease problems in the early 1990s led to very high levels of antibiotic use in fish feed, causing increasing levels of antibiotic resistance in the bacteria found in the feed. Once in the broader environment, the antibiotics are still active and can cause resistance on other non-target bacteria species, with implications for human health.

Antibiotics are also persistent, with little or no degradation of them occurring in the sediments over periods of months or even years. Antibiotics also suppress the decay of organic matter, thus affecting seabed recovery under aquaculture cages. The development of increasingly effective vaccines has now reduced the levels of antibiotic use.

There has been some use of chemicals in aquaculture within WA back in 2004, mainly formalin, sodium hypochlorite, malachite green and rock salt baths. By far, the most used chemical was malachite green, a synthetic dye used to colour fabric and paper. This was used principally in hatcheries rather than grow-out systems. Malachite green is also used to treat fungal and protozoal infections of fish and fish eggs. It is not registered for use in aquaculture and the *Australia New Zealand Food Standards Code* does not allow malachite green residues to be present in fish sold for human consumption.

The Commonwealth Government's Australian Pesticides and Veterinary Medicines Authority (APVMA) now has regulatory responsibility for veterinary medicine use in Australia, including the registration of vaccines, under the *Agricultural and Veterinary Chemicals Code Act 1994*.

Chemicals registered as suitable for aquaculture purposes are limited, which means that should any disease outbreak occur, it would take time to respond.

The consequences of any inappropriate use of chemicals caused by the absence of industry-wide protocols could be 'moderate' ('2') due to the lack of any relevant research and understanding of local impacts. However, with the current protocols and approvals processes, the likelihood of anything happening is 'unlikely' ('3').

Comments in Relation to Future Management

- The issue of the use of chemicals within aquaculture requires further data and refinement.
- Develop protocols, in consultation with industry, for the use of chemicals within aquaculture.
- Determine which chemicals will be permitted for use in WA and under what circumstances.
- Advise industry groups of protocols and research outcomes.
- Techniques for isolated parasitic dosing should be developed, rather than in-pen dosing.
- No impacts outside an aquaculture lease area will be a requirement of any future management actions.
- The discharge of treated water with detectable chemical residues which could enter wetlands or waterways should be minimised.

7.1.3.5 Water quality

Table 89 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			
Comments	• Industry may need to monitor quality of water – 'in' to a farm as well as 'out' from it. • Monitoring water quality will be part of a farm's environmental monitoring program and annual reporting initially carried out to determine if water quality is an issue. • Work with regulators to ensure that if aquaculture is the last industry into a particular area, aquaculturists do not bear the brunt of minimising nutrient levels. • Environmental water quality parameter guidelines are known and should be achieved outside any mixing zone.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	2	2	4	Low

Justification for Risk Ranking

In Western Australia, the *State Water Quality Management Strategy* (2004) 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 definition of environmental values and environmental quality objectives prior to their submission to the Environmental Protection

Authority (EPA) for review and endorsement. These values then guide environmental impact assessment and natural resources management.

The legislative force behind the strategy outlined above is the *Environmental Protection Act 1986* and associated regulations. These set down the standards that any facility that discharges into the marine environment must meet. There are a range of regulatory enforcement tools, which include a list of materials that cannot be discharged into the environment. One of these is materials is animal waste - this ruling could be applicable to aquaculture facilities.

The Department of Water produce guidance documents outlining their requirements and suggested actions to be taken by the proponent during design and operation of an aquaculture facility. These 'Water Quality Protection Notes' cover issues such as chemical blending (including storage, handling and disposal of chemicals), locating industrial sites near sensitive environments and the use of pond liners (both earthen and plastic) and are to lessen the potential for unacceptable impacts on the State's water resources. These documents are used by the Department during the assessing of any proposals and provide a consistent approach.

The Department of Environment and Conservation and the Department of Water are contributing to the development of water quality plans, which are managed by the various Natural Resource Management groups. These have been completed for Cockburn Sound and the Pilbara Coast.

As these reports are developed further, their 'outputs' will be taken on-board in respect to aquaculture operations for determining water quality criteria as part of the Environmental Monitoring Program. In light of these operational protocols and policies, the consequences would be 'moderate' ('1') with a likelihood being 'rare' ('2').

Comments in Relation to Future Management

- Utilize state-wide water quality criteria developed by relevant authorities.
- Incorporate site-based monitoring in environmental monitoring programs and ensure these feed into regional/catchment determinations.
- There is a preference for non-direct discharges for waste streams.
- Use the Department of Water's guidance statements *Water Quality Protection Notes* No. 2, 26 and 27 on aquaculture, nutrient and irrigation management plans, pond liners, vegetated buffers to sensitive water resources and waste disposal.

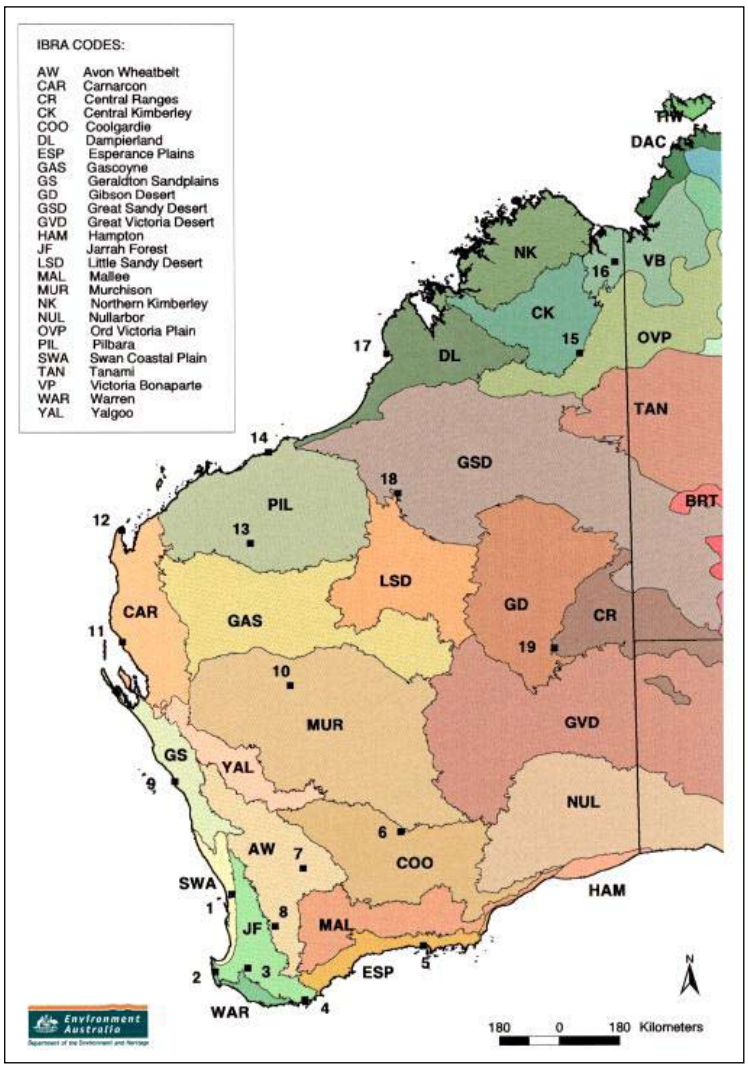
7.2 Impact of the Industry on the Catchment/Region (Cumulative Impacts)

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 - not just the aquaculture industry - within a region needs to comply with (e.g. 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.

The regions where aquaculture operators are currently licensed for land-based finfish production are:

AW	Avon Wheatbelt	ESP	Esperance Plains	MAL	Mallee
CAR	Carnarvon	GS	Geraldton Sandplains	SWA	Swan Coastal Plain
DL	Dampierland	JF	Jarrah Forest	VB	Victoria Bonaparte



7.2.1 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).

7.2.1.1 Nutrients

Table 90 Quantity and quality of water use

Description (Fletcher *et al*. 2004)	*If production by facilities in the region results in the release of nutrients, should a maximum/total amount allowable (e.g. total dissolved solids per day/week/year) for the whole regions be set?*
Level of impact	Catchment/Region
Comments	• There is always an opportunity to put waste onto land. • Aquaculture facilities usually discharge into a settlement pond prior to a macrophyte pond. • This is much more complicated than stream-dependent and depends on the system. There is a need to be realistic as next door may be a potato farmer or cattle farmer. Are the regulatory processors fair for aquaculture? • If there are stream regulatory objectives, there would be a need to match them. • Is there some overarching load for streams? • They have been doing it in the USA for years. • Are the bores monitored or going to be monitored in terms of extraction? – the suggestion was 'yes'. • There should be monitoring of industry output. • The existing water values should be defined and retained in keeping with the guidelines provided in the National Water Quality Management Strategy.

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

Justification for Risk Ranking

Discharges from a finfish farm have the potential to create significant changes to the quality of the waters into which the discharge is received (Donovan 1999). The major concerns relate to the discharge of:

- dissolved metabolic wastes from finfish activity and the biological breakdown of waste feed particles and finfish faecal matter;
- particulate nitrogen and phosphorous (originating from organic matter as finfish faecal matter), algal cells, waste feed particles and soil particles;
- suspended solids from particulate organic matter and the erosion of pond floor, walls and discharge channels; and
- excess phytoplankton.

The possible impacts of finfish farms' effluent on water quality include:

- creation of eutrophic zones within the receiving waters;
- increased fluctuation of dissolved oxygen levels;
- creation of visible plumes; and
- accumulation of nutrients within the receiving waters.

Water resource planning on an integrated catchment management basis precludes the treatment of fish farming as anything other than one of a number of potential users attempting to access these resources (Black 2001). The view is therefore that allocation of water resources is a multi-user rather than an individual-user problem. This has led to a broadening and deepening of the

perspective of many researchers investigating the environmental issues that affect freshwater aquaculture at this time.

The major impacts in the physical environment relating to aquaculture remain those of the potential threat of eutrophication - that is, the enrichment of an ecosystem with nutrient elements. In terms of land-based aquaculture, this outcome is most likely to occur as a result of the products of feed given to fish and the process of feeding itself.

The contributions of nitrogen, phosphorous and carbon in feed material given to fish, and the subsequent losses which occur, have the potential to increase nutrient content within the water body as a whole.

However, the process of eutrophication for any water body is complex. Naturally-occurring processes and conditions within a water body, as much as the imposed influence of an anthropogenic nutrient source, can influence the susceptibility, or otherwise, of a given river or stream to become eutrophic.

The key factors that have been noted as influencing the likelihood of eutrophication occurring at a site as a result of the development of aquaculture are as follows:

- the form of nutrient limitation that exists in the freshwater body prior to aquaculture production commencing;
- the quality of feed given and the management of feeding;
- the fish biomass generated and methods used in its production;
- the size of the pond and the rate at which water passes through it;
- the position of the site relative to natural obstacles (i.e. shallow water courses, rocks, islands);
- the depth of the pond; and
- the response of algal species resident in the stream to the nutrient additions made by aquaculture.

The Natural Resource Management groups, together with the Department of Environment and Conservation and the Department of Water are developing regional water quality guidelines (see section 1.3.5 of this paper) and these documents set-out criteria for regional water quality. These documents have not been completed across the State, but, when they are, criteria will be available for determining suitable regional levels of nutrients from all users of the water resource.

In light of the current levels of land-based aquaculture production in WA, it is considered that the consequences across any region would be ‘minor’ (‘1’), with a likelihood of these impacts occurring of ‘rare’ (‘2’).

Comments in Relation to Future Management

- There is a presence of pharmaceutical and disinfectant residues.
- Guidance documents for ‘best practice’ nutrient management need to be developed.
- There is a preference for non-direct discharges for waste streams.
- The risk level to water resources may determine the environmental viability of the project or the need for contaminant control systems. Management intervention in the project is approved in regard to this issue.

7.2.1.2 Sedimentation (particulate matter)

Table 91 Sedimentation impacts

Description (Fletcher *et al*. 2004)	*Can the collective amount of material released/escaping/dropping from the structures, including biological material or sediments from erosion, cause a problem for the catchment from sedimentation?*			
Level of impact	Catchment/Region			
Comments	• Environmental implications are expected to be low on a regional basis. • 'Best practice' management for each facility will ensure no regional or 'whole of industry' issues. • The continued trial of Semi Intensive Floating Tank System (SIFTS) technology should be encouraged.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	0	1	0	Negligible

Justification for Risk Ranking

There are two types of pond design used in Western Australia. Firstly, earthen ponds are used by many and, through their design, should minimize any likelihood of sediments or waste material being released into the catchment.

Ponds need to be drained on occasions and scraped to remove biological matter, i.e. faecal and excess feed. Any materials removed at this time should be disposed of in land-based facilities or as mulch on salt-tolerant vegetation.

New methods, such as the SIFTS (Semi Intensive Floating Tanks System), are trialling floating tanks within earthen ponds. The benefits of this system are the better application of feed and the continual removal of waste from the tanks. The allowance for a higher stocking density within each tank than would otherwise be possible in an open-pond system is a distinct commercial advantage to the farmer.

Other designs use closed recirculating systems, which usually consist of plastic tanks housed within sheds. Water treatment can be by waste stabilisation/sedimentation ponds, followed by holding ponds to store water pending reuse.

In both cases, biological material is collected and disposed of, rather than released through water discharge.

Sediment released due to natural events, such as storms, flooding etc, should be minimised through engineering design that is appropriate to the region. Current assessment in WA provides for the consideration of appropriate facility structures to avoid this issue, where at all possible.

This issue is not considered to be beyond 'negligible' at current industry levels, on a regional perspective, using agreed protocols.

Comments in Relation to Future Management

- 'Best practice' guidelines would assist industry for managing this environmental risk.
- Encourage the continued trial of the SIFTS technology.

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

Table 92 Regional impacts from the release or use of chemicals

Description (Fletcher *et al*. 2004)	*Can the collective amount of material released/escaping/dropping from the structures, including biological material or sediments from erosion, cause a problem for the catchment from sedimentation?*			
Level of impact	Catchment/Region			
Comments	• Environmental implications are expected to be low on a regional basis. • 'Best practice' management for each facility will ensure no regional or 'whole of industry' issues.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	0	1	0	Negligible

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 chemicals 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 a case-by-case basis from the Australian Pest and Veterinary Medicine Authority. 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, in a regional context, are considered to be 'negligible' ('0') with the likelihood as 'remote' ('1').

Comments in Relation to Future Management

Maintain the protocol on application, use and reporting of any chemical use.

- The design of a monitoring program should be considered for any site (including surrounding area) where chemicals are approved. This would assist in providing guidance on any impacts that could eventuate from use of chemicals.
- It should be considered who will be responsible for any clean-up should it be required – and who covers the costs.
- 'Best practice' guidelines would assist industry for managing this environmental risk.
- There are a range of regulatory enforcement tools, which include a list of materials that cannot be discharged into the environment. One of these is animal waste – and this prohibition could be applicable to aquaculture facilities.

7.2.1.4 Stream Flow

Table 93 Effect of facilities on stream flow

Description (Fletcher *et al*. 2004)	*Will the placement of facilities effect the flow of streams across the region?*			
Level of impact	Catchment/Region			
Comments	• Correct siting of facilities on an individual basis would remove any impact on stream flow across the region. • 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 and groundwater abstraction within declared management areas.			
Risk assessment values				
Organisation/Person	Consequence	Likelihood	Risk Value	Risk Ranking
After workshop	1	4	4	Low

Justification for Risk Ranking

The Department of Water administers the *Rights in Water and Irrigation Act 1914,* which requires an assessment against the regional impacts on stream flow that may be expected should any aquaculture facility become operational. The Department of Water has set down proclaimed groundwater areas where it is necessary to obtain a licence to extract groundwater. In areas outside of these proclaimed areas, licences are not required unless water is drawn from a confined aquifer. Even though the assessments are undertaken on a facility-by-facility basis, the impacts are considered cumulatively.

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 'minor' ('1'). The likelihood of these consequences occurring is 'possible' (4).

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

- Maintain the current Department of Water approval, assessment and licensing processes.
- Include the requirement for reporting of stream flow quality and quantity in any Environmental Monitoring Program.
- Avoid the establishment of aquaculture farms in protective buffers to water supply reservoirs, waterways and wetlands.

7.2.1.5 Water extraction

Table 94 Impacts of water extraction

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			
Comments	• 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 construction of structures on streams. • For fresh water sources, operator water use efficiency will be considered by the Department of Water when granting water allocation licences.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	2	3	6	Low

Justification for Risk Ranking

As for the previous issue, current application processes run by the Department of Water, administering the *Rights in Water and Irrigation Act 1914,* require an assessment against the regional impacts on groundwater that may be expected should the facility be operational.

The Department of Water has proclaimed groundwater areas, where it is necessary to obtain a licence to extract groundwater. In areas outside of these proclaimed areas, licences are not required. Even though the assessments are undertaken on a facility-by-facility basis, the impacts are considered cumulatively.

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'). This is higher than for stream flow, as it is likely more facilities will utilise fresh groundwater than saline water. 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

- Maintain the current assessment and licensing processes.
- Include the requirement for reporting of extracted groundwater quality and quantity in any Environmental Monitoring Program.

7.2.1.6 Seepage (e.g. salinisation)

Table 95 Effect of seepage on surrounding water table

Description (Fletcher *et al*. 2004)	*If the facilities are using land-based ponds, could seepage of the water (e.g. saltwater) affect the surrounding water table, soil, etc? If so, what levels/rates are un/acceptable?*			
Level of impact	Catchment/Region			
Comments	This is unlikely at regional level.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	0	1	0	Negligible

Justification for Risk Ranking

Under current licensing arrangements in WA, the Department of Environment and Conservation requires an Environmental Monitoring Report be forwarded for any aquaculture facility that produces over 1,000kg of product per year. Monitoring of pH, electrical conductivity and nutrient levels in water prior to entering the facility (from a bore), as well as downstream of the bore, detects any nutrient or salinity impacts occurring from the facility's operations likely to be due to seepage. Operators' using earthen ponds are required to maintain the clay lining of the ponds to minimize any salinisation impacts as part of their licence conditions.

It is important to ensure that there is not pond seepage, as this will increase pumping costs and can affect groundwater in local aquifers. Resealing also ensures that the final finish in the pond floor is smooth and that the pond drains well towards the outlet for the future harvest (QDPI&F 2006).

If suitable remediation process are utilized, 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 x 10^{-8} metres/second. The clay content should be adequate to eliminate or reduce the loss of water.

Seepage of water from ponds or tanks could be managed via the Environmental Harm and Pollution provisions of the *Environmental Protection Act*, or in the case of contaminated water, it may come under the Unauthorized Discharges Regulations (for instance under discharge of animal waste). This would not really constitute a regional issue – it is more likely to be considered as a localized issue, which is considered within each facility.

Comments in Relation to Future Management

- Ponds should be designed as a matter of course for minimum seepage, with clay linings.
- The Environmental Protection Act Environmental Protection Notices (Section 65) should continue to be used.
- The Department of Water's guidance statement *Water Quality Protection Note 27* should be used.

7.2.1.7 Dune morphology

Table 96 Impacts on dune morphology due to water use

Description (Fletcher *et al*. 2004)	*Are there any protocols needed to manage impacts on dune morphology in surrounding area?*			
Level of impact	Catchment/Region			
Comments	• The placement of facilities should be determined on a regional basis, based around zoning and adjacent users. • The potential impacts on dune morphology of aquaculture facilities should be determined at a regional level, so that proponents do not need to work through them as site-specific issues when a particular site is being assessed to see if it is suitable for aquaculture purposes. • Dunes would not be considered as suitable sites from the geomorphological perspective. • Dunes are likely to be subject to coastal erosion and therefore unstable.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	3	2	6	Low

Justification for Risk Ranking

This issue builds on - and links to - issues dealing with regional planning, site selection and terrestrial vegetation removal. It is also very dependant on the region in which the facility is to be located. Areas in the Kimberley are managed through different processes over large areas (i.e. Native Title agreements) with currently low levels of industry growth in comparison to the Gascoyne, where areas are being heavily impacted by other users of coastal environments.

There are control methods that can be incorporated into the construction phase to minimise damage to coastal dune systems. However, the zoning of these locations should have taken this into consideration, presumably by not zoning these dunal areas as being suitable for particular purposes. This having being said, there is considerable pressure on local government in recent times to open more areas for development. Some dunal areas are being removed for residential purposes and large industry.

From the aquaculture industry perspective, the consequences could be 'severe' ('3') if inappropriate sites are selected for land-based aquaculture facilities. The likelihood of this occurring is 'rare' ('2'), due to the guidance provided to local government by bodies such as the WA Planning Commission.

Comments in Relation to Future Management

- Maintain involvement by the Department of Fisheries into local planning activities to select suitable aquaculture sites at a regional level.

7.2.2 Ecological/community structure and biodiversity

7.2.2.1 Plankton (e.g. algal bloom)

Table 97 Impact of plankton on the region

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			
Comments	• Cumulative nutrient issues are of concern where catchment areas are small, and there are multiple aquaculture facilities. • Undertaking a regional assessment of the maximum level of aquaculture development will resolve this issue. • Stricter controls on nutrient output levels could be imposed to minimize any chances of plankton blooms.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	2	1	2	Low

Justification for Risk Ranking

Chlorophyll *a*, extracted from phytoplankton, is a common water quality parameter routinely used in characterizing 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 for the prawn industry 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 is being researched. Therefore, it has been considered more appropriate to refer to total nitrogen in pond discharges rather than chlorophyll, until there is further information available specifically on the impacts of phytoplankton on receiving waters.

In WA, nutrient enrichment or algal blooms would be covered under the 'environmental harm' provisions of the *Environmental Protection Act* or Pollution of Unauthorised Discharge Regulations. This may be a regional issue if the facility reaches beyond a certain size, but it is considered that this is unlikely to occur in the next five years.

The risk values reflect the possibility of current facilities growing at an exponential rate, being 'moderate' ('2'), however the likelihood is 'remote' ('1').

Comments in Relation to Future Management

- 'Best practice' guidelines for minimizing nutrient discharges should be developed.
- There is a preference for non-direct discharges.

7.2.2.2 Benthic communities (e.g. aquatic vegetation)

Table 98 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			
Comments	Cumulative nutrient issues are of concern where catchment areas are small, and there are multiple facilities.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	2	1	2	Low

Justification for Risk Ranking

Aquatic flora may be directly affected by the clearing of vegetation and native habitats during the construction and subsequent operation of finfish 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 has the potential to affect stream hydrology and increase erosion of stream banks (Donovan 1999).

The intake and discharge of water from a finfish farm has the potential to impact on creeks through an increase in stream flow and, subsequently, the volume of water carried within an estuary or creek.

Regulatory tools to manage the effects on benthic communities are provided through the *Environmental Protection Act* and are mainly considered at the regional level. Impacts would be managed via environmental harm provisions and/or Pollution and Unauthorised Discharge Regulations. It is more likely to be a localised issue and dealt with at the facility level so the risk value reflects this level of focus.

Comments in Relation to Future Management

- 'Best practice' guidelines for minimizing nutrient discharges should be developed.
- There is a preference for non-direct discharges.

7.2.2.3 Listed migratory bird species

Table 99 Listed migratory species

Description (Fletcher *et al*. 2004)	*Are there listed migratory species 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
Comments	• Proponents of aquaculture facilities need to consider this issue at the project planning phase and undertaken self-assessment against the requirement for *Environmental Protection and Biodiversity Conservation Act 1999* referral. • It is difficult to monitor or measure impacts on migratory species. • This 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 in close proximity could be an issue in regard to migrating species – it needs to be considered during regional planning activities.

Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	4	3	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 on July 16 2000, 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 finfish 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 to both. The criteria for migratory species include the following:

- substantially modify (including fragmenting, altering fire 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.

There may also be flow-on effects on migratory bird species due to inflated populations of gulls and this warrants further investigation. In addition, the population size and reproductive output of certain bird species requires further investigation to determine whether the feed taken from aquaculture farms is having any effect on the population of that species.

Based on the current and potential locations for finfish aquaculture, it is expected that there will be some interaction between migratory birds and aquaculture farms. 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')

Comments in Relation to Future Management

- Develop industry-specific protocols for dealing with marine animal interactions relevant to the region where aquaculture facilities are proposed.
- If required, undertake referrals to Commonwealth's Department of the Environment, Water, Heritage and the Arts under the EPBC Act.
- The placement of aquaculture areas should be considered during local/regional planning strategies in order to avoid sensitive bird habitats**.**

7.2.2.4 Threatened/endangered/protected species

Table 100 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			
Comments	When considering the location of any aquaculture parks (or other large areas set aside for the purpose of aquaculture) or zones, this should take into account conservation legislation.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	4	3	12	Moderate

Justification for Risk Ranking

Under the EPBC Act, migratory species protected under international agreements are considered to be 'matters of national environmental significance'. Referrals to the Federal 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 land-based aquaculture are birds and reptiles. Regions, such as those in the south-west and along the south coast of WA, are areas where relatively large numbers of protected floral species are found. These areas have generally been identified through research and 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. Most sites will be located on freehold land, so the ability to deal with species management (apart from vegetation clearance) will be less.

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 vegetation is reinstated through rehabilitation programs.

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')

Comments in Relation to Future Management

- Maintain current protocols against the *Environment Protection and Biodiversity Conservation Act 1999*.
- Ensure that the DEC continues to provide 'input' into the assessment process.
- Continue the referral to the Environmental Protection Authority for assessment under Part IV for larger facilities.

7.2.2.5 World Heritage/RAMSAR MPAs

Table 101 Presence of certain zones

Description (Fletcher *et al*. 2004)	*Are any of these types of zones present in the area? If there are, what species arrangements etc. are needed to meet their requirements (i.e. is development referable action under EPBC Act 1999)?*			
Level of impact	Catchment/Region			
Comments	• The requirement to obtain Native Vegetation Clearing Permits will ensure that RAMSAR and other priority heritage areas are protected indirectly. • Any aquaculture sites situated close to these areas may require a more detailed Environmental Monitoring Program.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	1	2	2	Low

Justification for Risk Ranking

Similar to issues 7.2.2.3 and 7.2.2.4, RAMSAR sites are protected under the 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.

The assessment process undertaken by the Department of Fisheries requires 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.

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 number of farming operations in these areas is small, which has meant that impacts are thought to be correspondingly low. The protocols in place at present would limit the consequences to 'minor' ('1'), with a likelihood of 'rare' ('2').

Comments in Relation to Future Management

- Site selection guidelines should identify how to locate any heritage issues that are on, or adjacent, to a proposed aquaculture site and how to avoid them.
- Site proponents should undertake EPBC Act referrals as required.
- The process of applications for proposed aquaculture sites being referred to the DEC should be maintained.
- Assessment through the Native Vegetation Clearing/Protection within the *Environmental Protection Act* under Division 2, Sec 51A, 51T should be maintained.
- Assessment through the EPBC Act should be maintained. This assessment is required in proposals that may impact on protected species.

7.2.2.6 Behavioural changes on species

Table 102 Significant changes to individual species

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			
Comments	• Require protocols for dealing with this issue over the whole of the industry – it may require region-specific protocols. • An assessment of this issue should be included in planning stage. • This assessment could be incorporated into an Environmental Monitoring Program if there is any doubt about possible interactions.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	1	2	2	Low

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). This information is unavailable for WA.

Species such as crocodiles, which may be attracted to fish farms in the northern regions of WA, have had very little reported in the way of interactions with aquaculture. These are more likely to occur with open, earthen ponds than with any closed tank system.

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

Comments in Relation to Future Management

- Develop protocols for managing and minimizing any interactions with individual species.
- Require the reporting of any interactions through aquaculture license conditions.
- In arid areas, ponds could become an attractant and potential migratory path for 'pests' (e.g. bird and mosquito-borne tropical diseases and cane toads).

7.2.2.7 Sensitive habitats

Table 103 Sensitive habitats

Description (Fletcher *et al*. 2004)	*Are there any sensitive habitats in the area that would be significantly impacted on by the presence of the facilities?*			
Level of impact	Catchment/Region			
Comments	There are possible issues but these are manageable via site selection guidelines and Native Vegetation Clearing requirements.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	1	2	2	Low

Justification for Risk Ranking

The Department of Environment and Conservation (DEC) currently require that 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 will be 'minor' ('1') with a likelihood of minor impacts occurring being 'rare' ('2').

Comments in Relation to Future Management

- Appropriate site selection is important.
- The requirement for clearance approval from the DEC should be maintained.

7.2.2.8 Scavengers

Table 104 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			
Comments	• Intensive farms operate indoors, so there is no issue. • There are very few instances to date with inland aquaculture in regard to interactions with scavenger species. • The use of appropriate feeding regimes should minimise any waste feed [and deter scavengers]. It is in the best interests of a farmer to manage feed additions, as they cost money.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	1	2	2	Low

Justification for Risk Ranking

Published reports of interactions between birds and sea-cage finfish culture are relatively few, although several species are known to take fish from ponds and cages (Black 2001). The desire to control scavenger birds by various lethal means conflicts with the desire of many members of the public to conserve these birds as wildlife (Goldburg & Triplett 1997).

Methods used in South Australia to control sea gull numbers involved 'pricking' their eggs to limit their viability. This method does not require scientific expertise and has been implemented by staff from finfish aquaculture operations. It has been a cheap and efficient way to lower seagull numbers.

In conjunction with different feeds and feeding techniques, the industry is assisting in controlling bird numbers. This activity has been sighted as necessary, due to the possibility of disease introduction via faecal matter from large numbers of scavengers.

Another potential scavenger is crocodiles, in the northern regions in WA. 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 generally consistent across regions - that of 'minor' ('1'). The likelihood of scavenger numbers being impacted is 'rare' ('2'). This value is based on the likely number of scavengers present due to other anthropogenic activities, i.e. rubbish dumps.

Comments in Relation to Future Management

- Develop an Environmental Monitoring Program that incorporates appropriate indicator species to measure any increase in numbers of scavengers under aquaculture cages.
- Ensure feeding regimes minimize feed wastage as much as possible.

7.2.2.9 Translocation between catchments

Table 105 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			
Comments	• Any movement of stock between aquaculture locations requires approval. • Strict controls already exist for farmers wishing to move stock from hatcheries to grow-out ponds.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	3	1	3	Low

Justification for Risk Ranking

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

The introduction of exotic organisms can be broken down further into two components: 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 fish. The possibility of the introduction of exotic plants and animals remains a risk to both the industry and the environment (De Jong and Tanner 2004).

In the 1970s, the import of Japanese goldfish infected with the bacteria *Aeromonas salmonicida* into Victoria introduced 'goldfish ulcer disease' to cultured and wild Australian goldfish and koi carp populations. It has been suggested that the risk of translocating native fish within their distributional range poses a greater threat than translocating exotic species because the disease would then spread to native populations that are known to be susceptible to the disease but may not have been exposed to the pathogen before. This is in comparison with the risk associated with translocating exotic fish that may be carrying an exotic disease that requires specific hosts and hence would be unable to infect the native fish.

While there have been no documented introductions of exotic animals or plants due to aquaculture in Western Australia, such introductions have been common elsewhere in the world. While the majority of such introductions occurred prior to the implementation of today's stringent protocols to prevent such occurrences, there is still a risk of similar introductions happening today. These historical introductions emphasise the importance of taking extreme care when translocating stock long distances.

The Department of Fisheries' translocation policies manage the importation and translocation of fish in and around WA, thereby reducing the risk of exotic disease introductions. Authorizations from the Department are required for the import or translocation of fish, and a veterinarian must certify the stock. There are also national regulations restricting the translocation of animals.

Under the current situation where translocation of native species only occurs intra-state, and on a scale that is probably less than the scale of movement for wild fish, translocation of native species is likely to represent a 'low' risk. A slightly higher risk would be associated with the inter-state translocation of barramundi for example, and it is important to maintain careful control over this process. If disease outbreaks occur in the areas these originate from, the risk could become 'high'.

Comments in Relation to Future Management

- Maintain the current protocols and approvals for all translocations of fish.

7.2.3 Physical structures and construction & tenure

7.2.3.1 Number of farms

Table 106 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? 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, the level of access still possible and collective wastewater discharge impacts.*
Level of impact	Catchment/Region
Comments	• Nutrient mass loadings are a function of individual facility discharges, and the number/biomass of facilities. • These potential issues need to be considered in the planning phase. • Industry would need to develop significantly over the next five years for this to be an issue.

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

Justification for Risk Ranking

The WA State Planning Strategy 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 for the zoning and placement of specific activities within each region. Therefore, this issue is very much linked to the 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 this 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 within a framework of consultation with local government and community, in order to resolve these issues in planning phase.
- ‘Best practice’ guidelines - and each facility meeting the relevant guidelines - will ensure regional impacts are not a risk.

7.2.3.2 Habitat removal

Table 107 Removal of terrestrial vegetation due to 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
Comments	Native vegetation protection should be achieved through an assessment of Clearance Applications.

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

Justification for Risk Ranking

It is widely agreed that habitat loss is one of the major causes of decreases in biodiversity. Because of this situation, 'land clearance' is a listed key threatening process under the EPBC Act.

Habitat destruction and fragmentation have had severe consequences for native terrestrial flora and fauna, while 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 finfish aquaculture, may have these consequences. Specific scientific research on the removal of vegetation for the finfish 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.

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*", Position Statement No. 2 – "*Environmental Protection of Native Vegetation in WA*".
- If possible, seek expressions of interest from operators to share facilities and/or access where possible, at the planning phase of aquaculture facilities.
- A clearing permit should be identified as a part of a suite of regulatory approvals required for an aquaculture development.
- Utilise the Native Vegetation Protection Regulations.
- Ensure use of Draft EPA Guidance Statement No. 33 – *"Planning and Development*" and Position Statement No.2 – *"Environmental Protection of Native Vegetation in WA"* when assessing potential aquaculture facilities.

7.2.3.3 Heritage Area effects

Table 108 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			
Comments	• Gain all necessary approvals to ensure heritage area protection. • If possible, undertake consultation with any indigenous communities during the preliminary planning phase of an aquaculture development.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	1	2	2	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), *Planning and Development Act 2005* and *Environmental Protection Act 1986* (EP Act) all have legal capacity to consider aspects of Aboriginal heritage. The main focus of the AH Act is the protection of sites with social and heritage significance. The primary focus of the EP Act is to consider proposals that have the potential to have an environmental impact.

The Department of Indigenous Affairs (DIA) has specialist expertise and is the prime department for Aboriginal heritage matters. The Environmental Protection Authority (EPA) can deal with Aboriginal heritage if it is in the context of an environmental setting. The EPA should compliment, not duplicate, the DIA's responsibility.

Comments in Relation to Future Management

- The DIA and the EPA have protocols to assess the impact of any development on heritage sites and to limit this impact.
- Continue to use EPA Guidance Statement No. 41 Draft – *"Assessment of Aboriginal Heritage"* when assessing potential aquaculture facilities.
- List all relevant agencies and their approvals in the Code of Practice.
- If possible, undertake consultation with any Indigenous/Aboriginal communities during preliminary planning phase for aquaculture in a particular region.

7.2.3.4 Soil quality

Table 109 Soil quality

Description (Fletcher *et al*. 2004)	*Are there 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			
Comments	• Determine the location of acid sulphate soils, so as to avoid costly remedial action later. • Contaminated soils also need to be considered if any excavation is involved. • Identify areas to avoid when planning for aquaculture activities.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	1	3	3	Low

Justification for Risk Ranking

Correct construction of the aquaculture facility is likely to lead to increased profitability through savings in maintenance and unexpected construction failures. The issue of acid sulphate soils requires careful consideration because of the repercussions to the operation of the facility should the decision be incorrect. Therefore, excavation and disturbance of known acid sulphate soils must be minimized.

If this type of soil is disturbed, it must be managed by burial, neutralisation or other forms of treatment. Any leakage of acid leachate must be prevented, minimised or treated due to the impact this could have an adjacent ecosystems. Areas where acid sulphate soils have been disturbed must be rehabilitated in order to limit any future impacts.

In WA, mapping of these types of soils has been undertaken by the Department of Environment and Conservation (DEC) for most parts of the State. Proponents should be encouraged to

contact DEC regional offices in order to determine whether this issue will be of concern for the aquaculture site being considered.

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 have the potential to be toxic to cultured organisms, include, acid sulphate soils, dispersive soils, expansive clays, organic soils, structured (aggregated) soils or ones that are 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 for pond construction, depending on its percentage of clay content (>70% clay) and elasticity. Utilising this data set will ensure that, where known, the consequences will be 'minor' ('1'). However, there is still a likelihood of 'unlikely' ('3'), since the whole of WA has not yet been mapped for acid sulphate soils.

Comments in Relation to Future Management

- A Code of Practice needs to provide guidance on how to deal with acid sulphate soils.

7.2.3.5 Water table

Table 110 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
Comments	• The aquaculture industry is small enough that any water extraction is likely to be minimal. • Many operators currently utilise stormwater run-off or groundwater to fill empty ponds. • The level of nutrients in water used in aquaculture facilities needs to meet water quality criteria if the water is being discharged into an aquifer.

Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	2	3	6	Low

Justification for Risk Ranking

This is considered to be more relevant at the individual aquaculture facility level. Any actions that raise the water table (run-off or overtopping) could create waterlogging and follow-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 recommends a special consideration of design characteristics if storm water, overtopping, biofilters or waterlogging of soils is likely to be a concern.

With current industry levels, the consequences could be 'moderate' ('2') due to the assessment and licensing processes undertaken by the Department of Water. The likelihood of a moderate impact happening is 'unlikely' ('3') but could occur due to the current level of knowledge and understanding of regional aquifers and any impacts due to water extraction allocation levels.

Comments in Relation to Future Management

- Maintain the assessment and regulation processes.

7.2.3.6 Infrastructure

Table 111 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			
Comments	• In some regions, there may be restrictions on the amount of land available to construct further infrastructure due to residential growth, vegetation loss, heritage issues or retention of wilderness areas. • The aquaculture industry is small, so encouraging local or state government to provide additional infrastructure may be difficult. • A lack of infrastructure may limit new players coming into the aquaculture industry, due to increased set-up costs.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	2	3	6	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 and the Abrolhos Islands, 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 necessary for aquaculture development.

The risk ranking is 'low' due to the currently small aquaculture industry, but any growth in areas such as the Pilbara and Kimberley will increase this risk to 'moderate'.

Comments in Relation to Future Management

- Work together with local councils to ensure that areas suitable for locating supporting infrastructure for aquaculture are considered when planning is carried out for coastal areas.
- Encourage aquaculture operators to utilize shared facilities wherever possible.
- Continue to use EPA Guidance Statement No. 3 *"Separation Distance between Industrial and Sensitive Land Uses"* (2005). This deals with seafood processing activities that are associated with marine-based finfish aquaculture.
- A Code of Practice will address construction and design issues that should be considered as a result of the removal of environmental protection provisions for managing these issues (i.e. a works approval).

7.2.3.7 Noise/odour

Table 112 Regional increases in noise

Description (Fletcher *et al*. 2004)	*Are there any regional implications regarding noise and/or odour that need to be considered?*			
Level of impact	Catchment/Region			
Comments	This is unlikely – noise and odour are local issues.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	0	2	0	Negligible

Justification for Risk Ranking

Where finfish farms are constructed near other rural users or have had residential development encroach on rural areas where they are located, there is the potential for operational noise to create a nuisance. Impacts are likely to result principally from aeration devices, pump operations and feeding operations. The level of impact will depend on the local background noise levels, the type of noise, distance to sensitive places and buffers (Donovan 1999).

The *Environmental Protection Act 1986* incorporates noise regulations that specify certain operational criteria that must be met by specific industries.

There is the potential in aquaculture facilities for odours to create a nuisance for adjacent properties. Impacts are likely to result principally from the disturbance of pond sediment after pond draining. The level of impacts will vary, depending on background odours, wind directions, distances to sensitive places and buffers.

Odours from facilities are controlled through Section 49 (Unauthorised Emissions) of the *Environmental Protection Act* (EP Act) and its associated regulations.

Considering the present industry and its location, the consequences are 'negligible' ('0'), with a likelihood of 'rare' ('2').

Comments in Relation to Future Management

- A Code of Practice should refer to the noise regulations that are incorporated into the EP Act.

7.2.3.8 Site constraints (e.g. topography, flooding)

Table 113 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			
Comments	• Aquaculture facilities are on private property, so an applicant would be selecting a site within the constraints of the latter. • This is not really a regional issue.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	0	3	0	Negligible

Justification for Risk Ranking

Site selection and evaluation must ensure that the proposed site will be capable of operating in an economically-viable and environmentally-responsible manner in accordance with legislation and any Code of Practice. The following list, although not exhaustive, identifies the major issues that must be considered when evaluating a potential finfish aquaculture site (Donovan 1999):

- access to water;
- capacity of the receiving environment to dilute and assimilate the discharge waters;
- environmental value of the site and the region;
- existing flora and fauna, both on and surrounding the site;
- existing water users;
- neighbouring land uses;

- potential impacts of the development on environmental values and biodiversity;
- proximity of Marine Parks, Fish Habitat Protection Areas and other relevant management areas;
- regulatory requirements of the development, site and region;
- soil types, including clay content, erosion potential and acid sulphate soils;
- topography and flood levels (average recurrence interval); and
- water quality and hydrology.

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 site's suitability forms part of broader land-use planning, as well as the assessment process for each proposal.

Considering the current planning activities in WA, the consequences of having an inappropriately sited operation is 'negligible' ('0') with the likelihood of it occurring being 'unlikely' ('3').

Comments in Relation to Future Management

- Consider broader planning activities and, where possible, the Department of Fisheries should participate in consultation processes for the zoning of land (to ensure suitable aquaculture sites are identified and zoned, with aquaculture as an appropriate activity).

7.2.3.9 Town Planning Schemes

Table 114 Town Planning Schemes

Description (Fletcher *et al*. 2004)	*Are there any regional planning schemes that provide direction on unsuitable locations for facilities or associated infrastructure?*			
Level of impact	Catchment/Region			
Comments	Ensure participation in consultation activities during the development of revised Town Planning Schemes.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	0	4	0	Negligible

Justification for Risk Ranking

Identification of suitable sites for aquaculture is imperative to ensuring aquaculture is considered as a valid resource user. Current Western Australian Planning Commission and local government planning activities should continue to include consultation with the Department of Fisheries and industry groups.

Considering the planning activities in WA, the consequences of not having a regional planning scheme that identifies aquaculture is 'negligible' ('0') due to current industry growth rates. However, with the likelihood of regional planning providing direction in the future, is 'possible' ('4').

Comments in Relation to Future Management

- Maintain links with the Western Australian Planning Commission and local government authorities.

7.2.4 Production

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

7.2.4.1 Regional carrying capacity

Table 115 Regional carrying capacity

Description (Fletcher *et al*. 2004)	*Is a maximum level of stocking for all individuals within the catchment/ region needed – e.g. to avoid any stunting of growth, increased disease risk, etc?*
Level of impact	Catchment/Region
Comments	• Cumulative nutrient issues are relevant to aquaculture facilities and related to biomass. • No work has been done in WA on the impacts of aquaculture and likely waste 'inputs' into a catchment. • Nutrients, sediments and wastes are potential issues where high stocking rates occur. • There is a need to consider all the aquaculture being carried out in a region and then 'link' this to all 'inputs' into waterways. • There should be a maximum stocking density set for a licensed site. • It must be ensured that the maximum biomass of permitted species does not exceed the maximum allowed tonnage across all species. • Tonnages may need to be capped as the aquaculture industry grows.

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

Justification for Risk Ranking

A lot more work needs to be done to understand (or determine) what are reasonable levels for aquaculture on a region-by-region basis. The Department of Environment and Conservation is currently developing environmental quality objectives for broader regions, but even these studies do not provide specific figures for suitable maximum levels for this industry.

Studies have been done on cage finfish farming in Lake Argyle, which provide some information on the site impacts of freshwater aquaculture. This data needs to be analyzed to determine whether it is relevant for aquaculture facilities that operate using ponds.

On the current levels of operation, the risks have been determined as 'minor' ('1') with a likelihood of 'rare' ('2'). When the number of facilities sited within a catchment increases, this ranking should be reconsidered.

Comments in Relation to Future Management

- The proper on-site management of nutrients at individual aquaculture facilities will 'manage' the cumulative issue on a catchment/regional basis.
- Regional planning exercises need to consider all activities that discharge into waters/ groundwater.
- The expected nutrient 'input' from aquaculture operations into the environment should be able to be assessed.
- Measurement of nutrient 'inputs' should be made part of the Environmental Monitoring Program and linked to regional reporting for Ecosystem-based Fisheries Management Plans.

7.2.4.2 Disease (e.g. proximity of facilities, translocation policy)

Table 116 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			
Comments	• 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 the possibility of disease transmission through the shared use of equipment. • This issue should be determined in conjunction with the regional carrying capacity in terms of aquaculture production. • Disease management to 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 discharges of chemically-contaminated waters from a site may impact users downstream.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	1	2	2	Low

Justification for Risk Ranking

The Department of Fisheries has a functioning translocation policy which ensures any disease transmission between sites and regions is minimised. Stock movements are closely managed, with health certification required prior to any movements.

With current protocols and policies, the consequences are likely to be 'minor' ('1'), with a likelihood of minor impacts being 'rare' ('2').

Comments in Relation to Future Management

- Maintain the current protocols.

7.2.4.3 Disposal of processing waste

Table 117 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			
Comments	• Onsite disposal of wastes needs to be managed appropriately and the processing waste removed offsite to an appropriate facility. • License condition prohibiting any dumping of viscera and offal in water – all waste is to be disposed of in land-based facilities.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	0	2	0	Negligible

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 be 'minor' ('1') to 'severe' ('3') depending on the region.

Comments in Relation to Future Management

- It should be recommended through a Code of Practice that the dumping of viscera and offal in water should be avoided – all waste to be disposed of in land-based facilities.
- A guideline could be developed as part of the Department of *Water's Water Quality Protection Notes* for any processing and offal disposal. This could consider composting then disposal to land, consignment to a by-products processing plant or, in the absence of other viable options, disposal to waste landfill. This could be included in a Code of Practice.
- No disposal should be carried out close to recreational use areas.

7.2.4.4 Disposal of unusable product

Table 118 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			
Comments	• 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	1	2	2	Low

Justification for Risk Ranking

The size of WA's aquaculture industry and its relatively low level of production restricts the amount of waste being produced. Any dead fish should be collected from ponds, etc, on a daily or weekly basis, and disposed of in land-based facilities, in a similar manner to processing wastes.

Guidelines for processing and offal disposal need to be developed, considering composting then disposal to land, consignment to a by-products processing plant or, in the absence of other viable options, disposal to waste landfill. If aquaculture facilities abide by current regulations and conditions, the risk from this issue is 'low'.

Comments in Relation to Future Management

- Maintain the current protocols on disposal in land-based facilities – which 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 facility should be required to have an agreed worst-case disposal arrangement). If each aquaculture facility is properly provided for, then regional issues will not arise.

7.3 Impacts of Individual Facilities on Environmental Wellbeing

These are the potential topics that may relate to what an aquaculture operator (and any authority from whom consent is needed in order for an aquaculture facility to go ahead) needs to consider for assessing the issues related to a specific 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 have not been developed, due to the nature of individual facilities and the difficulty in assessing issues in this context.**

7.3.1 Site Selection/Construction/Infrastructure

7.3.1.1 Habitat effects

Table 119 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			
Comments	Native Vegetation Clearing permit required.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	1	3	3	Low

Comments in Relation to Future Management

- Environmental Protection Authority/Department of Environment and Conservation guidelines should identify the requirements for this approval.

7.3.1.2 Erosion

Table 120 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			
Comments	Impacts from construction are possible and need consideration in the design of an aquaculture facility and, in some cases, will require active management.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	2	3	6	Low

Comments in Relation to Future Management

- Environmental Protection Authority/Department of Environment and Conservation guidelines for managing erosion and sedimentation are required.

7.3.1.3 Seepage

Table 121 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			
Comments	Ponds should be designed/constructed for minimal seepage 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	4	8	Moderate

Comments in Relation to Future Management

- This may be an ongoing issue.
- Environmental Protection Authority/Department of Environment and Conservation guidelines on construction techniques are required.

7.3.1.4 Rehabilitation

Table 122 Site rehabilitation

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

Comments in Relation to Future Management

- Environmental Protection Authority/Department of Environment and Conservation guidelines for rehabilitation are required.

7.3.1.5 Soil quality

Table 123 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			
Comments	This will be dependent on the particular site chosen.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	2	4	8	Moderate

Comments in Relation to Future Management

- Environmental Protection Authority/Department of Environment and Conservation guidelines for construction/site selection are required.
- A Code of Practice needs to provide guidance on this issue - where proponents can go for information, and simple tests to identify if acid sulphate soils are present on-site.

7.3.1.6 Noise/dust

Table 124 Noise resulting from facility

Description (Fletcher *et al*. 2004)	*Will construction of the facility result in an unacceptable increase in noise and dust to surrounding areas?*			
Level of impact	Individual facility			
Comments	• Some localised impact is highly likely. • Management techniques are simple – Noise Regulations apply. • A dust nuisance may be an offence under the *Environmental Protection Act*. • Local government may manage this potential issue via their planning development approval process.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	2	5	10	Moderate

Comments in Relation to Future Management

- Environmental Protection Authority/Department of Environment and Conservation guidelines to manage noise and dust are required.
- The issues of noise and dust should be separated, as they are quite different.

7.3.1.7 Infrastructure

Table 125 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			
Comments	• Discussions with local government should be held to determine whether aquaculture activity is allowed on the land a proponent is interested in – what does zoning suggest as a suitable location? • There should be a 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

- The Department of Fisheries should continue to provide all applicants/proponents with Ministerial Policy Guideline No. 8.

7.3.1.8 Waste (e.g. dredge spoilage)

Table 126 Disposal of dredge spoilage from ponds

Description (Fletcher *et al*. 2004)	*Do there need to be processes developed to plan for disposal of dredge spoilage?*			
Level of impact	Individual facility			
Comments	• Discussions with local government should be held to determine whether the activity is allowed on the land aquaculture activity is allowed on the land a proponent is interested in – what does zoning suggest as a suitable location? • The Department of Environment and Conservation have guidelines to manage disposal of spoilage into adjacent land.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	2	4	8	Moderate

Comments in Relation to Future Management

- Department of Fisheries guidelines on decommissioning are required.
- Department of Environment and Conservation/local government guidelines on stormwater flows are required.
- Department of Environment and Conservation/Environmental Protection Authority guidelines on pond de-sludging/disposal are required.
- Department of Environment and Conservation/local government construction guidelines are required.

7.3.1.9 Water Flow

Table 127 Regional water flows

Description (Fletcher *et al*. 2004)	*Will the construction of this facility interrupt water flow within the region (may need reference to the whole of catchment level assessment)?*			
Level of impact	Individual facility			
Comments	• Applicant should outline position of the proposed aquaculture facility in relation to surrounding areas. • The applicant should outline regional water/river/stream flows. • The applicant should outline how the proposed facility will be managed to minimise impacts on water flows within the region.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	2	4	8	Moderate

Comments in Relation to Future Management

- It is considered poor practice to construct aquaculture facilities on major waterways (third order streams and above) due to the risk of flooding, potential escape of exotic species and potential disruption to water flows/quality which could disadvantage downstream water users.

7.3.1.10 Buffers

Table 128 Setting buffer limits

Description (Fletcher *et al*. 2004)	*Is it necessary to define limits regarding proximity to fauna, other water bodies or industry users?*			
Level of impact	Individual facility			
Comments	Buffers to other sensitive areas/uses are a consideration and possible risk.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	2	4	8	Moderate

Comments in Relation to Future Management

- Site selection guidelines should also address appropriate buffers.
- Continue to use EPA Guidance Statement No. 3 *"Separation Distance between Industrial and Sensitive Land Uses"* (2005).

7.3.1.11 Alienation – interaction with other uses

Table 129 Alienation of other groups

Description (Fletcher *et al*. 2004)	*Will the construction of the 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			
Comments	• This is unlikely if the proposed facility is on private land, but if it is on crown land (public) this may be an issue, due to the exclusive nature of lease arrangements. • Proponents should provide details if it appears that removing water from river during the working of 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

Comments in Relation to Future Management

- Guidelines should identify alienation as a consideration (in terms of site selection and displacement of existing users).

7.3.1.12 Water table

Table 130 Impacts on water tables

Description (Fletcher *et al*. 2004)	*Will the construction of the facility have an impact on the water table (other than associated with soil quality issues dealt with above)? This may need to refer to 'whole of catchment' issues.*			
Level of impact	Individual facility			
Comments	Applicant will still require approval from the Department of Water for any water use and access.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	2	4	8	Moderate

Comments in Relation to Future Management

- The Department of Water assessment processes and licensing should be carried out as required.
- There should be a minimum vertical buffer of two metres between infrastructure (e.g. base of ponds) and the water table.

7.3.2 Operations

7.3.2.1 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 131 Health of cultivated stock

Description (Fletcher *et al*. 2004)	*Is a health surveillance monitoring system needed?*			
Level of impact	Individual facility			
Comments	• Outline the stocking density and cage/pond structures to be used in the proposed facility. • Outline the disease management protocol to be employed on-site.			
Risk assessment values				
Organisation/Person	Consequence	Likelihood	Risk Value	Risk Ranking
After workshop	3	2	6	Low

Comments in Relation to Future Management

- Where possible, the proponent should provide information for species considered for culture.
- The applicants should be provided with some concept of the likely Environmental Monitoring Program requirements and the Code of Practice they would operate under.

Table 132 Stocking density / biomass

Description (Fletcher *et al*. 2004)	*Are there are issues relevant to stocking density or biomass that should be considered?*			
Level of impact	Individual facility			
Comments	• Stocking density/biomass will relate to nutrient issues and management. • Outline the farm management practices that will be used to monitor stock and feed rates. • Feed rates should be related to stocking density – demonstrate an understanding on the relationship between the two.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	2	4	8	Moderate

Comments in Relation to Future Management

- Guidelines on the relationship between biomass nutrient generation and nutrient treatment/ disposal are required.
- Guidelines should state a preference for non-direct discharges of wastewater to land.

Table 133 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 facility?*			
Level of impact	Individual facility			
Comments	The husbandry techniques used need to comply with *Animal Welfare Act*.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	1	3	3	Low

Comments in Relation to Future Management

- Applicants should be made aware of their obligations under the Animal Welfare Act.
- Applicants should be informed of the license conditions that may be attached to any approval in regards to stock management, site rehabilitation and decommissioning.

Table 134 Predation

Description (Fletcher *et al*. 2004)	*Are predators (e.g. birds) a problem around this facility? If these predators are protected species, this may result in different actions being necessary.*			
Level of impact	Individual facility			
Comments	Outline the methods to be employed to minimize predation of stock – keeping stock indoors or the use of bird exclusion nets.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	1	4	4	Low

Comments in Relation to Future Management

- Guidance and relevant information should be provided on likely predator species.

- There needs to be guidance and an awareness of the methods that can be used to minimize any interactions with predators.
- There should be due consideration given to site security (i.e. fencing and other measures to deter intruders/poaching).

7.3.2.2 Use

Table 135 Water use

Description (Fletcher *et al*. 2004)	*Does the facility need to use water (e.g. fresh water/river/ground water) that is in limited supply? It may be necessary to refer to any catchment level limits.*			
Level of impact	Individual facility			
Comments	Outline the water sources, amounts required, treatment and disposal to be used on proposed aquaculture 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 current Department of Water protocols and licensing procedures should be maintained.
- Ensure that operations are designed and operated to be water efficient as practically possible.
- Water treatment, management and disposal should be compatible with the maintenance of downstream water resource values.

Table 136 Visual impact

Description (Fletcher *et al*. 2004)	*Does the facility need to meet any visual impact limitations?*			
Level of impact	Individual facility			
Comments	• Vegetation should be used as an appropriate visual screen. • The colour of sheds needs to be considered in order that they blend in as best as possible.			
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 the local government to see if any restrictions apply to the land parcel they are proposing to develop as an aquaculture facility.

Table 137 Air

Description (Fletcher *et al*. 2004)	*Does the operation produce greenhouse gases, other air pollutants or smells?*			
Level of impact	Individual facility			
Comments	• The use of alternative power and fuel sources should be encouraged. • Is a generator being considered for long-term or backup use at the proposed facility? • Is solar power a possible alternative?			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	2	5	10	Moderate

Comments in Relation to Future Management

- Guidelines on the use of alternative power sources so as to minimize emissions into the atmosphere would be useful.

Table 138 Energy

Description (Fletcher *et al*. 2004)	*What is the energy consumption for the facility and what is the energy efficiency rating?*			
Level of impact	Individual facility			
Comments	Solar power could be used for water heating. Are generators being considered for electrical power and, if so, what types?			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	0	3	0	Negligible

Comments in Relation to Future Management

- Information should be sought from the applicant on the power required for their facility and whether any alternative sources are possible.

Table 139 Noise/odour

Description (Fletcher *et al*. 2004)	*Does the operation of the facility include noisy machinery (e.g. pumps) or devices (e.g. bird scarers)? Would such activities affect neighbours or sensitive fauna?*			
Level of impact	Individual facility			
Comments	• The risk of unwanted noise generation by some aquaculture facilities is real and needs consideration. • Odour generation is a risk from carcasses, processing wastes and de-sludging operations. • The noise generated by any facility is managed under the Noise Regulations. • Odour may be an offence under the *Environmental Protection Act.*			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	2	5	10	Moderate

Comments in Relation to Future Management

- Guidelines are required in regard to buffer distances and the management of noise/odour-generating activities.
- Noise and odour generation are separate issues, as they are quite different in nature.

Table 140 Escape of cultured species or pests

Description (Fletcher *et al*. 2004)	*Is escapement of individuals an issue (may require reference to 'whole of industry' protocols)?*			
Level of impact	Individual facility			
Comments	• Outline the methods that are proposed to minimize escapes at the proposed facility – look at the Department of Fisheries' translocation policy. • Notification of any escapes is required. • The use of equipment between areas needs to be managed – equipment should be sterilised.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	2	2	4	Low

Comments in Relation to Future Management

- Guidance should be provided on the design of facility in order to minimize any escape of stocks.

Table 141 Habitat effects

Description (Fletcher *et al*. 2004)	*Will operations of the 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			
Comments	This impact should be highly unlikely, as the proposed facility is likely to be 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 in close proximity to aquaculture facilities could raise awareness of operators to this issue.

Table 142 Chemical theraputants

Description (Fletcher *et al*. 2004)	*Are these used? If so, what protocols are needed? Reference may be needed to 'whole of industry' protocols.*			
Level of impact	Individual facility			
Comments	• The environmental implications of chemical and medicine usage need to be considered. • Data on type, amount, frequency and toxicity of chemicals is needed to complete this element. • Concentrations of chemicals (or any known or likely impacts from them) must be contained within the lease area (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 on this issue is required.
- Techniques for isolated parasitic dosing should be developed.
- No impacts outside lease area (e.g. into waterways or neighbouring water supply sources) are a required outcome of management action [in regard to the use of chemicals and medicines].

Table 143 Lights

Description (Fletcher *et al*. 2004)	*Will the use of lights impact on sensitive species? Reference may be needed to 'whole of industry' protocols.*			
Level of impact	Individual facility			
Comments	The impact of lights on sensitive species is unlikely to be an issue.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	0	2	0	Negligible

Comments in Relation to Future Management

- No specific comments were made.

Table 144 Entanglement interactions

Description (Fletcher *et al*. 2004)	*Could the structures result in entanglement of large/protected species? Reference may be needed to 'whole of industry' protocols.*			
Level of impact	Individual facility			
Comments	Structures of the proposed aquaculture facility causing the entanglement of large/protected species 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.

Table 145 Gear and equipment movement

Description (Fletcher *et al*. 2004)	*Will the movement of equipment between farms result in the need for translocation protocols? Reference may be needed to 'whole of industry' protocols.*			
Level of impact	Individual facility			
Comments	• There is a need for proponents to outline the protocols they intend using to transfer and sterilise equipment. • This is more necessary within regions than between regions – because gear is out of the water longer for movements of equipment between regions, there is more time for organisms to die during transportation			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	3	3	9	Moderate

Comments in Relation to Future Management

- Translocation and equipment movement protocols should be maintained.

7.3.2.3 Waste

Table 146 Water quality

Description (Fletcher *et al*. 2004)	*Is the quality of the water used by the facility acceptable for release into the environment, freshwater or marine? The levels required should relate to 'whole of industry' levels.*			
Level of impact	Individual facility			
Comments	• Water quality guidelines are well-known. • There is a need to outline the protocols for water treatment on aquaculture sites. • Monitoring of discharges (from the proposed site) will be required.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	2	5	10	Moderate

Comments in Relation to Future Management

- 'Best practice' management for each aquaculture facility would ensure that there are no regional or 'whole of industry' issues. This 'best practice' should include adherence to water quality guidelines.

Table 147 Sedimentation

Description (Fletcher *et al*. 2004)	*Does the operation result in the sedimentation of habitat or physical environment (e.g. under the cage, near an outfall)? If yes, refer to appropriate levels for the catchment.*			
Level of impact	Individual facility			
Comments	The placement of sludge on land sites is possible.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	2	5	10	Moderate

Comments in Relation to Future Management

- 'Best practice' management for each aquaculture facility would ensure that there are no larger issues. This 'best practice' should include adherence to water quality guidelines.

Table 148 Waste Disposal

Description (Fletcher *et al*. 2004)	*For any deaths of the cultured species, are there adequate facilities for their disposal (e.g. local putresible waste landfills)?*			
Level of impact	Individual facility			
Comments	• Wide-scale deaths of fish may overload local waste disposal facilities. • A worst-case scenario contingency plan should be developed.			
Risk assessment values				
Organisation/Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
After workshop	2	4	8	Moderate

Comments in Relation to Future Management

- The guidelines on the waste disposal required are with local government.

Table 149 Processing

Description (Fletcher *et al*. 2004)	*Is there processing of product (particularly filleting etc) done on the facility? Is there any disposal of this waste on site?*			
Level of impact	Individual facility			
Comments	• Local government has a role in regulating health safety issues. • The new *Food Act* will outline the minimum requirements for any licensed aquaculturist undertaking processing of their 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	1	2	2	Low

Comments in Relation to Future Management

- Guidelines on waste disposal planning are required.
- Current protocols and authorizations should be maintained.
- Ensure any applicant/licence holder is aware of their obligations under the Food Act and any associated code.

Table 150 Sewage

Description (Fletcher *et al*. 2004)	*Does the facility have appropriate sewage treatment?*			
Level of impact	Individual facility			
Comments	• This is unlikely to be issue unless facility is very large (i.e. has a large workforce). • Even the facility has a large workforce, 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

- This issue is dealt with through the Ministerial Policy Guideline No. 8 assessment.
- The requirements for local government approvals should be maintained, as required.

Table 151 Bio-fouling

Description (Fletcher *et al*. 2004)	*Is bio-fouling removed from structures used in the facility? If so, what happens to this material when it is cleaned off?*			
Level of impact	Individual facility			
Comments	• Use Industry –wide protocol to manage this activity. • Do not wish to make activity over-onerous however need to manage sedimentation and deposition on land areas of 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 is required to be used to provide protocols for bio-fouling removal.

8.0 APPENDIX

Workshop Participants

Workshop Participants				Attendees
Dr	Rick	Fletcher	Department of Fisheries	Yes
Ms	Jo	McCrea	Department of Fisheries	Yes
Dr	Brian	Jones	Department of Fisheries	No
Dr	Sagiv	Kolkovski	Department of Fisheries	Yes
Dr	Brett	Glencross	Department of Fisheries	Yes
Dr	Janet	Howieson	Department of Fisheries	Yes
Mr	Andrew	Hill	Department of Fisheries	No
Mr	John	Looby	Department of Fisheries	No
Mr	Tony	Cappelluti	Department of Fisheries	No
Ms	Tina	Thorne	Department of Fisheries	No
Ms	Heather	Brayford	Department of Fisheries	No
Mr	Nathan	Harrison	Department of Fisheries	No
Dr	Lindsay	Joll	Department of Fisheries	No
Ms	Lyn	Hobbs	Department of Fisheries	Yes
Mr	Steve	Nel	Aquaculture Development Council	Yes
Ms	Jenny	Shaw	Department of Fisheries	Yes
Mr	Peter	Millington	Department of Fisheries	Yes (part)
Mr	Craig	Astbury	Department of Fisheries	Yes
Ms	Barbara	Sheridan	Department of Fisheries	Yes
Mr	Andrew	Beer	Central West TAFE	Yes
Mr	Greg	Jenkins	Challenger TAFE	Yes
Mr	Gavin	Sarre	Challenger TAFE	No
Dr	Nic	Dunlop	Conservation Council of WA	Yes
Mr	Peter	Skitmore	Department of Environment	Yes
Mr	Peter	Ryan	Department of Environment	Yes
Ms	Jade	Hankin	Department of Environment	Yes
Ms	Emma	Glencross	Department of Environment	Yes
Mr	Dan	Machin	Aquaculture Council of WA	Yes
Mr	Frank	Prokop	Recfishwest	No
Ms	Edwina	Davies-Ward	Marine and Coastal Community Network	No
Mr	Tim	Grubba	Department of Environment and Conservation	No
Mr	Kevin	Bancroft	Department of Environment and Conservation	No
Mr	Nick	Miller	Maxima Pearling Company	No
Mr	Guy	Westbrook	Maxima Pearling Company	Yes
Mr	Peter	Fraser	Marine Produce Australia	Yes
Mr	Steven	Hood	MG Kailis Group	Yes
Mr	Andrew	Tindale	Summermor Pty Ltd	Yes
Mr	Merv	Collinson	Summermor Pty Ltd	Yes
Mr	Quenton	Leach	Cell Aqua	Yes
Ms	Erica	Starling	Latitude Fisheries	Yes

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