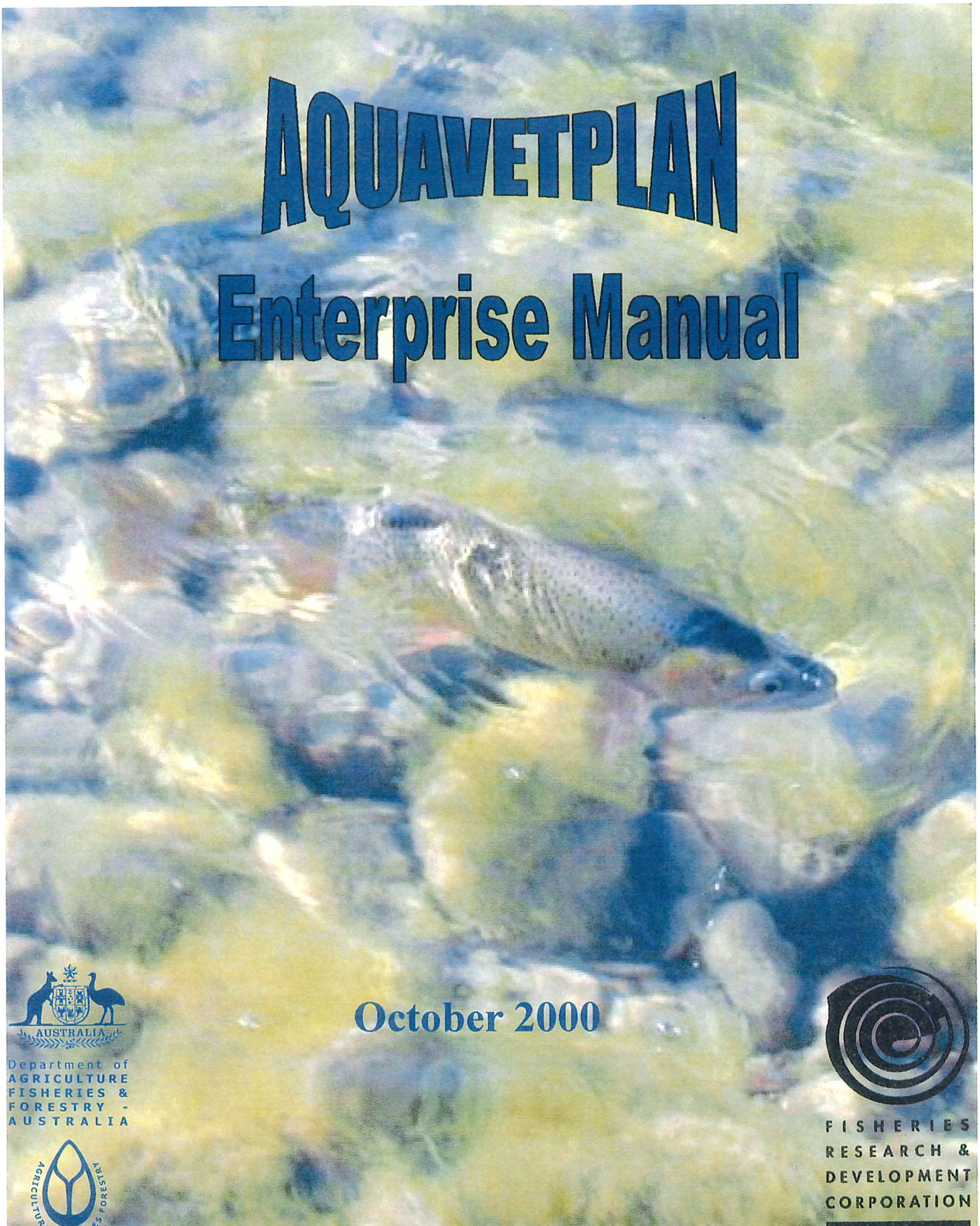
AQUAVETPLAN

Enterprise Manual



October 2000

Department of AGRICULTURE FISHERIES & FORESTRY - AUSTRALIA

FISHERIES RESEARCH & DEVELOPMENT CORPORATION

AGRICULTURE, FISHERIES AND FORESTRY - AUSTRALIA

HON WARREN TRUSS MP
MINISTER FOR AGRICULTURE, FISHERIES AND FORESTRY

MEDIA RELEASE

14 December 2000
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PUBLICATION RELEASED TO HELP MANAGE AQUATIC DISEASE OUTBREAKS

Federal Fisheries Minister Warren Truss today launched the first in a series of operational manuals that will help ensure Australia is prepared for emergency disease outbreaks among its aquatic animals.

Mr Truss said the *Enterprise Manual* is part of a series of manuals known collectively as AQUAVETPLAN. They are part of Australia's National Strategic Plan for Aquatic Animal Health and are designed to complement various State, industry or farm-based emergency plans.

"AQUAVETPLAN is a national management plan and set of operational procedures that would swing into action in the event of an aquatic animal disease emergency," Mr Truss said.

"Because of Australia's geographical isolation and strict quarantine laws, our aquatic animals are free of many of the diseases present in many countries. But that doesn't mean we can sit back and take our disease-free stratus for granted. We are developing a culture that is based on constant vigilance and a readiness to tackle any contingency.

"The release today of the *Enterprise Manual* is the next step in the national plan to improve our ability to quickly and effectively respond to disease outbreaks, whether they are foreign (exotic) or native (endemic) in nature.

"The *Enterprise Manual* is designed to be used by government and industry and will provide decision-makers with quick and easy access to the information they need to implement control strategies at short notice.

"The manual also provides industry with guidance on the various factors that need to be taken into account when making decisions during an emergency. It also includes information on various industry practices and structures and outlines approaches that should be considered in the face of an aquatic animal disease emergency.

"The *Enterprise Manual* provides Australia with an integrated, planned approach to aquatic animal disease emergencies and will greatly enhance our 'clean-green' image in international markets."

Mr Truss said other manuals in the AQUAVETPLAN series are already being prepared. They include the *Control Centre Manual*, which sets out the various roles people will assume during the different phases of an emergency.

"The Coalition Government is committed to helping ensure Australia's fisheries and aquaculture industries remain profitable and sustainable and continue to make an important contribution to the national economy and to communities across rural and regional Australia," he said.

Further inquiries:

Minister's office: Yvonne Best (02) 6277 7520 or 0418 415 772

AQUAVETPLAN ENTERPRISE MANUAL

Talking Points

Background

The growing importance of aquaculture and a deeper understanding of how disease can effect Australian industry have led to calls for our aquatic environment to be better protected.

- In 1996, two reports were released relating to managing aquatic animal health in Australia:

  - the Report of the National Task Force on Imported Fish and Fish Products (1996);

  - the Nairn Report — Australian Quarantine A Shared Responsibility (1996);

- The reports made several recommendations to the Government about aquatic animal health and quarantine;

- In 1998 AQUAPLAN, Australia's National Strategic Plan for Aquatic Animal Health 1998-2003, was developed to respond to the recommendations;

- AQUAPLAN was developed jointly by Government and the private sector and provides a strategic, national approach to dealing with aquatic animal disease.

What is AQUAVETPLAN?

- Under AQUAPLAN a program has been established specifically to address Australia's preparedness and response capability in the event of an outbreak of an aquatic animal disease;

- This program, known as AQUAVETPLAN, is similar to the approach adopted for terrestrial animals under AUSVETPLAN:

  - AQUAVETPLAN consists of a series of manuals that are being progressively developed in line with priorities set in consultation with State/Territory agencies and industry;

- The Enterprise Manual is the first in the series of AQUAVETPLAN Manuals;

- This Manual addresses preparedness and response options at a generic level (i.e. independent of a confirmed disease diagnosis); response options are discussed based on the extent to which control over water and aquatic animals is possible.

Who endorsed the Enterprise Manual?

- The final version of the AQUAVETPLAN Enterprise Manual was endorsed by the State and Territory Governments, the commercial fishing and aquaculture sector and the recreational fishing sector during 1999 and 2000;

- The Enterprise Manual was finalised within the Office of the Chief Veterinary Officer (OCVO) for publication under AQUAPLAN in November 2000;

- The Manual will be updated continuously as comments are received.

What is the Purpose of the Enterprise Manual?

- The Enterprise Manual is aimed at both government and industry personnel who may be involved in emergency disease preparedness and response:

  - The manual is designed to enable decision makers to access sufficient information on industry practices and environments to be able to create applicable control strategies at short notice;

  - The manual is also designed to inform industry personnel of the necessary steps and factors taken into account for decision-making under emergency conditions;

  - The Manual is meant to be complimentary to any State/Territory and industry plans that are developed.

How has production of the Enterprise Manual been funded?

- The Fisheries and Research and Development Corporation provided funding for travel and accommodation to gather the wide expertise required to produce this document;
- Fisheries Resources Research Fund provided funding for some salary support;
- In 1997, the Federal Government allocated $2.77 million over four years to develop and implement AQUAPLAN:
    - As a component of AQUAPLAN, final production of the Enterprise Manual has been funded from this budget.

Who was responsible for developing the Enterprise Manual?

- The project for the AQUAVETPLAN Enterprise Manual was initiated by the Fish Health Management Committee of SCFA:
    - To accomplish project objectives, the project leaders brought together experts from industry, State governments and Commonwealth agencies to scope the task, plan and organise the structure of the contingency planning manuals, and to form writing groups for each of the manuals.

How can the Enterprise Manual be obtained?

- The Enterprise Manual can be obtained directly from AFFA. The address is: Linda Walker, Agriculture, Fisheries and Forestry-Australia. GPO Box 858, Canberra, ACT 2601 AUSTRALIA. Email: linda.walker@affa.gov.au. It will also be downloadable from the AFFA website: http://www.affa.gov.au/outputs/animalplanthealth.html

How can I find out more about AQUAPLAN and the Preparedness and Response Program?

- You can find out more about AQUAPLAN and other projects under the Preparedness and Response program of AQUAPLAN by:

- obtaining the AQUAPLAN booklet from the website http://www.affa.gov.au/outputs/animalplanthealth.html or as a hard copy from the address below;

- referring to projects listed under AQUAPLAN's program number four — ' Preparedness and Response';

- speaking with FHMC representatives, their associations or their committees;

- Or you can contact:

Fish Health Management Committee Secretariat
Aquatic Animal Health
Office of the Chief Veterinary Officer
Agriculture, Fisheries and Forestry – Australia

Phone: +61 2 6272 4328
GPO Box 858
Canberra, ACT 2611
AUSTRALIA

You can also contact:

- Your local State/Territory Government aquaculture agency:

ACT	Chief Veterinary Officer, ACT Department of Urban Services
NSW	NSW Fisheries
NT	Department of Primary Industries and Fisheries
QLD	Department of Primary Industries
SA	Primary Industries and Resources South Australia
VIC	Department of Natural Resources and Environment
TAS	Department of Primary Industries, Water and Environment
WA	Fisheries WA

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AQUAVETPLAN

Enterprise Manual

Comprising:

Published with the assistance of the Fisheries Research and Development Corporation

AQUAVETPLAN is a series of technical response plans that describe the proposed Australian approach to an emergency aquatic animal disease occurrence. The documents provide guidance based on sound analysis, linking policy, strategies, implementation, coordination and emergency management plans.

This Management Manual forms part of:

AQUAVETPLAN Version 1.0, 2000

This document will be reviewed regularly. Suggestions and recommendations for amendments should be forwarded to the AQUAVETPLAN Coordinator (see Preface).

Record of amendments to this manual

[Insert record of amendments as necessary]

ISBN 0642 73000 8

All AQUAVETPLAN manuals will be revised and updated periodically to ensure that they keep pace with the changing circumstances and policies of the industries they cover. Recommendations for amendments should be forwarded to:

The AQUAPLAN Coordinator
Product Integrity, Animal and Plant Health
Office of the Chief Veterinary Officer
Agriculture, Fisheries and Forestry – Australia
PO Box 858
Canberra ACT 2601

http://www.affa.gov.au/outputs/animalplanthealth.html

Cover design: Linda Walker

Editing and production: Linda Walker

Preface

Scope of the Manual

This **Enterprise Manual** for aquatic animal diseases forms a part of the **Aquatic Veterinary Emergency Plan** or **AQUAVETPLAN**.

AQUAVETPLAN is an agreed management plan and set of operational procedures that would be adopted in the event of an aquatic animal disease emergency. At the time of publication the specific plans and the systems, which make up AQUAVETPLAN, are under development.

The **Enterprise Manual** is the first of the series of **AQUAVETPLAN** manuals to be commissioned and is designed to be used with other documents planned for development which will give further information on disease epidemiology, disinfection techniques, command structures and combat policies for selected diseases. Until these further manuals are written much useful information is to be found in the series of **AUSVETPLAN** manuals which address terrestrial animal diseases.

This manual is aimed at both government and industry personnel who may be involved in emergency disease preparedness and response. The manual is designed to enable decision-makers to access sufficient information on industry practices and environments to be able to create applicable control strategies at short notice. The manual is also designed to inform industry personnel of the necessary steps and factors taken into account for decision-making under emergency conditions. The manual should also be regarded as a training resource and an emergency briefing resource for inexperienced officers who may be involved in working on an aquatic animal disease control program.

This first manual provides much of the information needed for the development of more specific formal plans. State and industry plans, which have a more specific operational focus, have been, are being, or will be, developed should be complimentary to this manual. Until these more specific plans are developed, this manual is designed as a resource for use so that informed action can be taken in the face of a disease emergency. After the plans have been developed this manual may be a useful supplement to the formal plans.

The **Enterprise Manual** does not replace the State, industry or farm operational emergency plans but it is designed to complement them.

The **Enterprise Manual** has adopted a generic approach due to the diverse nature of the aquatic animal industries and the wide diversity of agents and hosts that may be involved in an emergency situation. In many cases little may be known of an agent and so a control strategy may need to be developed very quickly using first principles and the available knowledge. This **Enterprise Manual** will help to provide that knowledge.

The **Enterprise Manual** aims to provide brief information on industry practices and structures and then outlines approaches which should be considered in the face of an aquatic animal disease emergency.

The manual covers the entire range of aquatic animal industries and has been split into 'systems' as follows:

Open systems	Systems where there is no control of either host movement or water flow e.g. wild caught fisheries.
Semi-open systems	Systems where there is control of host movement but no control of water flow e.g. net pen culture.
Semi-closed systems	Systems where there is control of host movement and some control of water flow e.g. pond culture, race culture.
Closed systems	Systems where there is good control of both host movement and water flow e.g. aquaria.

Within the husbandry practices of a single industry there may be several of the above groupings represented in different phases of production e.g. in the case of prawn culture: open system for brood stock, closed system and semi-closed system for hatchery, and a semi-closed system for grow-out. This will be noted in the industry information in Section B.

The manual is split into three sections:

Section A provides definitions and general response structures. Section A also includes a summary of the linkages and lines of communications likely to take place during an investigation of an outbreak or in planning a response.

Section B addresses specific industry sector information needed for disease control or eradication.

Section C provides possible responses available in the various systems in the face of an aquatic animal disease emergency.

The document does not address the actions to take if one particular disease occurs in one particular species. It provides sufficient information so that timely and considered decisions can be made in the face of an identified or unidentified aquatic animal disease emergency in any system. Plans for specific diseases will follow during the development of **AQUAVETPLAN**.

Several organisations supported the development of this plan.

The Fisheries Research and Development Corporation provided funding for travel and accommodation to enable the gathering of the wide expertise required to produce this document. Support was also received from the Fisheries Resources Research Fund for some salary support. The contributions of industry and government groups who donated time and therefore salaries are gratefully acknowledged and are an indication of the commitment of these groups to the process. Members of the Fish Health Coordinating Group gave encouragement and support to the project. **AQUAVETPLAN** is part of the **AQUAPLAN** initiative of the Fish Health Management Committee (FHMC).

How to use this manual

1. Don't panic: this manual is not meant to be read from cover to cover.

2. The manual is divided into user-friendly sections:

- **Section A** provides general information on emergency response
- **Section B** provides information on industry practices relevant to disease control
- **Section C** provides information on response options
- **Appendices** provide ancillary information on Commonwealth and State legislation, zoonoses, diseases of concern, animal species currently used for aquaculture, use of chemicals and drugs in aquaculture and a list of useful contact numbers.

3. Select the production system which relates to current problem

To work out what system you are considering, ask yourself two simple questions:

1. Is movement of the host controlled?
2. Is movement of the water controlled?

Then select the appropriate section of the manual

Open systems (on blue paper)	Systems where there is no control of either host movement or water flow e.g. wild caught fisheries.
Semi-open systems (on yellow paper)	Systems where there is control of host movement but no control of water flow e.g. net pen culture.
Semi-closed systems (on pink paper)	Systems where there is control of host movement and some control of water flow e.g. pond culture, race culture.
Closed systems (on green paper)	Systems where there is good control of both host movement and water flow e.g. aquaria.

4. The manual is provided in loose-leaf folder format so the relevant sections can be easily removed and copied for other staff and to facilitate updates.

5. Read Section A when you receive the manual and review in the event of an outbreak.

6. In the event of a disease incident

- ***review Section A***
- ***read the part of Section B relevant to your industry***
- ***read Section C.1 - the overview and the section relevant to your industry/production system.***

Membership of writing groups

Members of writing groups were selected for their expertise in various facets of industries and systems. Due to the diversity of aquatic animal industries, expertise was needed from biologists, aquatic animal disease specialists, emergency management specialists and industry technical representatives. Additional input was received from other industry sectors in the form of husbandry information presented in Section B.

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Manual contents

Section A: Overview

Section contents

This manual aims to assist disease control operations in the field and so contains information which will be useful in all phases of a disease outbreak incident or emergency.

This manual can be used in a variety of aquatic animal disease emergencies including an exotic disease incursion or an outbreak associated with a previously unknown endemic agent.

A.1 Definitions

A disease outbreak emergency

A disease outbreak emergency is indicated when:

A population of aquatic animals is recognised as having undergone severe mortality events or significantly decreased productivity **and** the responsible authority within that State or Territory, is of the opinion that the cause may be an infectious agent. The responsible authority **may also** consider latent events, such as presence of an infectious agent but not the disease, as emergencies.

Under this deliberately broad definition, the term 'disease' usually refers to an infectious disease and, in particular, an exotic infectious disease. However, in practice, this is not necessarily the case: significant emergencies have been associated with new or emerging diseases and with toxins or environmental factors.

The term 'emergency' may have meaning within certain legislation and may have ramifications for issues such as funding. As this is an operational manual, such a legal meaning is not implied. The issue of funding of operations is addressed in Section C.

Figure 1 shows the steps involved in the lead up to the declaration of a disease emergency.

The steps taken by the state/territory's responsible authorities and the enterprise management in the lead up to an emergency are initiated with an alert phase. The alert phase is invoked when an aquatic animal disease incident is recognised and reported. The incident is investigated and interim management strategies are developed until the emergency disease is confirmed. These strategies and any means of control will depend on the extent of the likely threat to the ecosystem or industry.

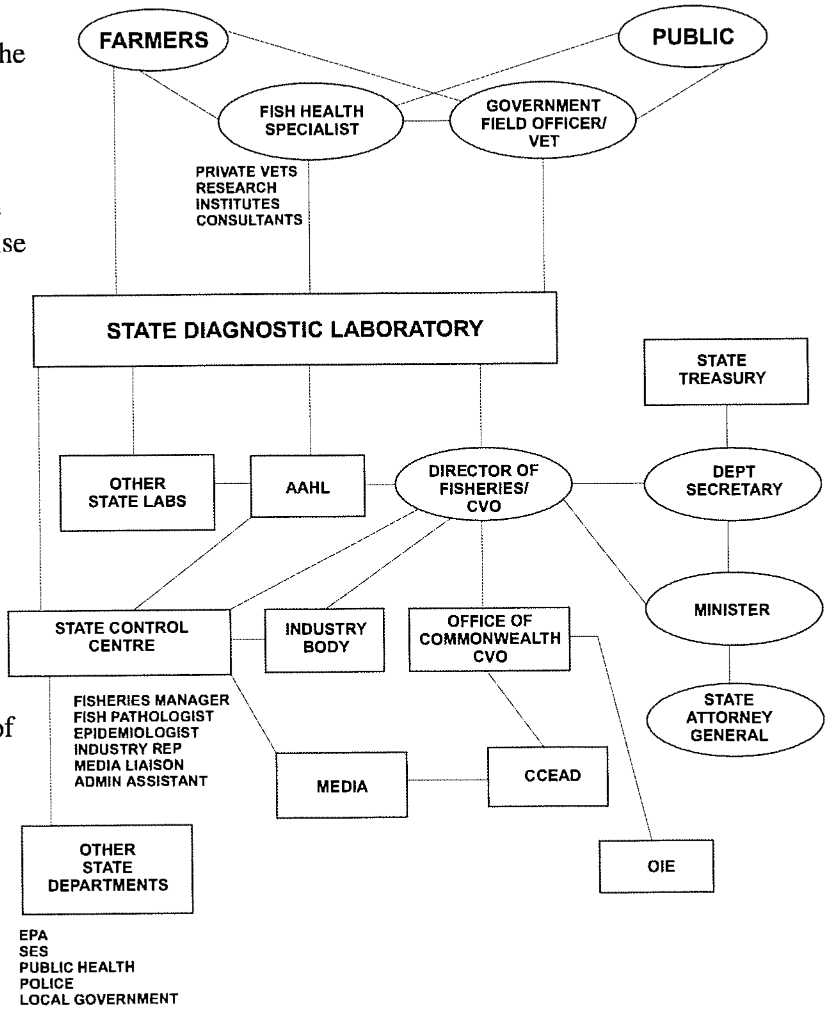

Figure 1: Steps in the management of aquatic animal disease emergencies

A.2 Terms used to define an emergency operation

Due to the nature of the aquatic environment and aquatic animal disease the following areas may be difficult to define. These areas may need to be revised as further information is received on the nature of the agent and extent of its spread.

A declared area is an area that has been subjected to a legal declaration and includes both a restricted area and a control area.

A restricted area is the area around an infected premises (or area) and is likely to be subject to intense surveillance and movement controls. It is likely to be relatively small. It may include some dangerous contact premises (or area) and some suspect premises (or area), as well as enterprises that are not infected or under suspicion. Movement of potential vectors of disease out of the area will, in general, be prohibited. Movement into the restricted area would only be by permit. Multiple restricted areas may exist within one control area.

A free area is an area known to be free of the disease agent.

A control area is a buffer between the restricted area and areas free of disease. Restrictions on this area will reduce the likelihood of the disease spreading further afield. As the extent of the outbreak is confirmed the control area may reduce in size. The shape of the area may be modified according to circumstances e.g. water flows, catchment limits etc. In most cases, permits will be required to move animals and specified product out of the control area into the free area.

Premises or areas are a production site and may range from an aquarium to an aquaculture lease in the open ocean.

The following definitions can apply to premises or areas

An infected premises or area is defined by the area in which the disease has been confirmed. Definition of an 'infected area' is more likely to apply to an open system such as an oceanic lease.

A dangerous contact premises or area is that which has had a direct, and possibly infectious, contact with an infected premises/area. The type of contact will depend on the agent involved in the outbreak but, for example, may involve animal movements or net/equipment movements.

A suspect premises or area is where the emergency disease is suspected but not yet confirmed. The reason for the suspicion varies with the agent however it may involve clinical signs or increased mortality.

A.3 Zoning

Zoning is the process of defining disease-free and infected zones in order to facilitate trade. The concept of zoning is based on the fact that diseases do not recognise national (or State boundaries) but are more likely to be restricted by geography. The AQUAPLAN Zoning Policy Guidelines have been developed based on the Office International des Epizooties (OIE) guidelines and highlight the issues that need to be considered when developing zoning policies.

In essence, zoning could allow Australia to designate areas as disease free, which would, in the event of an outbreak, still enable trade to continue from these regions. For example, if a disease is detected near Perth, Australia could use the concept of zoning to mount a case that trading partners could continue to trade with farms located on the opposite side of the country, such as in Townsville.

Zoning is not an easy or quick system to set up. If Australia elected to employ zoning as a trading tool then, under the International Aquatic Animal Health Code of the OIE, freedom must be proven (through rigorous testing) rather than inferred.

The requirements for testing for freedom and for recognising zones vary according to the biology of the disease agent.

A more full explanation of the principles and requirements of zoning can be found in the AQUAPLAN Zoning policy Guidelines and the *OIE International Aquatic Animal Health Code*, 1999, Chapter 1.4.4.

A.4 Key operational terms

Tracing is the process of locating animals, persons or objects that may be implicated in the spread of disease.

Surveillance is a systematic examination and testing to determine the presence or absence of a disease agent.

A Local Disease Control Centre (**LDCC**) is an operational unit that manages the disease control operation within a declared area. The LDCC manages the operations on infected premises (e.g. clean up) and coordinates surveillance and disease investigations at a local level (e.g. sample collection). There may be one or several LDCCs depending on the size of the operation. The operational guidelines of an LDCC are set out in the AQUAVETPLAN Control Centre Manual.

A.5 Management of aquatic animal disease emergencies

The linkages and lines of communication which may be used during the management of an aquatic animal disease emergency are summarised in Figure 1 (Section A.1).

Reporting

It is likely that, in most States/Territories, fish kills are reported initially by either farmers or members of the general public. These people would inform research institutes, private consultants, private veterinarians, Fisheries/Field Officers or the State Veterinary Diagnostic Laboratory directly.

No matter what the avenue of reporting, it is imperative that the State Veterinary Laboratory, or equivalent, is informed as soon as possible so that appropriate action is initiated. It is important that the State system is alerted, as the State government will be responsible for coordinating the response.

Coordination of the incident

Management of the incident is coordinated through State authorities. It is usually through a single State veterinary diagnostic laboratory (or equivalent) led by the State Chief Veterinary Officer (CVO) and/or Director of Fisheries. It is the State authority (Agriculture and/or Fisheries departments) which has the linkages to other emergency agencies if needed.

Lines of communication during the incident

The State CVO and/or the Director of Fisheries or delegates are the conduit for information within the State and to other States/Territories and Commonwealth agencies.

If the disease is of national importance the State CVO and/or Director of Fisheries will activate the Consultative Committee on Emergency Animal Diseases (CCEAD). This body is the communication network of the Commonwealth, CVOs, and in the case of aquatic animal disease emergencies, the Fisheries Directors of each State/Territory.

In the face of a disease of national or international significance, the CCEAD is the central authority for communications both within Australia and to international agencies. The Commonwealth Chief Veterinary Officer on behalf of Australia will carry out international communication.

The Office of the Commonwealth CVO is responsible for international reporting to the OIE.

A team approach

A task force or disease emergency management team may be formed. This team would include personnel with expertise relevant to the specific outbreak and so varies depending on the emergency. Industry representatives should play a key role in this taskforce.

The assistance of other agencies may be required to cope with issues such as public health, environmental protection and field operations. Examples of this are State Emergency Services, Police, Environmental Protection Agency and Health Department.

Liaison with these services will be largely at the task force level, although linkages at a higher level will often be forged by the CCEAD to secure cooperation.

Teamwork between State departments, Commonwealth agencies and industry representatives is essential to use effectively the limited resources available for management of aquatic animal disease emergencies.

Information management

Control of information and communication is important. Timely release of accurate information is the key to good information management. The aim is to keep relevant parties informed, reduce the spread of inaccurate information by rumour, and protect any appropriate trade (domestic or international) position.

Notes

Section B: Industry sector information

Section contents

B.1 Open systems

B.1.1 Introduction

Scope of this section

Aquatic animal disease emergencies occurring in open waterways will be difficult to manage due to the variety of animals, conditions, polluting sources and uses. If diseases and pests become established in an open system, they may only be controlled in a limited way. Eradication from the environment may not be an option.

This section provides information on fishing industry practices, which will be useful in deciding:

- whether control measures are warranted in open systems
- which control measures could be used; and
- how to implement these control measures.

It is not proposed to describe each individual fishery in detail.

Detailed description of individual Australian fisheries can be found in Australian Fisheries Resources (BRS, 1993)[1].

Information will be provided on the types or species of animals in these fisheries (i.e. pelagic or demersal finfish or crustacean), the types of technology involved in their capture (e.g. trawl, longline, pots) and information which will be useful in designing a disease control program. Section C includes details of possible management strategies in this system.

B.1.1.1 Overview of open systems

Definition of open systems

Open systems are waterways where there is little, if any, control over movement of animals and water flow. They cover a diverse range of environments including fresh, brackish and salt water, and provide habitat for a vast array of inhabitant animal species. Within these systems there is a broad range of human activities including commercial and recreational fisheries and other commercial and recreational pursuits. For control purposes, water and animals cannot be contained.

Due to their complex nature, the open systems have been separated into three groups that include fresh, salt, and brackish water environments:

- **Catchment waters**, in this context, include lakes, impoundments and river systems
- **Marine** refers to the oceanic environment
- **Estuarine** refers to the transitional zones between catchment and marine.

Open water, commercial fishing industries include:

- State, coastal, and estuary fisheries
- Commonwealth, deep-water, marine fisheries
- the important freshwater, lake and estuarine fisheries of the southern mainland States, Tasmania and the Australian river systems

[1] Kailola PJ, Williams MJ, Stewart PC, Reichelt RE, McNee A and Grieve C. 1993. *Australian Fisheries Resources.* Bureau of Resource Sciences, DPIE and Fisheries Research and Development Corporation, Canberra.

- large lakes of the scale of Lakes Eucumbene, Hume, Cowal, Brewster and Jindabyne in NSW. (Although these areas can theoretically be closed off, their size means they are more appropriately regarded as open systems. Stocked farm dams and the smaller commercial impoundments where the discharge water can be contained are considered semi-closed systems and are covered under Section B.3.)
- ocean ranching, including re-stocking and re-seeding of molluscs (scallops, clams, trochus, and abalone) and the practice of aggregating species around feeders and artificial reefs (snapper). Ranching is not yet a preferred farming method in Australian waters but is likely to grow in prevalence.

Within these open systems there are three main groups of animals:

- animals that are farmed (in semi-open systems - see Section B.2) which include both native and introduced species
- animals that form the basis of commercial and recreational fishing industries
- other animals that comprise the ecosystem fauna of the open waters of Australia.

Controlling diseases or pests in open systems

Diseases and pests are difficult, if not impossible, to detect and manage or eradicate in open water systems. Indeed, new (including exotic) disease agents may find potential new hosts and may prove to be transmissible to native species with potentially devastating results. Alternatively, agents that are a problem in other environments may not be a problem under Australian conditions.

The ecosystems for catchment, estuary and marine environments are quite different and have varied populations of important demersal and benthic species. When trying to develop a framework for management of disease outbreaks in this environment, it is important to not only consider the impact on commercial and recreational species but also to look at impacts through the system. Disease problems in one part of the general ecosystem could eliminate species or groups of species, which could then cause a problem in the overall food chain.

The following table provides an outline of the major groups that are important in these environments and, at a minimum, should be considered in the development of a disease control plan.

Major groups in open systems

	Habitat		
Type of life-cycle behaviour	**Catchment**	**Estuary**	**Ocean**
Mobile migratory	salmonids, galaxids, eels, carp	salmonids, galaxids, eels, arripis, prawns, crabs	salmonids, eels, scombrids, billfish, sharks, arripis, prawns, crabs
Mobile territorial		flounders	lobsters, lutjanids, squids
Semi-mobile	freshwater crayfish	crabs	abalone, scallops
Sedentary	freshwater mussels	oysters, clams, mussels	oysters

Detailed descriptions of individual Australian fisheries can be found in Australian Fisheries Resources (BRS, 1993). This publication provides an overview including species description, fishing techniques, gear, management and quality issues associated with each fishery.

B.1.1.2 Interactions of open systems, farmed systems, and aquaculture species

Farmed (especially semi-open and semi-closed) systems interact with open systems and could contribute significantly to the potential for disease outbreak. Farmed species may also act as the indicators of a problem originating from the open system. For further information on farming practices refer to semi-open, semi-closed and closed systems in Section B of this manual.

Diseases found in farmed systems have the potential to impact on wild animals, and any proposed controls on semi-open systems should include considerations of the potential impact and management on open water species.

Farmed species with direct contact to open systems include:

- farmed marine or estuarine finfish - salmon, ocean trout, tuna and snapper
- crustaceans - lobsters and mud crabs
- molluscs - Sydney rock oysters, Pacific oysters, pearl oysters and mussels.

Most farming activity takes place in the inter-tidal or coastal zone, and although farmed in open waters, stock animals are contained and managed within the farm environment (i.e. in semi-open systems).

Although farming in semi-open systems does not often take place in freshwater impoundments or rivers, semi-closed systems often utilise water from these sources and the effluent water from farms then flows back into the waterways. Due to this water exchange, this type of farming has the potential to transmit disease onto or off the farming enterprise. Escaped, released or translocated stock may also be carriers of disease that could be harmful for native aquatic animals.

B.1.2 Catchment

B.1.2.1 Introduction

Catchments have a range of native species including finfish, crustaceans and molluscs and many also have introduced species as well. Some systems are stocked periodically with a number of introduced and native species such as salmonids and golden perch.

General husbandry principles that apply to aquaculture and stocking of catchments for put-and-take fisheries do not apply to the management of aquatic animal stocks in open systems. The exception to this is the restocking of salmonids and native species into Australian freshwater lakes to support the recreational fishery. Husbandry practices and management of stock, broodstock selection, hatchery management and maintenance of biodiversity are to be covered under the semi-closed and semi-open system sections of this plan. Once the stock are released they are treated, in this manual, as if they were wild stock.

The main potential for disease introduction and transmission in catchments includes:

- the release of ornamental fish species
- effluent water from aquaculture sites
- seeding of exotic species
- environmental changes and degradation
- the use of live fish and fish product as bait
- migratory birds
- wildlife

- aquaculture feeds
- contaminated fishing or aquaculture equipment.

B.1.2.2 Practices

General use

The freshwater environment in Australia is utilised by: commercial fishers, the general public for the utilities and a variety of recreational activities, and agriculture and industrial activities. Under State/Territory legislation, not all freshwater and catchment systems are open to the public. Catchment areas may be closed to the public to conserve the quality of the water for human consumption and for environmental purposes to preserve endangered stocks of native fish and other aquatic animals.

Recreational fishing

The recreational fishers target both native and introduced species using a variety of net or hook and line fishing methods for finfish, and traps and nets for freshwater crustaceans. Many recreational fishers have boats and can move around and between areas. The equipment they use may be utilised without disinfection in a range of national and in some cases international waters.

Recreational fishing includes three main types of hook and line fishing activity:

- **Flyfishing** is predominantly a shore-based activity. Flyfishing involves the use of a long rod to cast artificial flies (lures), made from a variety of plastic, animal hair and/or fur and/or bird feathers, onto the surface of lakes and rivers. There are two different flyfishing techniques: wet and dry flyfishing. The main difference is that dry flies are used on the water surface and wet flies sink through the water column.
- **Trolling, spinning and lure fishing** involve the use of a rod and reel of line to cast an artificial lure into the water to entice a strike from a fish. A variety of lures are used and most are made from wood or plastic and fibreglass products. Trolling is an extension of casting where the lures are trolled behind the boat for lengthy periods of time in order to catch fish.
- **Bait fishing** involves the casting of a baited hook at the end of a static line. Bait fishers may throw burley (e.g. pollard, squashed shellfish, minced fish, blood, and offal) into the water to attract fish to the area to increase the chances of a catch. Bait comes in a variety of forms from worms, insects and grubs through to tomatoes and sweet corn, depending on the species being targeted. Live bait in the form of local or translocated native or aquarium fish is sometimes used, as are imported or local fish as dead bait.

Commercial fishing

The commercial fishing activity in inland Australia is centred on the Murray River, on a number of NSW lakes such as Lakes Cowal and Brewster, and on Lake Argyle in WA. Most other impoundments are open only to recreational fishers or are closed to protect stocks.

The commercial sector target Murray cod, callop and catfish for the edible fish industry, eels for stocking and farming, and carp for the petfood and fertiliser industries.

Commercial fishers generally use nets, traps and line fishing methods. However electric fishing is used in a number of waterways for carp. Electric fishing involves attracting and then stunning the fish which are then scooped from the water using nets.

Fishing boats are generally small (< six metres), of aluminium or fibreglass construction, and powered by petrol or electric motors, or oars or paddles. Craft of this kind are used by both the recreational and commercial sectors.

B.1.2.3 Premises and equipment

The equipment utilised in the recreational fishery has been described along with the activity above. Other premises and facilities used by recreational fishers and other users of the aquatic environment include camping sites, camping grounds, caravan parks, cabins and launching facilities. Most fish catches are cleaned either on the boat or riverbanks and the offal cast back into the water. The fish are then washed and stored on ice or frozen in portable facilities.

In the commercial industry there are few processing facilities for freshwater fish. Most activity will occur either on the boat, or the fish will be harvested and then processed at a shore-based facility. In the case of carp, they are normally taken whole to be processed in an industrial feed or fertiliser processing facility. Those fish that are processed for human consumption on the domestic markets have to be processed in facilities approved by the State Department of Health.

B.1.2.4 System inputs

Aquatic animals

Catchment systems have a wide range of native and introduced species including finfish, crustaceans and molluscs.

Natural recruitment occurs in all systems with the possible exception of some isolated water impoundments. However, in addition to natural recruitment of stocks, restocking occurs for salmonids and native fish for recreational angling and for the preservation of native species. The native populations of crustaceans, molluscs and eels are self-recruiting.

The main possible mechanisms for disease transfer include migration of vectors or secondary hosts (e.g. eels, barramundi) and/or translocation of species within their natural range and the introduction of new native or introduced species into a waterway. Translocation may occur for stocking purposes or through using live baitfish or releasing aquarium fish that are no longer wanted. Migrating eels can cover vast distances from the Pacific Ocean to inland waterways and may be carriers of infection.

The introduction of fish from different systems can introduce disease if the fish are infected (either overtly i.e. showing clinical signs, or covertly – as a carrier with no clinical signs). New disease introduction can devastate native fish populations since they may be naive and have no natural or acquired resistance to the disease. Alternatively, introduction of a new pathogen does not necessarily mean that disease will establish because local conditions may not be conducive to disease establishment.

Water

The water in catchment systems comes from rainfall or springs. This rainfall water usually runs over land into the tributaries of rivers or into the lakes or impoundments. As the water passes over the landmass it picks up bacteria, viruses, chemicals, nutrients and minerals from the surrounding environment. These inputs to the water systems may or may not have a significant effect on the ecosystem.

Other inputs to waterways include:

- water from storm water drains
- runoff from agricultural areas
- waste from domestic livestock
- chemicals, aquaculture, fertiliser, acid sulphate soils and land fill leaching
- chemicals such as hydrocarbons from fuels and oil from motors, anti-fouling and wastes from boats

- sunscreen cream has been identified overseas as a pollutant in holiday areas
- untreated sewerage from houseboats is more of a problem in estuarine areas
- sewerage runoff from recreational and camping areas and from septic systems continues to be of concern.

Such runoff may impact on the health of the inhabitant fish (e.g. epizootic ulcerative syndrome in native freshwater fish can be triggered by runoff from acid sulphate soils) or affect human food safety e.g. blue-green algal blooms.

Elevated nutrient levels from fertiliser and livestock runoff have been linked to problems of toxic algal blooms in the Murray-Darling river system.

Feed/bait

Bait and burley for both commercial and recreational activity includes live/dead fish, worms, insects, insect larvae, frogs, tadpoles, meat, offal and blood from a variety of animals and birds. For some species it may also include vegetable and cereal products such as sweet corn, tomatoes, pollard, and bran.

Other influences (including personnel, equipment, vehicles and stores)

The personnel involved in freshwater areas include recreational boaters and fishers and commercial fishers. Beyond general issues of hygiene and immunisation of workers for public health reasons, there is a need to educate the commercial fishers and the general public to advise authorities if fish kills and diseases are seen. This education needs to be based on establishing contact points for information and could be carried out through schools, fishing clubs, fishers co-ops, and local media outlets.

B.1.2.5 System outputs

Aquatic animals

There is a limited take of fish, freshwater mussels and crustaceans from both the recreational and commercial sectors in inland rivers and lakes.

Some, usually small, fish and shellfish may be taken for use as dead or live bait in the same, or nearby, locality.

Most fish taken are for processing or for human or pet consumption. There are a small number of brood fish taken live for breeding schemes. These are generally taken under license of the local State fisheries authority.

Water

The flow-through water in open catchment systems is often used for drinking water. The local public health authorities or State environmental protection agencies usually monitor water quality. Other monitoring may be carried out by farmers who use the water for domestic livestock, irrigation or by local aquaculturists.

Waste materials

Best practice use of the aquatic environment would require that people take their rubbish away when they leave but this is often not the case and food scraps are often left for birds and other scavengers to consume or spread.

Other wastes are generated into the system through the use of holiday facilities such as camping sites, caravan parks, and cabins. These contribute through the input of effluent water and sewerage outflows.

B.1.2.6 Groups involved in catchment management

These groups may vary between States but would generally include: Water Resources Commission, State agriculture and fisheries departments, environmental protection agencies, local government, lands department, health department, acclimatisation societies, all other recreational groups, farmers and conservation groups.

In the case of the Snowy Mountains, the Snowy Mountains Authority and national parks would be involved. In other States, where dams have been constructed to generate hydroelectricity, the electricity authorities would be involved.

B.1.2.7 Legislation and codes of practice

The legislation and Acts relating to the management of catchment fisheries are generally managed by State and Territory fisheries managers. The exception would be the Endangered Species legislation, which is under Environment Australia, and where waterways are within National Parks, the National Parks legislation. The recreational fisheries code of practice applies in all environments.

See Appendix 1 for information on relevant legislation.

B.1.2.8 Occupational health

There are potential human health issues associated with chemical spills, algal blooms (especially in the case of blue-green algae), and infectious organisms such as *Cryptosporidia*. Sewerage contamination can lead to infectious diseases such as hepatitis A.

See Appendix 2 for information on zoonoses.

B.1.3 Estuarine

B.1.3.1 Introduction

Estuaries are characterised by reduced salinity relative to the ocean. They are also subject to changes in salinity and frequent fluctuations in temperature and other environmental parameters linked to the tides and rates of fresh water flow. Estuaries are often the sites of ports and built-up areas and are often used for many recreational activities. Estuaries are important breeding areas for many marine fish and wetland birds.

B.1.3.2 Uses

The most common fishing practices occurring in estuaries are prawning, netting and hooking finfish, crabbing, recreational fishing and shellfish collection. These are supplemented by the aquaculture activities of shellfish farming, prawn farming and finfish grow-out.

Other recreational activities in estuaries include swimming and boating.

Estuaries are often ports or anchorages for marine fishing fleets, international cargo vessels and recreational craft including international cruising and sailing craft.

B.1.3.3 Premises and equipment

Both commercial and recreational fishers fish the estuarine and inshore resources.

The estuary harbours are home to the coastal fishing fleets and these craft, depending on their size, often travel significant distances to fish and then return to their homeports.

Commercial fishers in these areas use a variety of lines, traps, dredges, nets and trawls depending on the target species, e.g. crabs, prawns, finfish, and scallops. The scallop fisheries use dredges to extract the scallops from the sediment.

Recreational fishers use lines and rods to target most species, but can also use hoop nets and traps to target crabs. Recreational fishers also use boats and dinghies and these often have outboard motors.

The aquaculture sector has a number of different structures in these areas, dependent on target species. Shellfish farms have sheds, racks, trays, punts, sticks, and wharf facilities. The fish-processing sheds can have large processing facilities and can generate significant quantities of waste. There are restaurants and eating areas, which can sit right on the waterside and can generate processing and leftover wastes which will need to be disposed of in a suitable manner.

Estuarine areas also have boat ramps where fish are cleaned. There are camping facilities such as council facilities for tents and permanent caravan type structures, which also may have communal fish cleaning areas.

Also utilising the harbour and bunkering facilities of coastal ports and estuaries are an increasing number of pleasure and ocean-going boats either from other areas of Australia or from overseas.

B.1.3.4 System inputs

Animals

Animals in estuarine environments include cultured or wild fish, molluscs and crustaceans, and migratory birds.

Water

Water in estuarine areas includes ballast water, storm-water, sewerage (treated or overflow), and agricultural run-off.

Other

Other influences in estuarine areas include:

- aquaculture feeds, fish products, bait/burley
- rubbish dumping
- recreational boating inputs (weeds, water, mud brought in on trailer)
- processing waste from fish
- personnel.

Personnel working and enjoying estuarine areas include large numbers of users from a wide variety of backgrounds.

B.1.3.5 System outputs

Animals

Estuarine animals include fish, molluscs, crustaceans and migratory birds.

Water

Water includes tide flow, river flows.

Other

Other influences in estuarine areas include:

- ballast water uptake
- recreational boating (residual water in boats)
- waste from dredging materials
- disposal of unused material
- personnel
- movement of boats from estuaries is common either by water or over land by commercial and recreational users.

B.1.3.6 Groups involved

The groups involved in management of estuaries varies by State but are likely to include local authorities, port authorities, local government, and State departments (such as lands, National Parks, fisheries and environmental protection agencies).

B.1.3.7 Legislation and codes of practice

The legislation and Acts relating to the management of estuary fisheries are generally managed by State and Territory fisheries managers. The exception is the endangered species legislation which comes under Environment Australia, and the possibility of National Parks legislation. The recreational fisheries code of practice applies in all environments.

Marine aquaculture legislation may need to be considered and this generally falls under State fisheries departments.

Many ports operate under Commonwealth legislation rather than State legislation. Some estuaries are administered by the federal Department of Defence or have significant input from Aboriginal lands councils.

B.1.3.8 Occupational health

See occupational health sub-section (B.1.2.8).

B.1.4 Marine

B.1.4.1 Introduction

The open ocean waters include both motile and sessile wild-catch industries, the possible ranching sector, and the restock/re-seeding finfish and mollusc fisheries. Within these descriptive sectors there are large variations in the degree of mobility of the target species, which dictates that specific information is required on each specific species and industry in order that effective emergency management plans can be developed.

Motile species in open oceanic and estuarine systems include a variety of commercially and recreationally-important wild-catch finfish (e.g. tuna, mackerel, reef fish, whiting, bream, mulloway, redfish), wild-catch prawns (*Haliporoides*, *Penaeus* and *Metapenaeus* species), other crustaceans (e.g. rock lobsters, crabs, bugs), cephalopods (e.g. cuttlefish, squid and octopus), cygnathids (seahorses and pipefish). Harvesting larvae of many species including commercial molluscs and crustaceans is also an important industry sector.

Sedentary species, or those of limited mobility, include abalone, scallops and ostreaid oysters including the important pearl oyster species.

B.1.4.2 Practices

In a marine and coastal context, the enterprises are commercial or recreational fishing for molluscs, crustaceans, cephalopods, and finfish. The types of equipment and techniques used by the different parties to target these species vary.

Aquaculture husbandry practices and the management of stock, broodstock selection, hatchery management and biodiversity only become issues when restocking, ranching and re-seeding practices occur in open waters. Therefore the initial stages of these practices for disease management will be covered under the other systems sections of this manual. Once the stock is released into the general environment, then this section of the manual is relevant and the principles of managing disease in wild stocks should be applied.

In wild-catch fisheries, the criteria used for the selection of stocks for harvest should be considered. For the most mobile species, selection will be predominantly on the basis of identification of significant stocks. However if it is not known if these are the correct stocks, or not in quota, or non-market species is unknown, then wastage or 'by-catch' of non-target species can result. In the abalone industry, for example, while there are quotas allocated to larger areas, the specific microenvironments harvested tend to be those with the best stocks (or the most available). Stocks in areas of low level recruitment tend to be under-represented and under-utilised due to the extra fishing effort required. Therefore pressure is applied to the better stocks. This can impact on a disease control exercise as it can result in skewed data if commercial catches are used for surveillance purposes.

In the pearling industry there has been a shift, since the 1950's, from wild harvest of pearl oysters towards the culturing of pearls. There are now quotas set on the number of pearl oysters that can be taken from the wild and transported to farms for culture. In addition there are now hatcheries where spat is produced too and these also have a quota placed on them.

B.1.4.3 Premises and equipment

In general terms, wild-catch harvesting of pelagic and demersal species of marine and estuarine finfish occurs by trawl, seine or diving, set net, trap or line. The main construction materials of this gear are nylon, hemp and galvanised or stainless steel. Divers taking pearl oysters generally dive by hookah and wear drysuits composed of, for example, neoprene or nylon and urethane. They place the oysters into netting bags and send these up on lines to the boat on the surface.

The use of translocated species for bait from one area to another can have the potential, although difficult to prove in the open ocean, to transmit disease in all sectors of the open water system.

If gear is used to catch diseased fish from one area, consideration must be given to the likelihood of transmission of the agent if the gear is then used in another area. Transmission of the disease agent depends on the properties of the agent. The fishing gear can be heavily contaminated with biological material e.g. fish scales and mucus on nets and mud on 'otter' boards (which help keep the mouth of a net open) so consideration should be given to cleaning and disinfection routines before use in another, disease-free area. Evidence that disease can be transferred on fishing equipment has been shown, for example, with the viral disease, infectious salmon anaemia, in farmed Atlantic salmon in Scotland.

Trawl, seine or set net, trap or line gear in the oceanic environment is used from trawlers and other purpose-built fishing vessels. Ocean-going fishing vessels tend to be larger than recreational craft and range from five metres inshore to 100 metres for the larger international vessels and are generally designed to be very seaworthy and to provide a good work platform.

Recreational fishers tend to be highly mobile and the same gear or boats may be used in several areas within a relatively short time. Boats, lines, pots, nets, bait and burley are all part of the recreational fisher's kit and can be sources of disease transmission between areas.

B.1.4.4 System inputs

Animals

In the marine environment there are few outside inputs of live animals except for migratory fish, aquaculture activities, migratory birds and marine mammals, and humans.

Water

Potential sources of introduction of exotic pathogens in the marine environment are:

- effluent from aquaculture activities
- ballast water
- currents
- bait.

Natural and artificial baits are used in the marine environment and can vary depending on species targeted. These can be locally sourced or imported. Records documenting the source of any bait/feed used would be useful to determine whether such products could be carrying disease agents. Particular attention should be paid to imported products that potentially could carry exotic disease agents.

Personnel

Personnel in marine environments include:

- recreational fishers
- commercial fishers
- other users who may not come into direct contact with fish stocks such as recreational boaters.

Equipment

- equipment used in the marine environment includes:
- boats
- nets
- diving equipment including wet/dry suits and hookah apparatus
- other fishing equipment from commercial and recreational fishers.

Other influences in the marine environment include:

- trawler movement and inappropriate activities such as dumping of catch or by-catch
- imported product at processing plants at shore margins
- food such as recreational fisheries picnics, imported fish.

B.1.4.5 System outputs

Animals

Primary product

General method of harvest and magnitudes can be found in *Australian Fisheries Resources (BRS, 1993)*[2].

The primary product is dead fish and invertebrates for processing on shore or at shore margins, plus live animals for processing or sale as live animals (including export markets). In the future there may be an increasing output of live animals for grow-out in aquaculture situations, often at distance from the site of harvest.

Water

There is no control over water distribution. Disease spread can be affected by tides and currents.

Vehicles and equipment

Machinery and vehicles are likely to be moved on and off the area. Such movement needs to be considered if they are likely to contact other stock.

Other

Controls are needed on the following waste products:

- processing plant wastes
- wastes from shipping operations
- ballast water.

In addition, education is needed on disposal of fisher's refuse.

B.1.4.6 Groups involved

Government groups vary between States, however they will include primary industry departments (agriculture and/or fisheries), conservation agencies and water authorities.

Other groups that may be involved, or impact on the open oceans, include wild harvesters and fisheries harvest regulators, environmental regulators, aquaculture grow-out operators, and recreational fishers.

Other interactions which may have potential impact and need to be considered include issues of international regulation, international fisheries efforts in Australian waters, by-catch issues (not only as a source of infection, but for impacts of controls etc.), and the impacts on other species.

When considering industry groups for consultation in a marine and coastal open water environment, all groups which depend on the environment must be identified (i.e. any group representing fishing, aquaculture, tourism, recreational, health and environmental industries or viewpoints).

The fishing industry organisations for commercial species are grouped under the Management Advisory Committees (MACs) which report to the State fisheries on those fisheries that are in State waters or have been ceded to the States under the Off-shore Constitutional Settlement Agreements (OCS). The MAC structure for Commonwealth managed fisheries reports through the Australian Fisheries Management Authority (AFMA).

The fishing industry is represented at the State and national levels by industry associations, e.g. Tasmanian Fishing Industry Council. The key national agency is the Australian Seafood Industry Council (ASIC). This body has an elected industry board and its membership

[2] Kailola PJ, Williams MJ, Stewart PC, Reichelt RE, McNee A and Grieve C. 1993. *Australian Fisheries Resources*. Bureau of Resource Sciences, DPIE and Fisheries Research and Development Corporation, Canberra.

includes the major sectors of the commercial industry. The individual industries have their own individual associations such as the Tuna Boat Owners' Association, the Western Australian Rock Lobster Association and the Pearl Industry Association. These become key associations for managing disease outbreaks if the problem is in a specific industry sector.

The Australian aquaculture industry is represented by the newly formed National Aquaculture Council (NAC) and, again, there are industry groups such as the Tasmanian Salmon Growers Association, the Australian Prawn Farmers Association and the Tuna Boat Owners Association. These are key groups to consult with if disease occurs in, or can impact on, their farming sector.

B.1.4.7 Legislation and codes of practice

See Appendix 1

Examples are:

- the Commonwealth Fisheries Management Act
- the Fisheries Act
- State Fisheries Acts and Legislation, UNCLOS
- UN Agreement on Straddling and Migratory Fish Stocks
- London Convention
- off Shore petroleum and Minerals Exploration Acts
- land-based sources of marine pollution
- ballast water regulations
- Quarantine Act
- waste processing discharges from food processing and industrial wastes, MARPOL
- Black Marlin Code for Commercial Fishers and the Recreational Fisheries Code of Practice
- The Pearling Act
- various State livestock Acts covering notifiable diseases.

B.1.4.8 Occupational health

In general the risks to consumers from open ocean situations are low, except for in-shore areas due to interaction with human waste systems which can result in high levels of human pathogens in filter-feeding molluscs, or possibly high metal levels in fish high on the food chain. In general, the load of human pathogens from direct human contamination is low in other groups, with finfish generally showing low retention of human enteric bacteria except for transient loading with recent exposure.

Filter feeders may also accumulate shellfish toxins, while this is usually rare in other groups except ciguatera in higher food chain reef fish.

The working environment

The most important risk factor for working on the ocean is the ocean itself. The ocean can be an extremely hostile environment especially to inexperienced or poorly equipped workers.

In addition pearl divers have the risk of shark attacks as well as decompression sickness.

B.2 Semi-open systems

B.2.1 Introduction

B.2.1.1 Overview of semi-open systems

Finfish industries

Semi-open systems, generally used for culture of finfish, are typified by water-cage/net-pen systems in which the fish are contained or controlled in a relatively uncontrolled environment. Movement and control of stock is possible but there is no control over the movement of water in, through, and around the culture system.

In Australia the main industries using a semi-open system include the salmonid industry in Tasmania (growing Atlantic salmon and rainbow trout), the tuna industry in South Australia (growing southern bluefin tuna) and barramundi farming in the tropics and other regions where warm water is available. In addition, other finfish species such as snapper and stripey trumpeter are being introduced to semi-open systems and it is likely that these new species will increase in commercial importance.

The aquatic environment of semi-open systems is not modified, rather the aquatic environment is chosen for its suitability for the culture system. The fish are reared in cages that are moored in marine, estuarine or freshwater environments. They are usually in sheltered situations. Barramundi are also reared in intensive, indoor production systems with controlled environment buildings using underground (pathogen-free) water and a high level of recirculation through biofilters (see closed systems for more details).

Due to the high stocking density of fish within cages an adequate circulation of water through the cages is essential to the well-being of the fish. There is virtually no control over the water in which the cages are located. An impermeable liner can be placed around the cage to prevent any movement of water, but such a liner also prevents any oxygen-rich water reaching the fish, and waste products (e.g. ammonia) being diluted out.

In a semi-open system excess feed can fall through the cage and be deposited on the sea/estuary bottom under and near cages. Good management minimises such losses of feed to reduce waste and pollution. Some of the excess feed is consumed by cohabiting fish species or the crab collection under the cages. Faecal material, depending on water movement, is either carried away from the site or deposited on the sea floor near the cages.

Premises in semi-open systems are usually land-based however much of the equipment needs to be suitable for, and be able to withstand the harshness of, an open water site.

Important factors with respect to premises and equipment in semi-open systems are:

- boats are the main form of transport
- equipment used to house and contain the stock needs to be robust and strong and, in many cases, needs to be transportable either by towing or lifting onto boats
- premises can range from substantial buildings that contain machinery sheds, offices, mess rooms and laboratories, to simple sheds designed to protect workers from the weather

Fish cultured in semi-open systems are captured in the wild and towed to the grow-out site, or, as in the case of salmonids, transported by road from the hatchery. Once fish are located at the culture site they are generally moved by towing the net-pens. Barramundi systems can be cultured in controlled environment systems anywhere in the country and barramundi fry are often transported by air.

Fish species cultured in **semi-open systems** have varied growth rates. Salmonids are suitable for culture when they are around 70-100 grams in weight (15-20 centimetres in length), and are harvested 12-15 months later, when they are around 3.5-5 kilograms. Tuna can be anywhere from three to 45 kilograms when they are captured at sea, and then are harvested later the same year when they are conditioned for market. Barramundi are moved from nursery facilities to grow out cages when they reach about 80 millimetres total length. Marketable plate-size fish can be attained in six to eight months. Growing fish to two to three kilograms may take up to two and a half years.

Feed used in the culture of salmonids and barramundi is generally processed feed. Feed used for tuna is usually fresh and frozen baitfish that may be imported. Research is being conducted into the development of a domestic processed feed for farmed tuna and a commercial product may be available in the near future.

Mollusc Industries

Semi-open farming systems for molluscs usually have the shellfish either suspended in baskets from lines or housed in racks. Young shellfish may be harvested from the wild 'spat-fall' or cultured from brood stock in tanks in sophisticated hatcheries.

Algae cultures are used to feed larvae during the hatchery phase. As adults the molluscs filter feed and so are not actively fed during the grow-out period but rely on natural food floating through the lease.

The major commercial production of molluscs for human consumption is based on oysters (mainly Sydney rock, Pacific and flat oysters) and mussels.

In northern and north western Australia, pearl oysters are the basis of a large industry. Historically, the industry was based on a fishery but culturing techniques have enabled it to develop into the largest dollar value aquaculture industry in Australia.

Husbandry practices and disease control

In semi-open systems, husbandry practices that are most important with respect to disease incursion control include:

- location from where stock are sourced
- method of moving stock
- method of housing stock
- type of stock feed
- method of feeding stock
- handling of stock during the semi-open production phase
- practices employed to protect stock from predation and disease
- method of harvesting stock.

B.2.1.2 Interactions of semi-open systems and the environment

There is a two-way interaction between animals farmed under semi-open systems and the environment. This means that there is no barrier between the environment within and outside the farm area and water-borne agents can move freely in and out of the cages.

The animals within semi-open systems interact directly with outside populations both by escaping into the wild and by wild animals being attracted to the food source on, under and within the cages or other structures. Large structures such as racks and nets quickly become substrate for complex, biofouling communities consisting of sea plants and creatures.

B.2.2 Southern Bluefin Tuna cage culture

B.2.2.1 Introduction

The following table summarises the main features of the southern bluefin tuna industry sector.

Species	Southern Bluefin Tuna
Location	South Australia
Length of production cycle	2-9 months
Product	fresh and deep frozen
Annual production (tonnes)	4000 (1996-7 figures)
System	Net/sea cage culture
Feed used	Fresh and frozen fish (often supplemented with moist manufactured feed)

B.2.2.2 Practices

Farming southern bluefin tuna involves catching stock by purse seine net from the wild tuna fishing grounds in the Great Australian Bight. This can be 500 kilometres from the grow-out site.

Tuna for farms can only be stocked when the wild fish are present in South Australian waters which is usually between November and May and access to fish stocks is restricted by a quota system.

The juvenile tuna captured are usually three to four years old and weigh between 15 and 45 kilograms per fish. In some years, two to five year old stock are caught and then fish weight varies between three kilograms and over 50 kilograms per fish.

When tuna arrive at the grow-out site adjacent to Port Lincoln they are transferred from the tow-cage into two or three grow-out cages which may be located on several lease sites.

Tuna are not handled until they are harvested. All processes of capture and transfers are conducted by swimming through an underwater video panel. Grading is not done during the grow-out cycle.

All fish stocked are fattened and harvested prior to the fishing/stocking season the following year. Harvests of 40 to 400 fish are conducted at the cage site by hook and line or by crowding tuna in a net and capturing them with a gaff or a diver. Fish are killed (by a spike or blow to the head) and bled on site. Some operators partly remove the gills and viscera on the boat as well. Fish are placed in an ice-slurry to be processed and packed out that afternoon or the following morning in export premises on land.

Harvesting is done in response to fish condition or fatness, not size. All fish suitable for the Japanese fish markets are air-freighted as chilled or fresh, or are sea-freighted as deep frozen, whole fish both with their gills and viscera removed (i.e. a head-on, gilled and gutted product).

Cages are emptied within three to nine months of the initial stocking and all nets are completely removed from the water, cleaned and air-dried prior to the next season's stocking.

No chemicals or anti-foulants are used at any stage of the catching or farming operations

B.2.2.3 Premises and equipment

Fish are held in single or double collar polyethylene polar circle sea cages or rubber Bridgestone ocean cages, which are 32 to 50 metres in diameter.

Containment nets are 100 to 160 metres in circumference, seven to 20 metres deep with a mesh diameter of 75 to 200 millimetres and are made from polypropylene or nylon. Predator nets are usually 150-300 millimetre mesh and hang outside the containment net from the cage collar to the seafloor. Net washing is conducted in situ.

'Hiab' type hydraulic winches are commonly mounted on boats to assist in changing nets, lifting weights, mooring lines etc., purse-seine type vessels also have power blocks.

Service vessels for feeding and harvesting vary between companies and range from 12 metres to more than 30 metres in length. The same boats and trucks are used for carrying out feeding and harvesting operations and for transport. Forklifts are ubiquitous throughout industry.

All harvesting occurs on-site and all harvesting equipment is portable and is loaded onto boats prior to, and removed after, harvest. Harvest bins and processing factories are disinfected with export certified detergents after every use.

Most farms are able to fully equip a dive team with diving gear - the amount of gear available will depend on whether or not contract divers are used.

Grading equipment

All farms have a fully equipped workshop at their land-based service facility. Most farms have a laboratory facility - some have microscopes.

The tuna industry maintains a central research office with laboratory facilities and scientific staff at the marina in Port Lincoln. Specialist pathology facilities are available in Adelaide, which is a 45 minute flight or overnight bus trip from Port Lincoln.

Stores

Feed is stored at one of seven freezer store areas in the industrial area of Port Lincoln. Four of these sites also have factories with export processing facilities.

Other equipment, such as nets, trucks, feed bins, feed and harvest equipment etc. is stored in sheds. Each company owns or leases shed facilities for storage or as workshops for net and cage etc. repairs in the industrial part of the city.

Some companies have export processing facilities, canneries, storage sheds and large work areas all at the same site.

Vehicles

All workers live in Port Lincoln or the surrounding districts and therefore drive to and from either the factory/workshop site, the wharf, shipyard or marina facilities.

Trucks are used to transport feed from feed stores to where the boats depart. Forklifts are common at the shed/workshop areas and at the processing factories.

Refrigerated trucks are used to transport export product, destined for Japan, from the processing factories in Port Lincoln to the international airports of Melbourne or Sydney.

Personnel

Larger farms may have up to 70 workers. Some staff of the bigger companies have qualifications in aquaculture or marine sciences. The level of training and the competency of workers is very high, and the industry has collaborated in some areas (e.g. diving) to ensure high standards and protocols are maintained.

Workers may be involved in more than one activity but, generally, there are land-based staff (for fish processing, stores duties and engineers) and sea-based crew (for diving, feeding and harvesting). Practices are similar across farms, so workers from one farm would have little difficulty moving to another farms. Generally contractors are used for repairs and maintenance to farm equipment. Companies that own an export facility have a team of specialists to process the fish for market - these teams are relatively static and rarely perform tasks on the farms.

Some farms have contract divers; others have their own teams trained in commercial diving practices to do the work. Currently, divers do not disinfect themselves between dives, but this practice is achievable if necessary. Contract divers travel between net pens and between lease sites within a single workday.

B.2.2.4 System inputs

Animals

Southern bluefin tuna are captured at sea, transferred into a cage and towed to the grow-out site. One tow cage can supply tuna to many lease sites and multiple companies can be located on any one lease site.

Adult southern bluefin tuna attain body lengths in excess of 200 centimetres, more than 200 kilograms in body weight and can live for up to 45 years.

Tunas are highly migratory and the southern bluefin tuna has a circumpolar distribution between the latitudes of 30 and 50 degrees South.

Temperate tunas (i.e. southern and northern bluefin) have a unique system of cutaneous arteries and veins supplying blood to the muscle and *retia mirabilia* (heat exchangers minimising loss of heat produced by the fish's metabolism). This enables them to maintain a body temperature up to 15 degrees Celsius higher than the ambient water temperature.

Unlike most fish, tuna are ram ventilators, which requires them to constantly swim at a speed of at least 0.8 to one body length per second. They are very active fish and can attain swimming speeds of 20 body lengths per second.

The gill surface area is high (it approaches that of a mammalian lung) and has an extensive array of cross-linkages and fused lamellae to allow proportionally more dissolved oxygen to be removed from the water than any other fish. These cross-linkages and fused lamellae make tuna gills particularly vulnerable to obstruction by particulate matter and fine air/oxygen bubbles, which can lead to hypoxia.

There are many wild fish in the vicinity of open water cages and often many inside the cages themselves - species include schools of baitfish such as yellowtail chow, slimy, blue, and jack mackerel, tommy ruffs, salmon, anchovies, pilchards, small blennies and seahorses etc. There is little known about the movement patterns of these fish, but it is known that some species are migratory, and some which are more permanently resident in the area. These fish can act as a food source for the tuna but can also be important vectors of disease agents. It is likely that these fish harbour potential pathogens but the extent of this is unknown.

Aquatic animal and plant communities develop on the nets. Such fouling communities include green and brown macrophytes, blue mussels, juvenile rock lobster, and multitudes of small crustacea and finfish.

Water

Within a lease site, cages can be located in close proximity to each other (within 50 metres) and multiple companies can have fish on any one lease site. The minimum distance between lease sites is one kilometre.

Temperature ranges from a mean monthly minimum of 11-12 degrees Celsius in winter to a maximum of 22-24 degrees Celsius in summer. Temperatures above 24 degrees Celsius sometimes occur in summer, and cause stress to the fish - fish are not usually fed during such warm weather. Weather conditions can make the water rough in exposed sites making working conditions difficult.

Current flow varies between sites, but all sites have some daily variation in current flow - therefore there are certain times in the day when attempting certain management practices (e.g. setting harvest nets) is difficult. Periods of low to nil water current occurs during neap tides.

Feed/bait used

During grow-out, tuna are fed once, twice or continuously though the day with mostly a mixture of frozen and defrosted anchovies, pilchards, herring, mackerel and squid from a variety of sources including both Australian and imported feed. Fresh locally-caught baitfish are also fed when available.

Imported feed is supplied by, and stored frozen at, one of three wholesalers or in the companies' freezers in Port Lincoln. Imported products are potential carriers of exotic pathogens and for this reason research into products to replace imported feeds has a high priority.

Some operators supplement this wet fish diet with a vitamin and mineral premix. Research is currently underway to develop a semi-moist manufactured diet.

B.2.2.5 System outputs

Aquatic animals

Harvesting occurs in response to fish condition (fatness), not size, therefore each marketable fish can be as small as 15 kg or weigh in excess of 60 kg, depending on the initial stocking size.

Harvests of 40 to 400 fish are conducted at the cage site by hook and line, or by net crowding the fish and using gaffs or divers to retrieve the fish. Fish are killed (by a spike or blow to the head) and bled on site, with some operators partly removing the gills and viscera on the boat as well.

Fish are placed in an ice slurry on the boats to be processed and packed out that day or the following morning in export factory premises on land. The majority of product is exported to Japan, but small quantities also are sold in America and domestically in Australia - each fish is worth in excess of AU$1000.

Cages are completely emptied within two to nine months of the initial stocking.

Water

Fish are confined within cages and so an adequate circulation of water through the cages is essential to the well-being of the fish.

There is virtually no control over the water in which the cages are located, except if an impermeable liner is placed around the cage - such a liner prevents any movement of water, but also prevents any oxygen-rich water reaching the fish, and any water high in waste products (e.g. ammonia) being diluted out. If water conditions deteriorate the cages can be towed within the hour.

All areas in which fish are caged have some tidal movement of water - such movement may also be affected by weather patterns (e.g. wind). Lease sites within Boston Bay, South Australia and surrounds have their water exchange controlled mostly by wind action, and a back and forth action is created by tidal flow, therefore, on a neap tide if there is no wind there will be no water movement within a cage (except the swirling created by tuna swimming action).

Waste materials

Mortalities are either dumped in landfill, processed into blood and bone fertiliser at the abattoirs rendering plant, composted at the Resource Recovery Centre, or processed into protein supplements at Feedlink.

Gills and viscera are disposed of either via the abattoirs rendering plant (to be processed into blood and bone fertiliser), dumped in landfill, composted at the Resource Recovery Centre, or frozen to be used as leather-jacket bait.

Wastewater from the factories is discharged into Proper Bay either directly or via the municipal sewage treatment plant.

Personnel

Workers on farms usually leave the farm site at the end of each day. Boats may visit different farm sites.

On most farms the number of workers per farm remains reasonably constant. Contract workers, including divers, are hired by farms from time to time - divers may be employed on a regular basis.

Vehicles and equipment

Most workers use their own vehicles to get to and from home and the farm site. Boats are used to get between farm sites of the same company, and between farm sites of different companies if these are reasonably close, and weather conditions permit.

After initial fish transfer, cages are not towed by boats unless dictated by emergency situations (e.g. algal blooms, oil spills).

Generally each company has its own equipment and, apart from processing and freezer facilities, there are very few shared facilities.

B.2.2.6 Groups involved

Groups involved include:

- government bodies at both a national and State level
- Tuna Boat Owners Association
- state authorities and local councils
- community groups e.g. protection/conservation groups
- recreational fishing
- yachting/boating
- commercial fishers
- universities and other institutions
- other water users.

B.2.2.7 Legislation and codes of practice

In South Australia, fish and fish diseases are covered by the *Livestock Act 1997* and the *Fisheries Act 1982*. Capture fisheries are managed under the *Fisheries Act 1982*. Tuna aquaculture is managed under the Lower Eyre Peninsula Aquaculture Management Plan, Primary Industries and Resources, South Australia. Access to wild stocks is determined by a quota system under the Southern Bluefin Tuna Management Plan, Australian Fisheries Management Authority.

See Appendix 1 for information on relevant legislation.

The Tuna Boat Owners Association is currently developing a code of practice.

B.2.2.8 Occupational health

Public health

The following public health issues should be considered:

- the safety of the product if it is harvested when toxic algal blooms or chemical spills are suspected
- the potential to transmit zoonotic diseases (see Appendix 2) through the product
- quality of harvested product if emergency harvested due to disease
- availability of laboratories capable of testing for public health factors
- public access to waters adjacent to farming enterprises, especially if disease is suspected or confirmed
- drug residues in treated fish
- worker safety.

The following issues of workplace health and safety should be considered:

- the harshness of environment (e.g. bad weather conditions) can be an impediment to safe work practices
- diving is a regular activity on farms but requires specialised training and qualifications - it is illegal and extremely dangerous for untrained personnel to dive
- working 'on the water' requires experience and so can be dangerous to an inexperienced worker
- weather conditions and current flows should be considered if deploying liners (to isolate fish) or nets (to capture stock)
- ropes and nets are dangerous
- heavy equipment is often used
- operation of boats requires specialised qualifications and experience
- safety equipment is required when working 'on the water'
- threat to the safety of workers' health with collection of dead fish or decomposing stock
- the safety of workers preparing and applying chemical treatments.

B.2.3 Salmonid cage culture

B.2.3.1 Introduction

The following table gives a brief summary of the industry.

Species	Atlantic salmon	Rainbow trout
Production location	Tasmania, SA (research)	Tasmania
Length of production cycle	12-18 months	7-10 months
Product	fresh and smoked product	fresh and smoked product
Annual production (tonnes)	6000-7000 (1996-7 figures)	Approx. 500 (1996-97 figures)
System	sea-cage/net-pen culture	sea-cage /net-pen culture
Feed used	dried, pelleted ration	dried, pelleted ration

B.2.3.2 Practices

Atlantic salmon cage culture

Although the following text refers to Atlantic salmon, the same systems are used for both Atlantic salmon and rainbow trout.

Atlantic salmon farming consists of a freshwater stage (see Section B.3.6 Salmon hatcheries) and an estuarine/marine stage (the marine environment). Young salmon (smolt or pre-smolt) are usually introduced into the marine environment when they are between 12-17 months old and weigh 45-100 grams - in Tasmania this is from May to October.

Floating cages are used to house the salmon in the marine environment. These cages consist of a circular plastic support to which is attached a circular net. The circumference of these cages is 40-150 metres, and the nets have a depth of eight to 14 metres. Most cages are located in moderately protected areas (i.e. from wind and wave action) while the placing of cages in more exposed areas is currently being considered.

Fish are fed a commercial dry pelleted ration. One company operating in Tasmania presently supplies this ration. Some farms are evaluating imported feeds.

Salmon are usually harvested when they have attained a weight of 3.5-4.5 kilograms head-on, gilled, gutted (HOG) weight. This weight is usually attained after 12-18 months in the marine environment. During this growing stage, salmon are graded as required which ensures fish in the same pen are of similar size.

At temperatures above 18 degrees Celsius salmon are more susceptible to disease agents and often farmers will not feed fish. Hence warm summers where water temperatures are high are detrimental to growth and general health.

Freshwater bath treatments are used to control amoebic gill disease. These bath treatments require plastic liners and a source of freshwater.

Rainbow trout cage culture

Culture of rainbow trout is basically the same as for Atlantic salmon cage culture, except that rainbow trout do not go through a smoltification stage. When introduced to brackish or salt water, rainbow trout immediately go through an acclimatisation stage (i.e. there is no prior phase where they ‘get ready’ for the transfer to salt water). As rainbow trout do not perform well in full salt water (31-35 parts per thousand salt) they are usually only grown in sites with brackish water (15-21 parts per thousand salt). Transfer to such sites usually occurs when the fish are approximately 12 months old.

B.2.3.3 Premises and Equipment

On salmon farms boats are the main form of transport. Boats are used to transport and often to deliver feed around the farm, tow cages, change nets, as dive vessels, to transport personnel out to farm sites, for inspection of fish, and to help carry out day-to-day maintenance on cages and mooring systems. Most boats are made of aluminium, are 4.5-7 metres long, and have outboard motors.

Cages are moored to the sea bottom by an elaborate system of ropes and anchoring structures. The cages can be towed between mooring systems.

Most farms have an on-land facility with offices and buildings to house staff, machinery, feed and nets. Some farms have a dedicated laboratory.

Some farms have a processing facility near to the marine sites and cages are towed to this site for harvesting. Other farms truck harvested fish to a distant processing plant.

Farms have equipment for grading fish, transferring fish between cages and for freshwater bath treatments to control amoebic gill disease. Forklifts are used commonly around the land-based facilities and trucks are used to transport feed to the farm. Specialised trucks are used to transport young salmon from the hatchery to the marine site.

Harvesting equipment is heavy and not easily transportable, but at least one farm uses a large vessel to transport its harvesting equipment.

B.2.3.4 System inputs

Salmonid culture systems have a wide range of inputs that may be relevant with respect to disease. There are categorised below:

Aquatic animals

Atlantic salmon and rainbow trout to be used for culture are usually transported by land from the freshwater hatcheries to the marine sites between May and November, and may involve movement between zones of different status.

Fish are most stressed after they have been transferred from freshwater to saltwater. Young salmon undergo a physiological transition (known as smoltification) to make the transition from freshwater to saltwater. (Trout can acclimatise to salt or brackish water but do not smoltify.) This transition usually takes place in spring, however with photomanipulation out-of-season smolts can be ready to go to sea as early as May. Pre-smolts (young salmon that have not fully undergone the preparation to handle the transition to seawater) can be transferred earlier to brackish water sites and achieve better growth rates than in full freshwater at the hatchery.

On some farms, fish are graded to ensure the size of individual fish is reasonably consistent within the population in any particular cage. However, the use of grading and moving fish to achieve this size consistency as the fish are growing causes stress to the fish and can make them more susceptible to disease.

Stocking densities are high

Salmon are usually on-grown in net-cages for 12-15 months. There is usually 10 000-20 000 fish in each cage, depending on the size of the cage and the size of the fish. This results in a stocking density of four to eight kg per cubic metre of water.

Fish age

Younger fish are more susceptible to disease and other health problems. Younger fish are also more practical to treat than older fish due to reduced costs, ease of handling and fewer problems with residues than older fish.

Wild fish populations can act a vector for disease

There are many wild fish in the vicinity of semi-open water net-cages, and often many inside the cages themselves. Species including schools of baitfish such as yellowtail chow, slimy, blue and jack mackerel, tommy ruffs, salmon, anchovies and pilchards and small blennies etc. There is little known about the movement patterns of these fish, but there are definitely some species that are migratory, and some that are more permanently resident in the area. It is likely that these wild populations harbour potential pathogens but the extent of this is unknown.

Aquatic animal and plant communities develop on the nets even though they are changed frequently. Such fouling communities include green and brown macrophytes, blue mussels, juvenile rock lobster, and multitudes of small crustacea and finfish.

Water

Semi-open systems are located in estuaries and exposed marine areas and so there is no control on the flow of water around cages. However in some estuarine sites, freshwater flowing in from rivers can be a significant source of water. In these systems cages can be located very close to each other (within 50 metres).

In Tasmania, temperature ranges from about 9-10^{o}C in winter to 15-18^{o}C or above in summer. Temperatures may rise above 18^{o}C in summer, which causes stress to the fish and may also cause toxic algal blooms. Generally fish are not fed during this warm weather.

Feed / bait used

All salmon are fed on a dry, pelleted, commercial ration however the size of pellet varies according to the size of the fish. The average length of the pellet is from 3-12 millimetres.

Imported fishmeal and fish oils are used in the manufacture of these pellets, and the fishmeal component can make up to 45 percent of the ration. This fishmeal and fish oil must go through a pasteurising process before importation to ensure they are free from potential pathogens.

During the warmer months fish may be fed pellets of up to three percent of their bodyweight per day. During winter this feeding rate can be as low as 0.5 percent.

Feed is usually delivered to the farms on trucks in one tonne or 25 kilogram bags. The method for feeding fish varies between farms. On some farms the fish are fed by automatic feeders located on each cage. On others the fish are fed from a boat equipped with a water cannon which blows the feed into the sea cages.

Personnel

Practices are similar across farms, so workers from one farm would have little difficulty moving across to another farm. All farms have a 'mess room' or similar.

Larger farms may have up to 50 workers and at any one time, up to 30-40 of these may be out on the water. On these larger farms often teams specialise in one particular task, such as net changing or feeding. In contrast workers on smaller farms may be involved in more than one type of activity. Companies which own an export facility are an exception. They have a team of specialists to process the fish for market. These teams are relatively static and do not perform tasks on the farms.

Some of the bigger companies employ research staff. Some contract work is used for repairs and maintenance to farm equipment.

Some farms have contract divers others have personnel who are trained in commercial diving practices. Divers do not disinfect themselves between dives.

The level of training and competency of workers is very high, and the industry has collaborated in some areas (such as diving) to ensure high standards and protocols are maintained.

Equipment

Most farms have the equipment available to fully equip a dive team with diving gear however the amount of gear available depends on whether contract divers are used.

The type of harvesting equipment varies between farms. Some have harvesting equipment permanently installed on land or on boats. Others have transportable harvesting equipment, which is loaded onto boats prior to harvesting. Others have no harvesting equipment on site and cages are towed elsewhere to be harvested.

Forklifts are ubiquitous throughout industry. Hiab-type hydraulic winches are commonly mounted on boats to assist in changing nets, lifting weights, mooring lines etc. Grading equipment may also be available.

Most farms have some form of washing device to clean nets.

Most farms have a laboratory facility. Some of these have microscopes while all have fish dissecting equipment.

Some farms have a fully equipped workshop on site.

Service vessels for feeding and harvesting vary between companies and range in length from 12 metres to more than 30 metres.

On most salmon farms vehicles and boats usually have separate distinct functions.

Stores

Feed is stored on site at the land-based facility for up to two weeks.

All farms have a store where gear is kept but the amount of gear stored on site varies between farms.

Vehicles

Most workers live elsewhere and so drive to and from the farm each day.

Trucks are used to transport feed and live fish. Forklifts are used as the main on-land workhorse.

Other

Most farms have available, and use, medications for the fish such as anaesthetics and antibiotics. Most also use chemical treatments and freshwater. Most farms also use antifoulants.

B.2.3.5 System outputs

Aquatic animals

Salmon are harvested when they are around 3.5-4.5 kilograms. Harvesting is done either on site where harvesting facilities are available or the cages are towed to the harvesting site.

During harvesting, fish are crowded in the pen, and either drawn from the water using a fish pump, or collected with a braille (usually 20-30 at a time) and lifted into an anaesthetic tank.

Broodstock is transferred to hatcheries.

When the fish are bled carbon dioxide is used first to anaesthetise the fish. The carbon dioxide is bubbled through a bath containing the fish. When sufficiently anaesthetised the fish are moved onto a bleeding table. The fish are cut, usually near the base of the gills, to facilitate bleeding and then, within a few minutes, placed in an ice slurry.

If the processing is on site the fish are then either processed, which involves them being eviscerated, cleaned and packaged or, forwarded on to the value adding section. If the processing site is distant from the harvesting site, fish are trucked in bins (in an ice slurry) to the processing facility. Fish may be kept in the ice slurry for up to 24 hours before processing, but usually no longer than 12 hours.

Approximately 50 percent of fresh fish are exported overseas (using airfreight). These fish reach the overseas markets within 24 hours of harvesting.

A lot of the fresh fish is air-freighted to the mainland wholesale markets in Melbourne and Sydney - some go directly to restaurants and retail suppliers.

A proportion of salmon is sent to a value-adding process such as smoking (hot or cold).

Water

As there is a high stocking density of fish within cages it is important that there is an adequate circulation of water through the cages.

All areas used for salmon farming have some tidal movement of water. The water in these areas are also affected by weather (wind) and rainfall patterns (freshwater inflow).

In Tasmania, many of the farms are located in areas that are close to human habitation, and so are at the mercy of possible deleterious effects of this habitation, such as, sewerage runoff, pesticides and other toxic chemical usage, and an increased organic component in the water. Due, however, to the large water mass in which the cages are located there is a dilution effect.

There is no control over the water body in which the cages are located, unless an impermeable liner is placed around the cage. Such a liner prevents any movement of water in and out of the cage so that oxygen rich water from outside the cage is prevented from reaching the fish and water high in waste products (e.g. ammonia) inside the cage cannot be diluted out.

Waste Materials

Waste material from the farms includes excess feed, fish faeces, and treatment wastes.

Offal is another waste material and can amount to 20-50 percent of live weight depending on the end product (i.e. whether the final product is head-on or fillets). The offal is either buried or used in fertiliser production.

Treatment of bloodwater (the water in which the fish lay while bleeding) from harvested fish ranges from full treatment to direct discharge back into the marine environment.

Personnel

Workers on farms usually leave the farm-site at the end of each day.

Feed trucks may make multiple deliveries in a day to different farm-sites.

On most farms the number of workers per farm remains reasonably constant.

Contract workers, including divers, are hired by farms from time to time. Divers may be employed on a regular basis.

Vehicles and equipment

Most workers use their own vehicles to travel between home and the farm-site. Boats are used to move between farm sites of the same company, and between farm-sites of different companies if these are reasonably close, and weather conditions permit.

Boats are used to tow cages between sites - such tows can be up to 40-50 kilometres.

Generally most equipment on a farm-site is dedicated to that site - for sites in close vicinity to each other, there may be some pooling of more expensive items of equipment such as fish pumps or boats set up for net changing.

B.2.3.6 Groups involved

There are many groups involved in the operation of semi-open water net-cage culture systems.

Broadly, these groups include:

- Government bodies at both a national and state level
- Tasmanian Salmonid Growers Association
- State authorities and local councils
- community groups e.g. protection/conservation groups
- recreational fishing
- yachting/boating
- commercial fisherman
- universities and other institutions
- other water users.

B.2.3.7 Legislation and codes of practice

There are presently no codes of practice on farms, but a fish health code for salmon farming has been discussed jointly by industry and the Tasmanian Department of Primary Industry and Fisheries.

See Appendix 1 for further information on relevant legislation.

B.2.3.8 Occupational health

Public health

The following public health issues should be considered:

- safety of the product if it is harvested when toxic algal blooms are suspected
- the potential of the product to transmit zoonotic diseases (see Appendix 2)
- the quality of harvested product if it is emergency harvested due to disease
- availability of laboratories capable of testing for public health factors
- public access to waters adjacent to farming enterprises, especially if disease is suspected or confirmed
- drug residues in treated fish.

Worker safety

The following worker safety issues should be considered:

- the harshness of environment and dependency on weather conditions can make the work environment dangerous and can be an impediment to safe work practices
- due to daily variation in current flow there are certain times in the day when attempting certain management practices, such as changing nets may be unsafe

- diving is a regular activity on farms but requires specialised training and qualifications - it is illegal and extremely dangerous for untrained personnel to dive
- working in the marine environment requires experience and can be dangerous for the inexperienced worker
- equipment such as ropes, nets and heavy equipment are dangerous if not handled appropriately
- operation of boats requires specialised qualifications and experience
- safety equipment is required
- collection of dead fish ('morts') and decomposing stock may threaten workers' health
- contaminated water may needs appropriate disposal techniques
- preparing and applying chemical treatments may threaten workers' health
- divers can be exposed to toxic algal blooms and jelly fish swarms.

B.2.4 Barramundi cage culture

B.2.4.1 Introduction

Barramundi require warm (tropical) temperatures to sustain commercial growth rates. For this reason, farming in ponds and estuaries should only be undertaken in areas where the water temperature in winter remains above 20 degrees Celsius. In coastal regions this equates to north of Townsville. Barramundi can live at temperatures as low as 16 degrees Celsius but at this temperature growth ceases and the immune system is depressed making them unviable for farming.

There are three quite different methods currently used for growing barramundi fingerlings to market size:

- cage culture in purpose-built freshwater ponds which is the most common
- cage culture in estuarine waters, although relatively few companies are using this method at the present time
- intensive production indoors, in controlled environment buildings, using underground (i.e. pathogen-free) water and a high level of recirculation through biological filters (see closed systems for further details).

The controlled environment systems can be operated anywhere in the country. The capital and operating costs for these facilities are generally greater than for the equivalent level of production in outdoor cage operations. However, these systems can be sited close to markets, thus defraying costs associated with transporting product to market.

B.2.4.2 Practices

Barramundi aquaculture involves three distinct phases: hatchery, nursery rearing, and grow-out. Salt water is essential for the hatchery phase (which involves broodstock maintenance and larval rearing), while the nursery and grow-out phases can be conducted in either salt or fresh water. All three phases may take place at a single site such as at an estuary.

The hatchery phase

The hatchery component of barramundi farming, is very specialised, as it requires dedicated and expensive facilities, access to salt water, preferably saltwater ponds for larval rearing, and a considerable degree of technical skill. Broodstock can be kept in spawning condition year-round if housed in environmentally controlled tanks, with temperature and photoperiod emulating the natural spawning season.

Spawning requires the injection of reproductive hormones. Fertilised eggs are collected from the spawning tanks and transferred to incubators. Hatching takes about 14-17 hours, and larvae commence feeding one to two days after hatching.

Larval rearing is conducted intensively in hatcheries, or extensively in fertilised saltwater ponds. Larvae change to juvenile fish at 11-12 millimetres total length, which corresponds to about 12-20 days after hatching, depending on food supply and water temperature during the larval phase.

The majority of farmers source their stock as fingerlings from the few large farms with hatcheries. Fingerlings are generally sold between 25 and 45 millimetres total length. Larger fingerlings are more expensive but easier to rear. Alternatively some hatcheries buy fertilised eggs from other hatcheries and rear these to fingerlings.

The nursery phase

Fingerlings are maintained in nursery facilities until approximately 80 millimetres total length. Nursery facilities are small fibreglass tanks or fine-mesh cages (about one cubic metre) floating in larger tanks. In the nursery fingerlings are weaned from natural, live-food organisms to manufactured diets. Cannibalism can be a major cause of mortality during the nursery phase but this can be prevented with regular size grading of fish.

The grow-out phase

Fish are transferred to grow-out cages at about 80 millimetres total length. Cages are made from knotless mesh netting, and vary in size from 4 to 50 square metres and two to four metres deep. The netting must be changed and cleaned regularly as biofouling can reduce the size of the mesh openings, restricting water flow through the cages and leading to poor water quality.

Stocking densities of between 15 and 40 kilograms per cubic metre are common, but higher densities are used on some farms.

Barramundi are fed on commercially available pellet diets. A semi-floating pellet is now widely used because it is available to the fish for a longer time and satiation is more easily observed. When first weaned fish are fed up to six times per day. The frequency of feeding is reduced progressively to once per day when the fish are bigger than about 100 grams.

Water quality parameters need to be monitored frequently including dissolved oxygen, pH, temperature and light penetration. Aerators are used to maintain dissolved oxygen levels at greater than five parts per million. Water exchange rates vary depending on the intensity of production, but generally speaking about five to ten percent of the pond water is exchanged daily.

Marketable plate size-fish will be attained in six to eight months provided good husbandry practice is followed and fingerlings are supplied at the beginning of the growing season (late October until early November). Growing fish to two to three kilograms may take up to two and half years.

B.2.4.3 Premises and equipment

Boats are used to transport and, in some situations, deliver feed around the farm, to tow cages, as dive vessels, to change nets, to transport personnel out to farm sites, for inspection of fish, and to help carry out day-to-day maintenance on cages and mooring systems.

Cages are moored to the estuary bottom by an elaborate system of ropes and anchoring structures. Cages can be moved between mooring systems and the most commonly used method of moving fish around and between farms is by towing the cages.

Most farms have an on-land facility with offices and buildings to house staff, machinery, feed and nets. Some farms have a dedicated laboratory.

Harvesting equipment is heavy and not easily transportable, but at least one farm has the harvesting equipment located on board a large vessel.

Trucks are used to transport feed to the farm. Specialised trucks are used to transport young fish from the hatchery to the grow-out site. Forklifts are used commonly around the land-based facilities.

B.2.4.4 System inputs

Aquatic animals

Larvae are transferred from the hatchery to nursery facilities to grow to fingerling size and then transported to the grow-out sites until harvest.

Wild fish, zooplankton and benthic organisms are present in the surrounds of the farm.

Water

The water quality is directly affected by the local environment and tidal flows. Important water quality parameters include:

- temperature
- dissolved oxygen
- pH
- NH_3/NO_2 – ammonia, nitrates and nitrites
- salinity
- toxicants.

Feed used

Feeds are commercially produced and are milled and heat pelleted.

Personnel

Farm workers usually live off-site and travel from home to work-site.

Some contract work is used for repairs and maintenance to farm equipment.

All farms have a mess room or similar.

Other personnel may include fish health specialists and visitors.

Equipment

Equipment used includes:

- buckets
- handling nets
- cages/walkways/floats
- tanks
- clothing/boots
- vehicles
- graders
- water quality testing apparatus.

Stores

Feed is stored onsite at the land-based facility.

All farms have a store where gear is kept and the amount of gear stored on-site varies between farms.

Vehicles

Vehicles on the farms include trucks, tractors, six wheelers, boats/punts, and private cars plus excavators and earth moving equipment may be available.

B.2.4.5 System outputs

Animals

Product (table fish) may be sold by the producer directly to restaurants and other outlets and customers. Some product may be sold wholesale to fish markets. The majority of fish are sold dead but some fish may be sold live to restaurants and these are shipped in tanker trucks.

Water

Quality of effluent water from the cages depends on:

- treatments given to the cages e.g. overfeeding increases waste below cages
- water exchange (which is influenced by water flow past the cages and biofouling on the nets
- tidal movements (sea cages), water flows in natural waterways (land-based).

Waste materials

Waste materials include processing waste. The quantity depends on the size of the farm but varies from approximately one to 50 tonnes per annum.

Personnel

Workers on farms usually leave the farm-site at the end of each day.

On most farms the number of workers per farm remains reasonably constant. Contract workers, including divers, are hired by farms from time to time. Divers may be employed on a regular basis.

Feed trucks may make multiple deliveries in a day to different farm-sites.

Equipment

Equipment includes:

- harvest bins
- storage tanks
- transport tanks
- cold room store
- pond building/maintenance machinery
- private vehicles
- transport vehicles for product sales
- service punts/boats.

B.2.4.6 Groups involved

There are a large number of groups that are involved in the operation of semi-open water net-cage culture systems. Broadly these groups include:

- Australian Barramundi Farmers Association
- Government bodies at both a National and State level
- State authorities and local councils

- community groups e.g. protection/conservation groups
- recreational fishing
- yachting/boating
- commercial fishers
- universities and other institutions
- other water users.

B.2.4.7 Legislation and codes of practice

Two codes of practice are being developed for:

- barramundi hatchery production
- harvesting and processing.

Relevant legislation is listed in Appendix 1.

B.2.4.8 Occupational health

Public health

The following public health issues should be considered:

- safety of the product if it is harvested when toxic algal blooms are suspected
- the potential of the product to transmit zoonotic diseases (see Appendix 2)
- the quality of harvested product if it is emergency harvested due to disease
- availability of laboratories capable of testing for public health factors
- public access to waters adjacent to farming enterprises, especially if disease is suspected or confirmed
- drug residues in treated fish.

Worker safety

The following worker safety issues should be considered:

- the harshness of environment and dependency on weather conditions can make the work environment dangerous and can be an impediment to safe work practices
- due to daily variation in current flow there are certain times in the day when attempting certain management practices, such as changing nets may be unsafe
- diving is a regular activity on farms but requires specialised training and qualifications - it is illegal and extremely dangerous for untrained personnel to dive
- working in the marine environment requires experience and can be dangerous for the inexperienced worker
- equipment such as ropes, nets and heavy equipment are dangerous
- operation of boats requires specialised qualifications and experience
- safety equipment is required
- collection of dead fish (‘morts’) and decomposing stock may threaten workers’ health
- contaminated water may need appropriate disposal techniques
- preparing and applying chemical treatments may threaten workers’ health
- divers can be exposed to toxic algal blooms and jelly fish swarms.

B.2.5 Pearl oyster culture

B.2.5.1 Introduction

The majority of pearls are now produced by aquaculture techniques rather than gathered from wild stocks, as was the practice for over a century. The industry is based in the northern waters of Western Australia, Northern Territory and Queensland. The pearl industry is Australia's highest dollar value aquaculture industry.

B.2.5.2 Practices

The Australian pearling industry is based on the pearl oyster *Pinctada maxima*. Adult oysters are collected under license from the wild and used as the subject of seeding. Production of larval oysters from hatcheries for growth and use is currently under development.

After collection, adult oysters are held in steel framed, mesh panels which are placed on the seabed near the fishing grounds. After two to four months they are retrieved and seeded by technicians. After another one to two months on the seabed the oysters are transported to farms in coastal bays up to hundreds of kilometres from the fishing grounds.

At the farms, the oysters are usually suspended vertically in the water in mesh panels hanging from a horizontal long line between anchored buoys. A raft technique may also be used where the oysters are placed in wire baskets and hung below a floating raft.

Periodically the suspended oysters are retrieved and cleaned of biofouling.

Oysters producing round pearls are left in the water for two years whereas half-pearl seeded oysters are harvested eight to 12 months after seeding.

B.2.5.3 Premises and equipment

Many farms have shore facilities, however some are only accessible by ship.

Most ships or shore stations have basic laboratory facilities and diving facilities.

B.2.5.4 System inputs

Animals

Adult oysters are harvested from fishing grounds by divers. Spat is also sourced from hatcheries and contributes the majority of seed for growers.

Water

There is no control of water on open leases however many farmers hold several leases in various areas so there is the possibility of shifting the animals to different sites and therefore selecting different water conditions.

Shellfish farmers often have an intense interest in the quality of the water on their leases and many will take regular readings. Some areas have shellfish monitoring systems.

Feed

Some mollusc species such as pearl oysters and other bivalves on outside leases are not fed. They are filter feeders and rely on the plankton of the surrounding water. Hatcheries may use specific algal cultures for feeding young oysters.

Personnel

The work force on leases varies. The numbers of workers on any particular lease will vary depending on the jobs being performed. Some operations are ship-based rather than shore-based. The work on leases is usually conducted in time with tides so this should be considered when trying to contact personnel.

Vehicles

Pearling ships are open water vessels greater than 20 metres long. Smaller barges with handling and cleaning equipment may be used closer in shore on the farms.

B.2.5.5 System outputs

Animals

The main products are pearls and pearl shell. The meat is generally disposed of into the sea, however some is sold for human consumption.

Waste

Pearl oysters are filter feeders and are not fed.

Equipment

Equipment is usually shared between several sites.

B.2.5.6 Groups involved

Groups involved in pearl production include:

- State agriculture and fisheries departments
- Aboriginal lands councils
- Environmental groups and associations
- Aquaculture Council of Western Australia
- Pearl Producer's Association
- Western Australian Fishing Industry Council.

B.2.5.7 Legislation and codes of practice

Legislation relevant to aquatic animals and aquatic animal health is listed in Appendix 1.

B.2.5.8 Occupational health

Occupational health factors include:

- diving
- shell lacerations
- zoonoses (see Appendix 2)
- location (the majority of pearling is carried out on the open ocean in cyclone prone areas in very isolated areas of Australia's coast)
- operation of boats requires specialised experience.

B.2.6 Edible shellfish culture

B.2.6.1 Introduction

The aquaculture of shellfish for human consumption has a long history in Australia. The industry based on Sydney rock oysters has been operational for over 100 years. However more recently there is increasing interest and success in the culture of other species of shellfish. The main types of industry now involve rock oysters, Pacific oysters, mussels, flat (or mud) oysters and there is growing interest in scallops, abalone and tropical oysters such as the black lip oyster (see Appendix 3). The rock oyster and mussel industries are based on larvae acquired from natural spat fall in estuaries or production of larvae within hatcheries from wild-sourced brood-stock. Pacific oysters are produced in hatcheries from broodstock collected from commercial oyster leases. These hatcheries are semi-closed systems.

Rock oysters are grown on stakes or trays on racks in the intertidal zone of estuaries. Pacific oysters may be grown in trays on racks or off ropes. Mussels, scallops and flat oysters are generally grown on ropes or in bags off a long horizontal rope. Abalone are grown in tanks on shore or may be grown in tumblers which are floating barrels moored off ropes.

B.2.6.2 Practices

Rock oysters

Rock oysters are most commonly grown on racks in estuaries. Spat (young oysters) settle on hardwood or PVC sticks that are racked in estuaries where spatfall is most reliable. To encourage spat fall the sticks are often coated with a concrete slurry or tar.

Once covered in spat the sticks are then removed and treated in a number of ways. The traditional method then involves the removal of the sticks to racks in a low spatfall area of the estuary where the oysters are allowed to grow. Recently methods using trays or plastic mesh cylinders have been developed. Young (three to eight millimetres) oysters are removed from the sticks soon after settlement then placed into the trays or cylinders for growth.

Growth to market size takes two to three years. Harvested oysters can survive up to two weeks out of water and may often be held on land before shipment for sale. A purification process is carried out for 36 hours before sale. The purification tanks rely on filtered and UV-treated water. These facilities may be single company operations or cooperative operations.

Product is usually sold in-shell to fish markets, or less frequently directly from the farm gate as bottled, half-shell or in-shell product.

Most operations on the oysters are performed from flat-bottomed barges. During their production life oysters are often moved overland between leases either within or between estuaries.

Mussels

Mussels are raised mainly in southern waters. Spat collection sites and growing sites are usually different.

Vertical collector ropes are suspended in the water from long lines between anchored buoys in late winter to catch natural spatfall. The young mussels are stripped from the ropes in summer and put into 'socks' (netting bags) which are then rehung off ropes on the long lines. In addition to collection of wild spat, there is some hatchery production.

The crop grows for seven to ten months and is usually harvested between July and February when they are about five centimetres long. Mussels are generally sold in-shell to fish markets.

Pacific oysters and flat oysters

Pacific and flat oyster spat are mainly produced within controlled hatchery conditions. Rearing in estuarine leases can involve several methods. There is some natural spatfall in the Tamar River in Tasmania, but the majority of stock is produced in hatcheries and supplied to farmers as 'single seed' spat (i.e. they are not attached to sticks). Pond culture is occasionally used.

Transfer of spat to farms may involve interstate movement of stock. After the controlled hatchery stage transfer to farms (within and between states) may involve a period of growth in semi-open estuarine conditions.

Young oysters may be placed in flat plastic trays on intertidal racks, in plastic or wire mesh bags on intertidal racks or suspended in mesh bags from vertical ropes below anchored rafts or within bags clipped to horizontal steel wires which can be adjusted for depth between buoys or posts. Use of long lines provides a full sub-tidal existence, without the usual daily air exposure. Pacific oysters may also be removed from the water on a regular basis for removal of excess shell margin and for grading.

Oysters are harvested at 60-100 millimetres at one to two years of age.

B.2.6.3 Premises and equipment

There are marked similarities with the equipment used to produce filter feeders/bivalves of various species.

Sticks or slats are traditionally hardwood, 1.8 metres long and 25 millimetres square and often tarred or coated with a slurry of cement. Some sticks are now made of plastic, again with a cement slurry coating.

Racks are usually tarred hardwood or treated pine. Trays may be black plastic or galvanised wire. Bags may be wire mesh, black plastic mesh or synthetic netting. Ropes are usually synthetic and buoys are painted or galvanised metal or plastic.

Most of the production practices are performed from a barge or punt, but the operations also have a shore facility for storage, equipment service and some processing. These are usually sheds by the waterfront, although many leases are distant from the shore base and can only be reached by boat. There may be many leases in various areas serviced from one shore base.

B.2.6.4 System inputs

Animals

Young shellfish are sourced from either natural, local spatfall or from on-shore hatcheries. Spat may be sourced far from production sites.

Water

There is no control of water on open leases however many farmers hold several leases in different areas which means they can shift the animals to different sites and therefore different water conditions.

Intertidal species can be removed from the water for some time (from days to weeks depending on species and temperature).

Shellfish farmers will often have an intense interest in the quality of the water on their leases and many will take regular readings. There are shellfish monitoring systems in some areas aimed at detecting toxic algal blooms or bacterial contamination.

Feed

Filter feeders/bivalves on outside leases are not fed. They are filter feeders and rely on the plankton of the surrounding water. Hatcheries may use specific algal cultures for feeding young oysters.

Personnel

The work force on leases varies but most are relatively small operations employing less than ten people. The work on leases is usually conducted in time with tides so this should be considered when trying to contact personnel.

Vehicles

Many of the operations on water are performed from aluminium punts or barges with outboard motors. The boats may have hydraulic or winch powered lifting equipment. They often have the ability to carry high pressure cleaning equipment. Most farms have a truck or utility vehicle especially in oyster culture as the shellfish may be shifted overland between sites at various times. Tractors are used on some leases at low tide.

B.2.6.5 System outputs

Animals

Harvested animals are usually sent to fish markets however a proportion may be sold on site.

Waste

Shellfish are filter feeders and are not fed.

Equipment

Equipment is usually used between several sites. Old sticks and broken equipment are usually disposed to landfill or may be burnt. Old shell may be dumped on site from the barge.

B.2.6.6 Groups involved

Groups involved include:

- Queensland Oyster Grower's Association
- NSW Oyster Grower's Association
- Abalone Industry Association of South Australia
- South Australia Oyster Growers Association Inc.
- Tasmanian Oyster Research Council Ltd
- Australasian Abalone Producer's Association
- Victorian Mussel Grower's Association
- Western Australia Mussel Grower's Association
- Northern Rivers Sydney Rock Oyster Grower's Association
- State agriculture and fisheries agencies
- environmental agencies and associations
- health departments.

B.2.6.7 Legislation and codes of practice

Legislation relevant to aquatic animals and aquatic animal health is listed in Appendix 1.

There are shellfish sanitation schemes and codes of practice in New South Wales. Further information on sanitation schemes is available from the Australian Seafood Industry Council.

South Australia has a 1997 code of practice for South Australian oyster growers. South Australia, NSW, Tasmania and Western Australia have shellfish quality assurance programs. In South Australia the program is legislated under the *Fisheries Act 1982*.

B.2.6.8 Occupational health

Occupational health issues tend to be:

- lacerations from sharp shells
- zoonoses (see Appendix 2 for information)
- heavy lifting although many tender barges have hydraulic lifting equipment.

B.3 Semi-closed systems

B.3.1 Introduction

B.3.1.1 Overview of semi-closed systems

Semi-closed aquaculture systems are those in which species of finfish, crustacea or molluscs are contained so that the animals, water and other associated materials are not in direct contact with natural waterways. Water is usually taken from an adjacent natural source and discharge water or effluent from the enterprise is released back into this same waterway. Release of this water may be a continuous or intermittent flow, which is introduced directly or indirectly into the waterway.

It may be possible to completely contain the animals and water in the system if necessary, but the level of possible containment will vary between systems. However, it should be remembered the systems are not designed to be self-contained, therefore switching off incoming or outgoing water may have adverse affects on the stock after relatively short periods of time. For culture of some species (such as race culture of salmonids) this period may be only be a few hours, although for others (such as pond culture of freshwater crayfish), water control can be extended to several months.

Examples of semi-closed systems include crustacean, finfish and oyster hatcheries, prawn, freshwater finfish and crayfish grow-out ponds, and pump ashore abalone culture. Species farmed in semi-closed systems for at least part of their life cycle appear in Appendix 3.

The major industry sectors will be addressed separately in this section although several important common threads will be seen. In semi-closed systems there is some control over both stock movements and water flows. Many of the animals used in these systems are introduced from another site, be it a hatchery or nursery therefore there is often dissemination of stock from a single point. The animals are fed, usually with artificially prepared feeds. The animals are generally harvested by partially draining the ponds or similar, followed by netting. In many cases the holding ponds, dams or races can be dried out or cleaned, usually between stockings.

B.3.1.2 Interactions of semi-closed systems and the environment

Under normal operations most semi-closed systems have significant flow through of water from rivers, estuaries, dams or bores. They all have direct connection to the outside aquatic environment to varying extents, so it is necessary to consider animals (and possible disease agents) in the supply water and also contamination of downstream environments with disease agents in the effluent.

B.3.2 Native freshwater finfish

B.3.2.1 Introduction

Species used in this industry are: silver perch (*Bidyanus bidyanus*), golden perch (*Macquaria ambigua*), Murray cod (*Maccullochella peelii peelii*), freshwater catfish (*Tandanus tandanus*), Australian bass (*Macquaria novemaculeata*), the threatened Macquarie perch (*Macquaria australasica*), and three endangered species - eastern freshwater cod (*Maccullochella ike*i), Mary River cod (*Maccullochella peelii mariensis*) and trout cod (*Maccullochella macquariensis*).

The silver perch, golden perch and Murray cod sectors involve both hatchery and grow-out facilities, while catfish, bass and the threatened and endangered species are only produced at hatcheries for restocking as fingerlings for conservation and recreational fishing purposes. In total approximately six million fingerlings are produced each year, but silver perch and golden perch dominate the industry. Government hatcheries and research facilities in NSW and Victoria, and private, commercial enterprises are involved in this industry. Hatcheries and farms are located in Queensland, NSW, Victoria and South Australia; there are also silver perch farms in Western Australia.

Research by NSW Fisheries has demonstrated that silver perch is an excellent species for culture to market-size (400 grams to one kilogram) in earthen ponds and has the potential to form the basis of a large industry (more than 10,000 tonnes per year). In 1996/97 there were 146 licensed farms (around fifty in production) and 400 hectares of ponds that were either completed or under construction in NSW and Queensland. The industry has the potential to grow rapidly.

B.3.2.2 Practices

Broodfish are collected from the wild or farm dams and held in small (approximately 0.1 hectares) earthen ponds. They are recaptured annually by draining the ponds in the breeding season, winter for bass, and early spring through summer for the other species.

Murray cod, catfish and Mary River cod may spawn naturally in ponds, and the eggs are collected and taken to the hatchery. All species can be induced to spawn using exogenous hormones, usually human chorionic gonadotropin (HCG). Male and female silver perch, golden perch and bass spawn in tanks, and the cod species and, sometimes, bass are hand-stripped several days after injection. Fertilised eggs are incubated in fibreglass tanks or on troughs, usually in flow-through systems.

First-feeding larvae are stocked into earthen ponds (0.1 to 0.4 hectares) that have been fertilised with inorganic (nitrogen, phosphorous, potassium) and/or organic fertilisers (lucerne hay or poultry manure) to promote the production of phytoplankton and zooplankton. Larvae of all species initially feed on small zooplankton, then after a few weeks, larger zooplankton and insects. Bass larvae are reared intensively using rotifers and *Artemia* at some hatcheries.

The larvae of all species metamorphose and by five to seven weeks are fry and measure 25-40 millimetres in length. Silver perch are weaned onto artificial feed in the ponds. During this rearing period larvae and fry are regularly monitored for ectoparasites which, if present, can be treated using formalin (25-30 parts per million).

Fry are usually harvested by seine net or by draining the pond. Harvested fry are taken to tanks and quarantined for several days before being transported to stocking sites, farm dams etc. The larval-rearing ponds are usually left dry from late autumn to early spring.

Silver perch are cultured in three phases: hatchery, fingerling, and grow-out. This strategy is usually combined with a single-batch system where each pond has only fish of the same age, which are harvested completely before the pond is restocked.

Farms may be involved in one or two or all phases. Farmers either:

1. purchase fry from a hatchery and use phases two and three to rear fingerlings then market-size fish; or
2. purchase fingerlings only and grow these to market size (more than 400 grams).

The fish are cultured in static, aerated earthen ponds (0.1 to 0.5 hectares). Recommended stocking rates are 20 000 to 100 000 fish per hectare in the fingerling phase and 5 000 to 21 000 per hectare in the grow-out phase.

Approximate lengths of the phases are: hatchery for six to ten weeks fingerlings for three to four months; grow-out for 10 to 15 months. Annual production rates of up to 10 tonnes per hectare are achieved in the grow-out phase with good management.

Fish are fed a formulated diet (35-50 percent crude protein) at rates of up to 10 percent body weight daily for fry, five percent for fingerlings and three percent for fish larger than 50 grams.

B.3.2.3 Premises and equipment

Native fish hatcheries and farms are usually located near permanent rivers and creeks. Other types of water supplies are underground water and run-off. Water is pumped directly to ponds or to a reservoir from where it is gravity-fed to ponds and buildings.

Earthen ponds are the main production units used for broodfish, larvae, fingerlings and market-size fish. The ponds are constructed from impervious soils such as clay or clay-loams. Each pond has a separate inlet and screened outlet, and an internal or external harvest sump. Most silver perch ponds are aerated using electrically powered surface aerators such as paddlewheels.

Spawning, incubation, quarantine and purging tanks are generally fibreglass, circular, self-cleaning. Tank sizes range from 500 to 20 000 litres depending on the purpose. The water going into the tanks is usually filtered using sand and/or cartridge filters. Tanks are aerated using small compressors or high-volume, low-pressure air blowers.

NSW Fisheries policy directs that each silver perch farm must have an effluent/settlement dam into which water from all ponds and buildings must drain; no effluent is to reach any natural waterway.

B.3.2.4 System inputs

Animals

Broodfish are caught in the wild (rivers, creeks, lagoons etc.) and taken to hatcheries, farm dams and other fish farms. Fry and fingerlings are moved from hatcheries to farms. Market-size fish come from other farms.

Forage fish and crustaceans are moved from the wild and farm dams to feed broodfish.

Birds come from natural waters or other farms and include cormorants, egrets, darters, herons and ducks.

Water

The quality of the water entering the facility will influence fish health.

Surface waters from rivers, creeks, run-off, irrigation canals etc. may carry pathogens from wild fish, or other farms located upstream, plus small trash fish which may enter the water supply and become a source of pathogens.

Reservoir and effluent/settlement dam may contain trash fish or escapees from ponds and these fish are potential hosts of pathogens. Good management strategies will minimise risks and may include appropriate screens, efficient harvesting, and annual drying of the reservoir. Reuse of water from a 'clean' effluent or settlement dam will reduce the number of pathogens entering from the wild.

Underground water usually contains few or no pathogens.

Feed

Silver perch are fed artificial feed from weaning (at four to eight weeks of age) to market-size. The feed is steam pelleted or extruded and the main ingredients are meatmeal, field peas and lupins. The feed is 35 to 50 percent crude protein and most has low levels (approximately five percent) of imported fishmeal in most feeds.

The feed is usually trucked directly from feed mill to farm. The food conversion ratio is about 2:1 i.e. 20 tonnes of feed used to produce each 10 tonnes of fish.

With use of recommended feed and feeding strategies nutritional diseases are unlikely although contamination is possible if the feed is stored in moist, hot conditions.

Personnel

Many farms are owner/operator, with assistants. Larger farms working seven days per week may have two to ten employees who include managers, biologists and assistants.

Casual workers are used for harvesting, breeding, construction and maintenance etc.

Other visitors to farms can include hatchery staff delivering fry and fingerlings, transportation contractors, government extension officers and scientists and general visitors from other farms and interested public.

Equipment

Earthen ponds have wood or concrete boards, metal mesh screens and wire or plastic bird netting. Most ponds have aerators. The area of each pond is around 0.3 hectares and about one metre deep.

Building equipment include quarantine/purging tanks (fibreglass), PVC plumbing, filters and blowers.

Laboratory equipment includes microscope, balances, glassware and other lab equipment.

Shed equipment includes machinery, workshop, vehicles, feed storage and other general equipment. It can also include water quality meters and a secchi disc.

Nets used are seine nets for fingerlings and larger fish, hand nets and plankton nets.

Transport tanks are fibreglass and range from 500 to 4000 litres and are transported on a vehicle or by trailer.

Stores

Stores are used to house feed, hormones, and chemicals (formalin, malachite green, salt, anaesthetics, disinfectants, fertilisers).

Vehicles

Vehicles include four wheel drives, tractors and often four-wheel bikes. Vehicles may also include earth-moving equipment.

B.3.2.5 System outputs

Animals

Fry and fingerlings are moved from hatcheries to farms usually annually in spring/summer.

Fry are shifted to quarantine tanks and are usually treated with a daily salt bath then dispatched after several days. On many farms, fry are received into isolation tanks, salt-bathed and kept in quarantine for one to two weeks before being stocked in ponds.

Market-size fish are harvested live and transported chilled and whole to wholesalers, restaurants and fish markets.

Harvesting is done using a seine net for complete or partial harvest or the pond can be drained for a complete harvest.

Yields can be up to 250 000 fry from a rearing pond of 0.4 hectares and one tonne from 0.1 hectare pond or five tonnes of market-size fish from 0.5 hectares ponds.

Market-size fish are harvested to purging tanks to remove flesh taints and then salt-bathed and held for up to two weeks before being processed and sold.

The chain of handling is as follows:

- fry are harvested
- fry are transported in fibreglass transport tanks or plastic bags with approximately 10 kilograms of water and an oxygen atmosphere to the stocking site (fish farm or farm dam).
- grow out period (approximately 12 months)
- harvest live fish to purging tanks
- either live product via tanker transporter to a wholesalers tanks and/or restaurant
- or kill, chill and pack on ice then transport (usually by road) to wholesalers, fish markets, restaurants or retail fish shops.

Water

Ponds are static, with none or very limited water exchange. All effluent water is discharged into an effluent or settlement dam; no water directly enters natural waterways. Contaminated water may leave hatcheries/farms with live fish.

Diseases in ponds are usually treated in situ (with formalin or malachite green). Diseases may be readily contained on farms when diagnosed.

Waste materials

There are very few waste materials and these are generally buried on site.

Personnel

There is regular movement of staff on and off farm especially during spring, summer, and autumn.

Some farm visitors regularly visit many farms over several days such as personnel operating live-fish transporters and extension officers and students.

Vehicles/equipment

Hatchery and farm vehicles regularly move on and off farm.

Nets may be shared between farms.

B.3.2.6 Groups involved

Groups involved include:

- Warmwater Aquaculture Association
- New South Wales Silver Perch Grower's Association
- South Australian Aquaculture Industry Council Inc
- South Australian Aquaculture Association
- Freshwater Aquaculture Association (Queensland)
- National Aquaculture Council

- State departments of agriculture and fisheries
- water authorities
- environmental protection agencies and other environmental groups and agencies.

B.3.2.7 Legislation and codes of practice

NSW Fisheries has a Silver Perch Aquaculture Policy, which sets essential and desirable criteria for the location, design and operation of farms in NSW.

The NSW Silver Perch Grower's Association is formulating a code of practice.

Other legislation relevant to aquatic animals and health is listed in Appendix 1.

B.3.2.8 Occupational health

Pond mud is rich in bacteria and should be treated with caution especially if the operator has skin abrasions.

See Appendix 2 for information on zoonoses.

B.3.3 Prawns for grow-out

B.3.3.1 Introduction

The prawn culture industry in Australia is mainly based on the black tiger prawn (*Penaeus monodon*) and Kuruma prawn (*P. japonicus*). The cycle of production involves relatively few wild-caught broodstock, which produce post-larvae in a hatchery. These post-larvae are then transferred into earthen grow-out ponds that are linked by supply channels to neighbouring estuaries. The ponds are in the order of one hectare in size and 1.5 metres deep. A large proportion of black tiger prawn product is sold domestically whereas most Kuruma prawn product is sold for export.

B.3.3.2 Practices

Grow-out season for a crop of prawns in Australia is around 155 days for *Penaeus monodon* to a maximum of 190 days for the slower growing *P. japonicus*. Post-larvae are stocked into ponds when water temperatures are greater than 20 degrees Celsius at around 250,000 post-larvae per hectare or 25 prawns per square metre.

At stocking, ideal water quality parameters are salinity 25 parts per thousand, pH of 7.5-8.5, secchi depth 0.7-1.0 metre and a temperature of greater than 25 degrees Celsius.

Ponds are filled (1.5 metre depth) two weeks prior to stocking post-larvae to ensure optimum water quality. At one to six weeks after stocking, post-larvae are fairly hard to see due to their small size and their distribution throughout the pond. If the pond has been well prepared prior to stocking then no water inflow or outflow is required. It is standard practice to operate one aerator at night. Manufactured post-larvae feed is added to the pond in very small quantities during the first month.

After six weeks feed trays (one metre square mesh) are placed in the feeding strip on the pond bottom to judge feed consumption and to visually check prawns. Prawns will start to look for pelleted feed after a month and will be visible on the feed trays. Daily calculations of feeding rate are made based on size and survival of prawns in a pond, the previous day's feed consumption and general observation of the prawns.

Feeds (usually four to five) are spread out through a 12-16 hour workday. As a general rule 1-6 gram prawns are fed five percent of biomass, 6-15 gram prawns are fed four percent of biomass and 15-25 gram prawns are fed three percent of biomass.

If water conditions deteriorate, generally due to excess rainfall or over-feeding, feeding is reduced to allow pond water to stabilise.

As prawns increase in size, more careful visual inspection of the prawns can be undertaken by observing the feed trays and cast netting into the ponds. Individual weighing of a sample of prawns is undertaken weekly.

Daily water quality readings are taken including pH, dissolved oxygen, visibility and ammonia. Water exchange (inflow from, and outflow to the estuary) takes place according to water quality readings and availability of good quality water from estuary during high tides.

As biomass increase in the pond aeration is increased: four horsepower per tonne of biomass is a general rule. Aeration is left on all-night and, depending on the weather, may be turned on for periods during the day.

After 18-20 weeks prawns are harvested either by netting in the pond or by draining the pond. Production from a one hectare pond ranges from two to six tonnes depending on the species and geographic location. After harvest is complete the pond is drained and left to dry out. The pond bottom is tilled and re-leveled, agricultural lime is applied and, if the previous crop has been affected by mortalities, chlorine is applied. Good practice allows complete farm dry-out, i.e. all ponds and inlet and outlet channels remain empty for a minimum of four to six weeks.

B.3.3.3 Premises and equipment

Prawn farms consist of earthen ponds, generally one hectare in size, and 1.5-1.8 metres deep. The volume of water is about 15 000 cubic metres. Pond walls are generally 1:3 slope with a top width of a minimum of two metres to allow vehicle access around the pond. Inlet and outlet channels can be made of earth or concrete/plastic pipes/culverts. Generally inlet channels run down the centre between ponds and outlet channels run around outside perimeter of ponds. Each pond has an inlet pipe, which can be closed off from the inlet channel, and outlet pipe and/or monk which has an automatic overflow when pond water level reaches a maximum height. If lower levels of water are required the outlet pipe/monk can be adjusted right down to completely empty of pond.

There are electricity points around ponds for aeration equipment. Water is pumped up from the estuary by electric pumps into inlet channels. Pump size varies according to the number of ponds on a farm: a minimum of a 10-inch pump is required for four hectares of ponds.

Buildings associated with a farm generally include a feed storage shed/workshop, a processing shed (for cooking and packing prawns) and a residence for a farm manager.

Vehicles generally include a tractor with earth tilling equipment, excavator or scraper, four wheel motor bikes with feed blower attachment and a utility.

Equipment

Equipment used includes aerators, cast nets, feed trays, sprayers, water quality meters, microscope, harvest nets, prawn cookers, insulated bins, prawn washers, cooling tanks, brine tanks, cool rooms, brine freezer, grading machine, and a sorting table.

B.3.3.4 System inputs

Animals

Post-larval prawns from hatchery with less than 0.1 gram weight each and are usually size PL15 when transferred to the farm.

Although the incoming water is filtered when the ponds are filled, incidental animals at very early larval stages cannot be filtered out in the water. Incidental animals which may be introduced with water inflow from estuary can include native prawn and fish larvae, jellyfish, eels and crabs.

Water

Estuary water is greater than 10 parts per thousand salt with the ideal being 20-25 parts per thousand salt. In an estuary, water is best pumped from an incoming to a runout tide to ensure best quality water is obtained (i.e. water that is high in trace elements with low levels of suspended solids and nutrients).

Once the ponds are filled usually no water exchange takes place during the first 60 days of the crop. If required to improve pond conditions, approximately five percent of pond volume per day is exchanged. To encourage growth of algae in ponds, fertilisers can be added to incoming waters to encourage a bloom. Many farmers find that after a few crops the need for fertilisers is reduced and the pond will bloom up of its own accord if weather conditions are good. Algicides can be used to reduce unwanted blooms such as blue/green algae. Biocides can be used to reduce bacterial blooms.

Feed

Feed used is pelleted feeds, manufactured by steam or extrusion process, which are obtained from local or overseas feed mills. All prawn feeds contain imported ingredients.

Large farms directly import feed. Smaller farms buy from imported feed distributors or local mills in multiples of one tonne pallet loads that are delivered to the farm by truck. Average food conversion ratio is 2:1, therefore, a one hectare pond requires 10 tonnes of feed to produce five tonnes of prawns.

Personnel

A general rule is one farm hand per four hectares of pond. Farms tend to have strict control over entry of personnel other than workers and State officials: casual visitors are discouraged.

Stores

Feed is kept in a cool store during the growing season. Generally, a minimum feed for four weeks is kept on hand. Chemicals/fertilisers maybe stored in small quantities as they are usually brought in for immediate use.

B.3.3.5 System outputs

Animals

Primary product

The primary product is 20+ gram prawns cooked or green, chilled or frozen. The most common method of harvest is complete pond harvest through netting or drain harvesting. An average harvest of a one hectare pond is three to five tonnes. The harvested product is moved within the farm from the pond to the processing shed where prawns are graded, sorted, washed, cooked, chilled, brined and packed into styrofoam boxes for shipment to market as fresh chilled/cooked. Frozen (green/cooked) prawns are processed on-farm and stored for up to six months after harvest. Most prawn farmers make sales direct to wholesalers who, in turn, supply retail outlets and restaurants.

Secondary product and other animals

Birds can carry prawns from a pond and then drop them into other ponds or surrounding waters. Factors considered significant are the affect of migratory birds.

Crabs can walk out of farm area into surrounding waters.

Water

To allow water exchange, pond water is discharged as new water comes into the pond. Typically, a pond outlet cannot be made completely secure and some flow of water generally occurs at all times. Farms do not have a holding pond prior to discharge into the waterway due to land height: farms are typically located on a flood plain.

Ponds are emptied completely at the end of the crop. During this drain harvesting escape of animals in discharge waters into outlet waters is likely.

Waste material

Dead crustaceans are collected from the pond bottom after it is emptied and then buried in landfill. Organic and inorganic fine silt, which is removed from the centre of pond after draining also, becomes landfill.

Equipment

Nets and aeration devices taken from one pond and used in another are generally cleaned thoroughly between use (i.e. all marine organisms are removed from the equipment).

B.3.3.6 Groups involved

Groups involved include:

- NSW Prawn Farmers Association
- Australian Prawn Farmers Association
- Mackay Mariculture Association/Mackay Prawn Farmers Association
- Commercial Mariculture Council of Qld
- National Farmers Federation
- National Aquaculture Council
- State departments of agriculture and fisheries
- water authorities
- environmental protection agencies and other environmental groups and agencies.

B.3.3.7 Legislation and codes of practice

The Australian Prawn Farmers Association has recently published an Environmental code of practice for Australian prawn farmers. Each hatchery will normally establish its own protocol and manual of standard operating procedures, which include hatching techniques, sanitation, grow-out, and standard methodology.

Legislation relevant to aquatic animals and aquatic animal health is listed in Appendix 1.

B.3.3.8 Occupational health

The following occupational health issues should be considered:

- farm machinery can be dangerous if used without due care
- pond mud is rich in bacteria and should be treated with caution especially if the operator has skin abrasions.

Information on zoonoses can be found in Appendix 2.

B.3.4 Prawn hatcheries

B.3.4.1 Introduction

The production of post-larval animals for stocking into grow-out ponds necessitates collection of broodstock from the wild, though research is endeavouring to domesticate the animal to close the life cycle. This is being practised with limited success, but represents the trend for the future. Other species of prawn have been bred domestically on a worldwide basis, and a lot of work is now being undertaken in this field with *Penaeus monodon. Penaeus japonicus* has already been successfully domesticated in Australia.

B.3.4.2 Practices

Broodstock caught from the wild or grown in farm ponds are moved to maturation tanks in hatchery. The animals can only mate during molt when the female is soft, thus most hatchery operators prefer to receive roed up or berried broodstock from the wild where fertilisation has already taken place.

The broodstock, if ripe and ready to spawn, is placed in a spawning tank and her eggs are collected upon spawning. If the broodstock is not fully roed up, then she is ablated (one eyestalk is removed) thus accelerating the spawning process. Eggs are collected, rinsed and washed, sometimes in a weak solution of formalin to clean the eggs and to assist in avoiding vertical transmission of disease. The eggs are usually counted, and then placed in hatching tanks.

When the eggs hatch, they go through six stages of nauplii development and metamorphosis, and prior to the sixth stage, they are usually moved to larger tanks of seawater. These tanks can be round, parabolic or even cylindro-conical. In these tanks, the animals progress through three zoeal stages and three mysis stages before metamorphosing to a post larval shrimp.

These young shrimp are then usually kept in the hatchery until they reach fifteen days of age and are then sold to grow-out farms for culture. The entire process from egg to post larval animal fifteen days old takes normally about 25 days but this can be longer in the cooler winter months.

B.3.4.3 Premises and equipment

Each facility differs but has similar basic needs both here and overseas.

Hatcheries come in various sizes and the volume of tanks in the hatchery depends on the number of post larval animals the owner/operator has planned to produce. Thus there are large commercial hatcheries that produce 60 to 100 million post larval shrimp per annum, and others that produce 20 million or less.

Generally, hatcheries include a building to house the various tanks required for maturation, spawning, hatching, larval rearing, grow-out and algae production.

Ancillary support equipment includes pumps to take water from the sea or estuary, settlement ponds, reservoir tanks, heating equipment such as boilers to maintain water temperature, filtration devices, ultra violet flow-through devices to eliminate bacteria in the water column, food storage area, and a small laboratory and office.

B.3.4.4 System inputs

Broodstock

Animals are usually purchased from prawn trawlers and placed in maturation tanks. Some are produced in maturation ponds and are second or third generation. Wild broodstock are known to carry covert infections that can become problematic in an intensive farm situation.

Water

Water is the most important input in the hatchery. Pristine, high salinity water, between 32 and 35 parts per thousand salinity is required. Water is the most important vector of disease to the animals therefore it is treated very carefully prior to the introduction of either broodstock or larval animals.

Incoming water is filtered extensively and usually passed through ultraviolet light to eliminate the in-take of unwanted bacteria and other pathogens. The water is treated with EDTA to chelate heavy metals, and may be chlorinated in the tanks prior to the introduction of living animals. Chlorine has to dissipate prior to seeding any tank and this is done with sunlight and vigorous bubbling with air stones. Sometimes minimal amounts of sodium thiosulphate are used to remove the chlorine from the tank.

Feed

Feed for broodstock is usually fresh or frozen and consists of squid, liver, mussels, polychaete worms, and artificial high protein pellets. It is supplied by local bait feed suppliers. Pelleted feed is manufactured using a heat process and is supplied by an importer/distributor.

Larval feed consists of imported microencapsulated feed supplemented with algae of many species e.g. *Chaetoceros calcitrans, Chaetoceros mullerii, Tetraselmis spp., Skeletonema costatum* etc. Algal starter cultures are usually purchased from CSIRO and grown up on site. Another live feed used is imported brine shrimp (*Artemia salina*) which come in cyst form in tins and are rehydrated and hatched at the individual hatchery.

Personnel

Most hatcheries are operated by their owners. Some are completely a family operation, but most employ two or three qualified technicians with hatchery experience.

Equipment

Equipment is fairly specialised and consists of fibreglass tanks of varied sizes from one tonne to 25 tonnes or more. Some hatcheries use concrete tanks.

Air blowers, usually Roots blowers, are used to keep a constant supply of air to the tanks and in most hatcheries there is a stand-by generator in case of public power failure. Some hatcheries have well-equipped laboratories for water quality analysis and disease monitoring and others have very little support equipment.

Stores

An adequate supply of feed is necessary to complete a hatchery run. Chemicals used for cleaning and disinfecting tanks, air lines and air stones are also kept in reserve. Filter material, screens, dip-nets, weighing scales, freezers for feed storage, maintenance tools and spare parts are all kept in an adjacent store room.

Vehicles

Usually a hatchery that is associated with a farm, or comes under the same ownership, will have utility vehicles. Most hatcheries have transporter tanks that are hitched on to trucks to make routine larval animal deliveries to the farmers upon completion of sales.

When the hatchery has ponds on the property, four wheeled all terrain vehicles are commonly used.

B.3.4.5 System outputs

Animals

Post-larvae are the only product. They are harvested from their grow out tanks by concentrating them in small containers of a given volume so that a volumetric count can be made. They are then poured into a transporter and taken to the farm or packed into plastic bags containing salt water for shipping via air transport to farm. Excess feed including algae may be flushed out at the end of a production cycle.

Water

During the culture period water is not discharged. Generally hatcheries are required to have a settlement/holding pond for water outflow. Treatments such as chlorination can be undertaken in these holding ponds.

Tank discharge at harvest is high in organic matter through faecal accumulation, uneaten feed, and some dead larval animals and molt material.

Waste

Dead post-larvae are washed out with wastewaters into holding ponds. Spent broodstock are generally cooked and eaten.

Personnel

Movement of disease from one tank to another in the hatchery situation is a real risk. All hatcheries have a strict protocol governing hygiene. Separation of post-larvae production tanks from broodstock tanks and algae tanks is very important. Disinfection through footbaths for persons entering one operational area to another is advisable. Each tank has its own individual accessories and cross contamination should be avoided as any importation of disease (whether viral, bacterial or other) can spell disaster for hatchery production.

Equipment

All equipment is thoroughly cleaned and disinfected between hatchery runs. Regular dry out of all tanks, pipes, holding ponds is advisable between runs.

B.3.4.6 Groups involved

Groups involved include:

- NSW Prawn farmers Association
- Australian Prawn Farmers Association
- Mackay Mariculture Association/Mackay Prawn Farmers Association
- National Farmers Federation
- National Aquaculture Council
- State departments of agriculture and fisheries
- water authorities
- environmental protection agencies and other environmental groups and agencies.

B.3.4.7 Legislation and codes of practice

The Australian Prawn Farmers Association has recently published an environmental code of practice for Australian prawn farmers. Each hatchery will normally establish its own protocol and manual of standard operating procedures, which include hatching techniques, sanitation, grow-out, and standard methodology.

Legislation relevant to aquatic animals and aquatic animal health is listed in Appendix 1.

B.3.4.8 Occupational health

Chemicals are commonly used in hatchery operations (e.g. disinfectants, antifungals and antibiotics) which may pose a health risk.

Information about zoonoses can be found in Appendix 2.

B.3.5 Trout in freshwater

B.3.5.1 Introduction

Approximately 2000 tonnes of trout are produced annually in Australia mostly in northeast Victoria. Stocking densities vary across farms and within farms. Juvenile fish prior to grow-out are often held at greater densities to check growth (up to 60 kilograms per cubic metre). Trout that are growing out may be held at 15 to 30 kilograms per cubic metre.

B.3.5.2 Practices

Trout eggs are stripped from adult females in winter and incubated in hatcheries. After several months in tanks, the young fish are transferred to races that have large volumes of water running through them.

Fish are graded and moved around the farm at various stages of their lives. This involves seine nets congesting the fish at one particular point. The fish are then moved with either hand-nets or fish-pumps. Once over the grader, fish move in a water stream through pipes or lay-flat hose.

Fish are harvested using seine nets to crowd the fish and then either dip nets or fish pumps to move fish into harvesting bins.

B.3.5.3 Premises and equipment

Commercial production of rainbow trout (*Oncorhynchus mykiss*) in Australia is generally in earthen pond, flow-through systems. Every farm is uniquely set up, however ponds are generally about 20 to 30 metres long, 10 to 15 metres wide and one to two metres deep. Most farms pass water through the system once only, however, the same water may flow through a number of different ponds (i.e. ponds are set up in series).

Most farms have their own broodstock and hatchery. Upwelling incubators are the industry standard for holding fertilised eggs. Hatching down is done through Californian egg trays. Fry are generally grown in aluminium or fibreglass troughs. For slightly larger fry, circular tanks or small concrete tanks are used.

B.3.5.4 System inputs

Animals

The most commonly farmed species is the rainbow trout (*Oncorhynchus mykiss*) which may be from an on-site hatchery or may be introduced from other hatcheries or farms.

Water

There can be multiple farm sites on one river. Water quality is central to the health of the trout. Thus, chemical contamination, BOD/COD of inlet water, temperature, turbidity (which can cause gill irritation), low oxygen concentration can all cause stress and precipitate disease.

Feed/bait used

Specifically formulated trout rations (either steam-pelleted or extruded) are available from suppliers (e.g. Ridley Agriproducts, Gibsons Ltd). Depending on the specific ration and the efficiency of the farmer, feed conversion ratios can range 1.1:1 to 1.6:1.

The industry is moving towards higher energy rations to combat environmental concerns about nutrient levels in the waste streams. This change has led to reduced food conversion ratios.

Personnel

Personnel on these farms include employees, visitors, tourists (some farms are run as tourist operations) and fish health specialists.

Equipment

There is frequent sharing of equipment between sites by the same operator and occasional sharing of equipment between operators. Equipment includes fishing tackle on trout fishouts, grading sheds, nets and harvesting equipment (e.g. harvesting race), fish boxes and medication mixing equipment.

The farm may also have a hatchery with tanks and ozone treatment and UV water treatment. Processing equipment may be on site.

Vehicles

Vehicles include feed trucks that visit other farms/sites, tanker trucks/trailers that move young stock and transport for industry service personnel who visit several farms.

Most farms have access to tractors and may have light earth moving equipment.

Other inputs

Other inputs include chemicals such as salt, formalin, and drugs e.g. antibiotics, hormones and anaesthetics.

B.3.5.5 System outputs

Animals

Most trout farms have some level of direct sale to the public. Other marketing chains are too wide and too varied to generalise and/or summarise. Markets range from sale of live fish at local markets to the sale of smoked products to Hong Kong.

Water

Thus effluent water quality is central to controlling disease as many trout farms are in the same catchments and some are even on the same rivers.

B.3.5.6 Groups involved

Groups involved include:

- Australian Trout and Salmon Growers Association
- Western Australian Trout Growers Association
- Tasmanian Salmonid Growers Association
- National Aquaculture Council
- State departments of agriculture and fisheries
- water authorities
- environmental protection agencies and other environmental groups and agencies.

B.3.5.7 Legislation and codes of practice

Information on relevant legislation can be found in Appendix 1.

B.3.5.8 Occupational health

Occupational health issues to be aware of include periodic use of chemicals and drugs and use of heavy equipment.

Farms are often placed off fast running rivers with cold water. These rivers are potentially dangerous.

See Appendix 2 for information on zoonoses.

B.3.6 Salmon hatcheries and raceways

B.3.6.1 Introduction

Although salmon can be produced through to product in fresh water, most salmon spend only the first part of their life cycle in freshwater before being moved to sea-cages. Production of fish fully in freshwater is common in Victoria and species farmed are Atlantic (*Salmo salar*) and Chinook (*Oncorhynchus tshawytsha*) salmon.

The fresh water/seawater production style is common in Tasmania. For further information on the adult phase of salmon kept in freshwater, see the description under Section B.3.5 for trout. For further information on salmon (or trout) kept in sea-cages see Section B.2.3 on the semi-open system section of this manual.

B.3.6.2 Practices

The salmon farming industry can be subdivided into separate stages of the production process which progress from the broodstock, to the hatchery production of fry and smolts, to marine grow-out, to the distribution of the final product in domestic and export markets.

The broodstock, may be maintained at either freshwater or seawater farm sites, where they start to mature during late summer and early autumn (February-March). It should be noted that broodstock maintained at sea-cage sites are exposed to wild aquatic animals which may harbour potential pathogens (e.g. birnaviruses in marine finfish and invertebrates). The broodstock become fully mature and ripen in late autumn (May) at which time the milt (sperm) and ova (eggs) may be stripped and mixed to facilitate fertilisation and the generation of a new year-class of stock.

Fertilised ova (six to eight millimetres in diameter) are maintained at the hatchery facility while the embryos progress through the green and eyed stages until they hatch as alevins (yolk-sac fry) and develop into first-feeding fry (approximately 0.2 gram) ready to commence exogenous feeding.

When the fry have established a feeding pattern, they continue to be maintained in the hatchery facility until they develop into parr (one to two gram fish which display characteristic colouration) a process that takes a further two to three months (October-November).

Subsequently, parr are transferred to smolt-rearing facilities where they are maintained until smoltification: the physiological metamorphosis that facilitates the fish's survival in the marine environment. Typically, smoltification takes place approximately 15-16 months after fertilisation (in September-October) and occurs in response to the increase in day-length associated with the onset of spring. In some cases the development of fish to the smolt stage can be advanced by up to five to six months (in April-May) through photoperiod manipulation.

Smolts (60-100 gram fish which resemble adults and are capable of surviving in the marine environment) are transferred to marine farms for grow-out where they are maintained in floating net-cages as they develop into salmon (adult fish) ready for harvest. This process takes a further 12-20 months.

At all stages, salmonids require high levels of dissolved oxygen (generally greater than 80 percent saturation or five milligrams per litre).

During the freshwater stages of production, the majority of husbandry activities are associated with spawning, feeding and grading fry and parr, and the transport of smolts.

B.3.6.3 Premises and equipment

The majority of hatcheries are located on the upper reaches of major river systems where relatively consistent supplies of water can be extracted from areas with minimal industrial, agricultural and domestic sources of pollution.

There are generally separate egg incubation, larval rearing and broodstock holding areas. Egg incubators, larval-rearing tanks etc. are generally constructed from fibreglass and/or plastics. Their size is determined by life history stage and the scale of the operation. For example, first feeding tanks may range in volume from approximately one to ten cubic metres while smolt production tanks can range from four to 60 cubic metres. Raceways for holding broodstock are constructed from concrete and may be placed in series or in parallel.

Broodstock may be sourced from sea-cage sites, thus may be exposed to potential pathogens which may be transferred with the broodstock fish to hatchery sites. For many pathogens (e.g. the viral pathogens infectious pancreatic necrosis virus, viral haemorrhagic septicaemia virus, infectious haematopoietic necrosis virus), it is the young fry which are highly susceptible to disease. Under these circumstances, it is important that broodstock are maintained in facilities completely separate from egg incubation and larval rearing areas. In addition, it is advisable to maintain individual lines of eggs in separate areas with their own individual clean water supply.

B.3.6.4 System inputs

Animals

Whether maintained entirely in freshwater or returned to freshwater sites for spawning after a period of seawater residence, broodstock represent a possible vector for both vertical (primarily viruses) and horizontal (primarily bacteria and protozoa) transmission of pathogens to other stock held at hatchery sites.

Similarly, at sites where year-classes of stock overlap, the older cohort is a potential source of infection for the younger cohort.

Any transfers of new stock onto a site (e.g. the return of broodstock for spawning or the relocation of other life-history stages) may introduce disease organisms.

Water

The water supply represents a route for the entry of pathogens (principally bacteria) and parasites (mainly protozoa) shed from either other fish farmed upstream, wild and/or feral stocks inhabiting the watercourse. For conventional flow-through systems this is the most significant source of infection for farmed stocks.

With the adoption of water recirculation technology the volumes of water extracted from the source can decline and reduce the likelihood of disease introduction. The most sophisticated systems achieve a 95 percent reduction in water requirement and uses systems which facilitate complete disinfection (e.g. using ozone and ultraviolet light) of any make-up water introduced into the farm.

Importantly, the quality of water supply is a significant risk factor. Reduced water quality (e.g. extremes of temperature, inadequate levels of dissolved oxygen, excessive metabolite accumulation) can be a major cause of stress which may compromise immunocompetence leading to infection and/or change in fish health status from that of carrier to clinically diseased.

Feed

Feed ingredients, particularly fishmeal and fish oil, represent a potential source of infection especially if the drying and reduction process involved in their preparation have been carried-out incorrectly. Generally, however, the steam pelleting or extrusion cooking processes employed in the manufacture of complete formulations results in adequate heat-treating of ingredients and provides an additional level of protection against disease transmission via the feed.

Aquaculture feed may also be a source of nutritional disease. Contamination of the feed and/or poor quality control of both the final formulation and its ingredients can result in the development of a number of significant pathologies associated with nutrient deficiency or the ingestion of microbial toxins. Nutritional status can also influence immunocompetence.

The majority of feed is sourced direct from local manufacturers whose production and quality control procedures minimise the likelihood of microbial and/or nutritional disease.

Small quantities of start-feeds are also imported. However, quality control at manufacture combined with Australian Quarantine Inspection Service limitations on the types and sources of both ingredients and complete formulations again serve to limit the likelihood of microbial and/or nutritional disease.

The quantities of feed used are highly variable (the stock undergo an approximately 500 fold increase in size during production) but might be reasonably estimated to average approximately two percent of site biomass per day.

Personnel

The activity of personnel represents a disease risk factor. Husbandry activities that require fish to be handled directly may facilitate infection through damage to mucous and epithelial layers. Moreover, any procedure or omitted procedure that results in fish stress is also likely to cause disease.

There is also some risk of disease transmission by personnel via direct contact with contaminated fish and fish products, water and/or equipment and surfaces. Generally, relatively simple disinfection measures such as hand-washing, use of footbaths and changing/disinfection of protective clothing can be employed (in fact should be routinely employed as part of normal operations).

Equipment

Equipment used includes egg incubators, tanks, aerators, pumps, ultraviolet sterilisers, ozone generators, airlines, biofilters, and spare parts.

Vehicles

Vehicles also represent a possible vector for disease transmission. In particular, trucks and tanks used for live fish transport may transfer infected stock (most notably apparently healthy carrier fish) and contaminated water between sites. Consequently, care should be taken when moving live fish during disease episodes and simple disinfection measures should be applied to containers etc.

Vehicles used for the removal of large volumes of dead fish (especially those that have died as a result of a disease episode) represent a significant potential route for disease transfer. Here again, disinfection is possible but is more difficult, especially of the containers used to hold material for disposal, due to the decomposition of carcasses and the tendency of the resulting material to adhere to surfaces.

B.3.6.5 System outputs

Animals

Smolts (fish which resemble adults and are capable of surviving in the marine environment) are the primary product and are transferred directly to marine grow-out facilities using specially designed truck-mounted tank systems. On arrival they are discharged into net cages which float in the sea.

Water

Effluent water is a route for the entry to the water-course of pathogens and parasites shed by farmed stocks. For conventional flow-through systems, effluent treatment is generally limited to solids retrieval and as a consequence there is little likelihood of controlling the release of pathogens to the environment. Water recirculation technology can reduce effluent volumes to allow complete disinfection of effluent water.

Importantly, the establishment of disease within a recirculation system represents a significant threat as the system facilitates recycling of pathogens and continuous re-infection of stock. Furthermore, the microbial populations inhabiting the biological filters used to control water quality in these systems are as likely to succumb to any chemotherapeutic measures as the pathogen. As a consequence, chemotherapy can adversely affect water quality which in turn can influence stress and immunocompetence and hence the recovery process.

Waste materials

For effluent treatment refer to water (above).

Solid waste from effluent treatment in both flow-through and recirculation systems can be disposed of in landfill sites and/or utilised as organic fertilisers. Similarly, fish carcasses resulting from routine, non-disease related mortality and/or culling of excess stock can be disposed of in land-fills or processed (e.g. acid ensiled) to yield material which can be utilised as an organic fertiliser.

Personnel

Periodically personnel may be required to travel between sites to accompany live fish transfers or perform husbandry activities such as broodstock selection.

B.3.6.6 Groups involved

Groups involved include:

- Australian Trout and Salmon Growers Association
- Western Australian Trout Growers Association
- Tasmanian Salmonid Growers Association
- National Aquaculture Council
- State departments of agriculture and fisheries
- water authorities
- environmental protection agencies and other environmental groups and agencies.

B.3.6.7 Legislation and codes of practice

Legislation relevant to aquatic animals and aquatic animal health is listed in Appendix 1.

B.3.6.8 Occupational health

Occupational health issues to consider are periodic use of chemicals and drugs e.g. chlorine, formalin and antibiotics. Heavy equipment is sometimes used.

Farms are often placed off fast running rivers with cold water.

See Appendix 2 for information on zoonoses.

B.3.7 Marine finfish hatcheries

B.3.7.1 Introduction

The marine fish industry sector in Australia is relatively small and includes a number of species from both tropical and temperate climates. Most hatcheries are government research facilities and at present there is virtually no grow out being carried out. Therefore, this section will concentrate on hatchery production.

The following table lists the main species being investigated and their present status:

Snapper *(Pagrus auratus)* Mulloway *(Argyrosomus hololepidotus)* Western Australian dhufish *(Glaucosoma hebraicum)*	Snapper is in the early stage of commercial culture in South Australia, Western Australia and NSW. Mulloway is still in the research stage in NSW as is dhufish in Western Australia.
Australian bass (*Macquaria novaemaculata*) Black bream (*Acanthopagrus butcherii*) Greenback flounder (*Rhombosolea tapirina*).	Bass and bream are produced in WA (bream), NSW and Queensland (bass), for restocking and recreational fishing. Flounder are being produced in small numbers in Victoria and Tasmania, where some commercial farms have been established.
Golden snapper (*Lutjanus johnii*) Estuary cod (*Epinephelus tauvina*) Mangrove jack (*Lutjanus argentimaculatus*) Coral trout (*Plectropomus leopardus*) Dolphin fish (*Coryphaena hippurus*).	These tropical species are still in the research stage in the Northern Territory, Western Australia and Queensland. There has recently been some commercial success with the estuary cod and mangrove jack. Golden snapper and dolphin fish have been successfully produced in the laboratory.
Striped trumpeter (*Latris lineata*) King George whiting (*Sillaginodes punctata*) Other whiting species (*Sillago spp.*).	These temperate species are still in the research stage in Tasmania, South Australia and NSW, respectively.

B.3.7.2 Practices

Marine fish hatchery production is a complicated process involving the provision of a food chain consisting of microalgae, rotifers and *Artemia* or copepods. Broodstock are either wild-caught or hatchery-reared. Hormones may be used to induce ovulation and eggs are obtained by either hand-stripping or natural spawning in the holding tanks. Broodstock temperatures and photoperiods are generally manipulated in order to provide year-round spawning.

Developing eggs are generally incubated in fibreglass tanks of around 100 litres with upwelling water flow and light aeration. Hatched larvae are moved to fibreglass larval rearing tanks of 0.5-10 000 litres prior to feeding.

The larvae are very small and poorly developed at hatch and are unable to digest artificial diets. Feeding is generally with rotifers followed by *Artemia*, although copepods can be used and microalgae may be added to the tanks for the first 10 days or so. Generally, there is a weaning stage at around day 30 post-hatch (metamorphosis) during which the newly metamorphosed juveniles are trained to eat an artificial diet. Juveniles are reared in an onshore nursery facility with pumped seawater prior to transfer, at a weight of around 20-50 grams, into sea-cages.

Grow out is generally carried out in sea-cages (see tuna and Atlantic salmon descriptions in Section 2.1). The market size is reached at two to three years of age depending on species and size.

B.3.7.3 Premises and equipment

Marine fish hatcheries are generally insulated concrete buildings. Seawater is pumped direct from the local area into a header tank/s and gravity-flowed into the rearing area through a set of fine filters (see Section B.2.6 on oyster hatcheries and abalone). .

There are generally separate algal culture, rotifer culture, *Artemia* culture, egg incubation larval rearing and broodstock holding areas. Tanks are mostly constructed of fibreglass, sometimes concrete. In tropical areas, the algal culture unit may be outside (see Section B.2.1 on barramundi hatchery and farmed prawns). Grow out is generally carried out in sea-cages (see Section B.2.1 on tuna and Atlantic salmon). Onshore, recirculated tank systems may be used.

B.3.7.4 System inputs

Animals

Broodstock are generally wild-caught direct from the marine environment and, therefore, may be a source of infectious agents. Some juveniles may be caught from the wild for grow out. Live feed organisms may be imported or wild harvested (see below). Any animal introduced from the wild (open systems) may be carrying covert infections that could be problematic in intensive farming situations (semi-open, semi-closed or closed systems).

Water

Good quality marine water is pumped direct from the ocean and used untreated either as flow-through or recirculated. Filtration down to 0.2 micrometres is required for the algal culture facility, while one micrometre or coarse sand-filtered water is used elsewhere.

Some heating/cooling of water may be required and is generally conducted in recirculating systems to conserve energy. Recirculation, in particular, is used for larval rearing, nursery culture and broodstock holding.

Feed

Copepods are native to Australia and L-type rotifers have been in Australia for many years now. *Artemia* are imported from overseas in the form of cysts mainly from the USA. The new, small strain (S-type) of rotifer is a recent import from Japan and there are regular movements of both L- and S-type rotifers around the country generally in sealed containers by airfreight. Artificial diets and enrichment formulae for live feeds, larvae and early juveniles are imported from Japan and Europe (AQIS import permit is required). Grow out diets are generally produced within Australia, by Aquafeeds or Gibson's.

Personnel

Between five and 15 people are required to operate a marine fish hatchery depending on the level of output. Hatchery production is very labour-intensive and involves a broodstock team, an algal production team, a live-feed production team and a larval-rearing team as well as administrative and security personnel.

Labour is required during the normal working hours with staff on stand-by outside normal hours and a skeleton staff for weekends. Most staff are highly trained scientists as this industry is still mainly in the research phase. Commercial experience is limited in Australia.

There are frequent visits from overseas scientists, sometimes conducting experimental work on site.

Equipment

Fibreglass tanks, pumps, filters (including a 0.2 micrometre filtration system), nets, outlet screens, juvenile graders, microscopes, balances, blood and ovarian sample equipment. Most research facilities also have chemistry, histology and analytical laboratories or have access to such facilities through collaborative arrangements.

All equipment is normally sterilised in some form of sterilising agent, such as chlorine, between uses. Each culture area is generally equipped with an air-conditioner and maintained at a set temperature. Equipment from each area is generally kept separately and not used in the other areas, but this is not always the case.

Stores

A store is used to house enrichment formulae, yeast and formulated feeds, hormones, heparin, antibiotics, algal nutrient mixes and chemicals such as chlorine and formalin.

Vehicles

The main vehicles entering hatcheries are fish transport tankers collecting broodstock from fishing vessels.

B.3.7.5 System outputs

Animals

Currently movement of juveniles out of the nursery facilities and onto marine grow out sites is infrequent. However, in future, this will most likely occur throughout the warmer months of the year.

Some movement of rotifers is presently occurring due to the expense of continuous maintenance all year round. Some farms are finding it economically viable to import rotifers from larger establishments during the spawning periods.

Water

Water from larval tanks contains ammonia, solid waste, microalgae, rotifers and *Artemia*.

Water from juvenile and broodstock tanks contains ammonia and solid waste.

Waste materials

Waste materials include chemicals such as chlorine and formalin.

Dead fish are normally held in a mortality freezer prior to disposal by incineration or burial.

Personnel

There is frequent movement of scientists to overseas countries for conferences and study tours as this industry is growing rapidly, particularly in Europe and Japan.

Vehicles/equipment

The main vehicles leaving hatcheries are fish transport tankers transporting juveniles to farms.

B.3.7.6 Groups involved

Groups involved include:

- Marine Finfish Farmers Association of Western Australia Inc.
- National Aquaculture Council
- State departments of agriculture and fisheries
- water authorities
- environmental protection agencies and other environmental groups and agencies.

B.3.7.7 Legislation and codes of practice

Legislation relevant to aquatic animals and aquatic animal health is listed in Appendix 1.

B.3.7.8 Occupational health

An occupational health issue to be considered is the periodic use of chemicals and drugs.

See Appendix 2 for information on zoonoses.

B.3.8 Freshwater crayfish

B.3.8.1 Introduction

Crayfish are creatures adapted to freshwaters of damp terrestrial environment. The term lobster is more properly reserved for related, but distinct, animals found in marine environments.

A variety of species of crayfish may be farmed. Species can be divided into smooth crayfish, spiny crayfish, and burrowing crayfish. Species showing the best commercial potential are the smooth crayfish species: yabby (*Cherax destructor*), redclaw (*C. quadricarinatus*) or marron (*C. tenuimanus*) and the relative suitability of each depends on locality, climate and fishery laws in a given area. There are a variety of other species of yabby-like smooth crayfish, some of which are sometimes used for culture (most likely to be seen in northern NSW, southern Queensland or in southern Western Australia). Spiny crayfish are a group found on the eastern seaboard of Australia and in Tasmania. An example is the Murray crayfish (*Euastacus armatus*).

Some spiny crayfish grow to a large size but all appear to be unsuited to farming as they grow slowly, are aggressive amongst themselves and usually require water quality in excess of that which can be provided economically under farming conditions. Burrowing crayfish are generally small and are generally not considered to offer any potential for farming.

Most crayfish farming is semi-intensive and takes place in shallow, in-ground ponds with no, or limited, regular water exchange. Stock may be fed directly, or the ponds treated to promote the growth of natural food organisms, which are primarily decomposer organisms. Stocking densities may be increased if there are greater levels of water exchange and artificial aeration.

Farmed crayfish are generally offered for sale whole as a gourmet food. They may be live or cooked. Occasionally, processed products such as yabby pate may also be sold. Markets may be anywhere in Australia or may also be exported.

B.3.8.2 Practices

The best method of disease control may be determined by the mode of husbandry employed. Farming practices may vary from business to business and with the types of plant, location of farm, phase of production, species farmed, and product offered for sale.

Species-specific requirements

Smooth crayfish are best adapted to conditions commonly found on farm. Yabbies and redclaw in particular are resistant to poor water quality. Low levels of dissolved oxygen are rarely fatal. Marron are more particular in water quality requirements and usually require lower stocking levels and/or greater levels of aeration and/or water exchange.

Yabbies are adapted to temperate conditions and can withstand low quality water. Redclaw are adapted to tropical conditions. Marron are best grown in areas with an environment matching that of southern Western Australia. There may be legal limits on where a given species may be grown.

Yabbies and redclaw will breed readily in captivity, but are less likely to do so at cooler times of year or times of shorter day length. Marron must be in environments meeting specific requirements before they will breed.

Phases of production

There are several possible phases of production and each of these can involve differing husbandry practices.

Hatchery

Seed stock can be produced by natural reproduction or in a specialist nursery. Yabbies and redclaw will breed naturally in grow-out ponds but can also be produced in a specialist hatchery. Some species, most notably marron, will not breed in ponds and require a separate hatchery. For all species, fertilised eggs adhere under the tails of females for some time prior to hatching, and it is common practice to seed ponds by placing gravid females in the ponds and to wait for juveniles to leave.

Nursery

It is not common practice to utilise a separate nursery stage for crayfish but, in some instances, seeded ponds are steadily flooded, increasing in size as the crop grows. The extra water provides more room for growing stock and provides a source of feed from freshly inundated pasture.

Grow out

Grow-out is generally undertaken in outdoor earthen ponds. Under extensive conditions little is done to ponds but as farming intensifies (increased stocking and feeding rates) water exchange and aeration become necessary.

Some farmers consider that the presence of shelters in a pond enhance production. These shelters may be old car tyres, lengths of PVC pipe or other material.

Harvest

The most common form of harvest utilises traps and pots. It is also common to harvest by draining ponds and collecting the crop by hand. Redclaw are reputed to walk against a current and can be trapped by draining a pond and directing a flow of water through a trap.

An alternative method of harvest is to maintain a smooth bottom on the ponds and to use a drag net. This is quick but produces product with a relatively large numbers of injured individuals and is not suited to a legitimate harvest.

Purging

Crayfish are sold, cooked and eaten with gut intact. The quality of the product is improved if the animals are purged prior to sale so there is no apparent 'black line' visible in the cooked tail. Only a few operators maintain a purging facility.

Purging is most effective if stock is held in cages under water spray or drip systems. Purging systems that submerge crayfish are generally prone to problems. Purging is generally natural, with no addition of chemical agents.

Product at farm gate

In temperate areas, the growing season is from spring to harvest, when most of the crop is harvested at a size of about 40 to 80 grams per individual. In tropical areas, the growing season may be all year round and larger size animals 80 to 100 grams per individual may be the target size.

B.3.8.3 Premises and equipment

Type of premises and equipment used depends on the degree of intensity of farming.

Farming of freshwater crayfish is undertaken in shallow in-ground ponds with no or limited water exchange. Ponds may be covered with netting to prevent bird predation. This is good practice but expensive. Small boats may be used for access to water distant from the banks.

In some circumstances, farmers attempt to grow freshwater crayfish in very intensive systems. These are generally not commercial and often the aim is to sell the system rather than grow freshwater crayfish. Higher stocking densities and feed input require a much greater level of attention to maintenance of water quality. A higher level of water turnover is generally employed, and this may lead to higher levels of wastewater to be disposed of. Filter systems can be employed but they require continual maintenance. Intensive farming operations are usually in lockable sheds.

Little machinery is used in the process of farming, although small boats may be used to set and check traps. These boats may be transferred from pond to pond. A truck may often be used for the farmer to get from location to location.

Other equipment used includes aerators, in-pond shelters (old car tyres, PVC piping or other suitable material), harvest traps or pots, drag nets, purging systems which may use cages, four wheel dirt bikes, fencing.

B.3.8.4 System inputs

Husbandry practices may create a risk of disease arising in the farming operations.

Animals

Seed stock may come from remote hatcheries and be translocated over a considerable distance. Disease organisms may arrive with this stock, or in the transport water.

If ponds are stocked by the use of gravid females, the mother crayfish may also carry pathogens or commensals.

In extensive farms biota, other than crayfish, may become established in the open farm ponds. In most cases farmers attempt to increase production of natural food by promoting an infusion of zooplankton by flooding pre-grown pasture or adding material such as hay or lupins. Most activity in this area is generally undertaken taken during the early growth stages.

In uncovered ponds, water birds may be attracted to the area and may defecate into ponds. Water rats and foxes may also develop an interest in the crop.

From time to time, some operators attempt polyculture generally with limited success. Ideally other species will not predate on yabbies and will be suited to the same environment. Likely other species may be silver perch, or in more tropical areas, the grunter species. In cooler areas, especially where there is increased oxygenation of water, species such as rainbow trout may be held in the same ponds.

Water

It is common practice to dry out ponds between crops, or at least at regular periods. Ponds need to be filled. In many circumstances water is obtained by catchment of rainfall but may also be by pumping from local water-course, irrigation or come from a town water supply.

Ponds need water at other times as well. Evaporation (amount depending on local climate) may require ponds to be topped up to maintain levels. Water discarded for waste removal purposes may also need to be replaced. As stocking levels increase, it becomes more important to attend to water quality. At moderate levels of intensity, a fraction of the water may need to be replaced regularly.

Feed/bait used

Generally, extensive farms have no food input. Semi-intensive farms often supplement natural food production by flooding pre-grown pasture or straw. The next level of intensity may involve addition of judicious amounts of fertiliser to the water. Intensive farms may use low grade food such as lupins and cow pats, or high grade food such as high protein pellets. Addition of quantities of animal or fish flesh is generally detrimental to water quality and is poor practice.

Bait may be used to encourage entry to traps. This may be the same materials as used for feed but may sometimes consist of cattle offal.

Other (personnel, equipment, vehicles, stores)

In most extensive systems, there are few staff other than owner-operators. Boats may be used for access to parts of the ponds remote from the bank. Four-wheel motorbikes, trucks etc. may be used by farmers to transport stock and gear around. Pots/traps from other locations may be introduced to the water for harvest.

Casual staff may be employed at harvest or during stocking but these are generally unlikely to have had access to other operations.

B.3.8.5 System outputs

Animals

Freshwater crayfish are generally kept live after harvest and so generally the whole animal is presented for sale. They may be marketed live, either purged or unpurged or processed on-site.

When water quality falls below an acceptable standard, freshwater crayfish are capable of walking away overland. This can happen at night and may not be readily visible. Some farmers use fences about 30 centimetres high.

In inadequately protected ponds, predators such as water birds, water rats and foxes may eat some of the crop and move away from the ponds for cover. Survival of individual crayfish is unlikely but organic material may be transferred via the predator's gut.

Water

Most freshwater crayfish farms use ponds without regular water exchange. If more intensive levels of production are desired, some water exchange is desirable. Appropriate dispersal of this water is necessary.

In overstocked or poorly managed ponds, there can be a water quality collapse. In this case, the entire water contents of a pond may be disposed of and quickly.

Wastewater may go to pasture or may be discharged directly into waterways. Environmental protection legislation usually provides an incentive to dispose of wastewater to pasture but the actual practice should be checked.

Waste materials

After several years usage, soil on the bed of ponds can go sour. It is generally good practice to dry out ponds and aerate the soil but in some cases the soil may be removed and placed in other areas where its high nutrient load may be considered beneficial.

Purging facilities may reuse or discard water. Solid wastes may accumulate in poorly designed or maintained facilities.

Personnel

Commonly crayfish farmers walk into ponds or through damp mud at the margins. Materials may become attached to footwear and be transported in this way.

Vehicles and equipment

Harvest is often performed using a pot or trap. These may be removed from the water and stored in other locations.

If ponds are drain-harvested, in-water shelter material may be stored away from the pond. Old netting, traps or in-water shelter material (often car tyres) may be discarded if no longer in use.

Boats may be transferred from pond to pond. Trucks or other motor vehicles may be used for the farmer to get from location to location.

Water may be pumped and pumps and hoses may retain water or mud.

B.3.8.6 Groups involved

Groups involved include:

- Australian Freshwater Crayfish Growers Association
- Yabby Growers Association
- Tropical Freshwater Crayfish Farmers Association
- Marron Growers Association of Western Australia
- Yabby Producers Association of WA
- National Aquaculture Council
- State departments of agriculture and fisheries
- water authorities
- environmental protection agencies and other environmental groups and agencies.

B.3.8.7 Legislation and codes of practice

Legislation relevant to aquatic animals and aquatic animal health is listed in Appendix 1. South Australian crayfish growers have a code of practice relevant to the sourcing of stock and to pond construction but not to disease issues.

B.3.8.8 Occupational health

Occupational health issues to be considered are:

- the animals can nip - especially the larger ones!
- chemicals are not generally employed for freshwater crayfish. It is common for external parasites and unsightly commensals to be found attached to crayfish
- copper-based compounds are highly toxic to crayfish and unlikely to be used
- pond mud is high in bacteria so skin abrasions may become infected (see Appendix 2)
- blue-green algae blooms may occur in crayfish ponds.

B.4 Closed systems

B.4.1 Introduction

B.4.1.1 Overview of closed systems

A closed system is characterised by the following:

- premises are easily quarantined from the greater environment
- premises are usually relatively small and contained in a shed or under cover
- there is a low quantity (gross weight) of animals held within the system and hence individuals can be of high value
- stock is easily confined and accessed
- minimal water exchange (mostly biofilter systems are used).

The industry sectors that use this husbandry system can be divided into three groups:

Ornamental aquatic animals

The breeding and supply of ornamental animals to wholesale and retail outlets and direct sales to the public is a large and diverse industry. The operators involved are:

- breeders (commercial and hobbyists)
- collectors (wild harvest)
- importers
- zoos and parks.

Live animal trade

The collecting, holding and shipping of live animals, principally for the restaurant trade is a significant industry. Animals can be wild-caught or from aquaculture farms. The operators involved are:

- collectors (wild harvest)
- producers (aquaculturists e.g. barramundi and silver perch producers)
- transporters (using oxygenated tanks on trucks or trailers)
- restaurants or markets (with display aquariums on the premises).

Food fish hatcheries and grow-out facilities

The production of larvae or juvenile animals is for stocking of commercial ventures and the production of mature stock for human consumption.
The operators involved are:

- commercial hatcheries
- intensive grow-out facilities.

B.4.1.2 Interactions of closed system and the environment

There is relatively little interaction between closed systems and the environment as much of the water is recycled with the use of biological filtration. In many facilities the wastewater produced is either diverted to a settling pond or emptied into urban sewerage systems. There is also less chance of escape of the farmed animals in this system. Many farms are contained within a building therefore reducing the role of predators in disease spread.

B.4.2 Ornamental aquatic animals

B.4.2.1 Introduction

The closed water system is typified by a system in which both the stock and the water are closely controlled usually in tanks with attached filtration systems. Like all systems the health and survival of the stock within the closed system is highly dependent on water quality. In the closed system the water quality is controlled mainly by the health of a biological filtration system as opposed to water exchange as in the other systems.

In some ways, the filter can itself be regarded as a living organism. The biological filter functions to convert toxic nitrogenous wastes into non-toxic compounds and is made up of a matrix with a high surface area (such as shells, plastic or fibreglass wool) through which there is a constant flow of water.

In considering the operation of a closed system, it is important to consider the operation and interlinkages of the filtration system or systems.

B.4.2.2 Practices

Outdoor pond culture

Goldfish and livebearers are generally produced in earthen ponds (100 to 500 square metres) or in above-ground tanks (usually in the order of 5 000 litres). Water is generally sourced from either bores, dams or creeks and is recycled via settling ponds back into the systems or used for crop irrigation (see Section B.3.2 for pond culture systems).

In the case of outdoor pond culture, the fish spawn in the ponds, and the eggs are usually removed to other ponds to hatch and on-grow for sale.

Indoor culture

Most other species are kept and cultured indoors. Indoor culture covers the hobbyist with 10-100 aquaria in a shed or room of their house and the commercial breeder with a custom-built, temperature-controlled facility. It may be difficult to differentiate between these producers. Similar systems are also found in pet-shops.

Water is generally sourced from domestic mains or, in the case of larger enterprises, bores or springs.

Initial and replacement stocks are either obtained from the wild, other breeders, aquatic animal wholesalers or retail outlets. For indoor culture spawning takes place in small tanks. At a suitable time (species specific) the offspring are transferred into grow-out tanks, where they are held until sold.

B.4.2.3 Premises and equipment

Stock is usually held in glass aquaria, but fibreglass, moulded plastics and concrete tanks are also common. Sizes vary depending on the species farmed (60-80 litres are a common glass aquarium size).

The premises normally comprise a single shed with office, lab, packaging, and small store areas. Many premises have a small, equipped workshop often associated with the owner's house. A covered outside area may also be used for culture.

Power, water and sewerage connections are standard and hot water is often available.

If marine species are cultured the seawater is pumped from the sea near by or carted by truck or trailer in one to ten tonne tanks.

Air supply to tanks is usually from a central air blower with backup. Air and water plumbing is usually PVC and/or polypropylene.

Biological filters, sand, cartridge and carbon filters and protein skimmers are normally required and may be central to the whole facility, connected to only part of the facility or confined to individual tanks. The connection plan of the filters is a very important factor in potential disease spread and control responses.

Ten litre buckets, hand nets and screens of various pore sizes and material type (nylon and cotton) are routinely used.

Larger businesses often have a small laboratory or clean area with microscopes, weighing balances, glassware etc. suitable to maintain algal cultures.

There are often larger water pumps and plumbing to extract water from the sea or a bore and reticulate through facility. There are often numerous small water pumps for powering recirculating tanks.

B.4.2.4 System inputs

Animals

The introduction of animals onto the site will vary according to the species farmed. Initial breeding and replacement stock obtained from other breeders, imported or wild caught.

In the case of many ornamental fish producers, most stock is bred on site.

Feed

The majority of hobbyist use prepacked and imported dry foods. Commercial producers usually use dry pelleted or flaked feed obtained from local feed mills.

Juvenile and adult fish are fed either dry flakes or pellets and/or a mixture of beef heart, vegetables, mineral/vitamin premix, rolled oats etc. For marine animals a mixture of baitfish, prawns and vegetables is common. This type of feed is often obtained from the local bait supplier.

For some species algae are grown and fed to zooplankton (rotifers, copepods) which are then fed to the larval stages of the species farmed.

Artemia (brine shrimp) is a common zooplankton used and is often imported.

The amount of dry food fed per day is approximately five percent of the body weight of the animal.

Feed is stored on-site in storerooms (temperature controlled in the tropics), freezers and fridges, usually only in small quantities.

Chemicals, such as, chlorine, sodium thiosulphate, formalin, malachite green plus salts and fertilisers for algal production are stored on-site in small quantities.

Water

Water quality and quantity is normally controllable as well as parameters such as temperature and salinity.

In many premises, water, particularly seawater, is filtered through sand filters or similar.

Potable water (town supply) is often filtered through carbon filters to remove excess chlorine. Bore, stream, dam or spring water may also be used.

Personnel

The industry has many part-time one-person operators. Most enterprises are a small family business employing less than four people. Staff are usually skilled and normally involved in all aspects of production.

Vehicles

Most staff have a vehicle. Larger businesses would have utility truck or van to transport stock or stores. Marine businesses may have a trailer with tank for carting seawater.

B.4.2.5 System outputs

Animals

Juveniles or adults are sold depending on the size demand for the particular species. A 500 gram fish is approximately one year old.

B.4.2.6 Groups involved

Groups involved include:

- Pet Industries Joint Advisory Council
- National Aquaculture Council
- State departments of agriculture and fisheries
- water authorities
- environmental protection agencies and other environmental groups and agencies.

B.4.2.7 Legislation and codes of practice

Relevant codes of practice include the PIJAC Code of Practice for Aquarium Operations and the PIJAC Code of Practice.

Information on relevant legislation can be found in Appendix 1.

B.4.2.8 Occupational health

One occupational health issue to consider is the periodic use of chemicals and drugs.

See Appendix 2 for information on zoonoses.

Section C: Response options

Section contents

C.1 General principles

C.1.1 Introduction

This section of the Enterprise Manual deals with the responses involved in the management of the emergency. It presents, in general terms, the factors to consider in assessing the response options and is followed by a summary of the response options available. It also includes information specific to the four systems covered by this manual.

Responses may range from simply monitoring the situation while further information is being collected, through to quite drastic measures if the presence of a significant exotic pathogen is proven. There are a number of factors to consider in assessing the situation and deciding on the most appropriate response option. Many factors are appropriate to any aquatic animal disease emergency while others apply only to specific situations.

It is likely that for an aquatic animal disease emergency, an emergency management task force will be established which will need to make decisions based on available information and will liaise with the local disease control centre. See the AQUAVETPLAN Control Centre Manual for further details.

Each of the options discussed in these manuals could be used to a varying degree and in any combination depending on the:

- aim of operations (control or eradication)
- nature of the disease
- aquaculture systems involved
- location of outbreak
- economic impact on industry
- impact on the local environment.

The strategy adopted to control a disease outbreak is often dynamic, changing as more information is received on the disease agent, its likely spread, and the types of facilities affected. An outbreak which starts as a disease within a closed system can easily become a disease within an open system and vice verse.

Industry, State and national groups will also have to consider the following:

- cost
- lost production time and disruption to industry
- possible environmental impact
- possible occupational health and safety impacts
- impact on public access and activities
- potential for, and consequences, of failure to control the outbreak.

General benefits of effective management of an emergency disease outbreak include:

- maintenance of consumer confidence
- minimisation of trade disruption
- long term productivity is sustained (mortality decreased/morbidity decreased/trade access maintained)
- advantage of containment (requiring prompt action) versus negative impacts associated with more extensive control/eradication programs in terms of cost of control and loss of productivity
- minimisation of ecological and environmental impacts of disease spread.

In addition to management of the disease outbreak, management of public risk should also be considered e.g. announcements that rotten fish can constitute a public health risk. See Appendix 2 on zoonotic diseases.

The following sub-sections summarise the factors to consider in assessing the response options and the response options available when encountering an aquatic animal disease emergency.

C.1.2 Factors to consider in assessing the response options

C.1.2.1 Stage of the disease outbreak

- How long has the outbreak been going on?
- Has the agent already been spread?
- Are wild populations involved?

This information will assist to determine whether control is warranted and if so, how it should be approached. The level of containment would be system specific. If the outbreak has been occurring for sometime without any containment, attempts at control are unlikely to be successful especially in any non-closed systems.

C.1.2.2 Disease agent epidemiology, biology and stability

- Has an infectious agent been identified?
- How much is known about the epidemiology/biology of the agent? e.g. what is the host range?
- Are vectors a concern? Which species are susceptible to disease?
- How well does the agent survive in the environment?
- To which disinfectants is the agent susceptible?

For further information on the reportable disease agents see Appendix 4.

C.1.2.3 Site specific features

- What is upstream and downstream of the affected site?
- What are the construction materials of the holding structures?
- Is there a facility to hold effluent water?
- Is there a facility to harvest or treat animals on site?
- Can water input and/or output be controlled?

These factors will influence the choice of methods for control and indicate the likelihood of spread. A further source of infection may be identified if there are other facilities sharing common water. The construction materials of the structures on the site will determine the type of disinfection procedures that are possible.

C.1.2.4 System management practices

- What hygiene practices are already in place?
- What emergency procedures can be handled within existing procedures?

The site may have a contingency plan already, which will assist management of the disease. Information on hygiene practices should be obtained from the site manager, e.g. are there individual holding facilities and can water flows be controlled? A supply of disinfectant may be available on site for early response. The staff may be trained already in skills useful in a control program e.g. drug treatments, fish bathing. Records of water quality and movements of stock etc. (inputs and outputs) may be available on request. Some sampling equipment (e.g. boats and nets) may already be available on site.

C.1.2.5 Proximity of other establishments or natural environments with vulnerable species

- If the disease agent has not been contained what other aquatic animal populations are at risk?
- How can the outbreak be contained?
- What are the implications for likelihood of success of a control program?
- What monitoring could be undertaken in potentially exposed populations?
- Are divers required to sample fish at the site and/or in the outside environment?

Much of this information is likely to be available from local or regional State/Territory fisheries or agriculture officers (See Appendix 5 for contact numbers). Sampling equipment and reagents (e.g. fixatives, transport media, bacteriological plates, dissection equipment and nets) are likely to be available at State/Territory central veterinary and fisheries laboratories.

C.1.2.6 Stage of development of affected stock

- How much investment is at risk?
- What is the value of the stock?
- Can the animals be emergency harvested?
- Can diseased and unaffected fish be separated to allow grow-out of healthy animals?
- Can an emergency harvested product be processed on site to a safe form or will transportation protocols be required to carry it to processing plants?
- Can healthy or exposed product be sold for human consumption on the domestic or international markets?

Information on suitability for human consumption of emergency harvested animals may require input from health agencies (contact the Chief Medical Officer of the relevant State/Territory) and Seafood Quality Assurance programs (contact State/Territory Fisheries central office). Permission to transport affected stock and equipment off-site should be sought from the State/Territory Chief Veterinary Officer.

C.1.2.7 Effectiveness of treatment/vaccination/control measure

- Are any treatments available?
- What is the likelihood of 'carrier' animals remaining in the population?
- What are withdrawal periods for any drugs to be used?
- Are there environmental implications with the use of the treatment?

The local environmental protection agency may need to be consulted if disinfectant and drug treatments are used. Viral diseases cannot be treated effectively at the present time.

Permission for emergency use of antibiotics or antiparasitics may be obtained but consultation with the State/Territory Chief Veterinary Officer is required. Refer to Appendix 6 for further information on treatments for the reportable diseases.

C.1.2.8 Implications of the disease or control measures to the industry or trade relations

- What are the implications of either control or eradication strategies to the industry?
- To other industries?
- To the environment?

Trade occurs both nationally (interstate) and internationally and thus both State/Territory and Commonwealth government officers will need to be involved in discussions concerning these issues. These issues are most likely to be dealt with at the State/Commonwealth level rather than at a field officer level, however communication is necessary to ensure coordination.

C.1.2.9 Cost of control

- What is the cost/benefit ratio?
- In the short- and long-term?
- How long does a control program stay in place before it becomes untenable?

These issues are very likely to be decided at a high level (e.g. Director of Fisheries/Chief Veterinary Officer) but advice is likely to be sought from field operatives, aquatic animal health specialists, and industry representatives. Communication is necessary to ensure coordination.

C.1.3 Response options

C.1.3.1 Responses requiring no disruption to regular farm practices

When there is very little information available, (e.g. it is unclear whether the emergency is due to an infectious agent or some environmental factor) then continue regular farm practices. Maintain a health monitoring program and other activities, such as harvesting, grading and other practices. As more information becomes available, a more active option may present itself.

C.1.3.2 Responses requiring increased disruption to regular farm practices

The following responses may require extra resources both for the State authorities and for the producer. Extra resources such as equipment/materials, personnel, and time will be required to respond in any of the following ways.

C.1.3.2.1 Increased vigilance

Increased vigilance is required to ensure optimal environmental conditions are maintained at the facility. If an infectious agent is present then minimising stress on the affected aquatic animals by optimising environmental conditions can reduce the impact of the infection. Even in the presence of an infectious agent, disease (clinical signs and mortality) may not occur if good environmental conditions (good water quality, optimum stocking densities etc.) can be maintained to minimise stress.

Stress can be minimised on the animals by decreasing stocking density, reducing handling to the minimum level practical to the situation and by ensuring good water quality. Special attention should be given to suspended solids, dissolved oxygen, temperature, pH, and ammonia and nitrite levels. Past records of these parameters may be available from the farm manager/owner on request.

C.1.3.2.2 Movement control

To control spread of the disease agent, movement to and from affected site should be controlled. Control does not necessarily mean prohibit but may include movement by permit, and/or following drug treatment and/or disinfection.

Each of the following should be considered for control:

- primary aquatic animals (e.g. farmed stock)
- vectors
- secondary aquatic animals (e.g. animals other than the farmed stock)
- birds
- personnel
- equipment
- water (incoming and effluent).

C.1.3.2.3 Treatment

For some diseases (e.g. parasites and bacteria) treatments may be available. It is recommended that the current state of chemical registration should be checked to ensure that any chemical usage is carried out according to current regulations. The cost of treatment needs to be considered. Refer to Appendix 6 for information on available drug therapies and protocols for obtaining temporary permits for emergency use of drugs. For many other diseases (e.g. most, if not all, viral diseases) treatment of the affected stock is not an option.

Disinfection of farm equipment and other fomites may be appropriate when moving items on/off the affected site. Disinfection of personnel moving on/off the affected site and during final clean up at conclusion of the emergency situation should be considered. Disinfection protocols are available in the OIE International Aquatic Animal Health Code (http://www.oie.int).

Information on the following categories of treatments should be collected:

- chemical therapeutics (e.g. immunostimulants, antibiotics, antiparasitics)
- vaccines
- disinfection protocols.

C.1.3.3 Responses requiring major disruption to regular farm practices

In some instances (e.g. exotic incursion) it may be possible to undertake a stringent control/eradication program in order to protect unaffected premises, the industry sector, or the environment.

C.1.3.3.1 Isolation of premises/farm

For some systems it may be possible to isolate the affected premises/farm(s) to protect other operations and/or wild populations. Isolation of the affected premises can be achieved using the following means:

- voluntary/legislative (refer to Appendix 1)
- disinfection of incoming and effluent water

- prohibition of stock movements on or off the affected premises
- limited or no movement of equipment on/off affected premises (disinfection may be required)
- limited movement of personnel on/off affected premises (disinfection may be required).

Extra personnel are required to ensure restriction of movements (refer to Appendix 1). The State/Territory Chief Veterinary Officer or Director of Fisheries would be consulted on these matters.

C.1.3.3.2 Relocation of stock

There may be facilities to isolate either the infected stock from unaffected populations or unaffected stock from the infected animals. Permission for this action should be sought from Chief Veterinary Officer or Director of Fisheries. Laboratory testing may be required to prove freedom from disease (beware false negative or false positive results!).

C.1.3.3.3 Destruction of stock

The most serious response option, destruction of stock, has to be considered in some circumstances e.g. serious disease outbreak of OIE listed diseases. In this approach, diseased and untreatable animals would be destroyed depending on the agent involved, 'in-contact' animals may also need to be destroyed.

Exposed/affected/infected animals without clinical signs may be utilised (emergency harvest) to recoup some investment, depending on public health and trade issues. In some systems, animals other than the primary product may also be exposed/infected and need to be considered. These options are:

Primary aquatic animals (farmed stock);

- emergency harvest and sale
- emergency harvest, evisceration or other risk reduction measures as appropriate, cook on-site and sale
- destruction of aquatic animals, removal and disposal (or burial/ensilage on site).

Secondary aquatic animals (co-habiting non-farmed animals);

- destruction of aquatic animals, removal and disposal (or burial/ensilage on site).

C.2 Open systems

C.2.1 Introduction

Note: Read the general sections on Response Options (C.1) before reading this section.

The response options available in open water systems may be limited, especially in ocean and estuarine waters. The oceanic and estuarine systems are the least controllable systems with respect to both water and animal movement. Responses may be restricted to damage control of market impact or reduction of spread through human activity. Other possible options include wild stock reduction or segregation, which could be warranted in specific circumstances, but which is strongly influenced by the level of mobility of infected species.

C.2.2 Factors to consider in assessing the response options

C.2.2.1 Stage of the disease outbreak

In open systems where it is unlikely that active surveillance is operating, detection of a disease outbreak relies on reports of dead or dying fish from the public or fisheries officers. Moreover, it is likely that there are significant numbers of fish involved (e.g. pilchard mortality in 1995) and if an infectious agent is responsible, then it is probably at relatively high levels within the aquatic environment.

C.2.2.2 Disease agent epidemiology, biology and stability

Much of the value of possible response options will depend upon the expected natural rate of spread of the agent, which is dependent on:

- the course of the infection
- the transmissibility and lability of the agent
- the mobility of the host or hosts including vectors.

To assess these response options it is essential to have information on the identification of the agent, its natural hosts and vectors.

Experience has shown that even in confined stocks, a readily transmitted agent such as infectious haematopoietic necrosis virus (IHNV) is likely to spread (as a clinical infection) to all cages on a farmed site within two to four weeks. It may spread at least 10 kilometres in open unrestricted water flow, but is less likely to spread to areas outside the water flow. This situation may include spread through infection of other non-salmonid fish species, though there is currently little scientific data on such spread, or of susceptible and potential carrier species.

C.2.2.3 Site-specific features

Natural physical or behavioural barriers may inhibit the spread of both water-borne infection, and of stock migration. For more mobile species, or infections readily spread through water transmission, zones for monitoring and movement prevention will need to reflect natural barriers to water flow, such as headlands, water movement channels migratory limits of the infected stocks, and other possible carrier species.

C.2.2.4 System management practices

Possible response options may depend on the structure and operation of an industry. Information on these factors is presented in Section B: Industry sector information. The feasibility of limiting recreational activities may be a factor in assessing the likelihood of success of other activities.

C.2.2.5 Proximity to other establishments or natural environments with vulnerable species

It is important to maintain communication with other management authorities and industries (such as aquaculture industries) especially if there are vulnerable species located in the path of spread. This will allow industry and management authorities to prepare for a possible incursion of an infectious agent.

C.2.2.6 Stage of development of affected stock

The age of the affected stock may have future implications for catch rates and stock recovery and may influence future catch limits imposed on industry or recreational fisheries.

C.2.2.7 Effectiveness of any treatment/vaccination/control measure

It is unlikely that any treatment/vaccination would be applicable in open systems. Other control measures, such as limiting water flow in rivers, may not be effective and would have consequences for other users of the river system.

C.2.2.8 Implications of the disease or control measures to the industry and to trade relations

The effect of the disease on industries involved and on trade relations may determine the type of response required. Clearly, if little impact on the environment, industry or trade is expected then extensive control measures may not be warranted. However close attention would be warranted for an exotic incursion that could have quite widespread implications for industries and trade relations.

C.2.2.9 Cost of control

An important consideration is the cost-benefit analysis of a control measure.

C.2.3 Response options

An essential factor in minimising impact to fishing industries is coordinated and balanced information flow to the public and trading partners. Lack of information and lack of communication can cause unwarranted trade and financial impacts with loss of market confidence. Any public health risks must be addressed fully.

For a disease outbreak of local significance only, State authorities will establish a protocol for information management and dissemination.

For diseases of national/international importance, the Office of the Commonwealth Chief Veterinary Officer will establish a protocol for information dissemination.

It is important that all agencies involved in the management of the disease outbreak adhere to the agreed protocol. This will ensure information released is consistent, requests for information are directed to the appropriate source, and will allow other personnel to undertake their tasks unhindered by such requests.

Response options will depend on each emergency situation but could include one or more of the following.

C.2.3.1 Responses requiring no disruption to regular operations

In the first instance, especially when there is little information available, it may be most appropriate not to enforce any control measures but to simply monitor the situation. This may appear as the most realistic option for diseases of little current international concern.

The decision to monitor only (no active intervention) should not be taken lightly as failure to obtain data on the distribution of the agent may limit domestic or export market opportunities for a wider sector of the industry, and possibly may impact on other industries within the region. The lack of data may also allow the inadvertent spread through human activity to areas, which would otherwise not have become infected.

Active rather than passive surveillance will ensure that there are sufficient data for assurance that inadvertent spread can be minimised. It provides knowledge of the species affected, and the spatial and temporal distribution of the infection for market reassurance. Further information on surveillance and monitoring is found below.

C.2.3.2 Responses requiring increased disruption to regular operations

C.2.3.2.1 Increased vigilance

Surveillance for distribution of the agent may be necessary both to manage attempts at prevention of spread through human activity and to protect markets of uninfected areas especially those of open waters.

Surveillance needs include:

- knowledge of distribution of the agent in the affected species and movement patterns
- knowledge of other species, including predators in the areas and whether they are infected carriers or vectors.

For many diseases there is little data on the range of potential carrier species, and virtually no data on the potential of local endemic species to carry or become clinically affected by exotic disease agents.

Note that there may be a need to consider shellfish as vectors or reservoirs of finfish infections. For example, birnaviruses of infectious pancreatic necrosis (IPN) type have been isolated from filter-feeding molluscs. Depending on the agent this may be a true infection or short term retention of virus concentrated through filter feeding activity. Ectoparasites including crustacea (copepods, isopods) may transmit bacterial and viral disease agents between fish.

Surveillance techniques which may be considered:

- trace back to the geographical source if the disease agent is detected at harvest inspection (the ability to do so will require improved record keeping in many industries)
- where gross lesions are evident increase monitoring of fish for lesions at harvest or at processing in all areas (infected, uninfected and threatened)
- take more specific samples for laboratory testing from the animals at processing
- do specific catch surveys
- enlist the recreational and/or commercial fishing sectors for monitoring by increasing publicity of the lesions expected (this may be very effective in detecting new outbreaks,

but may provide an unmanageable level of irrelevant submissions and will not normally provide good negative surveillance data)

- conduct stock assessment (but the value of these as indicators of the effect of a disease incident will depend on the level and variability of prior background data).

C.2.3.2.2 Movement control

Prevention of movement of the agent through human activity may be a high priority. The following activities could be considered:

- wash down boats moving out of an infected area
- stop movement of risk product out of the area for processing
- suspend all catch activities if the agent is likely to be spread through normal product sales
- stop movement of fish from the area as bait from industry sector and recreational fisheries
- stop/discourage recreational fisheries in the area
- prevent movement of captured live animals to other areas
- inform trading partners to reduce the presence of foreign fishing vessels in infected areas
- cooperate with public health authorities to rapidly inform the public of the risks of disease transfer (as readily-caught dying fish are likely to be collected for use as bait or food, possibly in other locations).

C.2.3.2.3 Treatment

In open systems it is unlikely that treatment of a disease outbreak would be feasible.

C.2.3.3 Responses requiring major disruption to regular operations

C.2.3.3.1 Zoning

Zoning is the process of defining disease-free and infected zones[3] to allow effective management of disease control to reduce the risk of spread of disease by human activity. It may be necessary to establish geographical zones where fishing activities of various types can or cannot be performed. This process should be based on both knowledge of the current distribution of the agent and on the likely pattern of spread. The zoning may need to be reassessed as further knowledge is gained through surveillance.

In the case of open water, managed fisheries are already split into zones by their managing authorities according to hydrographic and stock distribution criteria. These zones may be used in a control program, e.g. the fishery affected by the outbreak may be closed and the fishing fleet may be able to transfer its activity to a zone adjacent to an infected area. This would allow the fleet to continue production as well as decreasing the number of potential hosts in the vicinity of the infected zone.

C.2.3.3.2 Relocation of stock

Removal of uninfected animals from a threatened area to a secure environment can be considered to preserve important genetic stocks. This becomes important in the case of severe diseases which may threaten the survival of a species or to ensure a source of disease-free stock for later scientific study of the disease. When considering this course of action the likelihood of freedom from the disease agent and the security of new environment should be considered to prevent the acceleration of spread of the disease to a new area. Infected animals

[3] OIE International Aquatic Animal Health Code, Second edition, 1997. Office International des Epizooties, Paris

may be removed from an infected area to a secure environment for further study of new or poorly understood diseases. Retention of infected stock in secure premises for further study may enable continued study of the disease after destruction of known infected stocks. In this case the security of the holding facility against escape of the agent is paramount.

C.2.3.3.3 Emergency harvest

Risks associated with the removal of infected animals for processing or destruction must be taken into account when considering emergency harvest, or deliberate reduction or elimination of infected stocks. It is likely the fishery would be closed as harvesting of diseased fish has legal implications and it would be difficult, or impossible, to sort healthy and diseased fish in a net from an infected zone.

If infected stock is harvested then the product should be processed to a non-infective product where it is considered that the product may come into contact with susceptible hosts. This usually involves evisceration as a minimum, but other processes such as freezing or cooking may be necessary. Initial processing on-site or at non-marine sites with effective water containment may be necessary. Emergency institution of water processing capability at processing plants may be used as many processing plants have evolved from home-port-based catch fisheries handling facilities and so have little effluent water treatment. Similarly it is essential to link boat and equipment hygiene to any emergency harvesting activity.

C.2.3.3.4 Destruction of stock

C.2.3.3.4.1 Eradication through wild stock reduction

In the case of a disease of international concern that could have an impact on the market access of other industry sectors, it may be necessary to reduce or even eradicate infected wild stock with limited mobility, such as shellfish.

Culling of infected stock may be necessary to maintain a healthy population, as fishers will selectively harvest healthy stock. The feasibility of stock reduction must be considered, as it may only be practical where the stock is sedentary, the infected area is small and the stock is well defined. It is unlikely to be feasible or effective where disease spread is rapid, or mobile populations are affected.

Ideally, diseased or potentially diseased stock should be removed rather than just killed *in situ*. The stock may be removed manually or heavily harvested with dredges. The impact on the ecosystem of operations such as heavy dredging must be considered and undertaken in consultation with appropriate environmental authorities.

Following stock removal, consideration must be given to re-seeding the infected area. There are differing opinions as to whether the residual populations should be left to re-seed the area. The policy for reseeding may depend on the long-term effect on the population of the whole region and the impact on other industries. For example, in fresh water, crayfish plague spread slowly but may wipe out a species completely (and has done so in several countries). For other diseases, such as bonamiosis, it is suspected that survivors of an epizootic are likely to be a selected population of those best adapted to the disease, but overall there is very limited data on the degree of natural resistance likely in a population.

C.2.3.3.4.2 Creation of a depopulated buffer zone

In the case of sedentary stock depopulation techniques, such as manual removal or dredging of stock, can be used to create a 'fire break' around the infected areas. This strategy can be effective with parasites with a high infective dose for which dilution significantly reduces the likelihood of infection. It can delay the rate of spread to allow time for infected stock to be removed. It has been used to limit the spread of *Bonamia* when introduced to the United

Kingdom - breaks of about 100 metres have provided short-term protection. This strategy is unsuitable for mobile hosts.

C.3 Semi-open systems

C.3.1 Introduction

Note: Read the general Sections C.1 on response options before reading this section.

The semi-open system is typically an aquaculture system in which there is control of animal movement but no control of water flow. Examples are net pen culture of fin fish and rack culture of shellfish.

The majority of farms using semi-open systems are situated on clumped leases within bays or estuaries and thus are highly regionalised. This means that in the event of an outbreak, the property of several farmers may be affected within a locality although other farming zones will probably be unaffected. The clumping of leases means that the environmental conditions at a set of sites are likely to be similar within a single region whereas the conditions may be significantly different in another zone/region or estuary. This may be important in the expression of either infectious or environmental causes of disease.

In situations where little is known about the incident, the initial response may be to do nothing more than monitor the situation until further information becomes available. Other options include:

- treatment of the affected population (through chemotherapy, fresh/saltwater baths or vaccination)
- emergency harvest
- complete quarantine with restrictions on movement of animals, all materials (including waste), personnel, vehicles and equipment.

Following the incident (after stand-down of the emergency response), the review process may indicate or recommend modification of practices which may assist in avoiding or controlling similar outbreaks in the future.

C.3.2 Factors to consider in assessing the response options

C. 3.2.1 Stage of the disease outbreak

If there is no on-going surveillance for known diseases, or there is an occurrence of a new disease, it is likely that by the time overt clinical signs become apparent, the infection will be well advanced. Early or rapid definitive diagnosis will increase the chances of controlling spread beyond the primary focus of infection.

If the disease has been present for some time, the value of strong control measures, such as quarantine and disinfection, is lessened as the agent may have already spread into natural waterways. The likely time of incursion will also indicate the extent to which tracing of stock or product will be necessary.

C. 3.2.2 Disease agent epidemiology, biology and stability

For a known disease, factors such as likely primary host(s), intermediate host(s) and/or vector species and their presence in the local environs may be quickly ascertained. For a newly emerging or exotic disease, lack of knowledge of the susceptibility of native Australian aquatic animals may make these predictions more difficult.

Consideration should be given to the likely source of infection of the stock, as this will indicate the likely contact throughout the farm or region.

The likely stability of the agent within the environment will assist in determining the type of disinfection or treatment techniques available or required and the likelihood of spread of the agent via waste, on equipment, in product and in effluent water.

C. 3.2.3 Site-specific features

The systems in place at the aquaculture site are very important in determining the likely spread of the agent and the ability to control such spread. An understanding of the flow of water is paramount. Is the area tidal? What is upstream or downstream?

C. 3.2.4 System management practices

The available response options may be limited due to the structure and operations of the affected site i.e. the system used, the species farmed, the size and locality of the facility, current management practices e.g. movement of stock within the site etc. Further information on these aspects is found in Section B.

Some farms are better prepared than others for managing a disease emergency. Request access to any records (such as stock movement, water monitoring results, occurrence of clinical signs, mortalities, contingency plans, maps of facility layout etc.) which would be useful in management of the disease outbreak.

C. 3.2.5 Proximity of other establishments or natural environments with vulnerable species

It is important to identify the location of other aquaculture facilities or natural environments with susceptible species. These could constitute either the source of infection or other populations at risk.

C. 3.2.6 Stage of development of affected stock

The stage of development of the affected stock can be important in the diagnosis and management of the disease. The stage of development may:

- provide an indication of the likely time of introduction of the disease to the system
- indicate likely further movements and other contacts, for example, if infected young have recently arrived from a central hatchery then further investigation of the hatchery is necessary
- indicate whether emergency harvesting (with at least some return to the farmer) can be considered to remove stock which are infected or likely to become infected.

C. 3.2.7 Effectiveness of treatment/vaccination/control measure

For known diseases, there may be available recommended treatments, vaccination and/or control measures (see Appendix 6).

C. 3.2.8 Implications of the disease and/or control measures for the industry and trade relations

The risk to other facilities and regions, to sustainability of the industry and to interstate and international trade will also impact on the selection of control measures enforced. For outbreaks of local concern which may affect more than one site but are unlikely to spread beyond State borders, the State/Territory Chief Veterinary Officer or Director of Fisheries may establish a local disease control centre and disease control taskforce. This decision will depend on information gathered from local State authorities and/or laboratories. For outbreaks of national/international concern, the Commonwealth Chief Veterinary Officer should be informed via the State Chief Veterinary Officer and a CCEAD meeting may be called.

C. 3.2.9 Cost of control

An important consideration of any control measure is the cost:benefit ratio of the consequences of implementing the proposed control measures and the likelihood of success of those measures versus not implementing any control measures (passive surveillance only).

C.3.3 Response options

Response to a disease emergency in a semi-open system may include one or several of the following.

C. 3.3.1 Responses requiring no disruption to regular farm practices

At the initial stages of a disease emergency it may be inappropriate to enforce any control measures. The most appropriate option may be to monitor the situation (passive surveillance) while essential information is being collected.

Passive surveillance should be undertaken until further information is available (on the history of the incident and the nature of the disease) to enable a decision on the next most appropriate action. Although this is a potentially low cost option (as it has minimal disruption to farm operations as well as State operations) there is an increased risk of further spread of the disease.

In the early stage of any campaign, monitoring and diagnosis should be used to help define the problem. In situations where the disease is not easily transmitted, monitoring may be used to define zones of infection, or alternatively, free zones to enable the continuation of trade.

In the case of a disease which spreads quickly, taking the 'monitor only' option for a long period can be costly. Delays in implementing appropriate control measures can lead to further spread of the disease. Then it may require a larger effort with less likelihood of success if it is decided that eradication is necessary.

Monitoring is an important part of any of the more active campaigns to ascertain and document progress.

C. 3.3.2 Responses requiring increased disruption to regular farm practices

C. 3.3.2.1 Increased vigilance

In order to gain further information on the host and geographic range of the infectious agent, collection of samples from the affected farm/region and adjacent farms/regions (active surveillance) is required. Increased resources are required at the operations level, including at the farm site(s) for collection of samples, at the diagnostic laboratory to undertake testing of the increased sample load), and at the policy level (establishment of a disease emergency taskforce) for liaison with the local disease control centre.

If the agent can be carried in dead tissues, on birds, in intermediate hosts, other susceptible species etc, then control of fishing birds and animals should be considered.

C. 3.3.2.2 Movement control

Movement control (quarantine) can be achieved by controlling inputs and outputs (see Section B).

Quarantine is a method of restricting access of people and materials into a dangerous site and restricting the movement of dangerous items to the outside environment.

Semi-open systems have a lack of control on water input and output and so are relatively difficult to quarantine. While movement of stock, personnel and equipment can be restricted other control measures may be more effective. It may be appropriate to disinfect personnel and equipment prior to leaving the infected premises. Recommended protocols for disinfection are found in the OIE International Aquatic Animal Health Code.

To restrict spread of the disease, it may be preferable to destroy diseased animals, undertake an emergency harvest on healthy but exposed animals and/or place exposed and at risk animals into quarantine - 'protective custody', if facilities are available - to allow grow out to market size (see below). Following such procedures extensive disinfection of the premises and equipment is essential.

C. 3.3.2.3 Treatment

Some pathogens, especially parasites and bacteria, can be susceptible to chemotherapy. This course of action should be considered if the therapy is likely to be effective as it is likely to be relatively cheap and animals are preserved for later sale. However, the likelihood of an incomplete response to treatment should be considered as should the likelihood of generating a carrier population (animals carrying the agent but showing no clinical signs following treatment).

Regulations concerning the use of registered or unregistered drugs should be considered. If stock is treated then subsequent harvest of stock may be restricted due to the presence of chemical residues. If the animals are destined for human consumption, recommended withholding periods prior to harvest need to be considered prior to treatment. Strict adherence to withdrawal periods is essential. These can be very long at low temperatures.

C. 3.3.3 Responses requiring major disruption to regular farm practices

C. 3.3.3.1 Isolation of premises/farm

All movement of stock on/off the premises can be prohibited. In semi-open systems, due to the lack of control of the water supply and effluent, this may not be very effective at reducing spread. Similarly, it will be difficult or impossible, to restrict the movement of wild aquatic animals around or within the aquaculture site. These wild animals may be vectors of the disease agent and thus provide a source of continued infection of the farmed stock. Removal of the stock (emergency harvest or destruction of stock) may be more appropriate.

Considerations when isolating a farm include:

- set up of a checkpoint (with associated inconvenience to operator, public, and transport industries)
- access to or for essential/emergency services
- impact on recreational activities
- waste output disposal - waste needs to be treated or kept on site
- it may require extensive resources and will need the use of suitable disease control legislation and the issuance of a quarantine order

- generation of significant media interest as placing premises under quarantine tends to be an emotive issue and therefore makes good press.

Advantages include:

- quarantine in this system may be an effective method of containment of a pathogen
- on a regional or national scale there may be preservation of trade by surveillance and zoning.

C. 3.3.3.2 Relocation of stock

Relocation of unaffected stock should only be considered when there is a very high probability the stock in question is not carrying the infectious agent. This may be considered if the stock in question are not susceptible to the agent, but facilities holding other species in the region need to be destocked and disinfected. Thus unaffected fish can be preserved. If the stock in question is susceptible to the disease, a reliable history of separation from the agent or a reliable detection test is needed to prevent movement of the disease agent with the stock. If this course of action is to be contemplated aspects such as using clean transport water and monitoring destination sites should also be addressed. The consequences of moving the disease agent with the stock should be carefully assessed as this course of action can make the overall problem worse.

C. 3.3.3.3 Emergency harvest

Selective harvest to recover some value of the stock as a course of action may be considered if there are clinically unaffected animals that are close to harvest age on infected premises. This action will preserve some value of the crop for the owner while removing potentially infected animals from the environment.

C. 3.3.3.4 Destruction of stock

Destruction of stock is the most severe measure and will cause major disruption to farm income and so should not be considered lightly. Notwithstanding, the quick removal of infected animals will markedly decrease the amount of infectious agent released to the environment and therefore decrease the likelihood of spread of the disease.

In general, disinfection will be used together with quarantine or destocking. Disinfection of the premises can be labour-intensive but could be used successfully in some situations. The methods of disinfection will depend on the agent in question (see OIE Aquatic Animal Health Code).

C.4 Semi-closed systems

C.4.1 Introduction

Note: Please read the general Section C.1. on response options before reading this section.

Semi-closed systems are characterised by a capability to have good control on farmed stock as well as some control, if only for a limited time, on water flow to and from the aquaculture facility. Thus there are several options available in semi-closed systems for control of disease.

All response measures can be considered as types of containment and control is possible at a number of levels. These levels are:

- production unit (e.g. single pond)
- farm/enterprise
- catchment/coastal area etc.
- zone
- country.

C.4.2 Factors to consider in assessing the response options

The following factors need to be considered in assessing the response options for a disease outbreak in semi-closed systems.

C.4.2.1 Stage of the disease outbreak

The speed of diagnosis of a disease is paramount. If the agent is detected quickly it is possible that there will be little, or no, spread beyond the primary focus of infection. However if the disease has been present for some time then strong control measures, such as quarantine and disinfection, are less useful as the agent may have already spread into natural waterways. The time of likely incursion will also give an indication of the required amount of tracing of stock or product.

C.4.2.2 Disease agent epidemiology, biology and stability

Factors such as likely primary host, carrier(s) or intermediate host(s), and their presence in the local environs can often be quickly ascertained. However, this prediction may be uncertain due to the lack of knowledge of the susceptibility of native Australian aquatic animals to exotic infectious agents.

The likely stability of the agent within the environment will define both the types of disinfection techniques required and the likelihood of spread of the agent via waste, on equipment, in product, and/or in effluent water.

C.4.2.3 Site specific features

The systems of water supply and output in the site are very important to determine the likely spread of the agent and the ability to control the agent. These systems vary between farms and it should be noted if:

- water comes from single or multiple sources

- water is piped directly to a single pond or flowed through several ponds (if water is reused in this way it decreases the chances of restriction of the disease to one production unit)
- effluent treatment ponds are available
- some production ponds could be used to treat effluent prior to release.

C.4.2.4 System management practices

An understanding is required of the management practices and the biology of the agent. Some farms will be better prepared than others for managing a disease emergency.

Normal farming practices may enhance the spread of the agent within the premises. Knowledge of these husbandry practices may indicate probable time of infection and the likelihood of spread to the external environment.

Recent operations of the farm must be ascertained and access to any records, which would be useful in management of the disease outbreak, should be requested. These should include stock movement, water monitoring results, occurrence of clinical signs, mortalities, contingency plans, maps of facility layout etc.

Further movement of live fish for grading purposes to a new pond, must be reconsidered. These movements should be studied to predict likely spread around the enterprise and to limit further spread.

Further information on this aspect is found in Section B.

C.4.2.5 Proximity of other establishments or natural environments with vulnerable species

Water discharge practices and facilities may significantly alter possible control measures. Some farming systems only take in or discharge water periodically into either settling ponds or directly into natural water courses. Some farms may be prone to flooding and so the potential for escape of stock may be important.

C.4.2.6 Stage of development of affected stock

The stage of development of affected stock can be important as it may:

- assist in the diagnosis of the disease and may indicate the likely time of introduction of the disease to the system
- indicate likely further movements and other contacts (for example, detection of infected young recently arrived from a central hatchery will require further investigation of the hatchery)
- indicate whether emergency harvesting should be considered to remove stock likely to become infected.

C.4.2.7 Effectiveness of treatment/vaccination/control measure

For known diseases, there may be available recommended treatments and vaccination and/or control measures (see Appendix 6).

C.4.2.8 Implications of the disease and/or control measures to the industry and to trade relations

Selection of control measures will depend on the risk to other facilities/regions, to sustainability of the industry and to interstate and international trade. For outbreaks of local concern which are unlikely to spread beyond State boundaries, the State/Territory Chief Veterinary Officer or Director of Fisheries may establish a local disease control centre and disease control taskforce depending on information gathered from local State authorities and/or laboratories. For outbreaks of national/international concern, the Commonwealth Chief Veterinary Officer needs to be informed via the State Chief Veterinary Officer and a CCEAD meeting may be called.

C.4.2.9 Cost of control

An important consideration of a control measure is the cost:benefit ratio of the consequences of implementing the proposed control measures and their likelihood of success versus not implementing any control measures (passive surveillance only).

C.4.3 Response options

Responses to a disease emergency involving a semi-closed system may include one or several of the following options.

C.4.3.1 Responses requiring no disruption to regular farm practices

Monitoring (passive surveillance), with no enforcement of other control measures is a low cost option however it can allow further spread of the disease. Taking the 'monitoring only' option, in the case of a disease which spreads quickly, can be costly as delays can lead to further spread of the disease. In this case, if a decision is then taken to eradicate or control then the job may be more costly and less likely to succeed.

Diagnosis should also be used in the early stage of any campaign to help define the problem while decisions for further actions are being formulated.

For some diseases, which do not spread easily, monitoring may be used to define zones of infection or alternatively, free zones to enable the continuation of trade.

Monitoring is an important part of any of the more active campaigns to ascertain progress.

C.4.3.2 Responses requiring increased disruption to regular farm practices

C.4.3.2.1 Increased vigilance

Collection of samples from the affected farm/region and adjacent farms/regions (active surveillance) is required to gain further information on the host and the geographic range of the infectious agent. Increased resources are required at the:

- operations level (the farm site) for collection of samples
- diagnostic laboratory to undertake testing of the increased sample load
- policy level (establishment of a disease emergency taskforce) for liaison with the local disease control centre (see Control Centre Manual).

If the agent can be carried in dead tissues, on birds, in intermediate hosts, other susceptible species etc., control of fishing birds and animals should be considered.

C.4.3.2.2 Movement control

Quarantine is a method of restricting the exportation of dangerous items to the outside environment and of restricting access of people and materials to a dangerous site. Semi-closed systems potentially can be placed under quarantine due to some control on water input and output. Depending on the nature of the system, control measures on water supply and effluent may be possible. Movement of stock, personnel and equipment can also be restricted. Disinfection of personnel and equipment prior to moving off the infected premises may be appropriate. Ponds where effluent water can be treated may be available. Recommended protocols for disinfection are found in the OIE International Aquatic Animal Health Code.

To restrict spread of the disease, it may be preferable to destroy diseased animals, undertake an emergency harvest of healthy but exposed animals, and/or place exposed and/or at risk animals into quarantine to allow grow out to market size (see below). Extensive disinfection of the premises and equipment is essential following such procedures.

C.4.3.2.3 Treatment

Some pathogens, especially parasites and bacteria, are very susceptible to drug therapies. Consideration may be given to this course of action if the therapy is likely to be effective. This approach may benefit the farmer in the short-term as the action is likely to be relatively cheap and animals are preserved for later sale. If considering drug therapy then factors to be considered are the:

- likelihood of an incomplete response to treatment
- likelihood of carrier animals (which carry the agent but show no clinical signs) remaining
- use of registered or unregistered drugs and the required withholding period if the animals are for human consumption. If the treatment option is used, it may restrict the later harvest of stock due to the presence of chemical residues.

C.4.3.3 Responses requiring major disruption to regular farm practices

C.4.3.3.1 Isolation of premises/farm

Quarantine is a method of restricting the exportation of dangerous items to the outside environment and of restricting access of people and materials to a dangerous site. The quarantine measures should be tailored to the particular husbandry system and the attributes of the pathogen.

Semi-closed systems are land-based and therefore can be quarantined from movements via land simply by controlling access via the main gate to the farm. Consideration should also be given to access ways via water.

Quarantine designed to restrict the spread of many disease agents will require control of stock and water so the security of both stock-holding facilities should be considered and may include installing meshes on outlets and water supplies.

In semi-closed systems, in-flowing water can be easily controlled by turning off pumps or closing weir gates, but the affect on water quality should be considered carefully. In some systems ponds may be cut off from water supply and drainage for relatively long periods with little affect. However, other systems that rely on regular supply of water, such as race culture of salmonids, will have a very short period before the stock will suffer, or die, due to decrease in water quality.

Consequences of quarantine include:

- a checkpoint is needed which will cause some inconvenience to operator, public, and transport industries
- access to or for essential/emergency services
- impact on recreational activities
- waste outputs need to be treated or kept on site

- extensive resources may be required
- the use of suitable disease control legislation and the issuance of a quarantine order
- possible significant media interest as placing premises under quarantine tends to be an emotive issue and therefore makes good press.

Advantages include:

- quarantine in this system is likely to be a very effective method of containment of a pathogen
- on a regional or national scale there may be preservation of trade by surveillance and zoning.

C.4.3.3.2 Relocation of stock

Relocation of stock should only be considered when there is a very high probability that the stock in question is not carrying the agent. The consequences of moving the disease agent with the stock should be carefully assessed as this course of action can worsen the overall problem.

Relocation may be considered if the stock in question is not susceptible to the agent. If the stock are susceptible to the disease, then a reliable history of separation from the agent or a reliable detection test is needed to prevent movement of the disease with the stock.

In the event of relocation clean transport water and monitoring destination sites should be done and ponds holding other species on the farm need to be destocked and disinfected.

C.4.3.3.3 Emergency harvest

If there are clinically unaffected animals close to harvest age on infected premises then selective harvest may be considered. This action will preserve some value of the crop for the owner while removing potentially infected animals from the environment.

The mode of harvest should be considered in this case as many systems rely on reduced water levels to enable netting of the stock. This may entail release of infective material into waterways unless an effluent collection facility is available where wastewater can be treated by chlorination, or another means, prior to release into the environment.

C.4.3.3.4 Destruction of stock

Destruction of stock is the most severe measure and will cause major disruption to the farm income so should not be considered lightly. Notwithstanding, the quick removal of infected animals will decrease markedly the level of infectious agents released to the environment and therefore the likelihood of spread of the disease.

Disinfection is used in concert with quarantine or destocking. The methods of disinfection will depend on the infective agent and may include drying out of ponds, chemical treatment of water, and chemical treatment of tanks and equipment. Disinfection of the premises can be labour intensive. Recommended protocols for disinfection are provided in the OIE International Aquatic Animal Health Code.

C.5 Closed systems

C.5.1 Introduction

Note: Read the general Section C.1. on response options before reading this section.

In closed systems the stock and water movement are highly controlled. Their self-contained nature of closed systems mean that there is a good chance of controlling an infectious disease within the affected facility.

However, the nature of the system brings other major difficulties and implications such as the treatment of a biofilter, the fate of animals while the biofilter is out of action and the high throughput and dissemination of animals from these facilities either into grow-out facilities or into retailers and home aquaria.

C.5.2 Factors to consider in assessing the response options

C.5.2.1 Stage of disease outbreak

In closed systems animals can be readily monitored for the presence of major infectious agents or in an outbreak is suspected then for clinical signs. Thus maintaining good record-keeping practices will facilitate tracing disease outbreaks.

C.5.2.2 Disease agent epidemiology, biology and stability

Disease factors that need to be considered in a closed system include:

- identification of disease agent
- species clinically affected (primary host) or able to carry disease agent (secondary hosts and vectors)
- ease of transmission of disease by water or other means
- lability of pathogen
- carrier species possibly involved and the likelihood of contact.

C.5.2.3 Site-specific features

Possible response options in a closed system may depend on the structure and operation of the enterprise. Aspects of the design of the facility to be considered include:

- separation of water supply from possible infected sources
- separation of water filtration systems from tanks or sections within the premises
- ability to isolate sections within the facility.

Information on these factors is presented in Section B.

C.5.2.4 System management practices

For closed systems it should be possible to control spread of the disease to the outside environment but it may be difficult to prevent spread within the system unless good system management practices are in place. Factors which may affect ability to control spread within the system include:

- physical separation and water supply separation between production stock and breeding stock and/or between infected stock and other stock
- separation of sources of feed and equipment (especially nets) between tanks or sections
- species involved in the outbreak as compared to species contained in the whole facility.

Further information on this aspect is found in Section B.

Consideration should also be given to the likely source of infection of the stock, as this will indicate the likely contact throughout the farm or region.

C.5.2.5 Proximity to other establishments or natural environments with vulnerable species

By the time the disease has become apparent the disease agent may well have escaped from the affected facility. Thus factors to consider include:

- ability to isolate the facility from the outside ecosystem
- likelihood of widespread distribution into the facility or into the wider population.

C.5.2.6 Stage of development of affected stock

The stage of development of affected stock can be important as it may:

- assist in the diagnosis of the disease and may indicate the likely time of introduction of the disease to the system
- indicate likely further movements and other contacts (for example, detection of infected young recently arrived from a central hatchery will require further investigation of the hatchery)
- indicate whether emergency harvesting should be considered to remove stock likely to become infected
- determine its location on the aquaculture facility, which, in turn, may determine the method of control of spread within the facility and the approach to containment.

Uninfected stock may be able to be separated or relocated to an unaffected site or, if appropriate, to grow-out facilities. If the stock cannot be moved then some sort of treatment may be possible. Alternatively destruction of stock should be considered (see below).

C.5.2.7 Effectiveness of any treatment/vaccination/control measure

In a closed system treatment or vaccination of animals should be relatively easy.

For known diseases, there may be available recommended treatments/vaccination and/or control measures (see Appendix 6).

C.5.2.8 Implications of the disease or control measures to the industry involved and to trade in general

The response options selected will be influenced by the potential consequences for the affected and potentially affected industry sectors if the disease were to spread and become enzootic. In addition, the control measures required to eradicate or to limit the spread of the disease may be impractical or too expensive to enforce.

Factors to consider include:

- likely importance of the disease to the industry or the environment

- status of the disease: i.e. is the disease notifiable in the State, nationally or internationally?

C.5.2.9 Cost of control

An important consideration of a control measure is the likely cost of the uncontrolled disease as opposed to the cost of the control measures. This must also be balanced with the likelihood of success.

The financial or ecological impact on the environment, industry and operator should be considered when deciding on measures to be used.

C.5.3 Response options

Responses to a disease emergency involving a closed system may include one or several of the following options.

C.5.3.1 Responses requiring no disruption to regular operations

Monitoring (passive surveillance), with no enforcement of other control measures is a low cost option however it has the potential for allowing further spread of the disease. Taking the 'monitoring only' option, in the case of a disease which spreads quickly, can be costly as delays can lead to further spread of the disease. In this case, if a decision is then taken to eradicate or control then the job may be more costly and less likely to succeed.

Diagnosis should also be used in the early stage of any campaign to help define the problem and while decisions for further actions are being formulated.

For some diseases, which do not spread easily, monitoring may be used to define zones of infection or alternatively, free zones to enable the continuation of trade.

Monitoring is an important part of any of the more active campaigns to ascertain progress.

C.5.3.2 Responses requiring increased disruption to operations

C.5.3.2.1 Increased vigilance

Collection of samples from the affected farm/region and adjacent farms/regions (active surveillance) is required to gain further information on the host and the geographic range of the infectious agent. Increased resources are required at the:

- operations level (the farm site) for collection of samples
- diagnostic laboratory to undertake testing of the increased sample load
- policy level (establishment of a disease emergency taskforce) for liaison with the local disease control centre (see Control Centre Manual).

C.5.3.2.2 Movement control

It may also be possible to separate infected stock from uninfected stock and ensure that there is control of movement of personnel, equipment, water and stock between the separated populations.

Stopping all water flow in and out of the facility/section should be considered to contain the infection within the facility or, at least, to prevent further spread of the infection from the facility. By definition, this strategy is relatively easy with closed systems. It may involve the facility as a whole or may involve the prevention of water exchange between parts of the same premises. The feasibility of the latter will depend on the type of facility and the degree to which it, and especially the filtration system, is compartmentalised. Although the systems are referred to as 'closed', in practice there is usually some water exchange periodically to remove nutrients from the system.

A second step is to stop the introduction of any new stock into the premises in order to maximise the time that the existing stock can be maintained without water exchange. Many facilities will have some water storage facility or temporary tanks or collapsible pools may be set up to take overflow before treatment.

With no water exchange, water quality may decrease depending on biological demand of the system, load on filters, stocking density, time frame, and capacity of the system to function without water exchange. These may lead to compromised systems and increased stock mortality.

If warranted, it may be possible to use water from a known uninfected source. The volumes of water used in closed systems may be relatively small and water could be trucked in from a known uninfected source or treated with UV, ozone or chlorine prior to use. Chlorine-treated water will need to be dechlorinated using carbon filters and/or aeration. The water may also need pH or temperature adjustment.

To decrease aerosol circulation and minimise spread between tanks and into the environment, air pumps can be switched off, circulation pumps can be used, or the tops of the tanks and filters can be covered with glass or plastic.

Switching off either air or water recirculation pumps will affect severely the filtration and oxygenation of water. Depending on factors such as species and stocking densities, the aquatic animals may survive for a period of time ranging from hours to days. The decision to switch off air or water recirculation pumps should be made with information of the expected survival of the species in question which may be gained from the aquarist as pump failures may have been experienced in the past.

Depending on the design of the facility, it may be possible to treat effluent water so as to inactivate any infectious agent, prior to release.

C.5.3.2.3 Treatment

Treatment or vaccination of some or all of the stock can be considered if aspects of the agent and the treatment make it practical and/or economical.

The following issues should be addressed when a treatment regime is considered as the sole means of control or as part of a control scheme:

- possible carrier animals remaining in the population
- contaminated water
- environmental and occupational health and safety issues
- development of resistance
- treatment costs
- withholding periods for product destined for human consumption.

Benefits of treatment include:

- preservation of stock
- preservation of cash flow
- possibly low cost.

C.5.3.3 Responses requiring major disruption to regular operations

C.5.3.3.1 Isolation of premises/farm

Isolation of premises/farm (quarantine) can be achieved by controlling inputs and outputs (see Section B).

Consideration should be given to the level of containment that is advisable during a confirmed outbreak or before an actual disease agent incursion is confirmed. Quarantine of an affected area and its water systems may either involve the whole facility or just part of a facility. This decision will depend on an understanding of the facility affected and the traffic between this and other facilities or within the facility. The information will be used to define which of the affected tanks, buildings, etc. to isolate and what should be controlled. This may involve cessation of shipment of stock, controlling the flow of effluent, and control of vehicular and personnel traffic. In the situation of quarantine of a premises, product and vehicles cannot be moved without suitable treatment and/or testing/certification.

Consequences of quarantine include:

- a checkpoint is needed which will cause some inconvenience to operator, public, and transport industries
- access to or for essential/emergency services
- impact on recreational activities
- waste outputs need to be treated or kept on site
- extensive resources may be required
- the use of suitable disease control legislation and the issuance of a quarantine order
- possible significant media interest as placing premises under quarantine tends to be an emotive issue and therefore makes good press.

Advantages include:

- quarantine in this system is likely to be a very effective method of containment of a pathogen
- on a regional or national scale there may be preservation of trade by surveillance and zoning.

C.5.3.3.2 Relocation of stock

Relocation of stock should only be considered when there is a very high probability the stock in question is not carrying the infectious agent. This may be considered if the stock in question is not susceptible to the agent, but tanks holding other species on the premises need to be destocked and disinfected. Thus unaffected fish can be preserved. If the stock in question are susceptible to the disease, a reliable history of separation from the agent or a reliable detection test is needed to prevent movement of the disease with the stock. If this course of action is to be contemplated aspects such as using clean transport water and monitoring destination sites should also be addressed. The consequences of moving the disease agent with the stock should be carefully assessed as this course of action can worsen the overall problem.

C.5.3.3.3 Emergency harvest

In multiple species farms, depending on the disease, it may be safe to continue trading in unaffected species if clean water and equipment is used for processing or transport. Product for human consumption may be emergency harvested if the animals are of suitable size, are deemed safe and are in good condition. This will allow the destocking of a farm with some recompense but food safety, processing waste and environmental safety should be considered.

Consequences of emergency harvesting include:

- infected stock may be present on the premises for a longer period with increased risk of environmental contamination
- quarantine measures may be sufficient to restrict escape of the disease agent.

Benefits include:

- some return can be expected for the farmer.

C.5.3.3.4 Destruction of stock

This extreme measure remains an option in particularly serious situations, such as where the level of mortality or evidence of rapid spread, warrants such an action or if the presence of a severe exotic pathogen is proven. This can be very effective in controlling a restricted outbreak of disease. Clearly the consequences of undertaking this action, such as loss of saleable stock or valuable broodstock, cost of disposal etc., are also extreme.

The decontamination of all infected materials/equipment (e.g. nets) and permanent structures (e.g. cement tanks) likely to have been exposed to the disease agent should be used following destruction of stock and may be used in several of the other strategies. It is very labour intensive.

Different materials and agents require different methods of cleaning and may vary from disinfection of earth ponds by drying out to treatment of concrete using hot disinfectants.

There is a range of disinfectants that are available and not all are suitable for all situations or all agents. Recommended protocols for disinfection are provided in the OIE International Aquatic Animal Health Code.

Appendices

Section contents

Appendix 1: Summary of current legislation with relevance to aquatic animal diseases

State/Territory/Agency	*Relevant Legislation*
Australian Capital Territory	The Stock Act 1993 The Animal Diseases Act 1993 The Nature Conservation Act 1980 The Fishing Act 1967
New South Wales	The Exotic Diseases of Animals Act 1991 The Stock Diseases Act 1923 The Fisheries Management Act 1994 The Fisheries Management Act (Aquaculture) Regulations 1995
Northern Territory	The Stock Diseases Act 1954 The Fisheries Act 1995
Queensland	The Fisheries Act 1994 The Fisheries Regulations 1995
South Australia	The Livestock Act 1997 The Fisheries Act 1982 The Exotic Fish, Fish Farming and Fish Disease Regulations 1984
Tasmania	The Animal Health Act 1995 Inland Fisheries Act 1995
Victoria	The Livestock Disease Control Act 1994 Fisheries Regulations 1998
Western Australia	Pearling Act 1990 The Exotic Disease of Animals Act 1993 The Stock Diseases Regulations Act 1996 Enzootic Diseases Amendment Regulations 1999
Commonwealth and International	For example: The Commonwealth Fisheries Management Act, 1991 The Fisheries Act, 1975 State Fisheries Acts and Legislation UN Agreement on Straddling and Migratory Fish Stocks, London Convention Off Shore petroleum and Minerals Exploration Acts Quarantine Act, 1908 and Ballast Water Regulations Waste processing discharges from food processing and industrial wastes, MARPOL. Black marlin Code for Commercial Fishers and the Recreational Fisheries Code of Practice

Electronic versions of Australian Acts and regulations can be found on the Internet at sites such as http://www.austlii.edu.au and http://www.dms.dpc.vic.gov.au.

International laws and treaties can be found on sites such as http://www.lexadin.nl/wlg/legis/nofr/legis.htm.

Appendix 2: Human Pathogens

Appendix 2: Seafood-borne Disease in Humans

class of pathogen	Disease causing agent	seafood susceptible to contamination			Distribution and habitat		Transmission and risk factors	Disease and symptoms	Seriousness	Prevention and control	Comments
		fin-fish	mollusc	crustacean							
virus	hepatitis A		oysters scallops		<u>world-wide</u> -fresh water -estuarine -sea water	mainly associated with faecal contaminated waters	consumption of raw or partially cooked fish and shell fish from sewage contaminated waters	incubation- 2 to 6 weeks sudden onset of fever, malaise, nausea, anorexia, joint pain and abdominal discomfort followed by jaundice	moderate to serious (can lead to chronic liver damage and cirrhosis)	cook shell fish ensure source water is uncontaminated	fatality rate is 0.1 - 1% in healthy individuals but up to 20% in pregnant woman
	hepatitis E	fish									
	Norwalk sp.		oysters clams		estuarine and sea water		consumption of raw or partially cooked shell fish from sewage contaminated waters or unhygienic handling by humans after product was cooked	nausea, vomiting, diarrhoea, abdominal pain, head ache fever mild illness with onset from 24 - 48 hours following consumption and persisting from 24 to 60 hours	mild		
	Snow Mountain Agent										
bacteria	*Clostridium botulinum*	**all aquatic animals** -fish can harbour *C.botulinum* in their intestinal tracts -shell fish & crustacea, in their gills and viscera			<u>world-wide</u> -fresh water -estuarine -sea water		consumption of undercooked or uneviscerated seafood where neurotoxin is produced by *C.botulinum* - also lack of human hygiene in processing.	lassitude; vertigo; double vision; difficulty speaking, swallowing and breathing; weak muscles; abdominal distension and constipation onset- 18 to 36 hours following consumption	serious (can be life threatening)	evisceration cook for at least 5 minutes at 85 ºC refrigeration	incidence world-wide is low -but mortalities are high if not treated immediately
	Vibrio parahaemolyticus	some fish (range unknown)	principally shellfish and crustacea		<u>world-wide</u> -estuarine -sea water		consumption of raw or partially cooked fish and shellfish or fish and shellfish recontaminated after cooking	onset- 4-96 hours median duration- 2½ days diarrhoea, abdominal cramps, nausea, vomiting, head ache, fever and chills	mild - moderate sometimes requires hospitalisation	-evisceration -cook seafood for 2½ mins at 55ºC -adequate refrigeration	sensitive to refrigeration below 5ºC

Appendix 2: Seafood-borne Disease in Humans

class of pathogen	Disease causing agent	seafood susceptible to contamination			Distribution and habitat	Transmission and risk factors	Disease and symptoms	Seriousness	Prevention and control	Comments
		fin-fish	mollusc	crustacean						
bacteria -cont	*V.vulnificus*		clams & oysters	crabs	world-wide -estuarine -sea water	consumption of raw or partially cooked or cooked but recontaminated shellfish and crustacea or via breaks in the skin during handling	usually a mild case of gastro in otherwise healthy individuals (diarrhoea, abdominal cramps, nausea, vomiting, head ache). In Immunocomprimised patients (leukemia, cirrhosis, lung carcinomas, steroid treated asthma or other wise), primary septicaemia can develop.	moderate - fatal (mortality following onset of septiceamia is greater than 50%)	evisceration cook oysters for 10 mins. At 50ºC refrigeration	
	V.cholerae				temperate -estuarine -sea water	consumption of raw shellfish from polluted bays and estuaries V.cholerae also present in low numbers in non-polluted waters	onset - 6 hours to 5 days duration 6-7 days Characterised by watery "*rice-water*" stools, abdominal cramps, nausea, vomiting, dehydration and shock. Death may occur following severe loss of fluid and electrolytes	moderate to serious may require intravenous rehydration	evisceration cook seafood for 3 mins. at 60ºC refrigeration	causes 'Cholera' often in local epidemics associated with breakdown of sewerage systems
	V.mimicus *V.alginolyticus* *V.fluvialis* *V.damsela* *V.hollisae* *V.furnesii*	species range unknown	species range unknown	species range unknown	world-wide -estuarine -sea water	consumption of raw or partially cooked or cooked but recontaminated fish and shellfish or via breaks in the skin during handling	found to be implicated with mild gastroenteritis as well as wound and ear infections	mild	evisceration cook seafood refrigeration wear gloves and keep wounds clean and dressed when handling fish	
	Aeromonas hydrophila *A.caviae* *A.sobria*	all seafood are potential carriers			freshwater & brackish water	transmission is via breaks in the skin from water and flesh during handling and through ingestion of contaminated water or seafood	cholera-like "rice and water" diarrhoea or a dysenteric illness with loose stools containing blood and mucous usually a mild case of gastro ensues in otherwise healthy individuals.	Mild to moderate serious for immuno-compromised		In Immuno-comprimised patients (leukemia, cirrhosis, lung carcinomas, steroid treated asthma or other wise), primary septicaemia can develop.

Appendix 2: Seafood-borne Disease in Humans

class of pathogen	Disease causing agent	seafood susceptible to contamination: fin-fish	mollusc	crustacean	Distribution and habitat	Transmission and risk factors	Disease and symptoms	Seriousness	Prevention and control	Comments
	Erysipelothrix rhusiopathiae	all seafood are potential carriers			world-wide freshwater	infection occurs via cuts and abrasions to the skin or through mucous membranes	swollen, slightly elevated patches appear on the skin of hands or fingers, associated with a burning, tingling sensation and intensely itchy. Mild arthritis of finger joints occurs. Headache, fever and heart or nervous system complications sometimes result. duration- 2 to 6 weeks. Relapses may occur. Although rare, symptoms can persist for a long time.	mild	prompt washing and dressing of cuts or breaks to the skin. Regular disinfection of workbenches and equipment.	More a problem for fish handlers/processors than consumers
	Leptospira *-interrogans* -serovar *-pomóna* -serovar *-canicola*						Mild cases - symptoms can last from 1 to several days with fever, headache, severe muscle pain, dehydration, nausea and photophobia.. Several days following onset a rash develops on skin, blood pressure is reduced with dysfunction of the kidney and liver before a long convalescence. Duration 3 to 6 weeks before complete recovery. Severe cases- symptoms can reoccur after an apparent 1-3 day recovery. with higher temperature, more severe headaches, rigors and chills, excruciating pains in calf muscle, thigh and back. Jaundice may develop, nose bleeds, haemorrhagia, protracted vomiting. Patients surviving the renal and myocardial failure of leptospirosis recover within 6 to 12 weeks. Fatalities occur following complete renal or irreversible myocardial failure.	mild to fatal	wear gloves and keep wounds clean and dressed when handling seafood	associated with water contaminated by urine of infected animalse (eg. rats, cattle etc.)

Appendix 2: Seafood-borne Disease in Humans

class of pathogen	Disease causing agent	seafood susceptible to contamination (fin-fish, mollusc, crustacean)	Distribution and habitat	Transmission and risk factors	Disease and symptoms	Seriousness	Prevention and control	Comments
bacteria -cont	*Mycobacterium marinum*	all seafood are potential carriers	world-wide freshwater	infection occurs via cuts and abrasions to the skin or through mucous membranes	onset- 2 to 9 weeks slightly raised, scaly, warm and red bumps from hand to arm with little to no pain, sometimes purulent. Infection via deep wounds can cause tendons and joints to swell and become stiff. No fever, head or abdominal pains	mild		Commonly referred to as swimming pool disease in humans. Often asscociated with tuberculosis and granulomas in infected fish
	Mycobacterium fortuitum *M.chelonae*				occassionally causes pulmonary or disseminated disease in humans and wound infections	mild	wear gloves and keep wounds clean and dressed when handling seafood	*Mycobacterium fortuitum* first isolated from frogs. *M.chelonae* first isolated from turtles
	Nocardia asteroides		world-wide	infection occurs via inhalation of the bacterium or through breaks in the skin	cough with sputum, progressive difficulty breathing, malaise, weight loss, fever, night sweats, chest pain, joint pain, liver and spleen enlargement	moderate		70% patients treated are immunosuppressed through other medication or predisposing illness
	Pleismonas shigelloides	all aquatic animals but particularly shellfish	freshwater	consumption of uncooked seafood	onset- 20-24 hrs duration- 1-7 days but usually 1-2 days in healthy adults fever, chills, stomach pain, nausea, non bloody or mucoid diarrhoea, or vomiting	mild in healthy adults mod in children <15yrs serious in infants or immuno-comprimised	rinsing seafood in clean or boiled water and cooking for at least 30 min. at 60°C.	
	Edwardsiella tarda		freshwater /marine		similar to *P.shigelloides* above	mild		

Appendix 2: Seafood-borne Disease in Humans

class of pathogen	Disease causing agent	seafood susceptible to contamination: fin-fish	mollusc	crustacean	Distribution and habitat	Transmission and risk factors	Disease and symptoms	Seriousness	Prevention and control	Comments
bacteria -cont	*Bacillus cereus*	all seafood are potential carriers			world-wide	contamination resulting from inadequate refrigeration and storage of fresh seafood or reheated previously cooked seafood (ie food must be rapidly cooled to, and kept below 4°C at all times).	Diarrhoeic strain onset- 6-15 hrs duration- 24 hrs watery diarrhoea and nausea, stomach cramps and pain, rarely vomiting emetic strain onset- 0.5 to 6 hrs duration <24 hrs nausea and vomiting, sometimes diarrhoea and stomach cramps	usually mild with possible serious complication	constant refrigeration of both fresh and cooked seafood	reheating may kill the bacteria in cooked seafood that has been poorly stored- but not the heat stable toxins produced by *B.cereus*
	Clostridium perfringens	species range unknown	species range unknown	species range unknown	world-wide freshwater /marine & soil	some organisms can survive cooking and multiply in the cooling down process and inadequate storage temperatures	onset- 8 to 22 hrs duration- 24hrs (1-2 weeks in the infirmed) intense stomach cramps, diarrhoea Type C strain enteritis necroticans or pig-bel disease	mild (common strain) to fatal (Type C strain)	refrigerate cooked foods quickly and maintain temperatures below 4°C reheating thoroughly to > 60°C for >10 mins.	duration is protracted in the young and the elderly the fatal Type C strain is very rare *C.perfringens* is also involved in transforming histidine to histamine in Scombroid poisoning.
	Listeria monocytogenes	raw & smoked fish			freshwater	prolonged exposure to temperatures either above 4°C or below 60°C (eg. cooked foods allowed to cool, or refrigerated/frozen foods to warm slowly at room temperature) usually associated with contamination through insanitary handling or facilities during food preparation	onset- 12 hrs to onset of gastrointestinal symptoms. a few days to 3 weeks to onset of the following manifestations of Listeriosis septicaemia, meningitis, (or meningoencephalitis), encephalitis and intrauerine infections leading to spontaneous abortion in pregnant women.	mild-serious	keep food at temperatures outside of the danger zone either below 4°C or above 60°C	most healthy people suffer no symptoms. the potentially fatal expressions of the disease are found in pregnant women (more so the foetus) and immuno- comprimised.

Appendix 2: Seafood-borne Disease in Humans

class of pathogen	Disease causing agent	seafood susceptible to contamination: fin-fish	mollusc	crustacean	Distribution and habitat	Transmission and risk factors	Disease and symptoms	Seriousness	Prevention and control	Comments
bacteria -cont	*Salmonella typhi* *S.arizonae*	all seafood are potential carriers			freshwater /marine	ingestion of bacterium with undercooked seafood septicaemia follows penetration of Salmonella organisms into small intestine	onset- 6 to 48 hrs duration- 1 to 2 days. May be prolonged depending upon age and health and dose ingested. acute symptoms - nausea, vomiting, abdominal cramps, monal diarrhoea, fever, headache chronic symptoms- arthritic symptoms may follow 3-4 weeks	moderate to serious	keep food at temperatures outside of the danger zone either below 4°C or above 60°C	usually associated with faecal contamination of water
	other Salmonella sp.				freshwater /marine	ingestion of bacterium with undercooked seafood septicaemia follows penetration of Salmonella organisms into small intestine	infections typically manifest as a self-limited gastroenteritis similar to S.typhi above but less severe. In less than 5 percent the infection spreads through the bloodstream, causing focal infection or abscess in almost any organ.	moderate to fatal		
	Shigella sp.				associated with waters polluted with human effluent	consumption of raw or partially cooked shell fish from sewage contaminated waters or unhygienic handling by humans after product was cooked	onset- 12 to 50 hours abdominal pain; cramps; diarrhoea; fever; vomiting; blood, pus or mucous in stools; tenesmus	moderate to serious		
	Campylobacter sp.				associated with un-sanitised water. Bacteria is present in intestinal tract of many animals including humans	ingestion of bacterium *Campylobacter sp.* and associated enterotoxins occurring in insufficiently cooked seafood which has cooled too slowly after cooking, or insufficiently heated during re-heating Or cross-contamination from human handling	onset- 2-5 days duration- 7-10 days (relapses < 25% of cases) diarrhoea with fever, abdominal pain, nausea, headache, and muscle pain	moderate to serious	Cooking **does not** destroy the heat labile toxin. Observing critical temperatures during handling and processing will minimise toxins produced by these bacteria prior to cooking.	complications can include- meningitis, urinary tract infections, reactive arthritis and rarely Guillain-Barre syndrome.

Appendix 2: Seafood-borne Disease in Humans

class of pathogen	Disease causing agent	seafood susceptible to contamination: fin-fish	seafood susceptible to contamination: mollusc	seafood susceptible to contamination: crustacean	Distribution and habitat	Transmission and risk factors	Disease and symptoms	Seriousness	Prevention and control	Comments
bacteria -cont	*E. coli*	all seafood are potential carriers			E.coli is present in all animal intestinal tracts and largely beneficial. Some strains however (such as O157:H7) are pathogenic to humans	transmission occurs by consumption of seafood which has been either insufficiently cooked or eaten raw.	onset- rapid Duration- up to approx 8 days abdominal pain, diarrhoea (initially watery becoming bloody), occasional vomiting, low fever	mild-moderate	cooking all seafood and rinsing food in sanitised or boiled water	Complications include: haemolytic uraemic syndrome (HUS) in the very young resulting in renal failure and haemolytic anaemia with some biotypes
bacteria -cont	*Staphylococcus aureus*	all seafood are potential carriers			present every where in environment	ingestion of bacterium *S.aureus* and associated enterotoxins occurring in insufficiently cooked seafood which has cooled too slowly after cooking, or insufficiently heated during re-heating. Or cross-contamination through human handling	onset- rapid Duration- 2-3 days nausea, vomiting, retching, abdominal pain and prostration	mild-moderate	ensure sanitary preparation area, fully cook all seafood and observe critical storage temperatures (0-4° C > temp > 60° C)	Complications include: haemolytic uraemic syndrome (HUS) in the very young resulting in renal failure and haemolytic anaemia
parasite nematode (roundworm)	Anisakid sp. eg *Anisakis simplex* *Psuedoterranova decipiens* *Contracaecum spp.* *Hysterothylacium spp.*	salmon, herring, flounder	squid, octopus	copepods	worldwide marine	consumption of undercooked or raw seafood contaminated with anisakis nematode larvae	onset- 1 hour to 2 weeks duration- typically less than 3 weeks severe cases result in acute abdominal pain similar to acute appendicitis. Typically self limiting and asymptomatic until diagnosed when an irritated throat brings up a nematode.	moderate to serious	rapid evisceration and removal of belly flaps in fish seafood should be fully cooked prior to consumption or if to be served semi-raw, then should be blast frozen to below -35ºC for a minimum of 15 hours (or -20ºC for 7 days)	nematodes move from viscera to the flesh if fish is not eviscerated promptly dead nematodes remaining in the flesh of seafood, while not causing anisakiasis in humans, may illicit an allergic response in humans

Appendix 2: Seafood-borne Disease in Humans

class of pathogen	Disease causing agent	seafood susceptible to contamination: fin-fish	mollusc	crustacean	Distribution and habitat	Transmission and risk factors	Disease and symptoms	Seriousness	Prevention and control	Comments
parasite-cont (nematode)	*Angiostrongylus cantonensis*		marine	marine	Southeast Asia and Pacific	Consumption of raw infected mollusc, vegetables contaminated with mollusc slime, or marine crustacea such as crabs and prawns which have themselves consumed infected mollusc	onset- 2 to 30 days (average- 3 weeks) nausea, vomiting, abdominal discomfort may occur soon after ingestion developing into severe headache and stiff neck with eosinophilic meningitis. Fever may be present in children and severely infected adults	moderate to serious	cooking all seafood and rinsing food in clean or boiled water	
	Gnathostoma spp.	Freshwater			Ecuador, Mexico, eastern Africa, Asia and Japan	consumption of undercooked fish or consumption of terrestrial animals which have eaten undercooked infected fish (eg pigs & poultry)	onset- several weeks? duration- ? Subcutaneous swellings, oedema and pruritus can lead to eosinophilic myeloencephalitis involving intense radicular pain, paralysis of the lower extremity and urinary retention to severe headache, coma and death.	mild to moderate	ensure all fish is eviscerated and cooked thoroghly.	An inability for these nematodes to mature in the human host means the larvae migrate through the internal organs or under the skin
	Capillaria phillipinensis	freshwater / marine			Asia, Middle East	consumption of uncooked or uneviscerated seafood	onset- symptoms develop over several weeks. Abdominal discomfort and pain and intermittent diarrhoea. Untreated will progress to 8 - 10 voluminous stools per day with significant weight loss, malabsorption, cardiac failure, low blood pressure, oedema, and hypoammaglobulinemia			
	Capillaria hepatica				Korea, Japan and Sth America		fever, shortness of breath; neck, chest and abdomenal pain			
cestode (tapeworm)	*Diphyllobothrium latum*	larva in viscera of both freshwater and marine fish. larva only migrate to the flesh of freshwater or anadromous fishes			worldwide	consumption (or tasting) of raw or undercooked fish	Onset- 10 days abdominal distension, flatulence, diarrhoea. Other minor clinical signs include: nausea, headache, nervousness, diarrhoea, weakness and a 'sensation that something is moving inside'. Visualisation of spent proglottid (tapeworm segment bearing ovule) in stool is often the first conirmation of diagnosis.	mild to moderate but can be serious for immuno-compromised		tapeworm grows from 3 to 10 feet long in the intestine
	D.pacificum				Peru					tapeworm about half the size of *D. latum*
	Diplogonoporus grandis	marine fish			Far East					

Appendix 2: Seafood-borne Disease in Humans

class of pathogen	Disease causing agent	seafood susceptible to contamination: fin-fish	seafood susceptible to contamination: mollusc	seafood susceptible to contamination: crustacean	Distribution and habitat	Transmission and risk factors	Disease and symptoms	Seriousness	Prevention and control	Comments
Parasite-cont trematode (flukes)	*Clonorchis sp.*	freshwater cyprinids			Asia & Pacific - *C.sinensis* & *O.viverrini* Europe - *O.felineus*	consumption of undercooked (pickled or salted) fish which are infected	onset- 1 to 4 weeks largely asymptomatic, however acute illness can occur with fever, epigastric pain and eosinophilia. Chronic infections can result in gall stones, inflammation and erosion of the bile duct and liver parenchyma. Blockages from extensive tissue fibrosis can result in liver enlartgement and cirrhosis with severe pain.	moderate to serious	ensure all fish is eviscerated and cooked thoroughly. ensure all fish is eviscerated and cooked thoroughly	average infection is ~ 2-3 dozen worms in the bile duct and liver. heavy infections can have upto 20,000 worms in the liver
	Mtagonimus yokagawai	freshwater fish			Far East	consumption of uncooked or uneviscerated seafood	diarrhoea, abdominal pain. The parasite can act to break down the lining of the small intestine allowing it's eggs to enter the blood stream infecting the liver, heart and brain			
	Heterophyes spp.	freshwater fish			Africa, SE Asia, Pacific	consumption of uncooked or uneviscerated seafood	diarrhoea, abdominal pain. The parasite can act to break down the lining of the small intestine allowing it's eggs to enter the blood stream infecting the liver, heart and brain			
	Stellantchasmus falcatus	diadromous fishes			Asia, Polynesia	consumption of uncooked or uneviscerated seafood	similar symptoms to *Heterophyes spp.* above	moderate to serious		
	Paragonimus spp,			freshwater crabs and crayfish	*P.westermani* dominates west Africa and east Asia- *P.mexicanus; P.kellicotti; P.caliensis* south and central America-	consumption of raw or undercooked freshwater crabs or crayfish	onset of symptoms- ~3 months starting with a dry cough developing into a rusty sputum pronounced on awakening, pleuritic chest pain difficult to distinguish from pneumonia or tuberculosis based on clinical signs alone	mild to serious	cook until muscles turn white or immerse in water above 55°C for 5 minutes	typically a disease of the lungs, juvenile worms may get lost on their journey to the lungs and end up causing ectopic lesions in other organs including the brain.
	Echinostomatid trematodes	freshwater fish	clams		SE Asia and western Pacific	consumption of uncooked or uneviscerated seafood	generally asymptomatic heavy infections can result in diarrhoea and vague abdominal discomfort with eosinophilia	mild		

Appendix 2: Seafood-borne Disease in Humans

class of pathogen	Disease causing agent	seafood susceptible to contamination: fin-fish	seafood susceptible to contamination: mollusc	seafood susceptible to contamination: crustacean	Distribution and habitat	Transmission and risk factors	genera of dinoflagellate implicated	Disease and symptoms	Serious-ness	Prevention and control	Comments
Parasite-cont trematode (flukes)	*Nanophyetus salmincola*	anadromous fishes (principally salmonids)	some freshwater snails		Northern Pacific	consumption of uncooked or uneviscerated seafood		onset- 5 to 8 days diarrhoea, mild abdominal discomfort and nausea	mild	ensure all fish is eviscerated and cooked thoroughly.	
	Metorchis conjunctus	freshwater fish			North America			onset- 1 to 15 days low fever, continuous epigastric abdominal pain and anorexia	mild - moderate		
Biotoxin	**Diarrhoetic Shellfish Poisoning** okadaic acid, dinophysis toxins, pectenotoxins and yessotoxin		all shellfish (esp mussels, oysters, scallpos, clams and cockles).		Japan and Europe (incl. Scandinavia and the Mediterranean) also reported from New Zealand and Tasmania	bioaccumulation of toxins produced in a number of dinoflagellate and other phytoplankton species consumed by shellfish.	*Dinophysis & Prorocentrum*	onset-½ to 3.hours duration- 2 to 3 days nausea, vomiting, diarrhoea and abdominal pain with headache chills and fever	mild gastro disorder	Avoid eating shellfish in areas where red tides are known to occur. •Cooking, and discarding the cooking fluids afterwards diminishes the amount of poison ingested.	
	Paralytic Shellfish Poisoning saxitoxin derivatives				world-wide		*Alexandrium, Gymnodinium & Pyrodinium*	onset- ½ to 2 hours tingling, burning, numbness, drowsiness, incoherent speech and respiratory paralysis recovery is usually complete so long as respiratory support is applied within 12 hours of exposure	death may occur due to cardiovascular collapse		Affected shellfish cannot be identified visually.
	Amnesic Shellfish Poisoning Domoic acid	marine fin fish (eg. anchovies)		crabs	North America, Europe and New Zealand	bioaccumulation of toxins produced in a number of dinoflagellate and other phytoplankton species consumed by shellfish and finfish.	diatom- *Nitvchia pungens*	onset- gastrointestinal, less than 24 hours - neurological, within 48 hours gastrointestinal symptoms- vomiting, diarrhoea, abdominal pain and neurological problems- confusion, memory loss, disorientation, seizure and coma	serious to fatal	Avoid eating shellfish in areas where red tides are known to occur. •Cooking, and discarding the cooking fluids afterwards diminishes the amount of poison ingested.	all fatalities have involved the elderly where symptoms can resemble Alzheimer's Disease

Appendix 2: Seafood-borne Disease in Humans

Class of pathogen	Disease causing agent	seafood susceptible to contamination: fin-fish	mollusc	crustacean	Distribution and habitat	Transmission and risk factors	Disease and symptoms	Seriousness	Prevention and control	Comments
Biotoxin cont	**Scombroid Poisoning** Histamine	scomberoides and other pelagics	abalone & scallops		world-wide marine	consumption of seafood where certain bacteria (eg, *Clostridia*) have been responsible for metabolising histidine to dangerously high levels of histamine if ingested by humans	onset- immediate to ½ hour headaches and itching skin to nausea, vomiting and diarrhoea tingling, burning sensation in mouth, rash on upper body, reduced blood pressure	The elderly or impaired patients sometimes require hospitalis-Ation	cold temperature is the only preventative to histamine production post harvest. Keeping temperature below freezing will delay the metabolism of histidine to histamine by bacteria.	
	Ciguatera Ciguatoxin	sub-tropical and tropical reef fish (eg. coral trout, grouper, mackerel)			Tropical and sub-tropical waters	bioaccumulation of toxins produced by the dinoflagellate *Gambierdiscus toxicus* as part of the reef fish communities diet	onset- less than 6 hours perioral numbness and tingling (paraesthesia) spreading to extremities, nausea, vomiting and diarrhoea, joint and muscle pain, headache, temperature sensory reversal, vertigo, physical exhaustion. cardiovascular signs include; arryhtmia, bradycardia or tachycardia and reduced blood pressure. duration- usually within several days from onset, however severe cases can persist for weeks, months and even years with recurring neurological symptoms.	Death is rare but can occur following respiratory and cardiovascular failure.	avoid consuming any reef fish, particularly large* (ie older) reef dwelling predatory fish NB. Large refers to the larger fish of a given species	susceptibility to the disease is a factor of; concentration of toxin in fish, quantity of fish eaten, as well as fish eating history of victim (ie accumulative affect over time). Not all fish of a given species from a given location will be toxic.
	Pufferfish Poisoning tetrodotoxin	puffer fish, parrotfish, angelfish	octopus (eg. Blue ringed)	crabs	Indo pacific	consumption of organs (eg.liver, gonads, intestines or skin) of the puffer fish and other animals (eg, newts, starfish and frogs) . Bacteria commonlly present in aquatic environments are required in producing these toxins.	stage 1. Onset - 20 min. to 3 hours slight numbness of lips and tongue, increasing paraesthesia in face and extremities with sensation of floating and difficulty in walking. Headache, epigastric pain, nausea, diarrhoea and/or vomiting may also occur.	fatal	avoid consuming any fish from the pufferfish family (*tetraodontiformes*) or at least ensure all tetraodontiformes are well eviscerated tetradotoxin is heat-stable and can not be made safe through cooking	Pufferfish or 'Fugu' is commonly eaten in japan after special preparation, but mortalities are not uncommon. mislabelling of this product as anglerfish resulted in 3 deaths in Italy in 1977.

Seafood-borne Disease in Humans

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Appendix 3: Species of animals used for aquaculture in Australia

Finfish – commercial operations

Common Name	Scientific Name	Product	Where produced	Destination	Systems involved
Atlantic salmon	*Salmo salar*	Whole, fresh fish; various smoked products; Eggs	Tas Vic SA	domestic markets and export	Hatcheries Raceways Sea-cages
Rainbow trout	*Oncorhynchus mykiss*	Eggs; chilled, frozen, or smoked	NSW Vic Tas SA WA	Domestic markets and export	Hatcheries Ponds Raceways Sea-cages
Brown trout	*Salmo trutta*	Live	Vic	Domestic waterways	Hatcheries Ponds Raceways
Silver perch	*Bidyanus bidyanus*	Live; whole, fresh	NSW Qld SA	Domestic markets	Hatcheries Ponds
WA dhufish	*Glaucosoma hebraicum*	Live; whole, fresh	WA	Domestic markets	Hatcheries Net pens
Mulloway	*Argyrosomus hololepidotus*	Live; whole, fresh	NSW	Domestic markets	Hatcheries Net pens
Snapper	*Pagrus auratus*	Live; whole, fresh	SA WA NSW	Domestic markets	Hatchery Net pens
Australian bass	*Macquaria novaemaculata*	Live	NSW Qld	Domestic waterways	Hatcheries
Black Bream	*Acanthopagrus butcherii*	Live	WA	Domestic waterways	Hatcheries
Golden perch	*Macquaria ambigua*	Live	Qld NSW	Domestic waterways	Hatcheries
Barramundi	*Lates calcarifer*	Live or fresh product	Qld SA NSW WA NT	Domestic market	Hatcheries Ponds Net-pens
Goldfish	*Carassius auratus*	Live	All states	Domestic market	Ponds
Eels	*Anguilla australis*	Live or chilled,	Vic Qld NSW	Export	Dams

		frozen product	Tas	markets	

Finfish – research and development

Common Name	Scientific Name	Product	Where produced
Greenback flounder	*Rhombosolea tapirina*	Research stage	Vic Tas
Golden snapper	*Lutjanus johnii*	Research stage	NT WA Qld
Estuary cod	*Epinephelus tauvina*	Research stage	NT WA Qld
Mangrove jack	*Lutjanus argentimaculatus*	Research stage	NT WA Qld
Dolphin fish	*Coryphaena hippurus*	Research stage	NT WA Qld
Coral trout	*Plectropomus leopardus*	Research stage	NT WA Qld
Striped trumpeter	*Latris lineata*	Research stage	Tas
King George whiting	*Sillaginodes punctata*	Research stage	SA

Crustaceans – commercial operations

Common Name	Scientific Name	Product	Where produced	Destination	Systems involved
Tiger prawn	*Penaeus monodon*	Chilled, whole	Qld NSW NT	Domestic markets	Hatcheries Ponds
Kuruma prawn	*Penaeus japonicus*	Live, dead, whole	Qld NSW	Domestic markets and export	Hatcheries Ponds
Brown tiger prawn	*Penaeus Esculentus*	Live, dead, whole	Qld NSW	Domestic markets and export	Hatcheries Ponds
Banana prawn	*Penaeus merguiensis*	Live, dead, whole	Qld NT	Domestic markets and export	Hatcheries Ponds
Marron	*Cherax tenuimanus*	Live	WA NSW SA	local market and some export	Juveniles from wild Hatcheries Ponds
Redclaw	*Cherax quadracarinatus*	Live	Qld NSW	local market and some export	Hatcheries Ponds
Yabby	*Cherax destructor*	Live	NSW SA Vic WA	local market and some export	Hatcheries Ponds
Western	*Panulirus*	Live, cooked or	WA	Export - small	Baited

Rock lobster	*cygnus*	frozen		quantity for domestic market	traps
Southern Rock lobster	*Jasus edwardsii*	Live, cooked or frozen	SA Tas	Domestic markets and export	Baited traps

Molluscs – commercial operations

Common Name	Scientific Name	Product	Where produced	Destination	Systems involved
Pearl oyster	*Pinctada maxima*	Spat for grow-out Pearls from seeded oysters Abductor muscle meat to Asia	WA NT Qld	Marine sites	Hatcheries Grow-out on long-line or raft technique
Sydney rock oyster	*Saccostrea commercialis*	Bottled, half-shell or in-shell product	NSW Qld	Estuaries and rivers	Grow-out using 'stick and tray
Greenlip abalone	*Haliotis laevigata*	Spat for grow-out or re-seeding Shucked and processed meat is frozen or cooked some live trade to Japan	Tas SA Vic	Marine sites	Hatcheries Grow-out in onshore tanks
Blacklip abalone	*Haliotis rubra*	Spat for grow-out See greenlip abalone	Tas	Marine sites	Hatcheries Grow-out in onshore tanks
Blue mussel	*Mytilus edulis planulatus*	Spat for grow-out Market size mussels sold live and in-shell to markets	NSW Vic Tas WA SA	Marine sites	Hatcheries Grow-out on long lines
Pacific oyster	*Crassostrea gigas*	Spat for grow-out Market size product sold frozen or live, in-shell	Vic Tas SA	Marine sites	Hatcheries Grow-out on racks or long lines
Southern scallop	*Pecten fumatus*	Spat for grow-out De-shelled and meat sold fresh, frozen or canned	Tas	Marine sites	Hatcheries Harvest from wild farmed product for grow-out in cages initially and then re-seeded onto sea

					floor

Reptiles – commercial operations

Common Name	Scientific Name	Product	Where produced	Destination	Systems involved
Saltwater crocodile	*Crocodylus porosus*	Skins, flesh, souvenirs	NT Qld	Local market and export	Hatcheries Grow-out in pens

Appendix 4: Australian National List of Reportable Diseases of Aquatic Animals

Disease Agent	OIE listed	NACA listed	Exotic to Australia
Finfish			
Aeromonas salmonicida (atypical strains)	No	No	No
Aeromonas salmonicida var. salmonicida (Furunculosis)	No	No	Yes
Aphanomyces invaderis (Epizootic ulcerative syndrome)	Yes	Yes	No
Channel catfish virus	Yes	No	Yes
Edwardsiella ictaluri (Enteric septicaemia of catfish)	Yes	No	Yes
Epizootic haematopoietic necrosis virus	Yes	Yes	No
Gyrodactylus salaris	Yes	No	Yes
Infectious haematopoietic necrosis virus	Yes	Yes	Yes
Infectious pancreatic necrosis virus	Yes	Yes	Yes
Infectious salmon anaemia virus	Yes	No	Yes
Myxobolus cerebralis (Whirling disease)	No	No	Yes
Oncorhynchus masou virus	Yes	Yes	Yes
Piscirickettsia salmonis (Piscirickettsiosis)	Yes	No	Yes
Renibacterium salmoninarum (Bacterial kidney disease)	Yes	Yes	Yes
Spring viraemia of carp virus	Yes	Yes	Yes
Viral Encephalopathy and Retinopathy	Yes	Yes	No
Viral haemorrhagic septicaemia virus	Yes	Yes	Yes
Yersinia ruckeri (Enteric redmouth disease/yersiniosis)	No	No	No (ERM) / yes
Crustaceans			
Aphanomyces astaci (Crayfish plague)	Yes	No	Yes

Disease Agent	**OIE listed**	**NACA listed**	**Exotic to Australia**
Baculoviral midgut gland necrosis virus	Yes	Yes	Yes
Baculovirus penaei	Yes	No	Yes
Infectious hypodermal and haematopoietic necrosis virus	Yes	Yes	Yes
Penaeus monodon-type baculovirus	Yes	No	No
Taura syndrome virus	No	No	Yes
Whitespot disease virus	Yes	Yes	Yes
Yellowhead disease virus	Yes	Yes	Yes
Necrotising Hepatopancreatitis	No	No	Yes
Molluscs			
Bonamia ostreae (Bonamiosis)	Yes	Yes	Yes
Bonamia spp. (Bonamiosis)	Yes	Yes	No
Haplosporidium costale (Haplosporidiosis)	Yes	Yes	Yes
Haplosporidium nelsoni (Haplosporidiosis)	Yes	Yes	Yes
Marteilia refringens (Marteiliosis)	Yes	Yes	Yes
Marteilia sydneyi (Marteiliosis)	Yes	Yes	No
Mikrocytos mackini (Mikrocytosis)	Yes	Yes	Yes
Mikrocytos roughleyi (Mikrocytosis)	Yes	Yes	No
Iridovirosis	Yes	No	Yes
Perkinsus marinus (Perkinsosis)	Yes	Yes	Yes
Perkinsus olseni (Perkinsosis)	Yes	Yes	No

Appendix 5: Aquatic animal disease emergency contact numbers in Australia

Organisation	Position	Telephone
CSIRO AAHL Fish Diseases Laboratory, Geelong	Fish disease specialists	03 5227 5118
National Offices of Animal and Plant Health, AFFA, Canberra	Commonwealth CVO	02 6272 4328
DPIF, Tasmania	Fish pathologist	03 6336 5389
	CVO	03 6336 5289
DNRE, Victoria	Fish pathologist	03 9217 4200
	CVO	03 9217 4247
NSW Fisheries	Fish pathologist	02 6626 1261
	Fisheries manager	02 4980 4919
NSW Agriculture	CVO	02 6391 3717
QDPI	Fish pathologist	07 4722 2610
	Fish pathologist	07 3362 9525
	Fisheries manager	07 3224 2184
	CVO	07 3239 3546
DPIF, NT	Fish pathologist	08 8989 2211
	Fisheries manager	08 8999 4321
	CVO	08 8999 2131
Fisheries WA	Fish pathologist	08 9368 3649
Agriculture, WA	CVO	08 9368 3535
PIRSA, (South Australia)	CVO	08 8207 7970
VPS, Adelaide	Fish pathologist	08 8372 3703
PIRSA, (South Australia)	CVO	08 8207 7970
Dept of Parks and Conservation, ACT	CVO	02 6207 2357

Appendix 6: Drug and chemical use in aquaculture

In considering therapy as a control measure for infectious diseases in aquatic animals a number of factors need to be examined. Firstly, for viral diseases, there are no current treatments available. Chemotherapy is not an option and the use of vaccination is at the experimental stages only. For serious viral diseases, especially OIE listed diseases, slaughter and disinfection – a major exercise - needs to be considered.

Vaccination against bacterial diseases is used as a preventative measure, for example, DPIWE Tasmania produces a killed bacterin vaccine against vibriosis which is used by the Tasmanian salmonid industry. Other vaccines for prophylaxis against certain bacterial diseases, e.g. furunculosis in salmon, are used overseas.

There are many treatments for bacterial and parasitic diseases of fish. In deciding whether treatment is the preferred option, selecting the most appropriate treatment requires knowledge not only of efficacy but also ease of application, human safety, target animal safety, regulatory aspects, toxicity and side effects of chemotherapeutants, potential problems of resistance and tissue residues, environmental impact of chemical use and costs.

Drugs not registered for use in aquatic animals in Australia can be given emergency use status with the agreement of the Chief Veterinary Officer of the State in question. Drugs can be used off label by a veterinarian if the chemicals are registered for use in another species. However, liability aspects of off-label usage apply. When using chemicals in the environment a close cooperation with the local Environmental Protection Agency will-be needed.

None of these issues can be adequately addressed in this manual. Your attention is drawn to these issues and a number of relevant references are listed below. These references are available in emergency at short notice from CSIRO AAHL, Geelong and the Office of the Chief Veterinary Officer, AFFA, Canberra. Included is the latest report of the National Taskforce on Aquaculture Drugs and Chemicals which was established in 1995 to examine the approval process for drug and chemical use in aquaculture.

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