Import Risk Analysis on Live Ornamental Finfish

AQIS
AUSTRALIAN QUARANTINE AND INSPECTION SERVICE

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Foreword

THIS IMPORT RISK ANALYSIS (IRA) ON LIVE ornamental finfish was conducted in response to findings of the World Trade Organization, in 1997, of inconsistency in the quarantine measures applied by Australia to live and non-viable finfish.

As an outcome of this IRA, Australia introduced new policies on the importation of live ornamental finfish. These policies were announced on 19 July 1999.

AQIS acknowledges the contribution of the independent scientists who provided advice on scientific issues and assisted with the analysis (see list on page iv).

Australian Quarantine and Inspection Service
July 1999

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Contents

TABLES

FIGURES

BOXES

Executive summary

Following a request from Canada in 1997, Canada's longstanding market access request for non-viable salmon was considered by a World Trade Organization (WTO) dispute settlement panel and Appellate Body. The WTO found that Australia had not complied with its obligations under the WTO Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement) with regard to the measures applying to salmon. The key findings were:

- Australia's import risk analysis (IRA) on uncooked wild-caught Pacific salmon from Canada did not fulfil all the requirements of the SPS Agreement in relation to an IRA and there was no IRA to support the restrictions on the importation of other uncooked salmon products; and
- there were arbitrary or unjustifiable distinctions in the level of protection applied by Australia in relation to salmon and other fish, and these distinctions resulted in a disguised restriction on international trade.

The WTO Arbitrator gave Australia until 6 July 1999 to address its obligations. In order to meet this deadline, and after consultation with stakeholders, AQIS adopted an accelerated approach to the IRAs on non-viable salmonids and non-salmonid marine finfish, and on live ornamental finfish. The policies arising from the IRAs were published on 19 July 1999 (Animal Quarantine Policy Memorandum 1999/51).[1]

This report describes in detail the IRA on live ornamental finfish.

Consultation

AQIS took several steps to ensure the scientific validity of the risk analyses, including considering the reports of several consultancies on identified gaps in information relating to these risk analyses. AQIS also contracted 12 independent scientists (in Australia and overseas) to review one or both of the draft reports as they were being prepared and assess the completeness,

1 Animal Quarantine Policy Memorandum 1999/51. Final reports of import risk analyses on non-viable salmonid products, non-viable marine finfish products and live ornamental finfish and adoption of new policies, 19 July 1999.

accuracy of scientific information in the report and the balance and objectivity with which scientific information was treated.

AQIS did not ask the independent reviewers to advise on Australia's appropriate level of protection (ALOP), as this is the responsibility of the Australian Government, having regard to the broad range of quarantine decisions and precedents within AQIS's purview.

To ensure that the process fulfilled the Government's commitment to an open and consultative approach to import risk analysis, AQIS held public meetings in 5 capital cities and 2 meetings of key stakeholders in Canberra. AQIS also made each chapter of the draft reports available to the public for comment by posting them on the AQIS Internet site.

In the course of the risk analyses, AQIS received 35 submissions on scientific issues on the live ornamental finfish IRA and the non-viable salmonid and non-salmonid marine finfish IRA.

AQIS considered all scientific issues raised in the submissions of respondents and sought the advice of the independent scientific reviewers on significant points in the submissions. All submissions were taken into account in preparing the reports.

The scientific information reviewed in these IRA reports is comprehensive and up-to-date and the independent scientific reviewers have agreed that the scientific analysis is accurate, objective and balanced. On this basis the conclusions in the risk analyses will be incorporated (where appropriate) into legal instruments and procedures for the importation of live ornamental finfish and non-viable salmonid product and non-salmonid marine finfish product in accordance with the recommendations set out in the reports.

Scope of the risk analysis

This IRA considers the quarantine risks to Australian animals and the environment associated with the importation to Australia of live ornamental finfish listed in Schedule 6, Part II of the *Wildlife Protection (Regulation of Exports and Imports) Act* 1982, from any source country.

International codes

In preparing this IRA AQIS, has drawn upon principles outlined in the Office International des Epizooties (OIE, or World Organisation for Animal Heath) *International Aquatic Animal Health Code* (the Aquatic Code) and the OIE *International Animal Health Code.*

The Aquatic Code classifies aquatic animal diseases as diseases notifiable to the OIE (transmissible diseases that are important for public health and/or trade reasons); and other significant diseases (diseases that are of current or potential international significance in aquaculture but of less importance than the notifiable diseases, are less widespread, or have less well-defined aetiology).

Australian quarantine policies

The *Quarantine Act 1908* and subordinate legislation, including Quarantine Proclamation 1998 (QP 1998), are the legislative basis of human, animal and plant quarantine in Australia.

AQIS's objective is to adopt quarantine policies that provide the health safeguards required by government policy in the least trade-restrictive way. Wherever appropriate, measures are based on international standards.

Under the Quarantine Act, the importation into Australia of any articles likely to introduce any infectious or contagious disease, or disease or pest affecting persons, animals or plants can be prohibited under proclamation of the Governor General, generally or subject to any specified conditions or restrictions.

In developing quarantine policies, the disease risks associated with importations are analysed using IRA, which is a structured, transparent and science-based process that provides the scientific and technical basis for quarantine policies and determines whether an import may be permitted and, if so, the conditions to be applied.

Import risk analysis

AQIS has evaluated the risks associated with individual diseases and disease agents, and has identified measures appropriate to the risks presented by the importation of live ornamental finfish. Based on this evaluation, risk management measures for these fish have been proposed, including the means for verifying the health certification provided by exporting countries. The IRA is 'generic' and addresses all relevant pests and diseases, to facilitate assessment of individual access requests according to the health status of the source country.

The IRAs were conducted according to the method previously set out by AQIS in its publication *The AQIS Import Risk Analysis Process Handbook* (1998). This process, which involves the risk analysis steps of hazard identification and characterisation, risk assessment and risk management, is consistent with Australia's obligations under the SPS Agreement and relevant recommendations of the OIE.

In the light of consultations with independent scientists and risk analysts, AQIS conducted this risk analysis on a qualitative, rather than a quantitative basis. This was due to the complexity of the analysis (the large number of species and disease agents considered), the limited data on some key questions (such as the minimum infective dose of many pathogens) and the uncertainty about some important issues, such as the susceptibility of native species to the disease agents under consideration. In deciding to use the qualitative approach, AQIS also took into account the fact that this is consistent with OIE recommendations and the obligations of WTO members.

Hazard identification

AQIS used the following criteria to identify the disease agents of quarantine concern that required further consideration in the IRA. A disease agent was given detailed consideration in the IRA if it was assessed to be:

1. carried by a Schedule 6 or related species of ornamental finfish
2. infectious;
3. (a) exotic to Australia, **or**
   (b) present in Australia but subject to official control; **and**
4. (a) OIE listed, **and / or**
   (b) likely to cause significant harm in Australia.

Where there were no definitive data relevant to categorisation, AQIS made conservative judgments, drawing upon scientific knowledge and observations made in similar situations, and other appropriate information.

Once the diseases that met the above criteria had been identified, AQIS identified those requiring consideration with higher priority (which were placed in group 1) or lower priority (which were placed in group 2). The disease agents were grouped on the basis of published scientific literature and advice of the independent scientists advising AQIS on the IRAs.

Risk assessment

Quarantine risk is composed of two related factors — the probability of the disease agent entering and becoming established in Australia, and the expected impact or significance (consequences) of such establishment. The IRA method used by AQIS addressed both these factors in a standardised manner to allow consistency in the overall approach to risk management, as follows.

- *Release assessment* — the probability that the agent will enter Australia as a consequence of the importation of live ornamental finfish.
- *Exposure assessment* — if the disease agent entered Australia in live ornamental finfish, the probability of susceptible fish being exposed to a dose sufficient to cause infection.
- *Probability of disease establishment* — combining assessment 1 and 2.

- *Consequence assessment* — the consequences of the disease agent establishing in Australia, in the ornamental finfish industry and in Australian natural waters.

These factors were categorised for each disease of concern, using standardised criteria to obtain qualitative measures of the probability of disease establishment and the consequences. These measures were applied to a risk evaluation matrix to determine if for ornamental finfish imports, Australia's acceptable level of protection (ALOP) would be met and whether risk management measures were warranted.

Risk management

For live ornamental finfish, the group 1 priority disease agents that do not meet Australia's ALOP were identified as:

- goldfish haematopoietic necrosis virus (GFHNV);
- iridoviruses of freshwater ornamental finfish;
- spring viraemia of carp virus (SVCV);
- *Aeromonas salmonicida* ('typical' strains and exotic 'atypical' strains);
- *Dactylogyrus vastator* and *D. extensus*;
- *Argulus foliaceus* and *A. coregoni*; and
- Lernaea elegans.

In the case of each disease, AQIS considered risk management measures that would be required if the importation of live ornamental finfish was to be permitted while meeting the ALOP. These measures include pre-export requirements for the country of origin and post-import measures that could be imposed in Australia.

Finally, the group 2 priority diseases were assessed to ensure that with the implementation of measures required for group 1 disease agents, risks associated with the group 2 disease agents would also meet Australia's ALOP.

Policies for import of live ornamental finfish

Live animals generally present greater risk than product and there are significant gaps in knowledge of the diseases of ornamental finfish species. Accordingly, AQIS will apply baseline risk management measures to all ornamental finfish imported. The measures for goldfish recognise the higher risks presented by that species.

As warranted by the conclusions of the risk analysis, each consignment of live ornamental finfish must be accompanied by:

- an animal health certificate from the competent authority attesting to the health of the fish in the consignment and the health status of the source population;
- certification from a competent authority that the premises of export / exporter are currently approved for export to Australia; and
- certification from a competent authority attesting that the fish had not been kept in water in common with farmed food fish;

and each consignment must be subject to:

- visual inspection of all fish on arrival to identify overtly diseased consignments and to ensure that the fish are of a species listed on Schedule 6;
- post-arrival quarantine detention for a minimum period in approved private facilities under quality assurance arrangements agreed with AQIS (the minimum period of quarantine will be three weeks for goldfish and one week for all other Schedule 6 listed finfish); and
- quarantine security over procedures in quarantine premises, including the disposal of sick and dead fish, transport water, packaging materials and other waste.

In addition to these baseline requirements, AQIS will apply the following risk management measures either singly or in combination, to address specific disease concerns associated with the importation of ornamental finfish:

- health certification from the competent authority that the source of the fish was free of specified disease agents;
- treatment either of the source population of the fish or of the fish for export, to address the likelihood that unwanted disease agents may be present;
- testing of imported fish during quarantine detention, either on an ad hoc or routine basis, to validate the certification provided by overseas competent authorities, and/or to provide additional data to improve the targeting of risk management measures on imports generally;
- treatment of imported fish during quarantine detention by appropriate means if the presence of specific disease agents is suspected or confirmed following diagnostic testing; and
- post-arrival quarantine detention greater than the minimum required (eg due to concerns over the risks posed by iridoviruses, the minimum quarantine period for gouramis and cichlids will be two weeks).

Equivalent approaches to managing identified risk may be accepted, either generally or on a case-by-case basis. Parties seeking to use alternative risk reduction measures to those listed in the new conditions would need to provide a submission for consideration by AQIS. Such proposals should include supporting scientific data that clearly explain the degree to which alternative measures would reduce risk.

The implementation of these conditions will provide for the continued importation of ornamental finfish. The established trade in live ornamental finfish will be permitted to continue under transitional arrangements until the new conditions are fully implemented.

Chapter 1
Introduction

1.1 Background to import risk analysis

THIS REPORT CONTAINS THE FINDINGS OF THE import risk analysis (IRA) on live ornamental finfish conducted by the Australian Quarantine and Inspection Service (AQIS). The report represents the conclusion of a process that began in May 1997 when AQIS invited stakeholder comment on its ornamental finfish quarantine policy review.[1] A separate report deals with the IRA on non-viable salmonids and non-salmonid marine finfish (AQIS 1999).[2]

In September 1997 AQIS advised stakeholders that it proposed to use the 'non-routine' approach to the ornamental finfish IRA, involving the formation of a risk analysis panel and proposed a panel membership.[3] A memorandum[4] informed stakeholders of the confirmation by the Executive Director of AQIS's approach and the panel membership. The panel met on 24 November 1997 and 7–8 April 1998, after which a progress report was circulated to stakeholders.[5]

In November 1998 a World Trade Organization (WTO) dispute settlement panel found that Australia's prohibition on the importation of uncooked salmon did not comply with its obligations under the WTO Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement). The key findings were:

- Australia's IRA on uncooked wild-caught Pacific salmon from Canada did not fulfil all the requirements of the SPS Agreement in relation to an IRA, and there was no IRA to support the restrictions on the importation of other uncooked salmon products; and

1 AQIS (26 May 1997), Animal Quarantine Policy Memorandum 1997/38, Importation of ornamental finfish.

2 AQIS (1999), *Import Risk Analysis on Non-viable Salmonids and Non-salmonid Marine Finfish*, AQIS, Canberra.

3 AQIS (17 September 1997), Animal Quarantine Policy Memorandum 1997/71, 17 September 1997, Ornamental finfish importation: policy review.

4 AQIS (21 November 1997), Animal Quarantine Policy Memorandum 1997/101, 21 November 1997, Ornamental finfish importation: policy review.

5 AQIS (19 May 1998), Animal Quarantine Policy Memorandum 1998/44, 19 May 1998, Import risk analysis: ornamental finfish — progress report.

- there were arbitrary or unjustifiable distinctions in the level of protection applied by Australia in relation to salmon and other fish, and these distinctions resulted in a disguised restriction on international trade.

In December 1998 Canada requested arbitration on the period within which Australia should be required to bring its measures into compliance. On 23 February 1999 the WTO Arbitrator gave Australia until 6 July 1999 to address its obligations.

In March 1999 AQIS consulted stakeholders on a proposal to conduct IRAs on non-viable salmonids (to address the first finding) and on non-salmonid marine finfish and ornamental finfish (the subject of the WTO findings) according to a common, accelerated timetable, to meet the WTO deadline. After due consideration of stakeholder comment, AQIS adopted the proposed accelerated approach.[6]

This report describes the IRA for ornamental finfish, and is in six chapters. Chapter 1 deals with the scope and background to the analysis and methods used to evaluate quarantine risk. Chapter 2 describes the ornamental finfish industry in Australia. Chapter 3 lists the hazards to be addressed and Chapter 4 contains the risk assessment. Chapter 5 contains recommendations on the measures to be applied to the importation of ornamental finfish and Chapter 6 makes concluding remarks with particular reference to the November 1998 WTO findings.

The following three studies were commissioned to investigate issues relevant to the ornamental finfish IRA.

Collection of baseline environmental data relevant to an evaluation of the quarantine risk associated with ornamental finfish importation into Australia. This study was to provide information on the risk that imported fish (and any associated exotic pathogens) may establish free-living populations that could provide for the establishment of exotic pathogens in Australia.

Identification and evaluation of the potential pathways whereby aquatic animals in Australia may be exposed to imported ornamental finfish and waste derived from them.

Identification of chemotherapeutants used in the ornamental finfish industry in Australia and overseas.

1.2 Scope of this risk analysis

The IRA considers the quarantine risks potentially associated with the importation to Australia of ornamental (aquarium) finfish as listed on Schedule 6, Part II of the *Wildlife Protection (Regulation of Exports and Imports) Act 1982*. Schedule 6 includes all freshwater and marine ornamental finfish species that may be imported into Australia without being subject to the provisions of the *Wildlife Protection (Regulation of Exports and Imports) Act 1982*. Species on Schedule 6 are listed in Appendix 1.

Schedule 6 is divided into two divisions. Division 1 deals with freshwater fish, including some brackish water species, and Division 2 deals with marine fish.

This IRA considers the disease and pest risks to Australian animals and the environment associated with the importation of ornamental finfish species, from any source, that are listed on Schedule 6. The pest risks posed by the fish species itself have already been addressed by Environment Australia and its predecessor organisations when the species was placed onto Schedule 6. Environment Australia is currently undertaking a comprehensive review of Schedule 6. AQIS will actively participate in that review and thus exercise its responsibilities in relation to pest risk posed by the importation of live ornamental finfish.

AQIS has evaluated the risks associated with individual diseases and disease agents, and has identified measures appropriate to the risks presented by ornamental finfish. Based on this evaluation, risk management measures have been proposed, including the means for verifying health certification provided by exporting countries (see Chapter 5).

6 AQIS (23 April 1999), Animal Quarantine Policy Memorandum 1999/27, Import Risk Analyses: Non-viable salmonid products, non-viable marine finfish products and ornamental finfish — decision on accelerated approach; and AQIS (30 March 1999), Animal Quarantine Policy Memorandum 1999/24, Import risk analyses: non-viable salmonid products, non-viable marine finfish products and ornamental finfish — consultation on process issues.

1.3 International framework

1.3.1 WORLD TRADE ORGANIZATION

As a member of the WTO, Australia has certain rights and obligations under the WTO Agreement, including the SPS Agreement. The SPS Agreement recognises the standards, guidelines and recommendations developed by the Office International des Epizooties (OIE, or World Organisation for Animal Health) for animal health and zoonoses as the relevant international benchmark. Under the SPS Agreement, measures put in place by a country must be based either on an international standard or upon a scientific risk analysis. A risk analysis must:

- identify the diseases whose entry, establishment or spread within its territory a WTO member wants to prevent, as well as the potential biological and economic consequences associated with the entry, establishment or spread of these diseases;
- evaluate the likelihood of entry, establishment or spread of these diseases, as well as the associated potential biological and economic consequences; and
- evaluate the likelihood of entry, establishment or spread of these diseases according to the SPS measures that might be applied.

The SPS Agreement defines 'appropriate level of sanitary or phytosanitary protection' as the level of protection deemed appropriate by the member country establishing a sanitary or phytosanitary measure to protect human, animal or plant life or health within its territory. This is termed 'appropriate level of protection' (ALOP) in Australia. The terms 'acceptable risk' and 'managed risk' are used with similar meaning. Further information on Australia's rights and obligations arising from the SPS Agreement may be found in the report *National Risk Management and the SPS Agreement* (Wilson and Gascoine, in press).[7] Animal Quarantine Policy Memorandum 1999/26[8] provides an explanation of ALOP and its relationship to quarantine risk management.

1.3.2 OFFICE INTERNATIONAL DES EPIZOOTIES

Australia is a member of the OIE and actively contributes to the development of international animal health standards. The OIE publication relevant to this IRA is the *International Aquatic Animal Health Code* (OIE 1997a)[9] (referred to in this report as 'the Aquatic Code'), which states:

> The principal aim of the [code] and its companion volume, *The Diagnostic Manual for Aquatic Animal Diseases*, is to facilitate international trade in aquatic animals and aquatic animal products… by providing detailed definitions of minimum health guarantees to be required of trading partners in order to avoid the risk of spreading aquatic animal diseases (OIE 1997a).

The OIE *International Animal Health Code* provides similar guidance in relation to trade in terrestrial animals and their products, including the requirements for an IRA, which are given in the OIE *International Animal Health Code*, Section 1.4. This section, which has been reviewed and updated more recently than the relevant section in the Aquatic Code, has been used by AQIS in structuring this analysis. A copy of the *International Animal Health Code* may be viewed on the Internet.[10]

The Aquatic Code categorises aquatic animal diseases as follows:

> Diseases notifiable to the OIE:
>
> transmissible diseases that are considered to be of socio-economic and/or public health importance within countries and that are significant in the international trade of aquatic animals and aquatic animal products.

7 Available at http://www.aqis.gov.au/docs/qdu/riskmgmtoc.htm

8 AQIS (22 April 1999), Animal Quarantine Policy Memorandum 1999/26, Australia's appropriate level of protection and AQIS's import risk analysis (IRA) process. (Available at http://www.aqis.gov.au/docs/anpolicy/a99-026.htm)

9 Available at http://www.oie.int/norms/a_fcode.htm

10 Available at http://www.oie.int/norms/A_Mcode.htm

> Other significant diseases:
>
> diseases that are of current or potential international significance in aquaculture but have not been included in the list of diseases notifiable to the OIE, because they are less important than the notifiable diseases; or because their geographical distribution is limited, or is too wide for notification to be meaningful, or is not yet sufficiently defined; or because the aetiology of the diseases is not well enough understood; or approved diagnostic methods are not available.

The Aquatic Code states:

> International trade in aquatic animals and aquatic animal products depends on a combination of factors that should be taken into account to ensure unimpeded trade, without incurring unacceptable risks to human and aquatic animal health.
>
> An exporting country should be prepared to supply the following information to importing countries on request:
>
> 1. information on the aquatic animal health status and national aquatic animal health systems to determine whether that country is free or has free zones of disease notifiable to the OIE, including the regulations in force to maintain its free status;
> 2. regular and prompt information on the occurrence of transmissible diseases;
> 3. details of the country's ability to apply measures to control and prevent diseases notifiable to the OIE and, where appropriate, other diseases;
> 4. information on the structure of the Competent Authority and the authority that it exercises;
> 5. technical information, particularly on biological tests and vaccines used and applied in all or part of the national territory.

The OIE-listed diseases relevant to ornamental finfish are shown in Box 1.1.

Box 1.1
OIE-listed diseases relevant to ornamental finfish

Diseases notifiable to the OIE

- Epizootic haematopoietic necrosis
- Infectious haematopoietic necrosis
- *Oncorhynchus masou* virus disease
- Spring viraemia of carp
- Viral haemorrhagic septicaemia

Other significant diseases

- Channel catfish virus disease
- Viral encephalopathy and retinopathy
- Infectious pancreatic necrosis
- Infectious salmon anaemia
- Red sea bream iridovirus disease
- White sturgeon iridovirus disease
- Epizootic ulcerative syndrome
- Bacterial kidney disease
- Enteric septicaemia in catfish
- Piscirickettsiosis
- Gyrodactylosis

Source: *International Aquatic Health Code* (OIE 1997a)

Several finfish diseases considered significant by Australia are not currently listed by the OIE (see Chapter 2).

1.4 Animal quarantine policy framework

1.4.1 LEGISLATION AND CONCEPTUAL FRAMEWORK

AQIS's objective is to adopt quarantine policies that are, wherever appropriate, based on international standards and that provide the health safeguards required by government policy in the least trade-restrictive way. In developing quarantine policies, the disease risks associated with importations are analysed using IRA, a structured, transparent and science-based process.

The *Quarantine Act 1908* and subordinate legislation, including Quarantine Proclamation 1998 (QP 1998), are the legislative basis of human, animal and plant quarantine in Australia. Section 4 of the Act defines the scope of quarantine as follows:

> In this Act, Quarantine has relation to measures for the inspection, exclusion, detention, observation, segregation, isolation, protection, treatment, sanitary regulation, and disinfection of vessels, installations, persons, goods, things, animals, or plants, and having as their object the prevention of the introduction, establishment or spread of diseases or pests affecting human beings, animals, or plants.

Subsection 13(1) of the Act provides, among other things, that the Governor-General in Executive Council may, by proclamation, prohibit the importation into Australia of any articles likely to introduce any infectious or contagious disease, or disease or pest affecting persons, animals or plants. The Governor-General may apply this power of prohibition generally or subject to any specified conditions or restrictions.

For articles prohibited by proclamation, the Director of Animal and Plant Quarantine may permit entry of products on an unrestricted basis or subject to compliance with conditions, which are normally specified on a permit. An IRA provides the scientific and technical basis for quarantine policies that determine whether an import may be permitted and, if so, the conditions to be applied. In practice, specific protocols have been established for a minority of imported aquatic animal products; most enter under standard conditions based on decisions of long standing.

The matters to be considered when deciding whether to issue a permit are set out in section 70 of QP 1998 and include the quarantine risk, whether the imposition of conditions would be necessary to limit the quarantine risk to a level that would be acceptably low, and anything else that is considered relevant. 'Quarantine risk' means the likelihood of the importation leading to the introduction, establishment or spread of a disease or a pest in Australia, the likelihood that harm will result (to humans, animals, plants, the environment or economic activities) and the likely extent of any such harm.

This IRA provides the basis for future consideration of applications for import permits outlined in QP 1998 in relation to the importation of ornamental finfish. In keeping with the scope of the Quarantine Act, only the factors relevant to the evaluation of quarantine risk (ie the risk associated with the entry, establishment and spread of unwanted pests and diseases) are considered in the IRA. Questions related to the potential economic consequences of importation (other than the economic impact of a disease) are not part of AQIS's process of evaluation.

The actions of the Director of Animal and Plant Quarantine or his/her delegate in reaching a decision under the Quarantine Act must take into account relevant provisions of other Commonwealth legislation, including the *Endangered Species Protection Act 1992* and the *Environment Protection (Impact of Proposals) Act 1974.*

The *Environment Protection (Impact of Proposals) Act 1974* and the administrative procedures under that Act require consideration of whether Commonwealth action (such as the granting of an import permit) is an action that will, or is likely to, affect the environment to a significant extent or that will have the effect of permitting or facilitating an action by another person that will result, or is likely to result, in such an effect. Decisions made by AQIS to permit the entry of live animals or animal products, made under the Quarantine Act and consistent with Australia's conservative approach to risk, are unlikely to lead to significant adverse effects on the environment. Nevertheless, AQIS would inform the Environment Minister of any intention to make a decision that is likely to result in a significant risk of harm to the environment. Furthermore, Environment Australia is given the opportunity to comment on proposals to develop new quarantine policies. In consultation with Environment Australia, AQIS is also developing guidelines to assist quarantine officers when making decisions to ensure that the likely effects on the environment are taken into account.

1.4.2 DOMESTIC POLICY ENVIRONMENT

In 1992 AQIS commissioned the then Bureau of Rural Resources, later Bureau of Resource Sciences (BRS), to conduct a major review of aquatic animal health and quarantine. The report, released in 1995, was a comprehensive examination of Australia's quarantine policies and practices regarding aquatic animals and their products (Nunn 1995). The BRS report identified concerns in relation to quarantine policy on the importation of several aquatic species, including ornamental finfish.

In 1995, the National Task Force on Imported Fish and Fish Products (NTF) was established to examine the BRS report and related issues. The NTF included representatives of relevant Commonwealth, State and Territory government agencies, commercial and recreational fishing groups, importers, aquaculturists, research organisations and environmental groups. It recommended that AQIS review aquatic animal quarantine policies and practices. The importation of live ornamental finfish was recommended for review with high priority (Higgins 1996).

In 1996, a committee chaired by Professor Malcom E. Nairn conducted a detailed independent review (Nairn et al 1996). Noting that the IRA process underpins Australia's quarantine policies and procedures, the Nairn committee identified six principles that should apply. The committee recommended that IRA should be:

- conducted in a consultative framework;
- a scientific process and therefore politically independent;
- a transparent and open process;
- consistent with both government policy and Australia's international obligations (under the SPS Agreement);
- harmonised, by taking account of international standards and guidelines; and
- subject to appeal on the process.

In its response (DPIE 1997), the Australian Government accepted all recommendations of the Nairn report relevant to the IRA process. The AQIS publication *The AQIS Import Risk Analysis Process Handbook* (AQIS 1998) sets out AQIS's approach to IRA, which is consistent with Australia's obligations under the SPS Agreement and with relevant recommendations of the OIE. Copies of the handbook can be obtained from AQIS or viewed on the Internet.[11]

The Australian Government also supported most of the recommendations in the NTF report and agreed to provide additional resources to AQIS so that it could conduct major reviews of aquatic animal quarantine. A series of policy reviews is being undertaken throughout 1997–2001.[12]

1.4.3 QUARANTINE POLICY ON ORNAMENTAL FINFISH

All goods entering Australia are subject to quarantine. They may be inspected on arrival and, if appropriate, they may be sampled and tested at the importer's expense whether or not prior permission to import is required and granted.

The importation of ornamental finfish species listed in Division 1 of Schedule 6 requires an annually renewable permit and approval of the premises where the fish will be held to undergo post-arrival quarantine. Exporters' premises must also be approved. All shipments are inspected at the port of entry and detained for at least a 14-day quarantine period (28-day quarantine period in the case of gouramis) in approved private quarantine premises. There is no mandatory quarantine detention or import permit requirement for marine fish (Schedule 6, Division 2) unless the fish are genetically modified.

Recently, AQIS modified its requirements for the importation of goldfish (*Carassius auratus*). All consignments of goldfish into Australia must now be accompanied by a certificate issued by a government official of the exporting country with an appropriate knowledge of fish health. In addition, the exporting premises must attest to the fact that the goldfish in the shipment have been examined and show no clinical evidence of disease, and that the goldfish originate from a country considered free from spring viraemia of carp (SVC) or from premises at which there has been no evidence of the presence of SVC for the three months immediately prior to shipment.

11 Available at http://www.aqis.gov.au/docs/anpolicy/risk.pdf

12 Available at http://www.aqis.gov.au/docs/anpolicy/a98-023.htm

1.4.4 INTERSTATE QUARANTINE

While the Commonwealth Government is responsible for regulating the movement of animals and their products into and out of Australia, the State and Territory governments have primary responsibility for animal health controls within Australia. Legislation relating to resource management or animal health may be used by State and Territory government agencies to control interstate movement of aquatic animals and their products.

Significant finfish diseases and disease agents that have a restricted or regional distribution in Australia include goldfish ulcer disease (found in New South Wales and Victoria), barramundi nodavirus (found in Queensland and the Northern Territory), aquabirnavirus (found in Macquarie Harbour, Tasmania), epizootic haematopoietic necrosis (found in New South Wales, Victoria and South Australia), 'atypical' *Aeromonas salmonicida* (found in Tasmania) and epizootic ulcerative syndrome (found in New South Wales, the Northern Territory, Queensland and Western Australia). In some cases, State and Territory governments impose mandatory control over the movement of live fish and their genetic material within Australia to prevent the spread of these diseases. There are no mandatory controls over the movement of non-viable salmonids or non-viable non-salmonid marine finfish within Australia on account of aquatic pathogens. However, under Tasmanian legislation, salmonids harvested from farms in Macquarie Harbour must be gilled and eviscerated and the gills and viscera disposed of by burial to prevent the spread of aquabirnavirus.

The *Commonwealth Mutual Recognition Act 1992* has the objective of reducing barriers (including requirements set out in legislation) to the free movement of goods between States and Territories. Quarantine measures enacted by State and Territory governments are exempt from the requirements of the *Commonwealth Mutual Recognition Act 1992*, provided that the measures are required to prevent the entry of diseases that are not present in that region and that would have a long-term and substantially detrimental effect on the State or Territory.

1.5 IRA method

The IRA process described in the *AQIS Import Risk Analysis Process Handbook* (AQIS 1998) provides the scientific underpinning of quarantine policy and practice. QP 1998 states that the Director of Quarantine, when making a decision on whether to permit an import access request, must consider the quarantine risk and the conditions that would be necessary to reduce quarantine risk to an acceptably low level. The IRA presents relevant information for the Director of Quarantine to consider when making a decision on an import access request.

Quarantine risk is composed of two related factors: the probability of the disease agent entering and becoming established in Australia, and the expected impact or significance of such establishment. Describing and addressing both in a standardised manner aids consistency in management of quarantine risks associated with the diseases considered in an IRA, and consistency in the overall approach to risk management.

In the light of consultations with several independent scientists and risk analysts, AQIS conducted this risk analysis on a qualitative, rather than a quantitative, basis. AQIS adopted the qualitative approach due to the complexity of the analysis (the large number of species and disease agents considered) and in recognition of the limited data on some key questions, such as the minimum infective dose of many pathogens, and uncertainty about some important issues, such as the susceptibility of native species to the disease agents under consideration. In deciding to use the qualitative approach, AQIS also took into account the fact that this is consistent with OIE recommendations and the obligations of WTO members.

General note on dealing with uncertainty and gaps in data

Many of the observations and assumptions in this risk analysis are generalisations and, as such, stakeholders may challenge them. However, AQIS contends that it is valid to generalise, provided that the nature of factors that may affect the applicability of key assumptions is understood and the implications of such factors for the analysis are properly taken into account. In the absence of definitive, quantitative data on factors relevant to quarantine risk, AQIS applies appropriately conservative professional judgment based on available scientific information and the advice of experts in relevant fields. This is a scientifically valid approach adopted by quarantine authorities throughout the world in the face of limited scientific data. Thus, AQIS's approach is consistent with international practice.

1.5.1 HAZARD IDENTIFICATION

AQIS will use the following criteria to identify the disease agents of quarantine concern that require further consideration in the IRA. A disease agent will be given detailed consideration in the IRA if it is:

1. carried by a Schedule 6 or related species of ornamental finfish;
2. infectious;
3. (a) exotic to Australia, **or**
   (b) present in Australia but subject to official control; **and**
4. (a) OIE listed, **and / or**
   (b) would be expected to cause significant harm in Australia.

Further details of these criteria are shown in Box 1.2. If there are no definitive data relevant to categorisation, AQIS makes conservative judgments that draw upon scientific knowledge and observations made in similar situations and any other appropriate information.

1.5.2 PRIORITY RANKING OF DISEASE AGENTS

AQIS categorised the disease agents according to the criteria set out in Section 1.5.1 and then identified the disease agents to be considered as higher priority.

Priority was based on the probability of a disease becoming established in Australia, the consequences that would arise from such establishment and the assessment of disease agents in the review by Humphrey (1995). Disease agents considered as higher priority were placed in group 1 and those as lower priority in group 2. The priority rating of each pathogen is shown in Table 4.1.

Considerations in determining the risk assessment priority

Based on published scientific literature and consultations with independent scientists assisting AQIS with the IRAs, each disease agent received a score (expressed as +, ++ or +++, with +++ being the highest score possible). The score is an assessment of the probability of the disease agent becoming established in Australia as a result of importation of ornamental finfish listed on Schedule 6, and of the consequences (according to criteria defined in Chapter 1) of such establishment.

AQIS also considered the assessment of disease agents contained in Humphrey (1995). The 'Humphrey score' is the sum of seven factors including pathogenic significance, risk of entry, international spread and possible socioeconomic consequences. The scale has a maximum of 30. AQIS consulted Dr Humphrey (who is one of the independent scientists assisting AQIS with the IRAs) on the application of the Humphrey review to the IRA.

Agents that received a score ≥++ for probability **or** for consequences of establishment were placed in group 1. Moreover, agents given a score ≥21 in the Humphrey classification (ie the top 1/3 of the Humphrey scale) were also placed in group 1 while those given a score <21 were placed in group 2.

The priority rating of each disease agent is set out in Table 4.1.

Box 1.2
Criteria for categorising disease agents

1 THE DISEASE AGENT IS CARRIED BY A SCHEDULE 6 OR RELATED SPECIES OF ORNAMENTAL FINFISH

The disease agent is known to be carried by one or more ornamental finfish species, or related species, named in Schedule 6.

2 THE DISEASE AGENT IS INFECTIOUS

A putative disease agent causes or is causally associated with a recognised disease and the disease has been shown to have an infectious aetiology.

The disease agent has been found in association with animals that are the subject of the IRA. The disease agent must be transmissible to susceptible hosts and may have been isolated. Ideally, Koch's[13] or Evans's (Thrusfield 1995)[14] postulates should be satisfied. This criterion excludes diseases of non-infectious aetiology, for example those caused by environmental (eg toxicosis), genetic or nutritional factors.

3(a) THE DISEASE AGENT IS EXOTIC TO AUSTRALIA

The disease agent is considered to be exotic if there is no report of the disease or detection of the causal agent in susceptible animals in Australia. The level of confidence that can be attributed to such a determination depends on factors such as the virulence of the organism, severity of expression of clinical disease and nature of targeted surveillance applied to the disease or disease agent in question.

Where a disease agent is present in Australia, but the strain(s) present in other countries is/are significantly more virulent, these strains will be considered in a similar manner to exotic disease agents.

3(b) THE DISEASE AGENT IS PRESENT IN AUSTRALIA BUT SUBJECT TO OFFICIAL CONTROL

If a disease agent or disease occurs in Australia, one or more State/Territory government(s) must have enacted legislation and be taking action to control or eradicate the disease or disease agent. For the purpose of this process, mandatory control measures would be deemed to exist if such measures relate to products within the scope of this analysis.

4(a) THE DISEASE AGENT IS LISTED BY THE OIE

The disease agent causes a notifiable or 'other significant' disease as listed by the OIE.

4(b) THE DISEASE AGENT WOULD BE EXPECTED TO CAUSE SIGNIFICANT HARM IN AUSTRALIA

The disease agent satisfies one or more of the following criteria:

- it would be expected to cause a distinct pathological effect in a significant proportion of an infected population;
- it would be expected to cause significant economic harm (eg increased mortality, reduced growth rates, decreased product quality, loss of market access, increased management costs); and/or
- it would be expected to cause significant damage to the environment and/or native species.

13 Koch's postulates refer to the experimental evidence required to establish a relationship of causation between a microorganism and a disease. The conditions are: 1) the microorganism must be present in every case of the disease, 2) it must be isolated and cultivated in pure culture, 3) inoculation of such culture must produce the disease in susceptible animals, 4) it must be observed in, and recovered from, experimentally diseased animal.

14 Thrusfield MV (1995), *Veterinary Epidemiology*, Blackwell Scientific, Oxford (UK), 479 pp.

1.5.3 RISK ASSESSMENT

Defining the probability of establishment of disease (release and exposure assessments)

The probability of a disease agent entering and becoming established in Australia depends on the factors shown in Box 1.3. Box 1.4 defines the terms used to describe the probability of such an event occurring.

> Box 1.3
> **Factors affecting the probability of a disease agent entering and becoming established in Australia**
>
> 1. The probability of the disease agent being present in the source country/region of the commodity (ornamental finfish) and, if present, its prevalence.
> 2. The probability of the disease agent being present in an infective form in the commodity on entering Australia.
> 3. The probability of the disease agent, having entered the industry or Australian natural waters, establishing infection in susceptible hosts (including native species) in Australia. This depends on the capacity of the disease agent to survive in its environment in an infective form, and the ease of infection of susceptible hosts and subsequent transmission of infection to others within a population.
>
> **Note:** The OIE describes the factors covered by points 1 and 2 above as the *release assessment* and those covered by point 3 above as the *exposure assessment*. These factors may be evaluated in terms of the probability of key events occurring. The descriptive terms used in this IRA (low, negligible etc) are defined below with a view to clarifying the description of probability in risk analyses.

> Box 1.4
> **Terms used to describe the probability of an event occurring**

High:	Event would be expected to occur
Moderate:	There is less than an even chance of the event occurring
Low:	Event would be unlikely to occur
Very low:	Event would occur rarely
Extremely low:	Event would occur very rarely
Negligible:	Chance of event occurring is so small that it can be ignored in practical terms

Note: These categories are not equidistant from each other; most fall into the range 0 < probability < 50%.

Defining the consequences of establishment of disease (consequence assessment)

The establishment of a new disease agent may have a biological effect and consequential effects on industry (eg the affected premises) and the environment. These consequences can be measured in quantitative terms (in relation to their economic impact) and in qualitative terms (in relation to their impact on society and the environment). The effects of a disease can usually be ameliorated to some degree by control or eradication methods, although these associated costs must be included in estimates of economic, social and environmental impact.

The biological effect of the establishment of disease is normally evaluated in terms of morbidity and mortality data reflecting epidemiological features of the disease. In this IRA, AQIS took into account the standard epidemiological approach to classification of morbidity and mortality rates. For example, a high mortality rate could be defined as one that is more than two standard deviations greater than the expected mortality rate for that population over a short period (less than one month), or a rate that is more than one standard deviation greater than the expected mortality rate for that population over the entire production cycle. A high morbidity rate could be defined as one that reduces production (however this is defined) below the normal range by more than two standard deviations over the whole production cycle. As there are limited data on how the establishment of exotic diseases in Australia would affect Australian species, it is not possible to estimate the biological effect of diseases in such quantitative terms. Accordingly, AQIS evaluated the likely consequences of the establishment of disease by taking into account the effect of the disease agent on the same or similar species overseas and the scientific advice of independent experts.

In considering the biological effect of the establishment of disease, AQIS also takes into account direct costs associated with controlling or eradicating the disease, including the pre-emptive destruction of in-contact healthy fish.

The economic effect of the establishment of disease is normally evaluated in terms of the costs arising from the biological effects and the commercial implications for domestic and international marketing of affected animals and their products (which may extend to unaffected animals and products subject to trade restrictions). AQIS does not take into account the economic effects of trade competition when considering the risks associated with importation.

The establishment of disease may also affect the environment in ways that are not readily amenable to evaluation in economic terms: it may reduce the social amenity of the environment (eg recreational fishing and enjoyment of the ecosystem) or result in environmental harm (eg by reducing biodiversity or upsetting the ecological balance).

The key factors in classifying the significance of a disease are shown in Box 1.5.

Box 1.5

Key factors in classifying the significance of disease

1. The biological effects on aquatic species.
2. The availability, cost and effectiveness of methods for control/eradication.
3. The economic effects at an establishment/industry/national level, including effects on marketing of the product.
4. The biological effects on native species and the environment, including any loss of social amenity.

Terms used to describe consequences

In this IRA, the impact or significance of the establishment of disease in Australia is classified into one of five categories, described as catastrophic, high, moderate, low or negligible, as described in Box 1.6.

The categories defined in Box 1.6 lie within a continuous range of consequences and are indicative of expected outcomes.

In the face of uncertainty and some data gaps, AQIS makes conservative judgments regarding the expected impact or significance of disease establishment.

Unrestricted estimate of risk (risk evaluation matrix)

AQIS has developed a risk evaluation matrix with the objective of providing a standardised process for evaluating quarantine risk, before and after the implementation of risk management measures. For each disease agent, the combination of probability and consequence (ie risk) can be represented by a cell in the matrix (see Figure 1.1).

The risk determined on the basis of ‘no risk management’ is the *unrestricted estimate of risk*. If this is in line with Australia’s ALOP, the risk would be considered acceptable without specific management (‘yes’ in Figure 1.1) and the importation would be permitted.

However, if the unrestricted risk exceeds the ALOP ('no' in Figure 1.1), the next step is to consider whether or how risk management measures may be applied to reduce the quarantine risk to the point where it conforms with Australia's ALOP. If the application of risk management measures cannot reduce the risk to an acceptably low level, the importation would not be permitted. If after applying risk management measures the risk was in line with Australia's ALOP, the risk would be considered manageable ('yes' in the risk matrix below) and the importation would be permitted. It should be noted that, where the probability of establishment of a disease is *negligible*, importation would be permitted regardless of consequences.

Box 1.6

Terms used to describe the severity of the impact (level of significance)

Catastrophic: associated with the establishment of diseases that would be expected to significantly harm economic performance at a national level. Alternatively or in addition, they may cause serious, irreversible harm to the environment.

High: associated with the establishment of diseases that would have serious biological consequences (eg high mortality or high morbidity and causing significant pathological changes in affected animals). Such effects would normally be felt for a prolonged period (greater than or equal to a normal production cycle) and would not be amenable to control or eradication. These diseases would be expected to significantly harm economic performance at an industry level. Alternatively or in addition, they may cause serious harm to the environment.

Moderate: associated with the establishment of diseases that have less pronounced biological consequences. These diseases may harm economic performance significantly at an enterprise/regional level, but they would not have a significant economic effect at the 'whole industry' level. These diseases may be amenable to control or eradication at a significant cost, or their effects may be temporary. They may affect the environment, but such harm would not be serious or may be reversible.

Low: associated with the establishment of diseases that have mild biological consequences and would normally be amenable to control or eradication. Such diseases would be expected to harm economic performance at the enterprise or regional level but to have negligible significance at the industry level. Effects on the environment would be minor or, if more pronounced, would be temporary.

Negligible: associated with the establishment of diseases that have no significant biological consequences, may be transient and/or are readily amenable to control or eradication. The economic effects would be expected to be low to moderate at an individual enterprise level and insignificant at a regional level. Effects on the environment would be negligible.

Figure 1.1

Risk evaluation matrix

PROBABILITY OF ESTABLISHMENT	N	L	M	H	C
H	yes	no	no	no	no
M	yes	no	no	no	no
L	yes	yes	no	no	no
VL	yes	yes	yes	no	no
EL	yes	yes	yes	yes	no
N	yes	yes	yes	yes	yes

SIGNIFICANCE OF CONSEQUENCES

'Yes' = the risk is acceptable and importation can be permitted.
'No' = the risk is unacceptable and importation cannot be permitted without further risk management.
Level of probability: H=high, M=moderate, L=low, VL=very low, EL=extremely low, N=negligible.
Level of significance: C=catastrophic, H=high, M=moderate, L=low, N=negligible.

Source: AQIS (prepared for this IRA, 1999).

In Chapter 4, the quarantine risk associated with specific disease agents is considered in detail. The conclusions reached for each disease agent identify the situation posing the highest risk associated with the agent and whether, based on the risk evaluation matrix, risk management is warranted or not.

1.6 Release assessment

1.6.1 INTRODUCTION

In evaluating the probability of an exotic disease agent establishing in Australia as a result of the importation of ornamental finfish, the following factors must be considered: firstly, the probability of a disease agent entering Australia via the fish being imported; and, secondly, the probability of that disease agent entering a commercial or breeding premises or Australian natural waters, and spreading from the index case to become established.

In assessing the likelihood of a disease agent entering Australia via shipments of ornamental finfish (release assessment), consideration is given to the following criteria:

- the host range and geographic distribution of the agent;
- the ease with which the agent can be detected;
- the expected prevalence of the agent in imported ornamental finfish; and
- the likelihood of the agent being present in fish without causing overt disease.

This section discusses the factors relating to the source country and the commodity (live ornamental finfish) that together constitute the *release assessment*. Section 1.7 covers the factors relating to the establishment of a disease in Australia, either within the industry or in Australian natural waters (the *exposure assessment*), based on the assumption that the disease agent has entered Australia. Chapter 4 contains a discussion of these factors with reference to individual disease agents. Critical to the release and exposure assessments is an evaluation of the various pathways through which a disease agent entering Australia in a shipment of ornamental finfish could become established. The following analysis aims to identify those pathways that may lead to disease establishment and to evaluate the likelihood of a disease agent successfully completing each pathway. To assist in this task, AQIS commissioned two projects. The first aimed to identify the pathways by which imported aquatic animals and associated waste products find their way into Australia's natural waters

(PSM 1999). The second aimed to collect environmental baseline data and addressed identification of those species of imported ornamental finfish that are most likely to survive and form self-maintaining free-living populations in Australia (Arthington et al 1999).

Although currently freshwater ornamental finfish are required to undergo quarantine detention on arrival in Australia, this analysis addresses the issues on the assumption that there is unrestricted entry into Australia of ornamental finfish listed on Schedule 6.

This section discusses the factors that need to be considered in assessing the probability of disease agents being present in imported ornamental finfish. As AQIS is conducting this IRA on a generic basis, the prevalence of disease agents in all potential source countries is considered.

1.6.2 INDUSTRY FACTORS

The commercial breeding of ornamental finfish in Australia has increased significantly since the mid-1980s when quarantine detention of imported freshwater ornamentals was introduced (PSM 1999). As a result of increasing import costs and international shortages of some species, the number of ornamental finfish imported is decreasing, while the Australian ornamental finfish breeding industry is expanding, with production aimed at import replacement. Marine fish comprise less than 1% of the total number of ornamental finfish imported (Table 1.1).

Table 1.1
Total number of ornamental finfish supplied to the industry, 1996–97

SOURCE	MARINE FISH	FRESHWATER FISH	TOTAL FISH
Imports	68 700	6 999 000	7 067 700
Commercial breeders	0	4 916 100	4 916 100
Collectors/divers	63 900	0	63 900
Totals	**132 600**	**11 915 100**	**12 047 700**

Source: PSM (1999)

Ornamental finfish species listed on Schedule 6 are predominantly warmwater, tropical species. Other than goldfish, coldwater species are not commonly traded in the Australian ornamental fish industry. Table 1.2 shows the relative volumes of the ornamental finfish groups most commonly imported.

Table 1.2
Relative volumes of imported freshwater ornamental finfish, 1999

FISH GROUP	PROPORTION OF IMPORTS (%)
Goldfish	22
Tetras	19
Livebearers	16
Barbs	11
Cichlids	10
Catfish	8
Other or not specified	8
Gouramis	6

Source: PSM (1999)

Many of the significant disease agents identified in this IRA are associated with coldwater fish species from temperate regions of Europe and the former Soviet Union. The vast majority of ornamental finfish imported into Australia are tropical varieties originating from ornamental fish farms in south Asia and south-east Asia (although some wild harvested species originate from other parts of the world such as South America and Africa, and are often transhipped through third countries). Singapore, Hong Kong and Malaysia supplied up to 80% of freshwater ornamental finfish imports to Australia, and Indonesia and the Philippines supplied 94% of the ornamental marine fish imported in 1997–98 (ABS 1998). There are also currently registered exporters to Australia in China, Germany, New Zealand, Sri Lanka and Thailand. Goldfish, which constitute approximately 22% of freshwater live fish imports, originate predominantly from farms in China, Malaysia and Indonesia (J Patrick pers. comm.).

Ornamental finfish are airfreighted into Australia in polythene bags, which are in turn packed in polystyrene boxes. There may be one or more bags per box, but each bag may contain only one species of fish (this is an Environment Australia requirement to help identify imported fish). Marine fish are packed at a much lower density than freshwater fish (usually only one fish per bag), due mainly to their size, aggressive nature and greater sensitivity to poor water quality.

Exporters aim to provide fish of good quality because high mortality or morbidity in shipments will lead to loss of trade. Fish that are obviously diseased are therefore unlikely to be packed into export shipments. However, disease agents can be carried by ornamental finfish species not showing clinical signs of disease, and such carrier fish may be included in shipments exported to Australia. The probability of such shipments containing infected carrier fish would be expected to reflect the prevalence of the disease agent in the country or zone of origin.

1.6.3 SOURCE FACTORS

Many of the disease agents generally recognised as causing serious disease in ornamental finfish affect fish in the food fish aquaculture industry (eg salmon and carp aquaculture). However, monitoring and surveillance practices associated with such aquaculture operations may provide a better knowledge of the disease status of cultured fish, including the absence of specific disease agents, than of wild fish. In conducting the release assessment, AQIS takes into account the probability of contamination of ornamental finfish with disease agents due to the fish originating from the same waterways as infected salmonids and other species of farmed food fish.

The prevalence of disease in aquatic animal populations varies markedly from one region or country to another, and the standard of surveillance and reporting of disease in aquatic animals also varies from country to country. This means that there may be more information on disease status from regions or countries in which surveillance and reporting are high priorities and are well supported by government and industry. Consequently, these regions or countries may appear to have a greater prevalence of disease than those that do not apply similar effort to surveillance and reporting.

AQIS recognises the wide variation in the effectiveness of surveillance of aquatic disease by exporting countries and takes this into account in considering quarantine risks and risk management options, particularly with regard to the speed with which epizootics and the emergence of previously unrecorded diseases are detected and reported. A lack of surveillance for a particular disease would not necessarily demand a ban on imports, depending on the availability of alternative measures to reduce risk to meet Australia's ALOP.

The competent authority is defined in the OIE Aquatic Code as 'the National Veterinary Services or other Authority of a member country having the responsibility and competence for ensuring or supervising the implementation of the aquatic animal health measures recommended in the Code'. As an importing country, Australia has the right to evaluate the competent authorities of exporting countries as part of a risk assessment process to determine the measures to be applied to trade in aquatic animals or their products. AQIS's knowledge of and confidence in information on the health status of fish populations is much greater for those countries that have a competent authority recognised by AQIS than for those that do not. For the countries that have a recognised authority, AQIS would normally accept statements regarding the presence or absence in that country of disease agents considered in this risk analysis.

The effectiveness and timeliness of surveillance will be important considerations where risk management measures are to be based on the regionalisation of fish diseases. It is AQIS's judgment that recognition of an exporting country's competent authority and a detailed understanding of its health status based on, *inter alia*, the implementation of the principles of surveillance and monitoring, are required to underpin a claim of disease regionalisation. If disease regionalisation is to be a basis of risk management for diseases of ornamental finfish, such understandings are normally developed through bilateral negotiations between the exporting and the importing country. AQIS would normally preface consideration of a regionalisation proposal on formal recognition of the competent authority and its surveillance and monitoring systems.

The validity of available information on host range and geographic distribution of disease agents depends on how easily the presence of disease agents can be detected. In particular, viruses are difficult to isolate and identify accurately, and require a relatively high degree of technical expertise. Consequently, there may be more accurate information on agents that are more easily detected.

Dead fish, transport water and packaging material can also carry disease agents and other organisms. Several pathogens such as *Aeromonas salmonicida* have life stages that can survive independently outside the fish host. In conducting the release assessment, AQIS takes into account the probability that material imported with live fish may be vectors for, or may otherwise disseminate, disease agents.

1.6.4 CONCLUSIONS

In summary, in this IRA AQIS considers the distribution and prevalence of disease in the country of origin and in the exporting country, taking into account where appropriate any lack of definitive data and the wide variation in the effectiveness of surveillance and monitoring around the world. In considering the absence or presence of diseases in regions or countries, AQIS takes into account the level of surveillance and monitoring applied, and geographic and temporal indices that indicate if a particular disease agent has shown the capability for rapid or extensive international spread. In the case of diseases that have shown the capacity for such spread or for which there is no evidence of an effective surveillance and monitoring system, AQIS adopts a conservative approach, and generally assumes the disease to be present.

1.7 Exposure assessment

1.7.1 INTRODUCTION

This section reviews the factors which need to be considered in relation to the exposure assessment. In this IRA, exposure assessment is considered in terms of the likelihood of disease establishment in the ornamental finfish industry and in Australian natural waters.

An understanding of these matters is central to the IRA, as the exposure of susceptible fish to infected imported fish is a major determinant of quarantine risk. The exposure assessment is based on the assumption that the disease agent has entered Australia. The pathways analysis identifies the pathways where there is a significant probability of disease establishment, and the ornamental finfish species (listed on Schedule 6) associated with those pathways. AQIS takes into account the probability of imported fish following a particular pathway (eg escape or release into natural waters) and other factors relevant to the quarantine significance of such exposure.

The ornamental finfish species that pose the greatest threat are those likely to survive the disease and shed the disease agent into the environment over a prolonged period, thus infecting native or feral fish populations and/or other species in Australia's natural waters. Fish that are clinically diseased and are actively disseminating disease agents are more likely to transmit disease into a susceptible population than subclinically infected fish. However, fish harbouring disease agents that cause subclinical infection (ie apparently normal carrier fish) are less likely to be intercepted along the supply chain and are therefore more likely to be supplied to end-users.

The same principles hold for marine ornamental finfish, although marine finfish diseases are less likely to be transmitted due to the significantly greater dilution factor associated with introduction of infectious fish or tissues into seas or oceans.

The primary role of live fish in disseminating disease agents is well recognised and is reflected in the emphasis the OIE Aquatic Code places on measures to ensure the health of traded live fish. As set out in the Aquatic Code, measures such as health certification, inspection, pre-export or post-arrival quarantine detention and testing for specific diseases may be applied to manage any risks associated with trade in live ornamental finfish.

The first case of disease in a susceptible population is the index case; in practice, the index case in an individual aquatic animal may pass unrecognised, even in commercial or breeding premises. However, quarantine risk analysis is concerned with the establishment of disease and thus the IRA primarily considers the probability of a disease agent being transmitted from the index case to other fish, resulting in the establishment of a disease in a population.

1.7.2 DISEASE INCURSIONS ASSOCIATED WITH IMPORTS

International trade in ornamental finfish has been implicated in the spread of several aquatic animal diseases. Fish imported into Australia are considered the sources of *Chilodonella cyprini* and *Chilodonella hexasticha*, with consequent epidemic mortalities in bony bream *Nematalosa erebi*, blackfish *Gadopsis marmoratus* and Murray cod *Macculochella peeli* (review by Humphrey 1995).

Similarly, ichthyobodiasis (costiasis) was described as a serious disease introduced into Australian fish through the importation of ornamental finfish (Ashburner 1976, review by Humphrey 1995). The first occurrence of ichthyophthiriasis due to *Ichthyophthirius multifiliis* occurred in a trout hatchery in Tasmania in 1933, and was believed to be due to the liberation of introduced goldfish. The parasite is also thought to have originated from Japanese carp imported into a Victorian trout hatchery before 1939 (Butcher 1941). It is now widely established as a serious pathogen in native and introduced fish species (Ashburner 1976, review by Humphrey 1995).

Trichodiniasis caused by *Trichodina* sp is also thought to have been introduced into Australia through the importation of ornamental finfish, with subsequent infection of native fish species (Ashburner 1976, review by Humphrey 1995). *Dactylogyrus* sp and *Gyrodactylus* sp infections are also reported to have been introduced into Australia through the importation of ornamental finfish (Ashburner 1976). The pathogenic cestode *Bothriocephalus acheilognathi* has spread widely because of movements of grass carp and other species, including ornamental finfish. This parasite was recently described in goldfish and carp in Western Australia (Langdon 1990a) and this is thought to represent a recent incursion of a previously exotic pathogen, perhaps arising from imported goldfish.

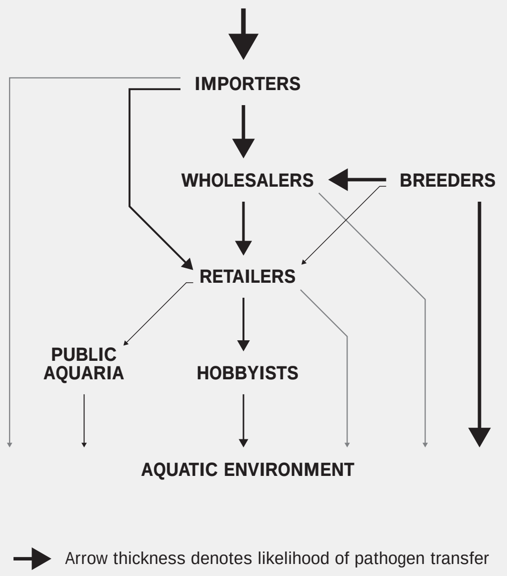
The potential for imported ornamental finfish to carry disease agents is demonstrated in the range of agents that have been isolated from ornamental finfish during quarantine detention in Australia, including rosy barb virus (birnavirus), black moor herpes-like virus, lymphocystis virus (iridovirus), *Aeromonas salmonicida*, *Aeromonas hydrophila*, *Edwardsiella ictaluri*, *Epitheliocystis*, *Saprolegnia* sp, *Chilonodella cyprini*, *Myxobolus carassii*, *Camallanus* sp, *Dactylogyrus* sp, *Gyrodactylus* sp and *Argulus* sp (review by Humphrey 1995).

1.7.3 INDUSTRY STRUCTURE

Figure 1.2 (based on PSM 1999) shows the main trends in movements of live ornamental finfish and exposure pathways within industry and into the aquatic environment. Some pathways would occur commonly, others uncommonly, rarely or exceptionally.

Freshwater species (the great majority of imported ornamental finfish) enter the country via fish importers who are, in most cases, also wholesalers. Most of these fish are sold to retailers who in turn sell primarily to hobbyists. Retailers also sell a very small number of fish to commercial, semi-commercial and backyard breeders, who in turn sell stock back to wholesalers and to a lesser extent, direct to retailers and hobbyists. Marine species follow a similar pattern although many retailers also import directly. A very small number of fish, mainly marine fish, may go into public aquaria for display.

Figure 1.2
Exposure pathways



Source: Drawn from information in PSM (1999)

1.7.4 PROBABILITY OF DISEASE ESTABLISHMENT IN THE ORNAMENTAL FINFISH INDUSTRY

The likelihood of a disease agent establishing in the Australian ornamental finfish industry is based on consideration of the *release assessment* for that agent (see Section 1.6) in combination with its *exposure assessment* for the industry (ie likelihood of the agent spreading in the ornamental finfish industry). The *exposure assessment* for the industry is based on the assumption that the disease agent has entered Australia and considers the following criteria:

- the host range and the relative numbers of these host species traded within the ornamental finfish industry;
- the likelihood of infected fish being detected (which is related to the prevalence of unapparent infection); and
- the transmissibility of the agent.

AQIS imposes controls on the procedures carried out at quarantine premises for freshwater finfish, including the disposal of live fish and waste (including dead fish). The probability of live fish escaping from quarantine premises is therefore remote (PSM 1999), and under AQIS control the improper disposal of waste from quarantine facilities is unlikely. AQIS agrees that activities at quarantine premises present a negligible probability of disease establishment.

The probability of disease establishment in breeding, wholesale or retail premises depends on the type of premises, its size, the range of fish species held and the management practices of the premises. For example, if a disease agent has a host range that includes fish species representing significant traded volumes, the agent is more likely to establish in the ornamental finfish industry.

If a disease broke out in wholesale premises servicing a significant part of the hobby sector or in a retail premises servicing many breeders, it could spread widely, particularly where potentially diseased fish had been traded widely before controls were applied. AQIS believes that such a scenario constitutes a significant pathway for disease agent establishment within the ornamental finfish industry.

Most imported ornamental finfish (whether freshwater or marine) are destined for hobbyist aquaria, from where disease agents are most unlikely to spread. A disease agent would affect susceptible fish until the host died or was treated, and would not be able to infect new fish because it could not complete its life cycle under hobbyist aquaria conditions. The probability of such fish entering other aquaria is extremely low.

For commercial reasons, industry practices mean that overtly diseased fish are unlikely to be transferred between industry sectors. As well, the industry has adopted a code of practice that recognises the importance of having in place sound procedures to minimise the opportunity for the transfer of disease agents. However, disease agents may be carried by ornamental species without causing overt disease; the likelihood of such carrier fish being transferred along the supply chain to end-users is considered to be high.

In addition, disease agents that are directly transmitted and that do not require an intermediate host for completion of their life cycle are more likely to establish than are those agents with more complex life cycles.

The marine ornamental fish sector is based on a relatively small number of fish but a wide variety of species and taxonomic groups. At present, marine ornamental finfish are not commercially bred in Australia. Due to the host specificity of the diseases considered in the IRA, it is highly unlikely that any individual disease would affect a sufficient number of species to have a greater than negligible impact at the premises level.

1.7.5 PROBABILITY OF DISEASE ESTABLISHMENT IN AUSTRALIAN NATURAL WATERS

The likelihood of a disease agent establishing in Australian natural waters is determined from the *release assessment* for that agent (see Section 1.6) in combination with the *exposure assessment* for the environment (ie likelihood of the agent spreading in Australian natural waters). The *exposure assessment* for the environment is determined by considering the following criteria:

- all factors contributing to the likelihood of the agent spreading in the ornamental fish industry, namely: the host range and the relative numbers of relevant host species traded; the likelihood of infected fish being detected (which is related to the prevalence of unapparent infection); and the infectivity of the agent;
- the likelihood that infected ornamental finfish will enter and survive for a prolonged period in Australian natural waters;
- the ability of the agent to survive in the environment outside a live fish; and
- the presence of susceptible host species in Australian natural waters.

A 1999 report has identified five categories of materials associated with ornamental finfish that can enter the aquatic environment: live fish, waste (including dead fish), transport water, effluent water and packaging (PSM 1999). The study initially determined whether exposure pathways existed; after evaluating potential pathways, it identified those considered significant. The study confirmed that each category of materials has distinct distribution and handling routes, and that some of these routes are potential pathways by which disease agents introduced into Australia via imported ornamental finfish may enter the aquatic environment.

Freshwater fish

Breeding premises in Australia use combinations of aquaria (50%), tanks (35%), and ponds and dams (41%), with some using a mix of systems, depending on the species of fish produced (PSM 1999). Static (62.5%) and recirculating systems (25%) are most common, but some outdoor operations use flow-through reticulation (12.5%) to maintain water quality in ponds. There is a considerable variation in the design and operation of wholesale premises, with about 8% using ponds or dams (PSM 1999). Almost all wholesalers surveyed were located in urban areas and were distant from natural waterways and aquaculture operations. However, there are no uniform legislated requirements covering the location of premises in rural or urban areas with regard to natural waterways.

There are two major routes by which live freshwater fish may be released into the aquatic environment (PSM 1999). First, unwanted and sick fish may be deliberately released into natural waters by hobbyists. This practice is termed ‘Christmas syndrome’ in the ornamental trade; it usually involves inexperienced or first-time hobbyists releasing goldfish.

Second, fish may escape from earthen or ground-level ponds (either grow-out ponds in breeding premises or hobbyists’ garden ponds) near or with a direct connection to natural waters. This may occur either through vandalism or because of accidental or inadvertent breakdown in holding systems (eg during floods). Only a small proportion of imported fish is estimated to reach local ornamental fish breeding premises (probably for use as broodstock). It is unlikely that these fish will escape into natural waters, but if they are infected they may infect other fish in breeding facilities and grow-out ponds and these infected pond fish may in turn find their way into natural waters. Intensive production conditions may lead to amplification of disease agent numbers. Goldfish and poeciliids (livebearers such as guppies) are the only fish listed on Schedule 6 that are produced in Australia in open, pond culture systems and that, when included in the host range of a particular disease agent, constitute a significant pathway by which that agent may be introduced into the natural environment.

Disease may also spread from pond culture operations to natural waters through the activities of piscivorous birds and the subsequent escape or release of feral or native fish that have been introduced into ponds as eggs or fry.

The likelihood of fish surviving to form a self-maintaining population depends on many factors, including the 'propagule pressure' of any release event. A propagule is the unit, or number of individuals, involved in an invasion event; propagule pressure is the effect on the probability of successful invasion of increasing or decreasing the size and the number of propagules (Arthington et al 1999). One important factor determining propagule pressure is the number of individual fish entering the environment in a given release event. For example, if 100 fish escape into a natural waterway from a single release event (eg flooding of an earthen pond), the propagule pressure is greater than that associated with 100 separate release events by hobbyists releasing fish into natural waters. Accordingly, AQIS considers the probability of introduction of disease agents through escapes from breeding facilities to be higher than the probability associated with 'Christmas syndrome' releases.

Arthington et al (1999) identified finfish from several groups as having a very high likelihood of surviving and forming self-maintaining populations in Australia. The report categorised species according to records of establishment of fish populations outside their natural range both in Australia and abroad. Some Schedule 6 finfish species were identified as having a significant likelihood of being introduced into the natural environment; those that could survive and form self-maintaining populations were considered to pose the greatest threat in terms of disease establishment. Both goldfish and poeciliids were classified by Arthington et al (1999) as having a very high likelihood of surviving and forming self-maintaining populations in Australia. AQIS agrees that the entry of goldfish and poecilids into the aquatic environment constitutes a significant pathway for disease establishment.

AQIS imposes controls on the conduct of freshwater finfish quarantine premises, including controls on the disposal of live fish and waste (including dead fish). A 1999 study (PSM 1999) considered that the probability of live fish escaping from quarantine premises was remote and that the disposal of waste from quarantine premises under AQIS control was satisfactory. AQIS agrees that activities at quarantine premises present a negligible probability of disease establishment.

Marine fish

Arthington et al (1999) recently assessed the probability of establishment of non-native marine (and estuarine) ornamental finfish. They found that:

There is not a single record of a marine finfish imported as an ornamental becoming established in an alien sea. On the other hand, a number of ornamental marine species have become established in the wild after entering a country via a different pathway from the aquarium trade itself. Thus there is no intrinsic reason why ornamental marine species could not become naturalised in alien waters. That they have not done so, at least as a consequence of the aquarium fish trade or hobby, indicates that certain features of the industry or hobby itself mitigate against the species involved becoming established in the wild as the result of accidental or intentional liberation…

1. Marine and estuarine species are far less likely to be kept in the open.
2. The size of the freshwater ornamental species trade is much larger than that of the marine side.
3. Generally speaking, marine species make far greater demands on the hobbyist than do freshwater species… keeping marine species is often the province of 'enthusiasts', who may be less likely to liberate their fish into the wild than the hobbyist…
4. Not only are marine ornamental species much more difficult to keep in captivity than freshwater species, but the great majority of them also are difficult to breed.

   …the propagule pressure for freshwater species will be considerably greater than for almost all marine species.
5. …many marine species, in contrast to those that live in freshwater or estuarine conditions, live under

> very stable conditions of temperature, water quality and chemistry… and they show little ability to cope with variation in those conditions. One would predict from these observations that estuarine fishes, in particular, but also freshwater fishes would have a much greater chance of survival than marine species if accidentally or deliberately released into the wild.
>
> While it is argued that, on average, the probability of an imported marine ornamental species becoming established in the wild is far less than for freshwater species, within that framework certain marine species will be more likely to establish than others… In this context, *estuarine species of Gobiidae* would appear to be the highest risk group.

AQIS takes this into account and also takes into account the current structure of the marine ornamental finfish industry, including the absence of commercial mariculture of Schedule 6 finfish species in Australia. AQIS considers that, while the probability of disease agents establishing in Australian natural waters due to imported live marine ornamental finfish would be significantly less than that posed by freshwater ornamental finfish, marine finfish importation constitutes a minor risk.

The direct disposal of untreated effluent water into the sea by public aquaria may also constitute an exposure pathway (PSM 1999). However, this pathway is mitigated to a great extent because of the high rates of water exchange usually applied in public aquaria, the high degree of filtration and disinfection used, the low stocking densities, the tremendous dilution effect associated with water discharges into seas/oceans, the use of fish health professionals and appropriate quarantine practices, and the very low numbers of imported fish that find their way into public aquaria.

If usage patterns of marine ornamental finfish changed (eg through the establishment of commercial mariculture industries based on Schedule 6 finfish species), AQIS would reassess the exposure pathways and associated quarantine risk, and take appropriate risk management measures.

PSM (1999) identified the disposal of transport water and waste fish from imported marine finfish consignments in importer premises (where there is currently no quarantine detention requirement) as a potential pathway. AQIS agrees that this is of borderline significance.

The disposal of fish and other wastes from premises other than importer premises is not considered to constitute a significant exposure pathway, because potentially infected material is widely dispersed once imported fish leave importer premises and because of the dilution factor provided by domestic waste disposal systems.

Metazoans

Most metazoan parasites are obligatory parasites and display varying degrees of host specificity. Many have life cycles that involve several host animals. Metazoans with indirect life cycles are not likely to propagate or survive in aquarium situations. Should these parasites enter Australian natural waters, they could not establish unless suitable intermediate hosts were present. In addition, metazoan parasites of fish do not normally cause significant disease.

1.7.6 CONCLUSIONS

For disease agents that may be carried by fish species having a significant likelihood of entry, survival and establishment in natural waters, the probability of disease establishment in natural waters was estimated to be one level of probability (as defined in Section 1.5.3) lower than the probability of establishment in the ornamental fish industry. A much lower probability was attributed to those disease agents carried by fish species which do not have a significant likelihood of entry, survival and establishment in Australian natural waters.

1.8 Consequence assessment

1.8.1 INTRODUCTION

This section discusses the factors considered by AQIS in assessing the significance of the impact or consequences of establishment of exotic disease. As outlined in Section 1.5.3, Box 1.6, AQIS considers all relevant factors and classifies the significance of each disease according to categories that have been defined in qualitative terms (‘negligible’, ‘low’, ‘moderate’, ‘high’ or 'catastrophic'). The probability of establishment and the significance of the consequences are considered together in estimating the risk.

Factors relating to the probability of entry and establishment are discussed in Sections 1.6 and 1.7.

The key points relevant to the consequences of establishment of individual diseases are set out in Chapter 4. This section describes the general considerations relevant to this assessment.

1.8.2 FACTORS RELEVANT TO THE IMPACT OF DISEASE ESTABLISHMENT

Biological effects

In Section 1.5.3, the effect of establishment of a disease was defined in biological terms (with reference to mortality, morbidity and the pathogenic effects of the agent) and in terms of economic or environmental impact. Many of the disease agents considered in this risk analysis have the capacity to cause marked pathological effects in a significant proportion of hosts in a susceptible population and to cause significant economic effects, were they to become established.

The biological effects of disease depend on the interaction of the environment, pathogen and host. The nature of this interaction reflects factors intrinsic to the pathogen (such as virulence and infectivity), the host (such as immune competence and population density) and the environment (such as quality of habitat for susceptible hosts). In most cases there is limited information on the effect of exotic pathogens under Australian conditions. However, AQIS considers overseas data on the species of fish that are susceptible to infection, the effect of infection on those fish populations and the influence of the physical environment on the outcome of infection.

The epidemiology of disease is generally not as well understood in fish populations as in terrestrial animals. On fish premises, 'normal' or baseline values for production and mortality are often highly variable, reflecting the significant effect of husbandry practices, stocking rates and stress on fish health. Many economically significant diseases of ornamental finfish are caused by opportunistic pathogens (ie they cause disease only when environmental or other conditions predispose fish to infection). For example, *Ichthyophthirius multifiliis* causes white-spot disease in a wide range of freshwater fish species when water temperatures are optimal for parasite multiplication and host fish resistance to infection is lowered due to stress.

This is an important consideration for the risk analysis. The complex interaction between host factors, environmental factors (including husbandry in fish premises) and agent factors make it difficult to predict accurately the effect of the establishment of exotic disease. Stakeholders have commented that Australian fish would be more susceptible to disease due to the historical absence of many pathogens. AQIS has made a series of conservative assumptions, including that domestically reared and wild fish in Australia (including native species) would be at least as susceptible to infection as fish of the same, or closely related, species reported as susceptible under similar conditions in other countries, and that the consequences of diseases becoming established would be at least as serious as reported overseas.

Environmental conditions (including husbandry) clearly influence the expression of clinical disease and the amenability of introduced disease to prevention and control. It follows that for diseases that have been shown by overseas experience to be amenable to prevention and control, similar methods may be applicable in Australia. For some diseases there are clear parallels. For example, enteric redmouth caused by the Hagerman strain of *Yersinia ruckeri* is controlled in Europe and North America by using various strategies, including immersion vaccination of fish using commercial vaccines. Immersion vaccination is routinely used in the Australian salmonid aquaculture industry to protect against *Vibrio anguillarum*. Thus, if *Yersinia ruckeri* (Hagerman strain) became established in Australia, it is likely that this disease could be controlled by similar means and the consequences of establishment mitigated.

Australia's capacity to respond to disease incursions

There are few diagnostic tests and therapeutic or prophylactic measures available in Australia, particularly for exotic diseases. Moreover, there are no contingency plans for specific diseases of fish (in contrast to terrestrial animals) and it has been argued that this would limit Australia's capacity to deal with the entry and establishment of new fish diseases.

This deficiency has been recognised and contingency planning for aquaculture emergencies is now well advanced at a national level. AQUAPLAN is a strategic aquatic animal health plan developed by the Department of Agriculture Forestry and Fisheries — Australia (AFFA) in consultation with aquatic industries and State agencies with responsibility for fisheries and aquaculture. Since the adoption of AQUAPLAN, significant progress has been made on preparedness and response plans to deal with aquatic disease emergencies. The components of an emergency aquatic animal disease plan have been drafted in consultation with industry, and a field handbook for recognition of aquatic animal diseases has been commissioned.

There have recently been coordinated responses to aquatic disease emergencies, including the 1998–99 pilchard mortalities, the invasion of marine zebra mussels in Darwin Harbour and the detection, during routine diagnostic submissions, of the microsporidian *Thelohania* (a notifiable disease agent) in freshwater crayfish in Western Australia.[15] AQIS has taken an appropriately conservative approach to the IRA, in the light of the high cost associated with attempts to eradicate new diseases and the low likelihood of success.

In the case of disease agents shown by overseas experience to be highly pathogenic (eg 'typical' strains of *Aeromonas salmonicida* and infectious salmon anaemia virus), AQIS has assumed that rates of morbidity and mortality in Australia would be comparable to those overseas. AQIS has also assumed that diseases that have been shown by overseas experience to be difficult or impossible to eradicate would present similar difficulties in Australia.

For the diseases that are routinely controlled overseas by husbandry practices (eg reduced stocking rates) or veterinary intervention (eg antimicrobial treatment), AQIS has assumed that a similar approach may be applicable in Australia, albeit at a cost to the infected premises and in some cases to the industry as a whole, and for some disease agents, to related industries as well. AQIS notes that there would be a need for regulatory approval of any drug or vaccine required that is not currently available in Australia if these were to be used to control an introduced disease.

AQIS notes that the application of measures for the control, prevention or eradication of disease is generally more difficult for viral diseases (particularly those that are transmitted vertically) than for diseases due to bacterial, protozoan or metazoan agents. Most bacterial diseases are amenable to treatment and/or prevention. The impact of diseases due to protozoan and metazoan agents may, in many cases, be substantially mitigated by the application of chemotherapeutants and/or improvements in husbandry and environmental conditions. For pathogens that have an indirect life cycle (such as *Trypanosoma carassii* and *Cryptobia borreli*), it may be possible to prevent transmission of infection in fish premises by excluding intermediate or alternative hosts. This method has been used to prevent the spread of *Myxobolus cerebralis* in New Zealand and is the basis for the regionalisation of this disease there.

Economic effects

For ornamental finfish premises in Australia, the most significant inputs are normally the cost of stock and costs associated with handling fish (eg for sorting or treatment) and with catching, packaging and transporting them.

Disease can result in increased mortality and/or reduced growth rates and reproductive performance. Measures for control, prevention or eradication of the disease would be an additional cost. In considering the impact of disease establishment, AQIS takes into account the costs associated with biological effects and costs associated with the implementation of control measures.

The establishment of disease can also have indirect consequences for the economic performance of other industries. For example, the value of domestic or export markets for the tuna and salmon industries could be reduced on disease-related grounds, pending clarification of the disease situation, or may be a result of unjustified perceptions of risk. Markets might be reopened if disease were eradicated or the affected premises

15 Fisheries Western Australia Internet home page: http://www.wa.gov.au/westfish/

implemented an appropriate risk management program (eg vaccination to underpin health certification).

Zoning or regionalisation of disease

WTO member countries recognise the concept of zoning, or regionalising, disease to minimise negative effects on trade. Zoning of aquatic diseases applies to trade in live ornamental finfish and genetic material, both internationally and through interstate movement restrictions in Australia. If an exotic disease became established, Australian authorities would try to regionalise it in order to maintain access to national and international markets. This would require additional specific regulatory measures such as movement controls, testing and certification, with attendant costs.

Effects on industry

Outbreaks of disease in wholesale or retail premises may have low to moderate consequences (as defined in Section 1.5.3), depending on the size of the premises, the range of fish species held and management practices.

As defined, moderate consequences would apply to disease outbreaks in premises where economic performance has been harmed significantly at the enterprise or industry sector level. This would particularly apply in cases where wholesale, retail or breeder premises serviced a significant part of the industry and a closure of operations due to a disease outbreak could have a significant economic impact, or where trade patterns could mean that potentially diseased fish had been traded widely before controls were applied.

A disease outbreak in a medium to small commercial or breeding premises would generally have low to negligible consequences.

The vast majority of imported ornamental finfish, whether freshwater or marine, are destined for hobbyist aquaria which, in terms of disease agent transmission are, on the whole, self-limiting. Disease agents would affect susceptible fish until the hosts die or are treated, and would not be able to infect new fish because of an inability to complete their life cycle under hobbyist aquaria conditions. The probability of such fish entering other aquaria is extremely low. In almost all such cases, consequences would be negligible.

Ecological and environmental effects

In considering the significance of impact of the establishment of disease, AQIS also takes into account effects on the environment. The establishment of disease can have biological or ecological consequences that could affect the survival of native species (including amphibians) that are not commercially exploited. For example, the ecological balance of freshwater systems and the quality of the environment could be disturbed by changes to the normal proportions of different animal species as a result of the establishment of disease or, equally, by the introduction of an exotic species which becomes a pest, such as *Cyprinus carpio*. These effects cannot be quantified. However, any event that would cause a decline in the numbers of endangered or threatened species or otherwise damage the environment, including through potential loss of biodiversity, would be of concern to the Australian community.

AQIS takes a conservative approach when considering the susceptibility of native fish and other species (eg amphibians), particularly endangered and threatened species, to infection with exotic disease agents. The establishment of any disease that is likely, on its own, to result in the extinction of a species (which equates to having a serious, irreversible effect on the environment) would be classified as ‘catastrophic’. In this regard, AQIS notes that the extinction of a species is almost always the result of many adverse factors, including environmental degradation, predation, competitor species and disease.

In considering the likely effect on native species of exotic disease agents, AQIS takes account of the propensity of exotic pathogens to affect a range of species overseas, including any that have a close taxonomic relationship with Australian native species. In the case of pathogens that infect a narrow and/or specific range of host species that are unrelated to Australian native species, AQIS assumes that the effects on native species would be negligible. However, for exotic pathogens that have a wide or non-specific host range, AQIS assumes that native species would be susceptible to infection and that the establishment of disease could have consequences as least as severe as those reported overseas.

Chapter 2
Ornamental fish industry in Australia

2.1 Characteristics and commercial value of the industry

2.1.1 CLASSIFICATION OF FISH RELEVANT TO THIS IMPORT RISK ANALYSIS

Australia's aquatic environments can be broadly divided into open sea, reef, estuarine and freshwater (Kailola et al 1993).

There are about 205 freshwater fish species in Australia, including 25 introduced species established in the wild (McDowall 1996). Almost all of the native species are unique to Australia.

All fish considered in this import risk analysis (IRA) (those on Schedule 6, Part II of the *Wildlife Protection (Regulation of Exports and Imports) Act 1982*) belong to the class Actinopterygii (Osteichthyes) or the class Chondrichthyes.

There are over 600 genera within these two classes, which represent the majority of ornamental finfish species traded within Australia and all those listed on Schedule 6. Schedule 6 lists 121 genera belonging to 32 families within nine orders of fresh and brackish water species, and 484 genera belonging to 52 families within 13 orders of marine species.

Commercial freshwater species of ornamental finfish commonly traded both within Australia and worldwide include the livebearing poecillids (guppies, mollies, swordtails and platies), the characins (tetras), cyprinids (eg barbs, danios, goldfish and koi carp), anabantids (eg Siamese fighters, gouramis and paradise fish), cyprinidonts (killifish and topminnows), cichlids (eg angelfish, discus and oscars), catfish and loaches.

Many marine ornamental fish species are traded and most are tropical coral reef species such as pomacentrids (eg anemonefish, damselfish), pomacanthids (eg angelfish), gobies, labrids (eg wrasses), scarids (parrotfish) and scorpaenids (eg butterflyfish).

2.1.2 INDUSTRY OVERVIEW

The ornamental fish industry has not been subject to detailed assessment in terms of its volume and value.

There is only limited statistical information on imports and exports of ornamental finfish. Much of the data presented in this section are based on estimates by industry members.

The ornamental fish industry in Australia, including accessories such as food, medication and tanks, has an estimated worth of A$135–150 million annually (J Patrick pers. comm.). Aquarium fish turnover is valued at A$25 million annually for the whole trade, with A$60 million retail value (PIJAC 1999). Industry sources estimate the retail market to comprise about 800 shops around Australia employing approximately 5000 staff (PIJAC 1999).

The ornamental fish industry includes trade in imported freshwater and marine fish species, and locally caught or reared fish. Keeping ornamental fish is a popular hobby worldwide; in Australia it is estimated that 12–14% of the population participate in this hobby (Patrick 1998). Fish aquaria are displayed in homes, offices and public areas.

Approximately 40% of the ornamental fish traded in Australia are imported from overseas (PIJAC 1999) at a cost to the importer of A$1.97 million for 1997–98 (ABS 1998). There are currently 32 ornamental fish importers in Australia, with Asia being the major source of their imports. The most commonly imported ornamental fish species are: goldfish (*Carassius auratus*), neon tetras (*Paracheirodon innesi*), white cloud mountain minnows (*Tanichthys albonubes*), guppies (*Poecilia reticulata*), platies (*Xiphophorus maculatus*), and swordtails (*Xiphophorus helleri*). The greatest proportion of these are goldfish, which constitute some 22% of imports (PSM 1999).

The total number of freshwater fish imports into Australia for 1997–98 is reported to be around 6.3 million fish at a cost to the importer of approximately A$1.76 million, down from about 7 million fish imported in 1996–97 (PSM 1999). Singapore, Hong Kong and Malaysia supplied up to 80% of freshwater ornamental fish imports in 1997–98 (ABS 1998).

The breeding of ornamental fish in Australia is increasing to supply growing demands from local and international markets. The retail value of freshwater ornamental fish production in Australia is estimated at A$25 million per annum (PSM 1999). In 1997–98, Australia exported 79,428 marine and freshwater ornamental fish at a value of A$1.3 million (ABS 1998). Almost 74% of exported fish are native Australian species, most destined for markets in the United States, Japan and Hong Kong (ABS 1998).

There is a well-established network of people in the ornamental fish industry, comprising importers, wholesalers, breeders, retailers, hobbyists and managers of public aquaria.

The Pet Industry Joint Advisory Council (PIJAC) is the industry's main voice in the community. A bi-monthly magazine, *Pet Industry News*, publishes information relevant to the ornamental fish industry in Australia. The PIJAC code of practice for aquarium operations provides guidance on proper care of fish and promotes State and federal regulation of the trade (PIJAC 1998).

2.1.3 DISTRIBUTION OF WILD AND AQUACULTURED ORNAMENTAL FISH RESOURCES IN AUSTRALIA

Marine ornamental fish

Marine ornamental fish are collected from the wild, mainly from the Great Barrier Reef in Queensland, but also from other areas in Queensland and from Western Australia (Brown et al 1997). Marine ornamental fish are also collected and exported from the Northern Territory, Victoria, South Australia and Tasmania (L Squire pers. comm.).

The commercial fishery for the collection of marine ornamental fish in Queensland extends along the entire east coast of Queensland, from its estuaries to the in-shore and off-shore reefs and islands (Couchman and Beumer 1992).

Over 500 species of reef fish, belonging to 50 families, are targeted for the aquarium fish trade (L Squire pers. comm.). They include angelfish, clown fish, damsel fish, trigger fish, gobies, wrasses, cheatodons and heiniochus (Couchman and Beumer 1992). In Queensland there are approximately 60 aquarium fish permits, with about 180 divers currently involved in the aquarium fishery (L Squire pers. comm.).

In Western Australia, the marine ornamental fish fishery is defined as the take of marine bony or cartilaginous fish of legal size for the purpose of live display in aquaria (Barrington 1994). Participants may not take freshwater fish for this purpose from any inland waters of the State or from waters within 800 metres of the mouth of any river, creek or inlet. The take of ornamental fish is not permitted within marine reserves and parks (Barrington 1994). Participants in the WA fishery target a diverse group of species using a variety of capture methods. However, most effort is not highly successful due to the considerable knowledge required to locate, collect, hold and then market the specimens (Barrington 1994).

Aquacultured ornamental fish

Local ornamental fish production in Australia is increasing steadily as the market grows. Freshwater ornamental fish are now farmed in various locations in Australia. Details of individual farms and hatcheries throughout Australia are not available; however, it is estimated that these farms and hatcheries supply up to 60% of the fish to the industry (J Patrick pers. comm.). In 1995–96, Queensland produced 885,000 fish and New South Wales produced 342,000 fish (Brown et al 1997).

The major producer of tropical fish in Australia is Queensland, while temperate fish species are mainly produced in New South Wales and Victoria (O'Sullivan 1992). Many native freshwater species such as rainbow fish (family Melanoteaeniidae) are easily bred and are popular in Australian and overseas ornamental fish markets. Other Australian native species gaining increasing popularity as aquarium fish include saratoga (*Scleropages leichardi*) and barramundi (*Lates calcarifer*) (Patrick 1998).

Aquaculture facilities include outdoor earthen ponds, above-ground ponds and indoor or covered ponds (Patrick 1998).

2.2 Health status

2.2.1 ORNAMENTAL FISH HEALTH IN AUSTRALIA

The health status of wild and aquacultured ornamental fish is receiving increasing attention from federal and State authorities. All States and Territories have laboratories involved in investigation, diagnosis and research of fish diseases and health. These are used to monitor disease episodes in ornamental fish, including imported fish.

Significant disease events are more likely to be recognised in aquaculture situations than in marine or freshwater wild stocks.

Information on ornamental fish health in Australia has been obtained from:

- published scientific literature;
- reports provided by Commonwealth and State or Territory government agencies, including official notifications to regional and international organisations; and
- published and unpublished material held by Commonwealth and State or Territory government agencies, universities, industry and research organisations.

Finfish diseases and disease agents listed by the World Organisation for Animal Health

The following finfish diseases and disease agents listed by the Office International des Epizooties (OIE, or World Organisation for Animal Health; see Section 1.3.2, Box 1.1) have not been identified in Australia.

Diseases notifiable to the OIE

- Infectious haematopoietic necrosis
- *Oncorhynchus masou* virus disease
- Spring viraemia of carp
- Viral haemorrhagic septicaemia

Other significant diseases

- Channel catfish virus disease
- Infectious pancreatic necrosis[1]
- Red sea bream iridovirus disease
- White sturgeon iridovirus disease
- Enteric septicaemia in catfish (*Edwardsiella ictaluri*)
- Piscirickettsiosis (*Piscirickettsia salmonis*)
- Gyrodactylosis of Atlantic salmon (*Gyrodactylus salaris*)
- Infectious salmon anaemia
- Bacterial kidney disease (*Renibacterium salmoninarum*)

The following finfish diseases listed by the OIE occur in Australia.

Diseases notifiable to the OIE

- Epizootic haematopoietic necrosis

Other significant diseases

- Viral encephalopathy and retinopathy
- Epizootic ulcerative syndrome

Finfish diseases and disease agents that are notifiable in Australia

The mandatory notification to authorities of the occurrence of specified ('listed') diseases provides information that assists in the prevention and management of disease outbreaks. Such information can be used in combination with official controls on the movement of live animals and, where appropriate, their products to establish disease-free zones within infected countries.

Specified finfish diseases and disease agents that are notifiable in Australia are shown in Table 2.1.

Internal restrictions on movement of live fish

During the preparation of this document, Chief Veterinary Officers of all States and Territories were asked to provide information on fish disease control zones and details of intra- or interstate movement controls on live finfish within their jurisdiction. Table 2.2 summarises their responses.

2.2.2 LIMITATIONS OF CURRENT INFORMATION ON THE HEALTH OF FINFISH IN AUSTRALIA

As is the case in other countries, Australia has less information on the health status of most of its finfish species than on that of terrestrial animals and established farmed aquatic species such as salmonids. Definitive diagnosis of fish diseases, especially viral diseases, is difficult. In many cases detection and identification methods are not yet applicable to large-scale testing. Specialised equipment and highly trained personnel are required to perform diagnostic tests. Routine health surveillance, particularly of wild populations, is costly and is not widely practised in Australia. Diagnosis of disease in farmed fish sites is generally based on an evaluation of clinical and pathological evidence. In most cases the presence of disease agents is only recognised after an outbreak of clinical disease in farmed fish.

1 An aquatic birnavirus has been confirmed in some wild marine species as well as farmed (sea-caged) salmonids in Tasmania, Australia, though the known distribution is limited to Macquarie Harbour on the west coast of Tasmania (Crane et al 1999). Experimental evidence indicates that the virus is of low pathogenicity to brook trout and Atlantic salmon and therefore should not be classified as infectious pancreatic necrosis virus (M Crane pers. comm.).

2.2.3 FUTURE DIRECTIONS FOR AQUATIC ANIMAL HEALTH IN AUSTRALIA

There is an increasing awareness of aquatic animal health issues in Australia. Several comprehensive reviews have critically assessed and recommended improved approaches to aquatic animal health and quarantine infrastructure (Jones 1996, Nunn 1995, Nairn et al 1996, Higgins 1996, SCARM 1997).

The Australian Government has made a strong commitment to improving the management of aquatic animal resources to ensure the effective development and profitability of the aquaculture sector and protection of the environment. The prevention and management of diseases are important in this context.

AQUAPLAN — Australia's national strategic plan for aquatic animal health

As a result of the Commonwealth Government's response to the above-cited reviews, Commonwealth, State and Territory governments and the private sector (including recreational fisheries and the ornamental fish industry) endorsed AQUAPLAN, a national strategy to address aquatic animal health issues, in 1998–99. AQUAPLAN operates through the following eight programs.

1. International linkages
2. Quarantine
3. Surveillance, monitoring and reporting
4. Preparedness and response arrangements
5. Awareness
6. Research and development
7. Legislation, policies and jurisdiction
8. Resources and funding

Under Program 3, Surveillance, monitoring and reporting, States and Territories provide quarterly reports to the Office of the Chief Veterinary Officer on the occurrence of diseases during each month of the quarter.

Diseases of finfish listed in AQUAPLAN are as follows.

- Epizootic haematopoietic necrosis
- Infectious haematopoietic necrosis
- *Oncorhynchus masou* virus disease
- Spring viraemia of carp
- Viral haemorrhagic septicaemia
- Channel catfish virus disease
- Viral encephalopathy and retinopathy
- Infectious pancreatic necrosis
- Infectious salmon anaemia
- Epizootic ulcerative syndrome (*Aphanomyces invadans*)
- Bacterial kidney disease (*Renibacterium salmoninarum*)
- Enteric septicaemia of catfish (*Edwardsiella ictaluri*)
- Piscirickettsiosis (*Piscirickettsia salmonis*)
- Gyrodactylosis (*Gyrodactylus salaris*)
- Furunculosis (*Aeromonas salmonicida* subsp *salmonicida*)
- Goldfish ulcer disease (*Aeromonas salmonicida* atypical strains)
- Whirling disease (*Myxobolus cerebralis*)
- Enteric redmouth disease (*Yersinia ruckeri*)

Table 2.1

Notification requirements for finfish diseases and disease agents in Australian States and Territories

STATE	DISEASE / DISEASE AGENT
Australian Capital Territory	None
New South Wales	*Aeromonas salmonicida* Bacterial kidney disease Infectious haematopoietic necrosis Infectious pancreatic necrosis Epizootic haematopoietic necrosis Viral haemorrhagic septicaemia Viral encephalopathy and retinopathy / Viral nervous necrosis Epizootic ulcerative syndrome Whirling disease Yersiniosis Enteric redmouth disease
Proposed additional diseases and changes	*Oncorhynchus masou* virus disease Spring viraemia of carp Infectious salmon anaemia Piscirickettsiosis (*Piscirickettsia salmonis*) Gyrodactylosis (*Gyrodactylus salaris*) Viral encephalopathy and retinopathy Furunculosis (*Aeromonas salmonicida* subsp salmonicida)
Northern Territory	
Proposed list of notifiable diseases	Epizootic haematopoietic necrosis Infectious haematopoietic necrosis Oncorhynchus masou virus disease Spring viraemia of carp Viral haemorrhagic septicaemia Channel catfish virus disease Viral encephalopathy and retinopathy Infectious pancreatic necrosis Infectious salmon anaemia Epizootic ulcerative syndrome (*Aphanomyces invadans*) Bacterial kidney disease (*Renibacterium salmoninarum*) Enteric septicaemia of catfish (*Edwardsiella ictaluri*) Piscirickettsiosis (*Piscirickettsia salmonis*) Gyrodactylosis (*Gyrodactylus salaris*) Furunculosis (*Aeromonas salmonicida* subsp *salmonicida*) Goldfish ulcer disease (*Aeromonas salmonicida* atypical strains) Whirling disease (*Myxobolus cerebralis*) Enteric redmouth disease (*Yersinia ruckeri* serovar)
Queensland	
Proposed list of declared diseases	Infectious haematopoietic necrosis *Oncorhynchus masou* virus disease Spring viraemia of carp Viral haemorrhagic septicaemia Infectious pancreatic necrosis Epizootic haematopoietic necrosis Channel catfish disease Infectious salmon anaemia Aeromonas salmonicida subsp salmonicida

Table 2.1 continued

Notification requirements for finfish diseases and disease agents in Australian States and Territories

STATE	DISEASE / DISEASE AGENT
Queensland	*Edwardsiella ictaluri* *Piscirickettsia salmonis* *Renibacterium salmoninarum* Enteric redmouth disease (*Yersinia ruckeri* serovar I and II)
South Australia	
Diseases notifiable under the *Fisheries Act 1982*	*Myxosobolus cerebralis* (whirling disease) *Aeromonas salmonicida* of finfish Viral encephalopathy and retinopathy — nodavirus Cichlid virus Epizootic haematopoietic necrosis Infectious haematopoietic necrosis of salmonidae Infectious pancreatic necrosis of salmonidae Viral haemorrhagic septicaemia of salmonidae
Diseases notifiable under the *Livestock Act 1997*	*Aeromonas salmonicida* (atypical strains) *Aeromonas salmonicida* subsp *salmonicida* *Aphanomyces invaderis* Epizootic haematopoietic necrosis Viral encephalopathy and retinopathy Channel catfish virus *Edwardsiella ictaluri* Epizootic haematopoietic necrosis *Gyrodactylus salaris* Infectious haematopoietic necrosis virus Infectious pancreatic necrosis virus Infectious salmon anaemia virus *Myxobolus cerebralis* *Oncorhynchus masou* virus *Piscirickettsia salmoninarum* *Renibacterium salmoninarum* Viral haemorrhagic septicaemia virus *Yersinia ruckeri* Spring viraemia of carp Viral encephalopathy and retinopathy
Tasmania	
List A diseases	Bacterial kidney disease Epizootic haematopoietic necrosis Epizootic ulcerative syndrome Furunculosis (*Aeromonas salmonicida* subsp *salmonicida*) Goldfish ulcer disease (*Aeromonas salmonicida*, goldfish atypical strain) Infectious haematopoietic necrosis Infectious pancreatic necrosis Oncorhynchus masou virus disease Spring viraemia of carp Viral encephalopathy and retinopathy Viral haemorrhagic septicaemia Piscirickettsiosis
List B diseases	Marine aeromonad disease (*Aeromonas salmonicida*, marine atypical strain) Streptococcosis of salmonids (*Lactococcus garvieae*)

Table 2.1 continued

Notification requirements for finfish diseases and disease agents in Australian States and Territories

STATE	DISEASE / DISEASE AGENT
Victoria	
Diseases of fish	*Aeromonas salmonicida* (other than goldfish) Epizootic haematopoietic necrosis Epizootic ulcerative syndrome Viral encephalopathy and retinopathy (including barramundi nodavirus)
Exotic diseases of fish	Bacterial kidney disease Infectious haematopoietic necrosis Herpes virus of salmonids type 2 Spring viraemia of carp Viral haemorrhagic septicaemia Whirling disease
Western Australia	
Diseases exotic to Australia	Bacterial kidney disease — renibacteriosis Channel catfish virus disease — ictalurid herpes virus (type 1) Enteric septicaemia of catfish — edwardselliosis Infectious haematopoietic necrosis Infectious pancreatic necrosis Infectious salmon anaemia *Oncorhynchus masou* virus disease — salmonid herpes virus (type 2) Piscirickettsiosis Spring viraemia of carp Viral haemorrhagic septicaemia *Aeromonas salmonicida* subsp *salmonicida* infection — furunculosis
Diseases present in Australia but not in Western Australia	Epizootic haematopoietic necrosis — redfin virus Viral encephalopathy and retinopathy — nervous necrosis virus
Diseases of special significance for export,import, relation to other programs, or to the State	*Aeromonas salmonicida* infection — goldfish ulcer disease *Anguillicola* nematode of eels Epizootic ulcerative syndrome

Source: State and Territory government agencies

Table 2.2

Controls on movement of finfish within and between States and Territories

STATE	CONTROLS
Australian Capital Territory	⦿ Licence required to import live fish into ACT. ⦿ Transport water to be treated in holding tank before release. ⦿ Containers, bags etc to be sterilised or burnt. ⦿ Any disease must be reported within 24 hours.
New South Wales	
Interstate	⦿ Barramundi fingerlings must test negative for viral nervous necrosis before import for grow-out. ⦿ Salmonids must test negative for epizootic haematopoietic necrosis before import for grow-out outside areas in New South Wales where this disease is endemic.
Intrastate	⦿ Salmonids for grow-out from areas where epizootic haematopoietic necrosis is endemic must be negative before translocation to other areas. ⦿ Salmonids for stocking in public waters must test free of epizootic haematopoietic necrosis, *Y. ruckeri* and *A. salmonicida.*
Queensland	⦿ Certification of imported fish for aquaculture is required. ⦿ Trade in diseased fish (Declared Diseases List) is prohibited.
Fisheries Act 1994	⦿ Restrictions relate to aquatic animals approved for rearing for aquaculture purposes. ⦿ Require 'freedom-from-disease certificate', stating that diseases on Queensland's Declared Diseases List have never been diagnosed in the farm/region of origin, or that a two-year eradication and monitoring program has been undertaken. ⦿ Require prophylactic treatment against ectoparasites within 48 hours of shipment and a certification on this treatment.
South Australia	⦿ Before introduction into areas where fish are kept or are to be kept, fish must be shown free from all diseases listed as notifiable. ⦿ A permit is required before fish can be brought into water bodies including aquaculture water bodies. ⦿ Certification thereupon required by the State of origin. ⦿ Contravention is an offence. ⦿ Specific protocols for movement of aquatic animals across the State border can be developed for species that are considered to be a significant translocation risk and are legislated under the *Livestock Act 1997*; contravention is therefore an offence. Protocols have been developed for barramundi, *Lates calcarifer.* ⦿ Specific conditions can also be attached to aquaculture licences for intrastate and interstate translocations if a specific translocation risk has been identified.

Table 2.2 continued
Controls on movement of finfish within and between States and Territories

STATE	CONTROLS
Tasmania	⦿ All imports must be authorised. ⦿ Authorisation may include requirements such as health certification, testing, or quarantine detention. ⦿ Despite authorisation, it is prohibited to import fish that are believed to be infected with a List A disease, List B disease, new disease or unknown disease. ⦿ Specifically prohibited are common carp and fish that can live at water temperatures below 10°C.
Northern Territory	⦿ The holders of an aquaculture licence under the *Fisheries Act 1998* and Regulations (Fisheries Regulations, Part 3, Divisions 1, 2 and 3) are responsible for: – obtaining a permit to import live material; – providing the Director of Fisheries with certification, to the Director's satisfaction, declaring the product to have been tested and found to be disease-free, prior to shipment, with a copy to accompany the shipment at all times; and – reporting on above-average mortalities and/or disease outbreaks to the Director of Fisheries.
Interstate	⦿ Importation of fish or aquatic life into the Northern Territory requires a permit. ⦿ A decision on granting an import permit application takes into account whether the fish or aquatic life to be imported pose a disease risk to people, fish or aquatic life in the Northern Territory.
Intrastate	⦿ Movement and release of fish or aquatic life into a body of water is restricted and may require a permit. ⦿ Restrictions on taking/moving/releasing fish and aquatic life considering *inter alia* the risk of the spread of contamination or disease to other fish or aquatic life in other areas; disease control areas can be declared and regulated.
Victoria	⦿ No regulations on movement of finfish into or within Victoria but it is an offence to introduce diseased finfish into the State. ⦿ Permit required to introduce live fish into the environment.
Western Australia	⦿ Controls on importation of live finfish from out of the State to reduce the risk of introducing epizootic haematopoietic necrosis virus, barramundi nodavirus and goldfish ulcer disease.
Interstate	⦿ Approval needed to bring into Western Australia fish that are not endemic there. ⦿ Health certification required for movement of live fish from eastern States (silver perch and barramundi). ⦿ All importation of live trout from eastern States must be authorised by the Executive Director of Fisheries (in writing) and would require health certification for freedom from epizootic haematopoietic necrosis virus, Tasmanian Atlantic salmon reovirus and possibly aquatic birnavirus. A disease does not have to be notifiable before absence can be cited as a condition of the import permit.
Intrastate	⦿ Health certification required for movement of live fish within Western Australia (black bream and snapper).

Source: Aquatic Animal Health Unit, National Offices of Animal and Plant Health, Agriculture, Forestry and Fisheries — Australia

Chapter 3
Hazard identification

As DESCRIBED IN CHAPTER 1, THE DISEASE agents addressed in this import risk analysis (IRA) are those that have not been reported in Australia or are subject to official control programs in Australia; that have potential to be carried by an ornamental finfish species listed on Schedule 6; that are listed by the World Organisation for Animal Health (Office International des Epizooties, OIE 1997a) or that are identified as potentially having a significant impact based on Humphrey (1995) and on a survey of the scientific literature. A conservative approach was taken in evaluating the potential for an agent to be carried by a Schedule 6 listed species, with a view to reassessment in Chapter 4 (Risk Assessment) based on a more detailed literature review.

Schedule 6 of the *Wildlife Protection (Regulation of Exports and Imports) Act 1982* (Appendix 1) lists ornamental finfish species that can be imported into Australia on a routine basis.

The potential for a disease agent to be carried by an ornamental finfish species was rated on previous reports of that agent in a fish in the same family as a species listed on Schedule 6, or on reports of the agent from a wide range of host species (indicating very low host specificity).

3.1 Identification of disease agents for further consideration in the import risk analysis

In this section, the Australian Quarantine and Inspection Service (AQIS) considers diseases and disease agents against several criteria to determine whether they should be given detailed evaluation in the IRA. To qualify for inclusion in the IRA, a disease or disease agent must be:

1. carried by a Schedule 6 or related species of ornamental finfish;
2. infectious;
3. (a) exotic to Australia, **or**
   (b) present in Australia but subject to official control; **and**
4. (a) OIE listed **and / or**
   (b) would be expected to cause significant harm in Australia.

Box 1.2 gives further details of these criteria.

Where definitive data relevant to categorisation are lacking, AQIS makes conservative judgments which draw upon scientific knowledge and observations made in similar situations and any other relevant information.

Table 3.1 sets out the classification of disease agents against these criteria for disease agents that are considered further in this risk analysis. Table 3.2 sets out similar information for disease agents that are not considered further.

3.2 Viruses

3.2.1 VIRUSES THAT WILL BE FURTHER CONSIDERED IN THE IRA

Iridoviruses

This section considers erythrocytic necrosis virus (ENV), Red Sea bream iridovirus (RSIV) and freshwater ornamental finfish iridoviruses.

Erythrocytic necrosis virus (ENV) causes viral erythrocytic necrosis (VEN). Host erythrocytes have damaged nuclei and DNA positive cytoplasmic inclusions (reviewed in Humphrey 1995). The resulting anaemia causes pallor of the gills and visceral organs, and hyperactive haematopoietic tissue (reviewed in Bernoth and Crane 1995).

VEN affects a wide range of vertebrates from elasmobranchs to reptiles. ENV has been confirmed from at least 20 families of marine and anadromous fish (Dannevig and Thorud 1999). In tropical marine species, ENV has been confirmed in wrasses and comb-toothed blennies and will probably affect other reef species (McAllister and Stoskopf 1993). The disease has been reported in the United Kingdom, United States, Canada, the Mediterranean, Portugal and Greenland (reviewed in Humphrey 1995).

Red sea bream iridovirus (RSIV) is the most important fish iridovirus in western Japan causing significant mortality (eg 70%) in juvenile red sea bream (Nakajima et al 1998; Nakajima et al 1999). The characteristics and relationships of the iridoviral disease agents are under review but preliminary evidence indicates the widespread distribution of an iridovirus with a single origin (Miyata et al 1997). Mortality primarily occurs in juvenile red sea bream although market-size fish have also been affected (Nakajima et al 1998).

Closely related iridoviruses have been isolated from diseased grouper in Thailand, Hong Kong, Taiwan and Singapore (Chua et al 1993; Chou et al 1998).

RSIV and closely related iridoviruses have been isolated from a range of marine finfish species including members of the Serranidae, Carangidae and Tetraodontidae. Schedule 6 lists some genera belonging to these families, although the agent has not been reported from any such listed genera.

Table 3.1

Disease agents that will be further considered in the IRA

DISEASE AGENT / PEST	1 — LIKELY ORNAMENTAL FINFISH ACRRIER	2 — DISEASE AGENT IS INFECTIOUS	3A — AGENT OR STRAIN EXOTIC TO AUSTRALIA	3B — CONTROL PROGRAM IN AUSTRALIA	4A — OIE LISTED	4B — SIGNIFICANT EFFECT
Viruses						
Erythrocytic necrosis virus (ENV), Red sea bream iridovirus (RSIV) and iridoviruses of freshwater ornamental finfish	Y	Y	Y	N	N	Y
Goldfish haematopoietic necrosis virus (GFHNV)	Y	Y	Y	N	N	Y
Infectious pancreatic necrosis virus (IPNV)	Y	Y	Y*	N	Y	Y
Pike fry rhabdovirus (PFR)	Y	Y	Y	N	N	Y
Spring viraemia of carp virus (SVCV) *Rhabdovirus carpio* (RVC)	Y	Y	Y	N	Y	Y
Viral encephalopathy and retinopathy virus (VERV)	Y	Y	N	Y	Y	Y
Bacteria						
Aeromonas salmonicida	Y	Y	Y*	N	N	Y
Chlamydia/Rickettsia spp	Y	Y	Y	N	Y	Y
Edwardsiella ictaluri	Y	Y	Y	N	Y	Y
Photobacterium damselae piscicida	Y	Y	Y	N	N	Y
Pseudomonas anguilliseptica	Y	Y	Y	N	N	Y
Yersinia ruckeri (Hagerman strain)	Y	Y	Y*	N	N	Y
Fungi						
None						
Protozoans						
Acanthamoeba spp	Y	Y	Y	N	N	Y
Brooklynella hostilis	Y	Y	Y	N	N	Y
Cryptobia bullocki	Y	Y	Y	N	N	Y
Cryptobia borreli	Y	Y	Y	N	N	Y
Henneguya spp	Y	Y	Y	N	N	Y
Microsporidium spp	Y	Y	Y	N	N	Y
Sphaerospora carassii	Y	Y	Y	N	N	Y
Sphaerospora renicola	Y	Y	Y	N	N	Y
Trypanosoma carassii	Y	Y	Y	N	N	Y
Trypanosoma murmanensis	Y	Y	Y	N	N	Y
Nematodes						
Philometra lusiana	Y	Y	Y	N	N	Y
Philometroides fulvidraconi	Y	Y	Y	N	N	Y
Monogeneans						
Benedenia epinephali	Y	Y	Y	N	N	Y
Benedenia melleni	Y	Y	Y	N	N	Y
Benedenia monticelli	Y	Y	Y	N	N	Y
Benedenia pargueraensis	Y	Y	Y	N	N	Y
Benedenia seriolae	Y	Y	Y	N	N	Y
Dactylogyrus extensus	Y	Y	Y	N	N	Y
Dactylogyrus vastator	Y	Y	Y	N	N	Y
Digeneans						
Clinostomum marginatum	Y	Y	Y	N	N	Y
Sanguinicola spp	Y	Y	Y	N	N	Y
Cestodes						
Caryophyllaeus fimbriceps	Y	Y	Y	N	N	Y
Eubothrium crassum	Y	Y	Y	N	N	Y
Eubothrium salvalini	Y	Y	Y	N	N	Y
Khawa sinensis	Y	Y	Y	N	N	Y
Crustaceans						
Argulus coregoni	Y	Y	Y	N	N	Y
Argulus foliaceus	Y	Y	Y	N	N	Y
Ergasilus sieboldi	Y	Y	Y	N	N	Y
Lernaea elegans	Y	Y	Y	N	N	Y

Y = yes; N = no
* some strains occur

Table 3.2
Disease agents that will not be further considered in the IRA

DISEASE AGENT / PEST	1 — LIKELY ORNAMENTAL FINFISH ACRRIER	2 — DISEASE AGENT IS INFECTIOUS	3A — AGENT OR STRAIN EXOTIC TO AUSTRALIA	3B — CONTROL PROGRAM IN AUSTRALIA	4A — OIE LISTED	4B — SIGNIFICANT EFFECT
Viruses						
Infectious haematopoietic necrosis virus (IHNV)	N	Y	Y	N	Y	Y
Herpesvirus cyprini (carp pox, epithelioma papillosum)	Y	Y	Y	N	N	N
Viral haemorrhagic septicaemia (VHSV)	N	Y	Y	N	Y	Y
Bacteria						
Aeromonas hydrophila	Y	Y	N	N	N	Y
Citrobacter freundii	Y	Y	N	N	N	Y
Edwardsiella tarda	Y	Y	N	N	N	Y
Flavobacterium columnare	Y	Y	N	N	N	Y
Flavobacterium psychrophilum	N	Y	Y	N	N	Y
Flexibacter maritimus	Y	Y	N	N	N	Y
Micrococcus luteus	N	Y	Y	N	N	Y
Mycobacterium chelonae	Y	Y	N	N	N	Y
Mycobacterium fortuitum	Y	Y	N	N	N	Y
Mycobacterium marinum	Y	Y	N	N	N	Y
Nocardia kampachi/seriolae	N	Y	Y	N	N	Y
Nocardia asteroides	Y	Y	Y	N	N	N
Photobacterium damselae damselae	Y	Y	N	N	N	Y
Pseudomonas chlororaphis	N	Y	Y	N	N	Y
Pseudomonas fluorescens	Y	Y	N	N	N	Y
Renibacterium salmoninarum	N	Y	Y	N	Y	Y
Streptococcus iniae	Y	Y	N	N	N	Y
Vibrio anguillarum	Y	Y	N*	N	N	Y
Vibrio cholerae	Y	Y	N	N	N	Y
Vibrio ordalii	Y	Y	N	N	N	Y
Vibrio salmonicida	N	Y	Y	N	N	Y
Fungi						
Aphanomyces invadans	Y	Y	N	N	Y	Y
Branchiomyces sanguinis	N	Y	Y	N	N	Y
Branchiomyces demigrans	N	Y	Y	N	N	Y
Ichthyophonus hoferi	Y	Y	N	N	N	Y
Saprolegniaceae	Y	Y	N	N	N	Y
Protozoans						
Chilodonella cyprini	Y	Y	N	N	N	Y
Chilodonella hexasticha	Y	Y	N	N	N	Y
Cryptobia salmositica	N	Y	Y	N	N	Y
Cryptocaryon irritans	Y	Y	N	N	N	Y
Glugea spp	Y	Y	N	N	N	N
Goussia carpelli	Y	Y	N	N	N	Y
Hoferellus carassi	Y	Y	N	N	N	Y
Hoferellus cyprini	Y	Y	N	N	N	Y
Ichthyophthirius multifiliis	Y	Y	N	N	N	Y
Kudoa spp	Y	Y	N	N	N	Y

Table 3.2 continued

Disease agents that will not be further considered in the IRA

DISEASE AGENT / PEST	1 — LIKELY ORNAMENTAL FINFISH ACRRIER	2 — DISEASE AGENT IS INFECTIOUS	3A — AGENT OR STRAIN EXOTIC TO AUSTRALIA	3B — CONTROL PROGRAM IN AUSTRALIA	4A — OIE LISTED	4B — SIGNIFICANT EFFECT
Protozoans (continued)						
Parvicapsula spp	Y	Y	Y	N	N	N
Pleistophora hyphressobryconis	Y	Y	N	N	N	Y
Scyphidia spp	Y	Y	Y	N	N	N
Tetrahymena corlissi	Y	Y	Y	N	N	N
Trichodina spp	Y	Y	N	N	N	Y
Trichdinella spp	Y	Y	N	N	N	N
Trichophrya spp	Y	Y	N	N	N	N
Tripartiella spp	Y	Y	N	N	N	N
Nematodes						
Camallanus spp	Y	Y	N	N	N	Y
Capillaria spp	Y	Y	Y	N	N	N
Monogeneans						
Gyrodactylus spp	Y	Y	Y	N	N	N
Digeneans						
Cryptocotyle lingua	Y	Y	Y	N	N	N
Cestodes						
Bothriocephalus acheilognathi	Y	Y	N	N	N	Y
Triaenophorus crassus	Y	Y	Y	N	N	N
Triaenophorus nodulosis	Y	Y	Y	N	N	N
Crustaceans						
Argulus japonicus	Y	Y	N	N	N	Y
Ceratothoa imbricata	Y	Y	N	N	N	Y
Ceratothoa gaudichaudii	N	Y	Y	N	N	Y
Lernaeocera branchalis	Y	Y	N	N	N	Y
Mothocya parvostis	N	Y	Y	N	N	Y
Nerocila orbignyi	Y	Y	N	N	N	Y

Y = yes; N = no
* some strains occur

Systemic iridovirus infections have been reported in Ramirez's dwarf cichlids (*Apistogramma ramirezi*) with 100% morbidity and up to 80% mortality (Leibovitz and Riis 1980). Iridovirus causing anaemia and mortality has been detected in the chromide cichlid (*Etroplus maculatus*) (reviewed in Bernoth and Crane 1995; McAllister and Stoskopf 1993). Iridovirus has also been reported from diseased gouramis (*Trichogaster* spp) (Anderson et al 1993; Fraser et al 1993) and angelfish (*Pterophyllum scalare*) (Rodgers et al 1997). The relationship of these viruses to ENV is uncertain.

ENV, RSIV and iridoviruses associated with ornamental finfish will be further considered in this IRA.

Goldfish haematopoietic necrosis virus (GFHNV)

A herpes virus isolated from moribund fish in Japan has caused epizootics of herpes viral haematopoietic necrosis of goldfish (HVHN) in cultured goldfish (*Carassius auratus*) with mortality rates approaching 100% (Jung and Miyazaki 1995). Diseased fish appear weak but do not exhibit other external signs. Internally, the spleen and kidney are discoloured and develop necrotic foci in the haematopoietic tissue, spleen, pancreas and lamina propria of the intestine. Carp (*Cyprinus carpio*) are not susceptible to this virus (Jung and Miyazaki 1995).

Sporadic cases of herpes-like virus have been reported from goldfish in Australia (reviewed in Humphrey 1995). The relationship of these to GFHNV is uncertain.

GFHNV will be further considered in this IRA.

Infectious pancreatic necrosis virus (IPNV)

In this IRA, the disease 'infectious pancreatic necrosis' (IPN) is defined as an acute disease of juvenile salmonids caused by infection with any one of several strains of aquabirnavirus. The various strains of virus that cause IPN — referred to as infectious pancreatic necrosis virus (IPNV) — differ in virulence and serological characteristics.

Two distinct serogroups of aquabirnaviruses have been identified (Hill and Way 1995). More than 18 strains of aquabirnavirus in both serogroups were isolated from non-salmonid fish.

Aquabirnaviruses have been identified in ornamental finfish species listed on Schedule 6. However, the relationship between these isolates and IPNV has not been established.

The clinical signs of disease caused by different aquabirnaviruses are markedly different. IPNV causes disease and mortalities in young salmonids. Natural diseases caused by aquabirnaviruses in farmed fish include yellowtail ascites, Japanese flounder ascites and eel nephritis. The aetiological agents of these diseases cross-reacted serologically with IPNV. Except for IPN, aquabirnavirus diseases occur in marine animals or in animals which spend most of their life in seawater (Reno 1999).

IPN is listed by the OIE as an 'other significant' disease (OIE 1997a) and can cause up to 100% mortality in salmonid fry (reviewed in Bernoth and Crane 1995). In non-salmonids, high mortalities occur among acutely affected fish but classic pancreatic necrosis is not observed (McAllister and Stoskopf 1993).

IPN and IPN-like viruses have a broad host range, affecting at least 20 fish families (including salmonids), from both fresh and marine waters as well as invertebrates. These viruses, including IPNV, are widespread in Europe (including UK), North America, Chile and Asia. Although an aquabirnavirus was recently isolated from several marine fish species (including sea-caged farmed Atlantic salmon and rainbow trout) on the west coast of Tasmania (Crane et al 1999), IPNV (aquabirnavirus which is pathogenic for salmonids) has not been reported in salmonids in Australia (M Crane pers. comm.).

IPNV will be further considered in this IRA.

Pike fry rhabdovirus (PFR)

Also known as hydrocephalus or red disease of pike, PFR is an infrequently reported, acute to subacute haemorrhagic syndrome associated with generalised oedema, haematopoietic necrosis and high mortality in pike fry (*Esox lucius*) (reviewed in Humphrey 1995). The disease occurs naturally throughout eastern and western Europe (McAllister 1993). PFR is readily transmitted by contact and by exposure to waterborne infectivity (Wolf 1988), and has not been reported in Australia.

The virus has been isolated from grass carp (*Ctenopharyngdon idella*), tench (*Tinca tinca*), white bream (*Blicca bjoerkna*) and stone moroko (*Pseudorasbora parva*) (reviewed in Humphrey 1995). Grass carp and white bream show haemorrhages on the ventral body surface and at the scale bases and ascites; tench show haemorrhages in the skin and at scale bases; and in the gudgeon PFR infection is inapparent (McAllister 1993). Serious disease has been observed only in pike (McAllister 1993). Serological evidence suggests PFR is distinct from SVCV and IHNV (reviewed in Humphrey 1995).

PFR will be further considered in this IRA.

Spring viraemia of carp virus (SVCV), *Rhabdovirus carpio*

Spring viraemia of carp (SVC) is listed by the OIE as a notifiable disease (OIE 1997a). The agent is a rhabdovirus causing mortality throughout Europe where carp are cultured (Wolf 1988). Clinical signs are mostly non-specific and include lethargy, darkening of the skin and loss of balance, oedema and necrosis in organs such as liver, pancreas, kidney, heart, brain, intestine and swimbladder.

SVC occurs mainly in young fish of all major cyprinid species. The disease can be transmitted by blood-sucking parasites such as fish lice (*Argulus foliaceus*) and leeches (*Piscicola geometra*). Fish species from other families are also susceptible to SVC, including pike (*Esox lucius*) and sheatfish (*Silurus glanis*) (OIE 1997b). Guppies are susceptible to experimental infection with spring viraemia of carp virus (SVCV) (reviewed in Bernoth and Crane 1995).

The virus was initially limited to the European continent (Wolf 1988; OIE 1997b). SVC has spread to many regions since 1929, including to the UK in 1988, almost certainly as a result of live fish transportation. The spread to new locations is often associated with grass carp (*Ctenopharyngodon idella*), which is resistant to the disease but acts as a carrier of the virus (reviewed in Humphrey 1995). Most recently, SVCV was isolated from goldfish and koi carp originating from China (Hill 1998). SVCV has not been recorded from Australia. All consignments of goldfish (*Carassius auratus*) imported to Australia must be accompanied by a government certificate attesting that the goldfish originate from a country considered free from spring viraemia of carp (SVC) or from premises at which there has been no evidence of the presence of SVC for the three months immediately prior to shipment.

SVCV will be further considered in this IRA.

Viral encephalopathy and retinopathy virus (VERV)

VERV is a nodavirus that causes vacuolating encephalopathy and retinopathy in larvae and juveniles of various fish species. The disease is also known as viral nervous necrosis (VNN). The virus has been detected in Australia in association with mass mortality in hatchery-raised larval and juvenile barramundi (Munday et al 1992). The disease is listed as 'other significant' by the OIE (OIE 1997a). The molecular biology and epidemiological data indicate that there is more than one virus causing viral encephalopathy and retinopathy in various fish species. Only one is known from Australia, while viruses of a number of fish species are reported in northern Asia and Europe (OIE 1997b).

New South Wales, Western Australia and South Australia impose movement restrictions on live barramundi with respect to VERV. Fingerlings are required to test negative for VER before entry into these States

Isolates of this virus have been reported in Europe and Australasia from many fish species, including the serranid *Epinephlus akaara* (OIE 1997b).

Given its association with finfish related to Schedule 6 species and the imposition of movement restriction on live barramundi (*Lates calcarifer*) in New South Wales, Western Australia and South Australia. VERV will be further considered in this IRA.

3.2.2 VIRUSES THAT WILL NOT BE FURTHER CONSIDERED IN THE IRA

Infectious haematopoietic necrosis virus (IHNV)

Infectious haematopoietic necrosis (IHN) is listed by the OIE as a notifiable disease (OIE 1997a). It is an acute rhabdoviral disease commonly occurring in wild and cultured salmonids. Mortalities approaching 100% occur typically among fry or fingerlings. In affected fish, major necrosis occurs in kidneys, haematopoietic tissues, pancreas, the gastrointestinal tract, and adrenal cortex. Survivors of IHNV infection develop protective immunity (Wolf 1988; OIE 1997b).

IHNV has been isolated from an individual Pacific herring (Kent 1998). White sturgeon (*Acipencer transmonatus*) and pike (*Esox lucius*) are susceptible to infection under experimental conditions (LaPatra 1995; OIE 1997b).

The geographic distribution of IHNV was limited to the Pacific rim of North America, but is now also present in continental Europe and Japan (reviewed in Humphrey 1995). The agent has not been reported in Australia.

Given that species reported to host IHNV belong to families and orders not included in Schedule 6, IHNV will not be further considered in this IRA.

Herpesvirus cyprini

Herpesvirus cyprini is also termed carp pox or epithelioma papillosum. In koi carp (*Cyprinus carpio*) it causes lesions on the body surface and fins, often coalescing to cover large areas of the epidermis. Although fish growth may be retarded, mortalities have not been reported. The infection remains mostly latent with disease symptoms appearing when fish are stressed (McAllister and Stoskopf 1993; reviewed in Bernoth and Crane 1995; Hedrick et al 1990).

This is a chronic viral infection affecting mainly fish older than one year in a wide range of cyprinids and other aquarium fish species.

The disease has a wide geographic distribution in North America, Asia and Europe (McAllister and Stoskopf 1993; reviewed in Bernoth and Crane 1995), but has not been reported in Australia.

As *Herpesvirus cyprini* is not considered to be a serious pathogen, this viral agent will not be further considered in this IRA.

Viral haemorrhagic septicaemia virus (VHSV)

Also termed Egtved disease, viral haemorrhagic septicaemia (VHS) is listed by the OIE as a notifiable disease (OIE 1997a). It is a rhabdoviral disease causing acute to chronic disease characterised by visceral haemorrhage and necrosis leading to high mortality (review by Humphrey 1995).

VHS affects many coldwater fish species, including salmonids, grayling (*Thymallus thymallus*), turbot (*Scophthalmus maximus*), cod (*Gadus* spp) and herring (*Culpea* spp) (OIE 1997b).

VHS has not been reported in Australia.

Given that species reported to host VHSV belong to families and orders not included in Schedule 6, VHSV will not be further considered in this IRA.

3.3 Bacteria

3.3.1 BACTERIA THAT WILL BE FURTHER CONSIDERED IN THE IRA

Aeromonas salmonicida

Aeromonas salmonicida causes a number of acute to chronic disease syndromes of fish, including furunculosis, goldfish ulcer disease, carp erythrodermatitis and ulcer disease of flounder.

The present taxonomy of *A. salmonicida* is ambiguous (Wiklund and Dalsgaard 1998). McCarthy and Roberts (1980) classified *A. salmonicida* into three subspecies, namely: *A salmonicida salmonicida, A. salmonicida* '*nova*' and *A. salmonicida achromogenes.* Bergey's Manual lists four subspecies: *A. salmonicida masoucida*, *A. salmonicida achromogenes*, *A. salmonicida smithia* and *A. salmonicida salmonicida* (Holt et al 1994). The relationship between the goldfish ulcer disease (GUD) biovar of *A. salmonicida* and either *A. salmonicida* '*nova*' or *A. salmonicida smithia* is uncertain. The taxonomic validity of the *A. salmonicida 'nova'* subspecies is also unclear. For the purpose of this IRA, the agent causing GUD will be referred to as '*A. salmonicida* GUD biovar'. *A. salmonicida achromogenes* is an atypical variety of *A. salmonicida* reported from salmonids and includes the former *A. achromogenes* and *A. masoucida*.

A. salmonicida salmonicida, known as the 'typical' strain of *A. salmonicida*, is reported from both salmonids and non-salmonids, causing a variety of diseases including furnunculosis of salmonids. *A. salmonicida* GUD biovar,

an atypical strain of *A. salmonicida*, is reported from non-salmonids (Carson and Handlinger 1988).
This biovar causes GUD in goldfish (*Carassius auratus*) and koi carp (*Cyprinus carpio*) and has been shown to cause disease experimentally in salmonids (Carson and Handlinger 1988).

A. salmonicida salmonicida has not been reported in Australia. A strain of *A. salmonicida* has been isolated from greenback flounder (*Rhombosolea tapirina*) in Tasmania and has been demonstrated to be culturally and biochemically distinct from both *A. salmonicida salmonicida* and *A. salmonicida* GUD biovar (J Carson pers. comm.). *A. salmonicida* GUD biovar is end.emic in Australia (Hamilton et al 1981; reviewed in Humphrey and Ashburner 1993; Sövényi et al 1988; Whittington and Cullis 1998; Whittington et al 1987) and is subject to specific movement restrictions in Tasmania and Western Australia.

All subspecies of *A. salmonicida*, will be further considered in this IRA, including *A. salmonicida* GUD biovar. Although this form occurs in Australia, there are specific movement restrictions imposed by Tasmania and Western Australia in relation to this agent.

Chlamydia / Rickettsia

These organisms are coccobacilliary, prokaryotic, obligate intracellular parasites, the chlamydias showing a more complicated cell division cycle than the rickettsias. They result in significant disease and economic impact (Inglis et al 1993; Khoo et al 1995), particularly in the case of *Piscirickettsia salmonis,* a major problem in Chilean marine salmonid aquaculture. Gross disease caused by rickettsia-like organisms isolated from blue-eyed plecostomus (*Panaque suttoni*) has involved renomegly, splenomegly and emaciation (Khoo et al 1995).

Epitheliocystis is caused by a *Chlamydia* found in a variety of marine and freshwater fish groups, including salmonids, cichlids and cyprinids, and (McCormick et al 1995) in leafy sea dragons (*Phycodurus eques*) in South Australian waters. Rickettsia-like organisms have also been isolated from blue-eyed plecostomus (*Panaque suttoni*), a South American freshwater ornamental finfish (Khoo et al 1995).

Piscirickettsia salmonis has not been reported in Australia. Both chlamydial and rickettsial organisms have been isolated from fish in Australia (McCormick et al 1995; Anderson and Prior 1992).

The OIE classifies disease due to infection with *P. salmonis* as an 'other significant' disease. Given the significant disease and economic impact associated with the Chlamydia / Rickettsia group, particularly *Piscirickettsia salmonis,* and uncertainty on the degree of similarity between Australian and exotic species, *Chlamydia* and *Rickettsia* spp will be further considered in this IRA.

Edwardsiella ictaluri

One of two main pathogens of fresh water aquatic animals belonging to this genus, *E. ictaluri* is of pathological and economic significance (reviewed in Humphrey 1995; Kuo and Chung 1994; Kusuda et al 1977; Hawke 1979; Humphrey et al 1986).

E. ictaluri has been recovered from a range of species including from diseased *Puntius conchonis* (reviewed in Humphrey 1995; Kuo and Chung 1994; Kusuda et al 1977; Hawke 1979; Humphrey et al 1986).

E. ictaluri has been isolated from imported ornamental finfish under quarantine detention in Australia (Cahill 1987).

E. ictaluri will be further considered in this IRA.

Photobacterium damselae piscicida

P. damselae piscicida (formerly *Pasteurella piscicida*) is a halophilic bacterium identified as an important pathogen of cultured marine fish, particularly in Japan (Inglis et al 1993). Typical pathological change includes granulomatous pseudo-tubercles in kidney and spleen as well as widespread internal necrosis.

P. damselae piscicida has not been reported in Australia. *P. damselae piscicida* has been associated with disease in a wide range of host fish species, including bream (*Pagrus pagrus*), grouper (*Epinephelus akaara*) and sole (*Solea solea*) (Daly 1999).

This subspecies will be further considered in this IRA.

Pseudomonas anguilliseptica

P. anguilliseptica is a serious pathogen of pond-cultured eels in Japan (Austin and Austin 1993). Eels and several other species, including goldfish, have been shown to be experimentally susceptible to *P. anguilliseptica* (Inglis et al 1993).

P. anguilliseptica has not been reported in Australia (reviewed in Humphrey 1995).

P. anguilliseptica will be further considered in this IRA.

***Yersinia ruckeri* (Hagerman strain)**

Yersinia ruckeri, a member of the Enterobacteriaceae, is is a recognised fish pathogen that causes enteric redmouth (ERM) in salmonids. At least five serotypes have been identified. The preferred serotyping scheme is that devised by Romalde et al (1993), which comprises serotypes O1 to O4 (Romalde et al 1993). Serotype O1 is subdivided into O1a and O1b. Serotype O1a (formerly Type 1) is the 'Hagerman strain', the most common and virulent of the serotypes (Inglis et al 1993; Austin and Austin 1993). The other serotypes are considered relatively avirulent.

Whereas all four serotypes are present in Europe and North America, only serotype 01b (which is moderately pathogenic in Atlantic salmon (J Carson pers. comm.) has been identified in Australia (Davies 1991). Although *Y. ruckeri* has been known to exist in Australia since the 1960s, there have been very few problems with disease and relatively few isolates have been described. In a survey of Australian fish farms, it was concluded that the virulent 'Hagerman' strain of *Y. ruckeri* was exotic to Australian Atlantic salmon (Humphrey et al 1987). Davies (1991) divided 135 strains of ERM bacterium by biotype, serotype and outer membrane protein. He demonstrated that the Hagerman strain is present in Bulgaria, Denmark, France, Italy, Switzerland, West Germany, Canada and the United States (Davies 1991).

The Hagerman strain of *Y. ruckeri* has been reported from goldfish probably originating from Singapore (McArdle and Dooley-Martyn 1985).

The Hagerman strain of *Y. ruckeri* will be further considered in this IRA.

3.3.2 BACTERIA THAT WILL NOT BE FURTHER CONSIDERED IN THE IRA

Aeromonas hydrophila

Inglis et al (1993) grouped the several aeromonads described in the literature into three main species of motile aeromonads (*A. hydrophila, A. caviae* and *A. sobria*) and the non-motile *A. salmonicida*, suggesting that many of the currently recognised strains of *A. hydrophila* may in future be reclassified into separate species.

A. hydrophila occurs naturally in fresh waters worldwide, including Australia (reviewed in Humphrey 1995); it is generally considered to be a secondary pathogen (Austin and Austin 1993) although more virulent strains are emerging.

Because *A. hydrophila* is present in Australia, it will not be further considered in this IRA.

Citrobacter freundii

Citrobacter freundii, a member of the Enterobacteriaceae, is increasingly being recognised as an emerging primary pathogen after being implicated in serious disease in rainbow trout and Atlantic salmon in Spain, the United States and Scotland (Austin and Austin 1993).

The ornamental species affected by *C. freundii* include Schedule 6 species such as *Symphosydon aequifasciatus*, *Pterophyllum altum* and *Poecilia reticulata* (Kuo and Chung 1994).

Citrobacter have been isolated from ornamental fish from Taiwan, Singapore, Bangkok and Hong Kong, both in fish tissue and shipment water (Shotts et al 1976). *C. freundii* has been identified from several ornamental species in Japan (Kuo and Chung 1994) and has been isolated from diseased angelfish (J Carson pers. comm.), diseased goldfish (L Owen pers. comm.), and redclaw crayfish (*Cherax quadricarinatus*) in Australia (Webster 1995).

Given its presence in Australia, *Citrobacter freundii* will not be further considered in this IRA.

Edwardsiella tarda

One of two main pathogens of freshwater aquatic animals belonging to this genus, *E. tarda* is of pathological and economic significance (reviewed in Humphrey 1995; Kuo and Chung 1994; Kusuda et al 1977; Hawke 1979; Humphrey et al 1986).

E. tarda has been isolated from a wide range of fish species, including tilapia, grass carp (*Ctenopharyngodon idella*), angelfish (*Pterophyllum scalare*) and Siamese fighters (*Betta splendens*) (reviewed in Humphrey 1995; Kuo and Chung 1994; Kusuda et al 1977; Hawke 1979; Humphrey et al 1986).

E. tarda has been reported in Australia, isolated from diseased rainbow trout (*Oncorhynchus mykiss*) and Australian eels (*Anguilla reinhardtii*) (Reddacliff et al 1996; Ketterer et al 1990).

As *E. tarda* has been recorded in Australia, it will not be further considered in this IRA.

Flavobacterium columnare

Flavobacterium columnare (formerly *Flexibacter columnaris*) causes columnaris, saddleback or cotton wool disease, commonly associated with freshwater aquaria-kept ornamentals, including *Symphosydon aequifasciatus, Pterophyllum altum, Poecilia reticulata, Chiclasoma severum* and the Japanese loach (*Misgurnus anguillicaudatus*) (Kuo and Chung 1994; Chowdhury and Wakabayashi 1990; Shotts et al 1976; Cahill 1987).

Given the cosmopolitan distribution of *F. columnare* throughout the world, including Australia, it will not be further considered in this IRA.

Flavobacterium psychrophilum

Flavobacterium psychrophilum (formerly *Flexibacter psychrophilus*) causes coldwater or peduncle disease in salmonids.

It has only been recorded from salmonids (reviewed in Humphrey 1995) and has been reported in Australia (Schmidtke and Carson 1995).

F. psychrophilum will not be further considered in this IRA.

Flexibacter maritimus

Flexibacter maritimus causes saltwater columnaris disease in marine finfish.

Flexibacter maritimus has been recorded from Australia (reviewed in Humphrey 1995) and will not be further considered in this IRA.

Micrococcus luteus

Micrococci are aerobic, gram-positive cocci generally not associated with disease in fish. An exception is *Micrococcus luteus* which is the agent of rainbow trout fry syndrome (Austin and Austin 1993).

Unspecified micrococci have been isolated overseas from fish and water of ornamental fish shipments originating from Taiwan, Singapore, Bangkok and Hong Kong (Shotts et al 1976). *M. luteus* is present in Australia though not associated with disease in fish (J Carson pers. comm.).

Given that *M. luteus* has not been reported from ornamental finfish, this species will not be further considered in this IRA.

Mycobacterium marinum, M. fortuitum and *M. chelonae*

Mycobacteriosis affects a wide range of freshwater and marine aquarium fish (Noga 1996; Lansdell et al 1993; Huminer et al 1986; Gomez et al 1993). Three species, *Mycobacterium marinum, M. fortuitum,* and *M. chelonae*, have been associated with disease in fish (Noga 1996; Austin and Austin 1993). *M. marinum, M. fortuitum* and *M. chelonae* have been isolated from fish in Australia (reviewed in Humphrey 1995; Inglis et al 1993) and will not be further considered in this IRA.

Nocardia asteroides and *Nocardia 'kampachi'/seriolae*

Nocardiosis of fish is usually a chronic disease, occurring sporadically and affecting only a small percentage of a fish population, causing light mortalities. An exception is *N. 'kampachi'/seriolae*, which is an important pathogen of cultured yellowtail in Japan but does not appear to have been recorded from any other species of fish (Inglis et al 1993, Austin and Austin 1993). *N. seriolae* includes isolates formerly described as *N. 'kampachi'* (Kudo et al 1988). *N. asteroides* has been isolated from neon tetras, giant gouramis, salmonids and yellowtail (Stoskopf 1993a).

Although *N. asteroides* is reported to have a worldwide distribution, it has not been reported to cause fish disease in Australia (J Carson pers. comm.).

Because of the apparent host specificity of *N. 'kampachi'/seriolae*, it will not be further considered in this IRA. Given the low pathogenicity of *N. asteroides,* it will not be further considered in this IRA.

Photobacterium damselae damselae

Photobacterium damselae damselae (formerly *Vibrio damsela*) was originally reported causing disease in damselfish (*Chromis punctipinnis*) (Ketterer and Eaves 1992).

P. damselae damselae has been reported in Australia, causing septicaemia and mortality in eels (*Anguilla reinhardtii*) (Ketterer and Eaves 1992), and will not be further considered in this IRA.

Pseudomonas fluorescens* and *P. chlororaphis

Three pseudomonads, *Pseudomonas anguilliseptica*, *P. fluorescens*, and *P. chlororaphis*, are considered pathogenic to fish.

There has been only one report of *P. chlororaphis* affecting fish — an outbreak involving heavy mortality in farmed amago trout (*Oncorhynchus rhodurus*) (Austin and Austin 1993). *P. fluorescens* is ubiquitous in fresh water and has been reported to cause disease in a variety of species (Inglis et al 1993), including rainbow trout and various cyprinids such as goldfish (Inglis et al 1993). *P. fluorescens* has a cosmopolitan, worldwide distribution (reviewed in Humphrey 1995), including Australia (Austin and Austin 1993). Given its presence in Australia, *P. fluorescens* will not be further considered in this IRA. *P. chlororaphis* has not been reported in Australia (review by Humphrey 1995); nevertheless, given its host-specificity and range, it will not be further considered in this IRA.

Renibacterium salmoninarum

Renibacterium salmoninarum causes bacterial kidney disease (BKD) in farmed and wild salmon. The disease is listed by the OIE as an 'other significant' disease.

R. salmoninarum does not occur in Australia, but it has only been reported from salmonids (OIE 1997b) and will not be further considered in this IRA.

Streptococcus iniae

Streptococci are an emerging problem in both freshwater and marine aquaculture. *Streptococcus iniae* has been associated with septicaemia leading to significant mortality in aquaculture (Stoffregen et al 1996; Eldar et al 1995; Sugita 1996; Perera et al 1996).

Streptococcosis of fish is associated with a wide range of species including cichlids and salmonids (Eldar et al 1995; Perera et al 1996).

S. iniae has been isolated from *Lates calcarifer* in Australia (Bromage et al in press).

Given its presence in Australia, *S. iniae* will not be further considered in this IRA.

Vibrio anguillarum, Vibrio cholerae* (Non O1), *Vibrio ordalii* and *Vibrio salmonicida

Vibriosis is a disease caused by infection with bacteria belonging to the genus *Vibrio*. Members of the genus are ubiquitous in marine environments and include significant pathogens such as *V. anguillarum*, *V. ordalii* and *V. salmonicida*.

V. anguillarum (serotype 01) and *V. ordalii* have been detected in marine waters and sediments around Tasmania (Cameron et al 1988); they have been associated with disease in salmonids and mullet and other fish in a variety of locations within Australia. *V. salmonicida* has only been isolated from salmonids and gadoids (Noga 1996). *Vibrio cholerae* is a pathogen of ornamental finfish and can be recovered from the aquatic environment, both freshwater and seawater. Isolates tend to be non O1 serotypes and not the classical toxigenic human *V. cholerae* strains. Non O1 *V. cholerae* has been isolated in Australia from diseased goldfish recently imported from Singapore (Reddacliff et al 1993) and from farmed barramundi in Western Australia (B Jones pers. comm.).

Because *V. anguillarum,* Non O1 *V. cholerae* and *V. ordalii* occur in Australia, and because *V. salmonicida* has a limited host range, *Vibrio* spp will not be further considered in this IRA.

3.4 Fungi

3.4.1 FUNGI THAT WILL BE FURTHER CONSIDERED IN THE IRA

No fungal pathogens lie in this category.

3.4.2 FUNGI THAT WILL NOT BE FURTHER CONSIDERED IN THE IRA

Aphanomyces invadans

Aphanomyces invadans has been identified as a primary aetiological component of epizootic ulcerative syndrome (EUS), a major disease affecting both wild and farmed fish. Over 100 freshwater and a number of brackish water species have been found to be susceptible (OIE 1997b). EUS is an OIE-listed disease designated as an 'other significant disease' (OIE 1997a).

EUS is considered identical to red-spot disease affecting various fish species in Australia (Lilley et al 1997; Callinan et al 1995).

Given its presence in Australia, *A. invadans* will not be further considered in this IRA.

Branchiomyces sanguinus* and *B. demigrans

The genus *Branchiomyces* has been associated with gill invasion and serious disease in a wide range of freshwater finfish species, including carp, tench, eels and pike (reviewed in Humphrey 1995). Two species, *B. sanguinis* and *B. demigrans*, are described in the literature. They have not been associated with Schedule 6-listed fish species.

Branchiomyces of uncertain species have been reported in Australia (reviewed in Humphrey 1995).

B. sanguinis and *B. demigrans* will not be further considered in this IRA.

Ichthyophonus hoferi

Ichthyophonus hoferi is typically associated with lesions in the more highly vascularised organs such as the heart, liver and spleen (Noga 1996). It causes disease in a variety of marine finfish species and has been isolated from fish in Australia (reviewed in Humphrey 1995).

Given its presence in Australia, *I. hoferi* will not be further considered in this IRA.

Saprolegniaceae

Saprolegnia infections occur commonly in ornamental fish (Reddacliff 1985). Saprolegniaceae are ubiquitous in freshwater ecosystems and appear to infect most species of fish as secondary invaders (Goven-Dixon 1993). Integumental damage and low water temperature initiate hyphal growth, leading to ulceration of the epidermis which results in osmoregulatory failure (reviewed in Humphrey 1995).

Because of their worldwide distribution, *Saprolegnia* spp will not be further considered in this IRA.

3.5 Protozoans

3.5.1 PROTOZOANS THAT WILL BE FURTHER CONSIDERED IN THE IRA

***Acanthamoeba* spp**

Members of this genus can cause severe disease in vertebrates, including in humans (Lom and Dyková 1992). Clinical signs in fish include gill swelling, ascites, emaciation and general haemorrhage (Woo and Poynton 1995). Several *Acanthamoeba* species have been associated with significant disease and economic loss in cultured fish. *Acanthamoeba polyphaga* is believed to be responsible for severe losses in the cichlid *Tilapia aureus* (Taylor 1977). *Acanthamoeba*-like organisms have been associated with severe proliferative gill disease and systemic granulomatosis in the European catfish (*Silurus glanis*) (Nash et al 1988).

Species of *Acanthamoeba* have also been found to infect goldfish and roach (Dyková et al 1996).

Acanthamoeba spp have not been recorded from finfish in Australia.

The genus *Acanthamoeba* will be considered further in this IRA.

Brooklynella hostilis

Brooklynella is the marine equivalent of the genus *Chilodonella*. *B. hostilis* is a highly lethal pathogen associated with gill epithelial destruction, haemorrhage, respiratory dysfunction, disorientation and death, and has been reported to cause disease in both wild and captive marine fish, such as angelfish and dhufish, from a wide range of geographic locations (Landsberg and Blakesley 1995; Langdon 1990b).

An unknown species of *Brooklynella* has been recorded in Australia from dhufish.

B. hostilis will be further considered in this IRA.

Cryptobia **spp**

Of the several species belonging to this genus, *Cryptobia salmositica*, *C. borreli* and *C. (Trypanoplasma) bullocki* are of considerable economic importance, causing disease and mortality in many fish species, both feral and cultured (Lom and Dyková 1992). *C. salmositica* is highly pathogenic to salmonids and can exist in some host species without causing clinical disease (Lom and Dyková 1992). *C. borreli* is the cause of sleeping sickness of carp, with high parasitaemia causing diffuse degenerative changes, anaemia and ascites leading to significant mortality, particularly in first year carp (Barckhausen-Kiesecker 1996; Dyková and Lom 1979). *C. carassi* of goldfish is a synonym for *C. borreli* (Lom and Dyková 1992). *C. bullocki* causes progressive ascites leading to gross ulcerative lesions, oedema, haemorrhage and necrotic changes (Woo and Poynton 1995).

C. salmositica is pathogenic to salmonids, but may be carried by seven species of fish, including sculpins, sticklebacks and suckers (Lom and Dyková 1992). None of these is listed in Schedule 6 or is a closely related species. *Carassius auratus* were found to be refractory to experimental infection with *C. salmositica. C. borreli* infections have been recorded in carp, rudd, tench, roach, minnows and gobies (Lom and Dyková 1992). *C. bullocki* infections are most common in flatfish although infections have been recorded in other groups (Lom and Dyková 1992).

C. salmositica is highly pathogenic to salmonids, with a discontinuous and limited distribution from northern California to southern British Columbia (Lom and Dyková 1992).

Langdon (1990b) has reported unidentified *Trypanoplasma* associated with anaemia in goldfish, *Cryptobia* causing gill infection in *Carassius auratus* and *Cyprinus carpio* in Australia. There are no records of *Trypanoplasma/Cryptobia* spp being associated with significant disease or economic loss in Australia.

Given their wide host range, significant pathological changes and absence from Australia, *C. bullocki* and *C. borreli* will be further considered in this IRA.

Henneguya **spp**

The association of *Henneguya* with ornamental finfish is a largely incidental finding and infections appear to be only mild (Gratzek 1993). In aquarium-kept fish, infections are self-regulating and associated with limited disease (due to the lack of alternate host), but there have been significant economic and pathological effects in catfish and salmonids under aquaculture conditions (Gratzek 1993).

Species of this genus mainly infect freshwater fish, though some infections have been reported from marine fish.

Numerous unspeciated *Henneguya* infections have been recorded from Australian fish (Reddacliff 1985; reviewed in Humphrey 1995).

Given the high pathogenicity and economic losses associated with *Henneguya* infections, exotic species of this genus infecting Schedule 6 fish will be further considered in this IRA.

Microsporidium **spp**

This genus includes about 15 species and was formed to contain identifiable species for which the generic positions are uncertain (Lom and Dyková 1992). Pathological changes range from xenoma induction to liquefaction of host musculature. Xenomas are induced by *M. cotti* and an unknown species of *Microsporidium*. *M. seriolae* and another unspeciated microsporidian are important pathogens of cultured fish in Japan. Both species infect the musculature with the latter inducing liquefaction or ‘Beko’ disease (Lom and Dyková 1992). ‘Beko’ has also been described from the Red sea bream, *Pagrus major* (Amigo et al 1994). *M. takedai* infects many species of salmonids. In chronic cases lesions occur only in the heart muscle, with lesions spreading to the skeletal muscles in acute infections (Lom and Dyková 1992). Prevalence may reach 100% in some salmonid species with heavy losses in cultured and wild fish.

As the status of microsporidian species in Australia is uncertain, exotic members of the genus *Microsporidium* affecting Schedule 6 fish will be further considered in this IRA.

Sphaerospora renicola **and** ***S. carassii***

Many species of *Sphaerospora* have been reported to infect fish. These are generally coelozoic in the urinary tract of freshwater and marine species although some species have been recorded as causing gill and skin infections (Fioravanti et al 1994). Several of these species are associated with morbidity and mortality in fish. These include *S. renicola, S. molnari, S. tinca, S. ictaluri, S. carassii* and *S. epinephali.*

S. renicola is the cause of renal sphaerosporosis and swimbladder inflammation (SBI) in carp (it may also be the cause of Csaba's blood protozoan infection) (Molnar 1993). In heavy infections the parasite spreads to the eye, causing haemorrhaging and necrosis. Approximately 20% of carp fry and first-year carp from pond farms in northern Germany displayed acute or chronic signs of SBI (Korting 1984a). Disease caused by *S. carassii* is characterised by branchial and renal sphaerosporosis resulting in massive invasion, usually accompanied by high mortalities (Waluga 1983).

Sphaerospora spp are considered relatively host-specific (Lom and Dyková 1999). *S. renicola* and *S. carassii* are associated with ornamental finfish species, specifically *Carassius* spp.

Sphaerospora sp has been proposed as the cause of proliferative kidney disease (PKD), one of the most economically damaging diseases of salmonids. Kokanee salmon, chinook salmon and various salmonids from British Columbia and the United States have had natural infections of PKD associated with *Sphaerospora oncorhynchi*-like spores (Kent et al 1993 and 1995). Further, *Sphaerospora* parasites have been recorded in non-salmonid fish in direct contact with salmonids with PKD (Hedrick et al 1988). Should *Sphaerospora* be the cause of PKD, the most likely sources of infection are sticklebacks, harbouring *S. elegans,* and carp, harbouring *S. renicola* (Lom and Dyková 1992).

S. renicola is widespread in Europe, Israel, Bulgaria, the former USSR and Czechoslovakia (reviewed in Humphrey 1995; Lom and Dyková 1992). *S. carassii* was originally described in Japan and infects *Carassius auratus*, *C. carassius*, *Cyprinus carpio* and *Rutilus rutilus*. This disease is now indigenous to Europe, the former USSR and Hungary (Molnar 1979).

S. aldrichettae, *S. mayi* and several unidentified *Sphaerospora* species have been recorded in Australia (reviewed in Humphrey 1995). *S. renicola* and *S. carassii* have not been recorded in Australia (reviewed in Humphrey 1995).

S. renicola and *S. carassii* will be further considered in this IRA.

Trypanosoma carassii **and** ***T. murmanensis***

Piscine trypanosomes are transmitted by blood-sucking vectors and most species are not known to cause disease except for *Trypanosoma carassii* (*danilewski*) which, when inoculated experimentally, infects goldfish, tench, eels and a variety of ornamental fish (Woo and Poynton 1995). Infection causes anaemia and may lead to death, although usually the host recovers and is refractory to further infection (Lom and Dyková 1992). In the marine environment, *T. murmanensis* causes anaemia, emaciation and lethargy. It has caused mortality in experimentally infected cod and flounders.

Eight species of piscine trypanosomes and one undefined trypanosome have been recorded in Australia, associated with subclinical infections in eels and other native Australian fish (reviewed in Humphrey 1995). *T. carassii* and *T. murmanensis* have not been reported in Australia.

T. carassii and *T. murmanensis* will be further considered in this IRA.

3.5.2 PROTOZOANS THAT WILL NOT BE FURTHER CONSIDERED IN THE IRA

Chillodonella cyprini* and *C. hexasticha

Chillodonella are important pathogens of a wide range of temperate and tropical fish. The principal signs of infestation are respiratory distress, clamped fins and excessive mucus production, though death can be sudden with minimal signs of disease. Infestations can be severe and are a common problem encountered by retailers and wholesalers of freshwater aquarium fish (Gratzek 1993). In Europe and the Middle East, *C. cyprini* causes heavy mortalities in trout and carp hatcheries and in warmwater fish ponds, respectively (Ashburner and Ehl 1973). *C. hexasticha* is associated with seasonally recurrent (sporadically high) mortalities (Langdon et al 1985).

Both *C. cyprini* and *C. hexasticha* have been reported in Australia (Langdon and Humphrey 1988) and will not be further considered in this IRA.

Cryptobia (Trypanoplasma) salmositica

Cryptobia salmositica is highly pathogenic to salmonids and can exist in some host species without causing clinical disease (Lom and Dyková 1992). This agent has a discontinuous and limited distribution from northern California to southern British Columbia (Lom and Dyková 1992). It can be carried by seven species of fish, including sculpins, sticklebacks and suckers (Lom and Dyková 1992), none of which is listed in Schedule 6 or is a closely related species. *Carassius auratus* was found refractory to experimental infection with *C. salmositica.*

Given that it is highly unlikely to be carried by a species listed in Schedule 6, *C. salmositica* will not be further considered in this IRA.

Cryptocaryon irritans

Cryptocaryon irritans is the marine equivalent of *Ichthyophthirius multifiliis* (whitespot). Marine whitespot is the cause of serious epizootics in aquarium and farmed fish (reviewed in Humphrey 1995). The disease is characterised by dark body colouration, eyeball opacity, excessive mucus production, respiratory distress and lethargy, leading to death (Beck et al 1996).

C. irritans has been recorded in Australia from more than 13 species of fish (reviewed in Humphrey 1995; Diggles and Lester 1996) and will not be further considered in this IRA.

***Glugea* spp**

Some *Glugea* spp are highly pathogenic to fish in aquaculture and have serious economic consequences; they can also have serious effects on wild fish stocks (reviewed in Humphrey 1995). As *Glugea* infection has been associated with immunosuppression, secondary infections are likely.

Few *Glugea* species are associated with ornamental fish species. *G. heraldi*, a common pathogen of the Atlantic seahorse (*Hippocampus erectus*), causes boil-like lesions and significant mortalities to seahorses maintained in captivity (Blasiola 1981). *Glugea* spp have been tentatively identified in the ornamental cyprinids *Nothobranchius eggersi* and *N. korthausae* (Lom et al 1995).

There is limited information on the presence of *Glugea* spp in Australia. *G. atherinae* has been reported in marine fish (atherinids) in Tasmania (X Su, pers. comm.). Other *Glugea*-like species have also been reported as incidental findings in studies of pilchards and galaxids in Australia (Langdon 1992). *G. stephani* has not been reported in Australia (reviewed in Humphrey 1995; X Su pers. comm.), but this species is not known to be associated with ornamental fish (Lom and Dyková 1992).

Given the limited disease impact associated with *Glugea* spp in ornamental finfish, no further consideration will be given to the genus in this IRA.

Goussia carpelli

Goussia spp have been associated with growth retardation, emaciation and enteritis and may cause epizootic mortalities, especially under farmed conditions. In carp grow-out and hatchery operations, coccidiosis caused by *G. carpelli* leads to high financial losses, with up to 100% of young fish being affected (Osterreich 1996).

G. carpelli has been reported in Europe and North America (Oesterreich 1996) and from goldfish in Australia (Lom and Dyková 1995).

G. cichlidarum and *G. trichogasteri* have been recorded in aquarium fish (in cichlids and gouramis, respectively) (Kim and Paperna 1993; Lom and Dyková 1992). The fish coccidia, including *Goussia* spp, have narrow host rages, usually fish species within the same genus (Molnar 1995). *G. subepithelialis* and *G. sinensis* are quite host specific to common carp and silver and bighead carp, respectively. *G. carpelli* infection is probably restricted to the fish genera *Cyprinus* and *Carassius*.

In Australia, several *Goussia* species have been reported from fish, including short-finned eel (*Anguilla australis*), silver perch (*Bidyanus bidyanus*) and Murray cod (*Maccullochells peeli*) (reviewed in Humphrey 1995).

Given its presence in Australia, *G. carpelli* will not be further considered in this IRA.

Hoferellus spp

Of the *Hoferellus* species described in freshwater fish, two have been recorded as significant pathogens. *H. cyprini* is common in the renal system of cyprinids throughout Eurasia. It causes mild disease characterised by necrosis and focal inflammation (reviewed in Humphrey 1995). *H. carassii* is the cause of goldfish kidney enlargement disease (also known as goldfish bloater disease). It is a common problem in Asia, North America and Japan, with losses of up to 20% recorded (reviewed in Humphrey 1995). This genus has close morphological similarities to *Sphaerospora* and it has been proposed that *H. cyprini* may be synonymous with *Sphaerospora renicola* (Lom and Dyková 1985).

Both *H. cyprini* and *H. carassii* have been reported in Australia, (reviewed in Humphrey 1995; Munday 1996) and will not be further considered in this IRA.

Ichthyophthirius multifiliis

I. multifiliis, the aetiologic agent of white spot disease, is a very pathogenic protozoan parasite of fish, causing major problems in aquaculture. It parasitises freshwater fish in cultured and wild populations from most continents, including Australia. The parasite is likely to have spread as a result of live fish transportation. Disease outbreaks occur mostly during spring as the water warms and when the fish are spawning (Dickerson and Dawe 1995).

Since *I. multifiliis* has been reported in Australia (reviewed in Humphrey 1995), it will not be further considered in this IRA.

Kudoa spp

The genus *Kudoa* contains species which may cause disease of economic importance, many of the 37 species causing post-mortem myoliquefaction (Cheung 1993). Infection with *K. thyrsites* does not usually cause increased mortality but it does affect the market value of infected fish because of the myoliquifaction. There is usually a high degree of host specificity and a balanced relationship between parasite and host, but *K. paniformis* appears to cause heavy and continuing infections and *K. clupeidae* may induce heavy mortalities in young clupeoids (Lom and Dyková 1992).

K. thyrsites infects many species of marine fish (Cheung 1993). *K. amamiensis* is a serious pathogen of cultured yellowtail in Japan; it is thought that infection arises from associations with coral fish of the ornamental fish genera *Abudefduf*, *Chromis* and *Chrysiptera*.

Many species of *Kudoa* have been recorded in Australia, including *K. thyrsites*, *K. nova* and *K. clupeida*. *Kudoa* spp have been reported in cerebral infections of barramundi fry (*Lates calcarifer*), kingfish (*Seriola grandis*) and yellowtail kingfish (*Seriola lalandi*), resulting in pathological changes in muscle tissues (reviewed in Humphrey 1995). Infestation of southern bluefin tuna (*Thunnus maccoyii*) has also been reported (Munday 1996).

There are no statutory controls for these agents in Australia.

Kudoa spp will not be further considered in this IRA.

Parvicapsula spp

Members of this genus are generally non-pathogenic to their fish hosts. However, one unidentified species of *Parvicapsula* has been the cause of epizootics in marine pen-reared salmonids in the United States, with recorded mortalities of up to 30% (Lom and Dyková 1992).

Unidentified *Parvicapsula* spp unassociated with disease have been recorded in the tropical reef fishes, the Australian butterfly fish and the porcupine fish (Lester and Sewell 1989).

As members of the genus are generally non-pathogenic to their fish host and as it is unlikely that the species causing mortality in pen-reared salmonids in temperate waters is carried by tropical marine ornamental finfish, *Parvicapsula* will not be further considered in this IRA.

Pleistophora (Plistophora) hyphressobryconis

Pleistophora spp are invasive microsporan protozoa that have been associated with tissue destruction and epizootic mortalities. Pleistophorans are not host-specific and may cause severe disease in aquaculture (reviewed in Humphrey 1995). Infection may result in spinal curvature, equilibrium disfunction, weight loss, muscular paralysis, fin degeneration and death (Dulin 1977). *P. hyphressobryconis*, *P. anguillarum*, *P. gadi*, *P. macrozoarcides*, *P. cepediane* and *P. ovariae* have been associated with severe disease and/or death (reviewed in Humphrey 1995; Dulin 1977; Gratzek 1993).

Of these, only *P. hyphressobryconis* is associated with ornamental finfish species, affecting mainly tetras, but also a variety of other freshwater ornamental fish including angelfish, barbs, rasboras, and goldfish (Gratzek 1993; Lom and Dyková 1992).

P. hyphressobryconis occurs in neon tetras in Australia (B Jones pers. comm.) and will not be further considered in this IRA.

***Scyphidia* spp**

Scyphidia is an economically important ectoparasite of farmed trout in Europe (reviewed in Humphrey 1995) and has been reported in a cichlid (*Haplochromis* sp) (Paperna 1980). Dense colonies attached to gills or integument can result in local irritation. However, the agent is not considered a primary pathogen and is normally associated with poor husbandry conditions.

The genus *Scyphidia* has not been recorded in Australia and it will not be further considered in this IRA.

***Tetrahymena* spp**

Tetrahymena are generally free-living protozoa that occasionally become parasitic. Three species appear to be particularly pathogenic, although species identification is often uncertain. *T. corlissi* is the agent of 'Tet' disease of tropical aquarium fish. This histophagous parasite invades the skin, muscle and body cavity organs and is frequently fatal to the host. *T. pyriformis* may invade the fry of various hosts and destroy surface tissue as well as internal organs. A species similar to *T. rostrata* has been found associated with cranial ulcerations in freshwater farmed Atlantic salmon (Ferguson et al 1987).

The genus has a wide geographic distribution and infects many hosts, particularly the live-bearing fish, cichlids and tetras. The dwarf cichlid appears to be particularly susceptible (Gratzek 1993).

The pathogenic potential of *Tetrahymena* spp that may be exotic to Australia is not considered sufficient to warrant their further consideration in this IRA.

***Trichodina* spp**

Trichodina species are generally considered to be harmless in small numbers but can proliferate rapidly and cause respiratory distress, especially after extreme temperature drops or in poor water quality conditions (Langdon 1990b). Representatives of this group are particularly pathogenic and species specific. *T. fultoni* infection in eels causes marked external signs and mortality (Markiewicz and Migala 1980). *T. speroidesi* infections of fish lead to gill damage and death (Bunckley-Williams and Williams 1994). *Trichodina* sp has been reported to cause significant mortalities in Sri Lankan hatcheries (Subasinghe 1992). *T. reticulata* infects *Carassius auratus*, *C. carassius* and *Cyprinus carpio*, and has caused considerable mortality in Japanese fish farms (review by Humphrey 1995).

T. australis, T. jadranica and *T. nesogobii* and unidentified species of *Trichodina* have been reported in Australia from marine finfish (Su and White 1995).

As *Trichodina* spp occur in Australia and there are no statutory controls for these agents, they will not be further considered in this IRA.

***Trichodinella* spp**

Trichodinella are common parasites of freshwater and marine fish that in certain situations proliferate and lead to significant disease. There are approximately 10 known species, of which *T. epizootica* is considered the most pathogenic. Humphrey (1995) considers several species to be synonymous with *T. epizootica*.

As *Trichodinella* have been recorded in Australia and are usually associated with opportunistic disease, they will not be further considered in this IRA.

Trichophrya spp

Many authors quote 'trichophryasis' as a disease associated with gill damage, including necrosis, but there is no evidence of serious disease in association with *Trichophrya*. Massive invasion of gills, possible only in fish predisposed by environmental and other factors, is likely to cause irritation and hamper oxygen exchange (Lom 1995). This common parasite is not associated with significant disease or economic loss and will not be considered further in this IRA.

Tripartiella spp

All 17 species belonging to this genus are found on the gills of freshwater fish (Lom and Dyková 1992). *Tripartiella* sp infection has been described in Australia (reviewed in Humphrey 1995) and no records of significant pathogenicity or economic loss can be attributed to the genus. Accordingly, *Tripartiella* will not be considered further in this IRA.

3.6 Nematodes

3.6.1 NEMATODES THAT WILL BE FURTHER CONSIDERED IN THE IRA

Philometra lusiana

Philometra/Philometroides lusiana have been described in wild fish and have been reported to cause production losses, including mortalities, in farmed carp fry (Bauer et al 1973). *P. lusiana* infects carp and may lead to haemorrhage, exophthalmia, impaired swimbladder function as well as market rejection due to lodgement of large female worms under the scales (Borisova et al 1987).

P. lusiana will be further considered in this IRA.

Philometroides fulvidraconi

Some species belonging to this genus have been reported to cause disease in freshwater and marine fish. *Philometroides fulvidraconi* causes philometroidiasis of the yellow catfish. Major signs of the disease are eyeball protrusion, inflammation of orbits and complete loss of eyeballs in serious cases (Yu et al 1993).

One species of philometroidian nematode has been described in Australia from the yellowbelly, though there is no record of associated disease (reviewed in Humphrey 1995). *P. fulvidraconi* has not been recorded from Australia.

P. fulvidraconi will be further considered in this IRA.

3.6.2 NEMATODES THAT WILL NOT BE FURTHER CONSIDERED IN THE IRA

Camallanus spp

This nematode causes obstructive enteritis in a wide variety of freshwater tropical fish, leading to reduction of reproductive potential and growth rates. Live-bearing fish such as guppies and swordtails seem to be most frequently infected. An intermediate host such as an aquatic insect is involved in the life cycle of the parasite (Gratzek 1993).

Camallanus spp. have been detected in Australian fish and therefore will not be further considered in this IRA (reviewed in Humphrey 1995).

Capillaria spp

Capillaria nematodes are frequently found in freshwater aquarium fish (Gratzek 1993). Their clinical significance is difficult to determine and they are usually only found post-mortem. Anecdotal evidence suggests they may affect reproductive potential and growth rates. *Capillaria* spp have been reported to cause ulceration and emaciation. *C. philippinensis* causes capillarasis in its freshwater fish intermediate hosts. The primary hosts include humans, monkeys and birds (Ko 1995).

Several species of freshwater ornamental fish have been infected experimentally and include guppies, carp and rasboras (Ko 1995).

Given the lack of evidence to indicate that *Capillaria* is a serious pathogen of aquatic animals and the fact that there are no public health controls specific to this agent in Australia, no further consideration will be given to this nematode in this IRA.

3.7 Monogeneans

3.7.1 MONOGENEANS THAT WILL BE FURTHER CONSIDERED IN THE IRA

***Benedenia* spp**

The capsalid monogeneans are parasitic on the body surface of mainly marine teleosts. While records of *Benedenia* (*Neobenedenia*) from wild marine fish are few, these monogeneans cause significant disease in a wide variety of cultured fish including aquarium species (Cone 1995). Untreated infections may lead to blindness, scale loss, and the development of open lesions; secondary bacterial infections often lead to mortalities. *B. epinephali*, *B. seriolae*, *B. pargueraensis, B. monticelli* and *B. melleni* all cause mortalities in their fish hosts and have a wide distribution throughout tropical and subtropical areas (Ogawa et al 1995; Dyer et al 1992; Cheung 1993; Sindermann 1970).

There have been numerous reports of *Benedenia* spp occurring in Australia (reviewed in Humphrey 1995). Significant infections have been recorded from aquaria-kept samson fish, kingfish and dolphin fish.

As the identification of benedeniad species recorded in Australia is uncertain, and because these parasites have been reported as causing significant economic and pathological problems, *B. epinephali*, *B. seriolae*, *B. pargueraensis, B. monticelli* and *B. melleni* will be further considered in this IRA.

Dactylogyrus vastator* and *D. extensus

These monogeneans are cosmopolitan parasites common in aquarium fish and may infest all major groups, particularly goldfish, angelfish and discus. Two species in particular are highly pathogenic and of economic importance: *D. vastator* and *D. extensus* (Gratzek 1993). *D. vastator* causes disease in carp and goldfish. Infection causes extensive degeneration leading to respiratory failure and death of the fish. *D. extensus* also occurs on the gills of carp and goldfish but is considered to be less pathogenic than *D. vastator*. Infection results in copious mucus production and localised damage.

D. vastator is endemic in central Asia but has been introduced to Europe, Israel, and North America (Cone 1995). *D. extensus* is endemic in Asia, central Europe, Israel, Japan and North America (Bauer et al 1973). *Dacytolgyrus* sp have been recorded in Australia from goldfish, discus and dhufish (reviewed in Humphrey 1995).

Both *D. vastator* and *D. extensus* will be further considered in this IRA.

3.7.2 MONOGENEANS THAT WILL NOT BE FURTHER CONSIDERED IN THE IRA

***Gyrodactylus* spp**

There are 348 named species of *Gyrodactylus* described in teleosts and amphibians (Cone et al 1995). Inapparent infections are common; however, infestation may lead to haemorrhagic lesions, excessive mucus production and localised ulcerations (Gratzek 1993) and, in guppies, to mortalities (Korting 1984b). There is an added concern that these monogeneans may actively transmit aeromonad bacteria. *Aeromonas hydrophila* has been isolated from gyrodactylids removed from goldfish (Langdon 1990b). *G. salaris*, a pathogen listed by the OIE as an ‘other significant’ disease, affecting Norwegian fisheries, is the only major pathogen in this group and appears to be restricted to salmonids (OIE 1997b).

Gyrodactylus spp have been described and associated with dermal infection and disease from goldfish and other unspecified fish species in Australia (reviewed in Humphrey 1995).

Gyrodactylus spp will not be further considered in this IRA.

3.8 Digeneans

3.8.1 DIGENEANS THAT WILL BE FURTHER CONSIDERED IN THE IRA

Clinostomum marginatum

Clinostomum marginatum infections may result in damage to the muscle and viscera of many fish species both wild and cultivated. Heavy infections may result in stunted growth (Gratzek 1993).

Three other species of *Clinostomum* have been recorded from Australia, none associated with significant economic loss or disease (reviewed in Humphrey 1995).

As *C. marginatum* has a broad host range, may affect marketability of finfish products and has not been identified from Australia, it will be further considered in this IRA.

Sanguinicola spp

Sanguinicola are economically important digenean parasites of the vascular system of fish, especially in the culture of carp and salmonids (reviewed in Humphrey 1995). The life cycle involves a gastropod molluscan intermediate host. Acute and chronic sanguinicoliasis is described, with thrombosis due to obstruction of branchial capillaries by eggs in the acute form, and renal glomerular occlusion and nephritis in the chronic form. Heavy mortalities may occur in carp and trout.

Sanguinicola has not been recorded from Australia and will be further considered in this IRA.

3.8.2 DIGENEANS THAT WILL NOT BE FURTHER CONSIDERED IN THE IRA

Cryptocotyle lingua

Cryptocotyle lingua causes the formation of black spots on the skin on a number of inshore western Atlantic species including herring and cunner. Massive cercarial invasion has been linked to blindness and mortality in immature herring. Massive metacercarial invasion does not often occur in aquaria due to the absence of intermediate hosts (molluscs and crustaceans). However, ornamental marine fish may act as carriers for the parasite (Cheung 1993). *C. lingua* has not been recorded in Australia.

Given that this digenean is not associated with serious disease or economic loss, it will not be further considered in this IRA.

3.9 Cestodes

3.9.1 CESTODES THAT WILL BE FURTHER CONSIDERED IN THE IRA

Caryophyllaeus fimbriceps

Caryophyllaeus fimbriceps infects cypriniforms and is an economically important cestode parasite of cultured carp (*Cyprinus carpio*) in Europe and the former USSR, infection resulting in haemorrhagic enteritis (Korting 1984b; Wootton 1989). Impact on aquaculture tends to be seasonal (peaking in spring), and may involve high mortalities of fish of up to two years of age (Soulsby 1982).

C. fimbriceps has not been reported in Australia.

C. fimbriceps will be further considered in this IRA.

Eubothrium crassum and *E. salvalini*

Eubothrid cestodes are economically important intestinal parasites of wild and farmed salmonids in North America and Europe. Nutritional demands made by these helminths may adversely affect growth, condition and fitness, increasing susceptibility to environmental stress such as that caused by zinc (Dick and Choudhury 1995). The two main species of importance are *Eubothrium crassum* and *E. salvalini*.

The parasite has an indirect life cycle, with copepods acting as the intermediate host, and a wide range of fish species acting as the final host, including *Lota lota* (burbot), *Salmo salar* (Atlantic salmon), *Morone americanus* (white perch), *Myxocephalus quadricornis* (fourhorn sculpin), *Micropterus salmoides* (largemouth bass) and *Mylocheilus saurinae* (peamouth).

Neither eubothrid species has been reported in Australia.

Given their wide host range and absence of reports from Australia, both *E. crassum* and *E. salvalini* will be further considered in this IRA.

Khawia sinensis

Khawia sinensis has been reported in Europe, China, Japan, Russia, and Germany (reviewed in Humphrey 1995; Soulsby 1982; Korting 1984b; Wootton 1989). The lifecycle, associated disease and host range are similar to those of *Caryophyllaeus fimbriceps*. Infection induces loss of gut epithelium and mortalities may reach 100% (Morley and Hoole 1994; Korting 1984b).

K. sinensis has not been reported in Australia and will be further considered in this IRA.

3.9.2 CESTODES THAT WILL NOT BE FURTHER CONSIDERED IN THE IRA

Bothriocephalus acheilognathi

Bothriocephalus acheilognathi (formerly *B. gowkongensis*) is a highly pathogenic cestode (reviewed in Humphrey 1995) that infects a range of fish species, causing intestinal obstruction, perforation, emaciation and death, especially in young fish. It readily infects many species of plankton-eating fish and has been reported from *Cyprinus carpio* and *Carassius auratus*. It is an economically serious problem in cultured carp in Europe.

B. acheilognathi has been previously reported in Australia (Langdon 1990a) and will not be further considered in this IRA.

Triaenophorus spp

These cestodes are parasitic in the intestine of the definitive host, usually a predatory fish, and are generally associated with minimal disease (reviewed in Humphrey 1995; Soulsby 1982). The intermediate stage in the tissues or body cavity of fish may cause peritonitis and cysts in the musculature. There are two species of pathogenic importance: *Triaenophorus nodulosis* and *T. crassus* from the United States and Europe.

Definitive and intermediate host species include species of walleye (*Stizostedion*), pikes (*Esox*), whitefishe (*Coregonus*) trout-perch (*Percopsis*) 'salmonids', 'sea lamprey', and yellow perch (*Perca flavescens*).

Given the relatively minimal pathological changes associated with infection, no further consideration will be given to the genus *Triaenophorus* in this IRA.

3.10 Crustaceans

3.10.1 CRUSTACEANS THAT WILL BE FURTHER CONSIDERED IN THE IRA

Argulus spp

These cosmopolitan non-host-specific branchiuran parasites, often known as fish lice, are found predominantly on the skin and gills of freshwater fish. Heavy infections may cause mass mortalities, especially in younger cultured fish. Local necrosis and ulceration may occur, serving as a site for secondary infection (reviewed in Humphrey 1995). Argulids may act as vectors of spring viraemia of carp (SVC) (Lester and Roubal 1995). There are over 100 species of *Argulus,* two of the most significant being *A. foliaceus* and *A. coregoni* (Kabata 1985; Lester and Roubal 1995).

A. foliaceus is a common parasite of carp in Europe and Asia, and affects a wide range of hosts, including cyprinids and salmonids (Lester and Roubal 1995). *A. coregoni* occurs primarily in salmonids but may also infest cyprinids. Neither species has been reported in Australia (reviewed in Humphrey 1995).

Given the wide host range and absence from Australia, *A. foliaceus* and *A. coregoni* will both be further considered in this IRA.

Ergasilus sieboldi

Ergasilid copepods occur on gills of fresh and brackish water species, and may cause severe gill damage, anaemia and secondary infection, sometimes resulting in heavy losses of fish stocks. *E. sieboldi* is a serious pest, causing severe gill damage of tench in Europe (Wootton 1989).

E. australiensis (*E. lizae*), *E. intermedius, E. ogawai, E. orientalis, E. semicoleus, Ergasilus* sp., *E. spinilaminatus* and *E. spinipes* have been reported in Australia (reviewed in Humphrey 1995).

E. sieboldi has not been reported in Australia and will be further considered in this IRA.

Lernaea elegans

Lernaeid copepods, or anchorworms, are important parasites of freshwater and marine fish species and may be fatal in low numbers, especially in young fish. In non-lethal infections, weight loss and local ulceration occur and the fish may be unsightly. Outbreaks may occur in epidemic proportions. Nine species are reported from many common fish and tadpoles. The most economically important, causing massive mortalities, are *L. elegans* and *L. cyprinaceae* (Kabata 1985). There is some taxonomic confusion between *L. elegans* and *L. cyprinaceae* — the latter is considered a specific parasite of the genus *Carassius* even though it has been misidentified and in many cases should have been recorded as *L. elegans* (Kabata 1985).

L. elegans and *L. cyprinaceae* have occurred in cultured carp, goldfish, bait minnows and trout (Kabata 1985).

L. cyprinaceae has been reported in Australia (reviewed in Humphrey 1995) and will not be further considered in this IRA.

L. elegans has not been reported in Australia and will be further considered in this IRA.

3.10.2 CRUSTACEANS THAT WILL NOT BE FURTHER CONSIDERED IN THE IRA

Argulus japonicus

There are over 100 species of *Argulus,* of which *A. japonicus* is considered among the most serious pathogens (Kabata 1985; Lester and Roubal 1995).

A. japonicus has been reported in Australia (reviewed in Humphrey 1995) and will not be further considered in this IRA.

***Ceratothoa / Mothocya / Nerocila* spp**

Most isopods of fish are cymothids, of which there are over 300 species described (Lester and Roubal 1995). Most of these are parasites of marine fish. *Nerocila orbignyi* and *Mothocya parvostis*, which infest the gills and skin of cultured *Dicentrachus labrax* and *Girella punctata*, and *Ceratothoa gaudichaudii* and *C. imbricata*, which affect salmonids in Chile, are four species associated with farm production losses (Lester and Roubal 1995). *Alitropus* and *Cirolana* are also reported to affect fish (Kabata 1985). In general, serious outbreaks due to isopods are rare and effects are usually not pronounced or extensive (Kabata 1985).

Nerocila orbignyi and *C. imbricata* have been recorded from Australia (reviewed in Humphrey 1995).

As neither *M. parvostis* nor *C. gaudichaudii* have been associated with ornamental finfish species, and as *Nerocila orbignyi* and *C. imbricata* have been recorded in Australia, none of these four species will be further considered in this IRA.

Lernaeocera branchalis

Lernaerocernid copepods occur on marine fish and may be highly pathogenic. The most prominent species is *Lernaeocera branchalis*, which occurs primarily in the branchial cavity of gadoids (Lester and Roubal 1995). As this species has been reported in Australia, it will not be further considered in this IRA.

Chapter 4
Risk assessment

4.1 Methods

IN CHAPTER 3, THE AUSTRALIAN QUARANTINE AND Inspection Service (AQIS) identified the disease agents that would be the subject of further consideration in the risk analysis, based on defined criteria. The criteria include the absence of the agent from Australia and features of the disease agent, including its ability to cause serious disease and its status according to the Office International des Epizooties (OIE, or World Organisation for Animal Health).

Importing live animals is more likely to introduce a disease agent than importing product, because the live animals are introduced directly into the national animal population.

If sufficient information on disease agent epidemiology is known, risk management measures either singly or in combination, such as restrictions on source, testing, and treatment may be used to mitigate specific risk factors.

Whenever there are significant gaps in knowledge for particular groups of animals, a more general approach may be needed to address the risks. Using this approach, baseline risk management would be applied to all such animals imported. For ornamental finfish species, far less is known of the diseases and their epidemiologies than those of farmed food fish or terrestrial animals. The general risk posed by this uncertainty needs to be addressed. Of the Schedule 6 species, Humphrey (1995) identified goldfish as a high risk species. This finding is verified by the disease-specific risk assessments below as well as by the analysis of likely pathways by which disease agents may be introduced into Australian natural waters. The higher risk presented by goldfish needs to be addressed in setting risk management measures.

4.1.1 PRIORITY RANKING OF DISEASE AGENTS

As a next step, AQIS identified the disease agents to be considered as higher priority. This was based on the probability of a disease becoming established in Australia, the consequences that would arise from such establishment and the assessment of disease agents in the Humphrey review (1995) (see Section 1.5.2). Disease agents considered as high priority were placed in group 1 and those as lower priority in group 2. The priority rating of each pathogen is shown in Table 4.1.

This chapter provided details of the risk assessments for the disease agents identified in Chapter 3.

Disease agents carried solely by marine ornamental finfish

Of the disease agents identified for further consideration in Chapter 3, the following are carried solely by marine finfish:

- Erythrocytic necrosis virus (ENV) and red sea bream iridovirus (RSIV)
- *Photobacterium damselae piscicida*
- *Brooklynella hostilis*
- *Cryptobia bullocki*
- *Microsporidium* spp
- *Trypanosoma murmanensis*
- *Benedenia epinephali*
- *Benedenia melleni*
- *Benedenia monticelli*
- *Benedenia pargueraensis*
- *Benedenia seriolae*

The consequences of establishment for disease agents scored as either + or ++ were considered. From the risk evaluation matrix in Chapter 1, none is considered likely to have more than moderate consequences of establishment in Australia. From the matrix, it can be seen that an agent with a moderate, or less than moderate, score for consequences of establishment would require a low, moderate or high probability of establishment for the appropriate level of protection (ALOP) to be exceeded. Given that the probability of a disease agent establishing via marine ornamental finfish is significantly lower than that of freshwater species (Section 1.6), the risks associated with the above disease agents are not considered likely to exceed the ALOP. Accordingly, individual risk assessment will not be undertaken on these disease agents. Any uncertainty in the risk these disease agents do pose would need to be addressed by baseline risk management measures deemed necessary for all marine ornamental finfish.

Several marine ornamental finfish species were identified as potentially posing a higher risk in that they are currently farmed overseas as food fish and as such, imported specimens may be supplied from farmed stock where prevalence and titre of disease agents is expected to be higher than in wild-caught animals.
Pink ling (*Genypterus blacodes*) a maricultured food fish belonging to the Family Ophidiidae is listed on Schedule 6. A few other species of marine food fish such as tiger puffers (*Takifugu rubripes*) and silver trevally (*Pseudocaranx dentex*) belonging to families with members represented on Schedule 6, are also commercially farmed overseas. In addition, the future development in Australia of aquaculture industries based on these species may be at risk from disease agents introduced via importation of these same species. Aquaculture industries based on species currently listed on Schedule 6, should they establish in Australia, may also be significant pathways by which exotic disease agents may be introduced into Australian natural waters. Risk management options recommended for marine ornamental finfish would need to address the higher risk posed by these aquacultured species.

Agents identified as those carried solely by marine ornamental finfish are listed as group 3 disease agents in Table 4.1.

Metazoans with complex life cycles

Of the disease agents identified for further consideration in Chapter 3, the following metazoan parasites were identified as having indirect life cycles:

- *Philometra lusiana*
- *Philometroides fulvidraconi*
- *Clinostomum marginatum*
- *Sanguinicola* spp
- *Caryophyllaeus fimbriceps*
- *Eubothrium crassum*
- *Eubothrium salvalini*
- *Khawa sinensis*

As stated in Section 1.7, many metazoan parasites have life cycles that involve several host animals. As such, metazoans with such indirect life cycles are less likely to propagate or survive in closed systems such as aquaria. Should these parasites enter Australian natural waters, they could not establish unless suitable intermediate hosts were present. In addition, metazoan parasites of finfish do not normally cause significant disease. None of the above listed agents is considered likely to have more than a moderate level of impact in terms of consequences of establishment in Australia. Again, using the risk evaluation matrix in Chapter 1, it can be seen that an agent with a consequences score of moderate or less than moderate, would require a low, moderate or high probability of establishment to exceed the ALOP. Given the generally lower disease significance of metazoan parasites, and the lower likelihood of their becoming established in Australia via the importation of ornamental finfish, these disease agents are not considered likely to exceed the ALOP. Accordingly, these agents will not be assessed for risk individually. However, the uncertainty of the risk posed by metazoan parasites with complex life cycles would need to be addressed by baseline risk management measures deemed necessary for all ornamental finfish.

Agents identified to be metazoan with complex life cycles are identified as group 3 disease agents in Table 4.1.

4.1.2 RISK ASSESSMENT

The risk assessment covers the following factors.

- *Release assessment* — the probability that the agent will enter Australia as a consequence of the importation of live ornamental finfish.
- *Exposure assessment* — if the disease agent entered Australia, the probability of susceptible fish being exposed to a dose sufficient to cause infection.
- *Probability of disease establishment* — combining release and exposure assessment.
- *Consequence assessment* — the consequences of the disease agent establishing in Australia.

Each of the above assessments is described in qualitative terms and is defined in Section 1.5.3.

Table 4.1
Ornamental finfish disease agents — priority in the IRA

DISEASE AGENT / PEST	INITIAL ASSESSMENT — PROBABILITY OF ESTABLISHMENT	INITIAL ASSESSMENT — IMPACT	HUMPHREY SCORE	PRIORITY GROUP	COMMENT
Viruses					
Erythrocytic necrosis virus (ENV) and red sea bream iridovirus (RSIV)	+	+	24 (ENV)	3	Solely marine host
Iridoviruses of freshwater ornamental fish	+/++	+	11–16	1	
Goldfish haematopoietic necrosis virus (GFHNV)	++	+/++	Not applicable	1	
Infectious pancreatic necrosis virus (IPNV)	+/++	++/+++	26	1	
Pike fry rhabdovirus (PFR)	+	+	18	2	Humphrey score <21
Spring viraemia of carp (SVC) *Rhabdovirus carpio* (RVC)	++	++	29	1	
Viral encephalopathy and retinopathy (VER)	+	+/++	15	2	Host range does not include species closely related to Schedule 6 species
Bacteria					
Aeromonas salmonicida — 'atypical'	++	++	28	1	All atypical strains are considered except GUD-biovar as it is present in Australia without national controls
Aeromonas salmonicida — 'typical'	++	+++	28	1	
Chlamydia/Rickettsia spp	+	+	24 (*P. salmonis*)	2	Only significant pathogen exotic to Australia is *Piscirickettsia salmonis* which is restricted tosalmonids

Table 4.1 continued

Ornamental finfish disease agents — priority in the IRA

DISEASE AGENT / PEST	INITIAL ASSESSMENT — PROBABILITY OF ESTABLISHMENT[a]	INITIAL ASSESSMENT — IMPACT[a]	HUMPHREY SCORE	PRIORITY GROUP	COMMENT
Edwardsiella ictaluri	+	+	21	2	Insignificant pathogen other than of catfish
Photobacterium damselae piscicida	+	++	20	3	Solely marine host
Pseudomonas anguilliseptica	+	+/++	18	2	Humphrey score <21
Yersinia ruckeri (Hagerman strain)	+	++	23	1	
Protozoa					
Acanthamoeba spp	+	+	17	2	Humphrey score <21
Brooklynella hostilis	+	+	22	3	Solely marine host
Cryptobia (Trypanoplasma) borreli	++	++	18	1	
Cryptobia bullocki	+	++	18	3	Solely marine host
Henneguya spp	+	+	19	2	Does not include *H. salminicola*, which only occurs in salmonids
Microsporidium spp	+	+/++	21	3	Significant species are marine
Pleistophora hyphressobryconis	++	++	21	1	
Sphaerospora carassii, S.renicola	++	++	20	1	
Trypanosoma carassii	++	++	16	1	
Trypanosoma murmanensis	+	++	16	3	Solely marine host
Nematodes					
Philometra lusiana	+	+	18	3	Complex life cycle
Philometroides fulvidraconi	+	+	18	3	Complex life cycle
Monogenians					
Benedenia epinephali	+	+	17	3	Solely marine host
Benedenia melleni	+	+	17	3	Solely marine host
Benedenia monticelli	+	+	17	3	Solely marine host
Benedenia pargueraensis	+	+	17	3	Solely marine host
Benedenia seriolae	+	+	17	3	Solely marine host
Dactylogyrus extensus	++	+	17	1	
Dactylogyrus vastator	++	+	21	1	
Digenians					
Clinostomum marginatum	+	+/++	17	3	Complex life cycle
Sanguinicola spp	+	+/++	21	3	Complex life cycle
Cestodes					
Caryophyllaeus fimbriceps	+	+/++	18	3	Complex life cycle
Eubothrium crassum	+	+/++	13	3	Complex life cycle
Eubothrium salvalini	+	+/++	13	3	Complex life cycle
Khawa sinensis	+	+/++	18	3	Complex life cycle
Crustaceans					
Argulus coregoni	++	+	19	1	
Argulus foliaceus	++	+	19	1	
Ergasilus sieboldi	++	+	17	2	Numerous *Ergasilus* spp present in Australia. Minimal impact expected
Lernaea elegans	++	+	22	1	

[a] +, ++, +++ = relative score assigned by AQIS to each disease, with +++ the highest score possible

4.1.3 UNRESTRICTED RISK ESTIMATE

The combined probability and consequences of disease establishing represent the unrestricted risk assessment (ie the risk if no management measures are applied). As presented in the risk evaluation matrix in Section 1.5.3, the unrestricted risk estimate either exceeds, or meets, the ALOP. Risk management measures would be required (in the former case) or would not be justified (in the latter case).

The conclusions are summarised in a box at the end of the assessment for each disease agent.

4.2 Risk assessments for high priority disease agents

4.2.1 GOLDFISH HAEMATOPOIETIC NECROSIS VIRUS (HERPESVIRAL HAEMATOPOIETIC NECROSIS OF GOLDFISH)

Geographic distribution

Three epizootics of herpes viral haematopoietic necrosis of goldfish (HVHN) have occurred in Japan; the first and second epizootics occurred in fish breeding ponds in Aichi Prefecture in spring 1992 and in autumn/winter 1992, and the third epizootic in Aichi and Nara Prefectures in spring 1993.

An earlier report (Ferguson et al 1989) described high mortalities in shipments of goldfish imported from the United States into Canada. The condition, named visceral necrosis of goldfish, was believed to have been caused by a bacterial infection. However, Jung and Miyazaki (1995) pointed out the histological similarity to HVHN and suggested that visceral necrosis may also be associated with a viral infection, and that bacteria might be secondary invaders. This view is supported by the fact that the bacteria isolated from the diseased fish did not cause visceral necrosis when used to infect other fish. Therefore, it appears that HVHN has occurred at least once in the United States and was misreported as a bacterial disease.

Host range and prevalence

The disease has only been reported in goldfish (*Carassius auratus*). Goldfish of all ages were affected and mortalities reached almost 100% in the three reported epizootics. Transmission studies confirmed the pathogenicity of the virus to goldfish (Jung and Miyazaki 1995). Koi carp (*Cyprinus carpio*) inoculated with the agent were not affected.

Detection methods

Diseased goldfish showed no specific external signs, but appeared weak and remained at the bottom of the pond. Internal signs of disease included pale colouration of the gills and liver, ascites, splenomegaly and white nodular lesions on the spleen, swollen pale kidneys and an empty intestine (Jung and Miyazaki 1995).

Electron microscopy of infected cells of naturally and experimentally infected fish showed intranuclear capsids sometimes in crystalline arrays (Jung and Miyazaki 1995).

The virus was isolated in cell culture at 20°C from spleen and kidney tissue (Jung and Miyazaki 1995). The physical and morphological characteristics of the virus, as well as the apparent pattern of replication, suggested that it is a member of the Herpesviridae (Jung and Miyazaki 1995).

Herpes viruses characteristically produce carrier states which remain inapparent until the animals are stressed.

Stability of disease agent

The virus was stable at pH 11 but was inactivated at pH 3. Treatment with ether markedly reduced the infectivity of the virus (Jung and Miyazaki 1995).

Susceptibility of host species in Australia

Captive and wild goldfish would be susceptible to this disease agent. Koi carp (*Cyprinus carpio*) are not susceptible to infection. The susceptibility of other fish species to this virus is not known (Jung and Miyazaki 1995) but, given the apparent host specificity of this agent, it is not considered likely that this agent would affect Australian native species.

Transmission

The natural mode of transmission is not known, however, the fact that fish of all ages became infected suggests that horizontal transmission plays a major role in epizootics. Disease outbreaks occurred at water temperatures of 15–20°C and subsided when temperatures rose above 25°C (Jung and Miyazaki 1995). It is possible that goldfish carry the virus asymptomatically outside the temperature range of the disease outbreaks (Jung and Miyazaki 1995).

Release assessment

In addition to information presented on release assessment in Section 1.6, the following key points are relevant to the likelihood of goldfish haematopoietic necrosis virus (GFHNV) entering Australia via the importation of ornamental finfish.

- The disease has only been reported in Japan and possibly North America.
- Of the Schedule 6 species, the agent has only been reported in goldfish.
- Goldfish are imported into Australia in significant numbers mostly from Asia, although not directly from Japan.
- Methods for detecting the agent require a high level of technical expertise and as such the disease may be under-reported. Sacrifice of the fish is required for definitive diagnosis.
- Goldfish of all ages are affected, with mortalities reaching almost 100%; disease outbreaks are therefore likely to be quickly recognised and dealt with. There is no information on fish becoming asymptomatic carriers. However, patent disease only manifests at a water temperature of 15–20°C and it subsides when water temperature rises above 25°C.
- Moribund fish appear weak and do not show any other external signs of disease. There is a very small likelihood that fish in the early stages of infection may be inadvertently included in shipments destined for export to Australia.

Exposure assessment

In addition to information presented on exposure pathways (Section 1.6), if the disease agent entered Australia, the following key points would be relevant to the establishment of GFHNV in the ornamental finfish industry.

- The virus has a direct route of transmission and appears to infect goldfish of all ages.
- Goldfish are the only species susceptible to infection and comprise a major component of the ornamental finfish industry in Australia.
- Moribund fish appear weak but do not show other external signs of disease. There is a very small likelihood that fish in the early stages of infection may be transferred along the supply chain to end-users.

In addition to information presented on exposure pathways (Section 1.6), if the disease agent entered Australia, the following key points would be relevant to the establishment of GFHNV in Australian natural waters.

- Only goldfish are known to be susceptible to this disease agent.
- There is a significant probability of goldfish entering and surviving in Australian natural waters and becoming self-maintaining populations in the wild.
- Feral populations of goldfish are present in Australian natural waters.

There is a moderate probability of GFHNV causing infection in the goldfish industry in Australia. If the agent entered Australia, the probability of infection in natural waters would be expected to be only one level of probability lower than that for the ornamental fish industry.

Consequence assessment

Effects on commercially significant species

GFHNV was the cause of severe epizootics reported in goldfish breeding ponds in Japan in 1992–93. The disease affected goldfish of all ages with mortalities reaching almost 100%. The epizootics occurred at water temperatures of 15–20°C and subsided when water temperature rose above 25°C.

Goldfish are susceptible to the agent and comprise a major component of the ornamental finfish industry in Australia. Serious impacts to goldfish breeding premises may be expected should the disease establish, although consequences are not likely to be significant at a 'whole industry' level.

Ecological and environmental effects

GFHNV has not been reported from any species other than goldfish. There is no evidence to suggest that the establishment of GFHNV would have a significant effect on wild finfish, including species native to Australia.

Unrestricted risk estimate

For the unrestricted importation of goldfish, the probability of GFHNV establishing in the ornamental finfish industry would be low. The consequences of establishing in the goldfish industry would be low to moderate. Thus, for GFHNV, the risk associated with the unrestricted importation of goldfish would not meet Australia's ALOP. The implementation of specific risk management measures would be warranted.

A summary of the risk assessment is shown in Box 4.1. Appropriate risk management measures are discussed in Chapter 5.

Box 4.1

Risk assessment — goldfish haematopoietic necrosis virus

RELEASE ASSESSMENT (R)

The probability of goldfish haematopoietic necrosis virus (GFHNV) entering Australia as a consequence of the unrestricted importation of live goldfish would be low. For the importation of other species of ornamental finfish, the probability would be negligible.

EXPOSURE ASSESSMENT (E)

If GFHNV entered Australia, the probability of susceptible animals in the ornamental finfish industry being exposed to a dose sufficient to cause infection would be moderate.

The probability of susceptible animals in Australian natural waters being exposed to a dose sufficient to cause infection would be low.

PROBABILITY OF DISEASE ESTABLISHMENT (R + E)

The probability of GFHNV becoming established in the ornamental finfish industry as a consequence of the unrestricted importation of goldfish would be low (L). For other freshwater finfish species and marine species, the probability would be negligible (N).

The probability of GFHNV becoming established in natural waters as a consequence of the importation of goldfish would be very low (VL). For other freshwater finfish species and marine species, the probability would be negligible (N).

CONSEQUENCE ASSESSMENT

The consequences of the of GFHNV establishing in the ornamental finfish industry would be low to moderate (L–M), due primarily to effects on farmed goldfish.

If the disease became established in natural waters, the consequences to native and introduced species, both wild and captive, would be negligible to low (N–L).

Whilst the effect on the environment cannot be discounted, there is no reason to expect that the establishment of GFHNV would affect the survival of any vulnerable or endangered species in Australia or have any significant effect on the natural environment.

UNRESTRICTED RISK ESTIMATE FOR IMPORTATION OF ORNAMENTAL FINFISH

From Figure 1.1 (risk evaluation matrix):

- probability of establishment in the ornamental finfish industry from goldfish = L
- significance of consequences for the goldfish industry = L–M
- importation risk for GFHNV = unacceptable ('no' in Figure 1.1).

That is:

- the risk associated with the unrestricted importation of goldfish does not meet Australia's ALOP; and
- risk management measures are warranted for goldfish.

4.2.2 INFECTIOUS PANCREATIC NECROSIS VIRUS (INFECTIOUS PANCREATIC NECROSIS)

In this IRA, the disease ‘infectious pancreatic necrosis’ (IPN) is defined as an acute disease of juvenile salmonids caused by infection with any one of several strains of aquatic birnavirus. The various strains of virus that cause IPN — referred to as infectious pancreatic necrosis virus (IPNV) — differ in virulence and serological characteristics.

Hill and Way (1995) reviewed the serological classification of aquatic birnaviruses, many of which are serologically related to reference strains (Ab, Sp and VR299) of IPNV. Some of these viruses were isolated from non-salmonid fish and can be called IPNV as they produce IPN in salmonid fry. For many of the aquatic birnaviruses serologically related to IPNV, there is no evidence that they are pathogenic to salmonids; they should not therefore be described as IPNV (Hill and Way 1995).

In reviewing the scientific literature on aquatic birnaviruses, Reno (1999) noted that it was difficult to evaluate the virulence of non-salmonid isolates for salmonid fish as many different experimental protocols had been used. Water-borne infectivity trials demonstrated that IPN occurred in brook trout downstream from striped bass (*Morone saxatilis*) infected with an aquatic birnavirus (McAllister and McAllister 1988). Immersion challenge of juvenile brook trout with aquatic birnaviruses isolated from various aquatic hosts gave clear evidence of the presence of IPNV in non-salmonid fish and other aquatic hosts (McAllister and Owens 1995).

Aquatic birnaviruses have been identified in ornamental finfish species listed on Schedule 6. However, the relationship between these isolates and IPNV has not been established. Accordingly, AQIS has considered general information on aquatic birnaviruses in determining the likelihood of IPNV becoming established in Australia as a consequence of the importation of ornamental finfish.

Geographic distribution

IPN has been reported in North and South America, Europe and Asia. The disease was initially reported in eastern Canada and eastern United States and later in western United States (Reno 1999).

IPN has not been reported in salmonids in Australia. However, an aquatic birnavirus was recently isolated from a sea-caged Atlantic salmon on the west coast of Tasmania (Crane et al 1999). The isolate was neutralised by a pan-specific rabbit antiserum raised against IPNV-Ab strain and by a commercial, pan-specific IPNV-neutralising monoclonal antibody. The infected fish were runted 18-month old ‘pinheads’ but did not show clinical signs typical of IPN. Pancreatic lesions were seen by histopathological examination. The virus was isolated from other fish species in the region including farmed rainbow trout (*Oncorhynchus mykiss*), wild flounder (*Rhombosolea tapirina*), cod (*Pseudophycis* sp), spiked dogfish (*Squalus magalops*) and ling (*Genypterus blacodes*) (Crane et al 1999). Experimental infections of salmonid species with this virus showed that it is non-pathogenic for brook trout and Atlantic salmon fry, which indicates that it should not be classified as IPNV (M Crane pers. comm.). Infection of brook trout and Atlantic salmon was effected by direct inoculation of virus. In these experiments it was clear that, in brook trout fry, the reference strain of IPNV (Erwin strain obtained from Fish Diseases Laboratory, Weymouth, United Kingdom) was highly pathogenic causing overt disease associated with high mortality (approximately 90% losses). Laboratory examinations demonstrated that these fish had histopathological lesions typical of IPN which were associated with the presence of virus (demonstrated by immunoperoxidase tests). At the doses used, the reference strain of IPNV was, at most, of low pathogenicity to Atlantic salmon fry; histopathological changes were not observed in these fish. In these experiments, the Tasmanian aquatic birnavirus (TABV) was of low pathogenicity to both brook trout and Atlantic salmon. For example, when TABV was injected into brook trout (considered the most susceptible species to IPN), there were very few losses (4–11% in the infected experimental groups compared to 8% in the uninfected control group) and of these only the occasional fish showed histopathological lesions (M Crane pers. comm.).

Host range and prevalence

Aquatic birnaviruses have been isolated from non-salmonids including *Esox* spp, *Morone saxatilus*, *Cyprinus carpio, Perca fluviatilis* and *Rutilis rutilus* and these isolates, under experimental conditions, have been found to cause mortality in salmonids (reviewed in Reno 1999).

Aquatic birnaviruses, not confirmed as causing IPN, have been isolated from apparently healthy fish of the following Schedule 6 listed species: *Carassius auratus* and *Symphosydon discus* (Adair and Ferguson 1981) and *Brachydanio rerio* (Ahne 1982). Aquatic birnavirus has also been isolated from *Xiphophorus xiphidium* (Ahne 1985). *Xiphophorus xiphidium* is not listed on Schedule 6, however, other species of *Xiphophorus* are listed.

IPN primarily occurs in salmonid fry and fingerlings and rarely in older fish. Recently, there has been a marked reduction in the reporting of IPNV in North America although the virus remains widely dispersed in Europe and IPN outbreaks also occur in salmonids throughout Asia. Fish that survive IPNV epizootics may become long term carriers. The prevalence of infection in naturally infected brook trout varies from less than 5% up to 99% (Reno 1999). IPNV isolates vary in virulence. Experimental infection of brook trout fry with 15 isolates caused mortality of 7–98% (Wolf et al 1969). Survivors of epizootics due to other aquatic birnaviruses such as yellowtail ascites virus and eel nephritis virus, may also become long-term carriers (Reno 1999).

Detection methods

Because the clinical signs of IPN disease are not specific, diagnosis is based on histopathology, virus isolation in cell culture and confirmation of identity using serological methods (OIE 1997b). PCR has also been used to detect aquatic birnaviruses (Reno 1999). Currently there are no *in vitro* tests capable of distinguishing pathogenic IPN viruses from non-pathogenic IPN-like viruses. Pathogenicity can only be determined by experimental infection, as discussed previously. Aquatic birnaviruses should only be classified as IPNV if it can be demonstrated that they cause IPN in salmonid species (usually brook trout).

Ornamental finfish species may be asymptomatic carriers of aquatic birnaviruses; such infection would ordinarily not be detected.

Stability of disease agent

IPNV is an unusually stable virus. It retains infectivity for 60 minutes at pH 3–12 (Parsonson 1997). It remains infectious after treatment with chloroform or ethyl ether and survives for 30 minutes at 60°C. It survives for nearly a year at 4°C and for 2 months at 15°C in buffer. The virus is also stable for long periods in seawater, brackish water and unsterilised fresh water (reviewed in Reno 1999).

Susceptibility of host species in Australia

In addition to recognised susceptibility of salmonids, IPNV has a wide host range. Several fish species in Australia, including introduced salmonids, would be expected to be susceptible to infection with IPNV.

Transmission

Evidence suggests that IPNV is transmitted both vertically and horizontally. Faeces and urine of infected fish are likely to be the source of virus in horizontal transmission (Reno 1999). The virus is also transmitted via reproductive products (Wolf et al 1968).

Aquatic birnaviruses were isolated from the gut and faeces of a goldfish and a discus fish (Adair and Ferguson 1981) which suggests that horizontal transmission could occur via faeces.

Release assessment

In addition to information presented on release assessment in Section 1.5, the following key points are relevant to the likelihood of IPNV entering Australia via the importation of ornamental finfish.

- IPNV has a broad geographic distribution.
- The detection of IPNV requires a high level of technical expertise and therefore the disease may be under-reported. Sacrifice of the fish is required for definitive diagnosis. In addition, because of its broad geographic distribution overseas, it is often not targeted during standard surveillance programs.

- Aquatic birnaviruses have been isolated from apparently healthy fish of three species of ornamental finfish listed on Schedule 6. These isolates do not cause disease in ornamental finfish and there is no evidence that they cause IPN in salmonids. This low incidence of virus isolation from ornamental finfish species indicates a minimal probability of IPNV being present in imported, Schedule 6 listed finfish.

Exposure assessment

In addition to information presented on exposure pathways (Section 1.6), if the disease agent entered Australia, the following key points would be relevant to the establishment of IPNV in the ornamental finfish industry.

- Aquatic birnaviruses not confirmed as IPN have been isolated from several ornamental species including goldfish and poeciliids. Goldfish and poeciliids constitute a significant part of the ornamental finfish industry in Australia.
- Ornamental finfish may be asymptomatic carriers of aquatic birnaviruses and, if the agent entered Australia in ornamental finfish, it is likely that infected fish will be supplied to end-users.
- Aquatic birnaviruses, including IPNV, have direct routes of transmission and are vertically and horizontally transmissible.
- IPNV is highly stable and can survive for long periods in the environment.

In addition to information presented on exposure pathways (Section 1.6), if the disease agent entered Australia, the following key points would be relevant to the establishment of IPNV in Australian natural waters.

- Aquatic birnaviruses (not confirmed as IPNV) have been isolated from several ornamental species including goldfish and poeciliids. Goldfish and poeciliids are associated with significant pathways by which infected fish may enter and survive in Australian natural waters.
- IPNV has a wide host range and it is expected that there would be susceptible species in Australian waters.

There is a moderate to high probability of IPNV causing infection in the ornamental finfish industry in Australia. If the agent entered Australia, the probability of infection in natural waters would be expected to be only one level of probability lower than that for the ornamental fish industry.

Consequence assessment

Effects on commercially significant species

There are no reports of IPN or any other disease associated with aquatic birnaviruses in ornamental finfish species. Aquatic birnavirus infections of freshwater ornamental finfish, if they occur, are not likely to result in disease.

Disease from IPNV causes substantial losses in young salmonids in northern Europe and North America, especially under conditions of stress or high water temperature. In countries where infection with IPNV is endemic, mortality rates of up to 70% have been reported in fry and fingerlings up to 20 weeks of age. Under experimental conditions, highly virulent strains of IPNV have been reported to cause mortality rates higher than 90% in brook trout fry.

IPNV has also been linked with serious morbidity and mortality in the immediate post-smolt period and, as a consequence, IPN is considered to be one of the most economically significant diseases of salmon farms in Norway (A McVicar pers. comm.). Failed smolt syndrome may cause substantial loss of Atlantic salmon post-smolts.

There are no effective chemotherapeutic agents or proven vaccines available for the treatment or control of IPN. Moreover, there is no evidence of maternally transferred immunity or that heritable resistance is protective against disease. Overseas, the disease is controlled by maintaining strict hatchery hygiene, screening broodstock and minimising stress.

It is expected that the establishment of IPNV in Australia would cause significant mortalities in young rainbow trout, which would cause economic losses in the farmed rainbow trout industry and may affect the recreational trout-fishing sector. The occurrence of 'failed smolt syndrome' could cause significant losses in individual batches of Atlantic salmon smolts but would not be expected to lead to major overall consequences for the Atlantic salmon industry.

Internationally, IPNV has a significant economic effect on fish farming industries. It is a notifiable disease in several countries and certification that broodstock are free of infection may be required for trade in eggs within countries and for export. Costs are associated with testing and the inability to use gonadal products from certain populations or individual fish (A McVicar pers. comm.).

The establishment of IPNV would affect farms exporting eyed ova, as they may be required to implement increased testing to preserve their export markets. However, the effects of establishment of IPNV would primarily be felt at an individual premises or regional level rather than a whole industry or national level.

IPNV has been isolated from non-salmonid hosts and has been shown to sometimes cause serious disease. For example, high mortality occurs in virus-infected Atlantic menhaden (*Brevoortia tyrannus*), but striped bass (*Morone saxatilis*), which seemingly became infected from consuming infected menhaden, did not die from virus infection (McAllister and Owens 1995). Generally the detection of IPNV in non-salmonid finfish is an incidental finding that is not associated with disease.

Ecological and environmental effects

The literature indicates that infection with IPNV is of little pathogenic or economic significance in wild salmonids or non-salmonid finfish overseas. There is little evidence to suggest that the establishment of IPNV would have a significant effect on wild finfish, including native finfish in Australia.

Unrestricted risk estimate

For the unrestricted importation of ornamental finfish, the probability of establishment of IPNV in Australian natural waters would be negligible. The consequences of establishment would be moderate to high. Thus, for IPNV, the risk associated with the unrestricted importation of ornamental finfish would meet Australia's ALOP. The implementation of specific risk management measures would not be warranted.

A summary of the risk assessment is shown in Box 4.2.

Box 4.2

Risk assessment — Infectious pancreatic necrosis virus

RELEASE ASSESSMENT (R)

The probability of infectious pancreatic necrosis virus (IPNV) entering Australia as a consequence of the unrestricted importation of ornamental finfish would be extremely low.

EXPOSURE ASSESSMENT (E)

If IPNV entered Australia in ornamental finfish, the probability of susceptible animals in the ornamental finfish industry being exposed to a dose sufficient to cause infection would be moderate to high.

The probability of susceptible animals in Australian natural waters being exposed to a dose sufficient to cause infection would be low to moderate.

PROBABILITY OF DISEASE ESTABLISHMENT (R + E)

The probability of IPNV becoming established in the ornamental finfish industry as a consequence of the unrestricted importation of ornamental finfish would be extremely low (EL).

The probability of IPNV becoming established in natural waters would be negligible (N).

CONSEQUENCE ASSESSMENT

The consequences of IPNV establishing in the ornamental finfish industry would be negligible to low (N–L).

If IPNV became established in natural waters, the consequences to native and introduced species, both wild and captive, would be moderate to high (M–H), due primarily to effects on the farmed and the recreational freshwater salmonid sectors.

While the effect on the environment cannot be discounted, there is no reason to expect that the establishment of IPNV would affect the survival of any vulnerable or endangered species in Australia or have any significant effect on the environment.

UNRESTRICTED RISK ESTIMATE FOR IMPORTATION OF ORNAMENTAL FINFISH

From Figure 1.1 (risk evaluation matrix):

- probability of establishment in natural waters = N
- significance of consequences = M–H
- importation risk for IPNV = acceptable (‘yes’ in Figure 1.1).

That is:

- the risk associated with the unrestricted importation of ornamental finfish meets Australia’s ALOP; and
- risk management measures are not warranted.

4.2.3 IRIDOVIRAL DISEASES OF FRESHWATER ORNAMENTAL FINFISH

Iridoviruses have been associated with a variety of wild and cultured fish and several have been reported in freshwater ornamental fish species, of which the most recognised are chromide cichlid virus, Ramirez' dwarf cichlid anaemia virus and iridoviruses in gouramis and angelfish. There is no information on the relationship between these viruses.

Geographic distribution

Iridoviruses associated with ornamental finfish have been reported in the United States (Fraser et al 1993), South America (Leibovitz and Riis 1980), Singapore (Armstrong and Ferguson 1989, Anderson et al 1993) and the United Kingdom (Rodger et al 1997).

Leibovitz and Riis (1980) reported an acute disease in Ramirez' dwarf cichlids (*Apistogramma/Microgeophagus ramirezi*) imported from South America into the United States.

Similarly, a systemic viral disease associated with iridovirus-like particles affected young adult chromide cichlids (*Etroplus maculatus*) from Singapore (Armstrong and Ferguson 1989).

Iridovirus-like virions were reported from dwarf gourami (*Colisa lalia*) imported into Australia from Singapore (Anderson et al 1993). Iridovirus was isolated from two separate stocks of diseased three spot gouramis (*Trichogaster trichopterus*) farmed in Florida, United States. The virus was isolated from the spleen and intestine of moribund fish; however, no *in vivo* infectivity studies were performed with the isolated virus (Fraser et al 1993).

Systemic iridovirus infection was reported in freshwater angelfish (*Pterophyllum scalare*) bred in the United Kingdom (Rodger et al 1997). The mortality rate in the affected stock was higher than 70%.

Host range and prevalence

Leibovitz and Riis (1980) reported 100% morbidity with 40–80% mortality in five shipments of Ramirez' dwarf cichlids (*Apistogramma/Microgeophagus ramirezi*), which are listed on Schedule 6. Iridovirus-like particles have also been reported in chromide cichlids (*Etroplus maculatus*) (Armstrong and Ferguson 1989), which are not listed on Schedule 6.

Anderson et al (1993) reported iridovirus-like virions in dwarf gourami *Trichogaster lalius*. In addition, an iridovirus was isolated from moribund gouramis (*T. trichopterus*) (Fraser et al 1993). In a separate study, an attempt to demonstrate that iridovirus is the cause of disease in gouramis was not successful, although there was a strong correlation between disease and the presence of virus (R Francis-Floyd pers. comm.).

In a single report, freshwater angelfish (*Pterophyllum scalare*) (listed on Schedule 6) were shown to have a systemic iridovirus infection in which diseased fish showed abdominal distension and pale gills. More than 70% of the affected stock died (Rodger et al 1997).

Iridoviruses and amphibians

During the past 30 years amphibian population declines have occurred in many parts of the world including Australia (Laurance et al 1996, Cunningham et al 1996, Berger et al 1998, Longcore et al 1999). The causes of this decline have not been determined.

Montane rainforest amphibian populations in Queensland, Australia and Central America have declined sharply in recent years (Laurance et al 1996, Berger et al 1998). Disease has been proposed as the likely cause of the disappearance or sharp decline of stream-dwelling frog species in the montane rainforests in Queensland (Laurance et al 1996) as declines spread in a pattern consistent with an epidemic. Although the affected frog species are taxonomically diverse, they all breed in and inhabit rainforest streams, which suggests that a water-borne pathogen may be involved (Laurance et al 1996). It has been hypothesised that the introduction of exotic pathogens through the release of aquarium fish may have affected amphibian populations (Laurance et al 1996), although no evidence has been produced to support this.

Histological investigations of dead frogs gathered from declining populations in Queensland and western Panama revealed cutaneous chytridiomycosis (Berger et al 1998). This fungus is cosmopolitan and occurs mainly in soil and water. However it was not found in archived frog samples collected from the wild before population declines (Berger et al 1998). A preliminary transmission experiment demonstrated that the chytrid fungus is associated with a fatal disease of frogs suggesting it is the cause of amphibian declines (Berger et al 1998). In addition, a chytrid fungus was recently isolated from a captive blue poison dart frog which died of an epidermal infection in Washington DC, United States (Longcore et al 1999). The fungus has been identified as *Batrachochytrium dendrobatidis*.

Two members of the *Ranavirus* genus within the *Iridoviridae* family have been identified in Australia; epizootic haematopoietic necrosis virus (EHNV) was isolated from redfin perch in Victoria (Langdon et al 1986) and Bohle iridovirus (BIV) was isolated from the ornate burrowing frog in Queensland (Speare and Smith 1992). A serological survey conducted in Australia and Venezuela indicated the presence of antibodies against ‘ranaviruses’ in populations of the giant toad (Zupanovic et al 1998). However, a causal link between ranaviruses and frog population declines in Australia has not been established.

An iridovirus-like agent has been proposed as the causative agent of natural outbreaks of ‘red leg’ disease reported during mass mortalities of the common frog in the United Kingdom (Cunningham et al 1996). The viral particles were demonstrated by electron microscopy in epidermal lesions of diseased frogs but were not seen in healthy tissue. Examination of frog carcasses revealed two main disease syndromes: skin ulceration with or without necrosis of distal limbs, and systemic haemorrhages (Cunningham et al 1996). The presence of overlapping pathological characteristics between the two syndromes suggested that they may be different manifestations of the same disease (Cunningham et al 1996). It was also thought that temperature variation and opportunistic invasion of bacteria such as *Aeromonas hydrophila* may be factors determining the syndrome presented. Examination by electron microscopy of frog cell line cultures inoculated with homogenates of skin from affected frogs revealed unidentified small, round, virus-like particles and adenovirus-like particles (Cunningham et al 1996). The possible role of these agents in the syndromes has not been determined.

Iridovirus infections have also been associated with high mortalities in tiger salamander (*Ambystoma mavortium*) populations in southern Saskatchewan, Canada (Schock et al 1998). The virus isolated was identified as a ranavirus but one distinct from other ranaviruses. The virus appears to be waterborne but, while susceptibility of other amphibians and fish at the site has not been fully assessed, preliminary results suggest that chorus frogs and wood frogs, which inhabit the same ponds where salamander mortalities occurred, do not carry the virus and are not susceptible to infection (Schock et al 1998).

Jancovich et al 1997 reported on an endangered tiger salamander (*Ambystoma tigrinum stebbinsi*) population in south Arizona, United States experiencing a recurring epizootic. An iridovirus (named *Abystoma tigrinum* virus) was isolated from a diseased salamander and was shown to be the primary pathogen in these epizootics.

Other entry pathways for such disease agents are shown by the recent seizure at Cairns airport of 10 juvenile green pythons (*Chondropython viridis*) (Anon 1999). Scientists at the CSIRO Australian Animal Health Laboratory isolated a virus identified by electron microscopy as an iridovirus (Anon 1999) from two of the snakes. Green pythons are native to the Cape York Peninsula in far north Queensland, Papua New Guinea and Indonesia.

Detection methods

Iridoviruses produce characteristic cytoplasmic inclusions in infected host tissue. Electron microscopy can be used to confirm the presence of virions within the cytoplasm.

Stability of disease agent

There is no information available on the stability of iridoviruses isolated from freshwater ornamental fish.

Susceptibility of host species in Australia

Ornamental fish species in Australia such as gouramis and cichlids would be susceptible to iridovirus infections. The susceptibility of Australian native species to iridoviruses associated with ornamental fish species is not known. There is no evidence suggesting iridoviruses as a significant cause of disease in native species in Australia including any disease related to the decline in frog populations.

An iridovirus isolated from frogs in Australia, BIV was shown to be pathogenic for barramundi (*Lates calcarifer*) but not for rainbow trout (*Oncorhynchus mykiss*) (Moody and Owens 1994).

Transmission

There is no information available on the natural transmission of iridoviruses discussed above. However, as in many other viral infections, horizontal transmission via ingestion of infected excreta and cannibalism of dead fish is likely.

Release assessment

In addition to information presented on release assessment in Section 1.5, the following key points are relevant to the likelihood of iridoviruses associated with freshwater ornamental finfish entering Australia via the importation of ornamental finfish.

- Iridoviruses associated with freshwater ornamental finfish have been reported in the United States, South America, Singapore and the United Kingdom.
- Iridovirus infections associated with high morbidity and mortality have been reported from cichlids and gouramis. On at least two occasions, iridoviruses have been detected in quarantined gouramis imported into Australia.
- Most infected fish developed clinical signs 24 to 96 hours before death. Infected yet apparently healthy fish may be included in shipments for export to Australia.

Exposure assessment

In addition to information presented on exposure pathways (Section 1.6), if the disease agents entered Australia, the following key points would be relevant to the establishment of iridoviruses associated with freshwater ornamental finfish in the ornamental finfish industry.

- Gouramis and cichlids are susceptible to iridoviruses and are commonly traded in Australia.
- Horizontal transmission via ingestion of infected excreta and cannibalism of dead fish is likely.

An iridovirus infection in a gourami farm in Florida, United States was reported with high prevalence of infected fish indicating the ability of the virus to establish and spread in fish farms.

In addition to information presented on exposure pathways (Section 1.6), if the disease agent entered Australia, the following key point would be relevant to the establishment of iridoviruses associated with freshwater ornamental finfish in Australian natural waters.

Although extensively bred in the ornamental fish industry in Australia, gouramis and cichlids are not raised in ponds and therefore are not associated with significant pathways by which infected fish may enter the natural environment.

There is a low to moderate probability of iridoviruses associated with freshwater ornamental finfish causing infection in the ornamental fish industry in Australia. If the agent entered Australia, the probability of infection in natural waters would be expected to be significantly lower than that for the ornamental finfish industry.

Consequence assessment

Effects on commercially significant species

Ramirez' dwarf cichlids (*Apistogramma/Microgeophagus ramirezi*) appear to be highly susceptible to infection, experiencing 100% morbidity with 40–80% mortality (Leibovitz and Riis 1980).

Anderson et al (1993) reported Iridovirus-like virions by electron microscopy in stromal cells of the lamina propria in dwarf gourami (*Colisa lalia*). However, virus-associated lesions were not observed, which suggests that the viral infection did not contribute to the mortality of fish.

Iridovirus was isolated from two separate stocks of diseased three spot gouramis (*Trichogaster trichopterus*) (Fraser et al 1993). The virus was isolated from the spleen and intestine of moribund fish, although aetiology of disease was not confirmed. However, mortalities reached 70% with lesions of a type that indicated a systemic iridovirus infection as the cause of death.

Rodger et al (1997) reported systemic iridovirus infection in freshwater angelfish (*Pterophyllum scalare*). The mortality rate in the affected stock was higher than 70%.

Gouramis and cichlids are produced locally in Australia on a very small scale. Effects on industry of these iridoviruses establishing in freshwater ornamental finfish are expected to be at a premises level and not at the 'whole industry' level.

Ecological and environmental effects

The susceptibility of Australian native fish to the iridoviruses associated with freshwater ornamental finfish is not known. There is experimental evidence that cross-infection from frogs to fish can occur (Moody and Owens 1994). The reverse may also be possible (A Hayatt pers. comm.) but has not been shown.

The origin of the frog iridovirus, BIV, in Australia is not known. Although it may be possible that BIV originated from a fish iridovirus (L Owens pers. comm.), a survey of the literature did not reveal any information supporting a causal link between any ornamental finfish-related iridoviruses and BIV and the reported declines in populations of native frogs.

There is currently no evidence that iridoviruses carried by freshwater ornamental finfish would affect the survival of any vulnerable or endangered species in Australia or have any significant effect on the environment. AQIS will, however, maintain a close watching brief on this group of viruses to ensure that any significant new information leads to appropriate quarantine measures.

Unrestricted risk estimate

For the unrestricted importation of gouramis and cichlids, the probability of iridoviruses establishing in the ornamental fish industry would be low to moderate. The consequences of establishment would be low. Thus, for iridoviruses, the risk associated with the unrestricted importation of gouramis and cichlids would not meet Australia's ALOP. The implementation of specific risk management measures would be warranted.

A summary of the risk assessment is shown in Box 4.3. Appropriate risk management measures are discussed in Chapter 5.

Box 4.3

Risk assessment — iridoviral diseases of freshwater ornamental finfish

RELEASE ASSESSMENT (R)

The probability of iridoviruses associated with freshwater ornamental finfish entering Australia as a consequence of the unrestricted importation of gouramis and cichlids would be low to moderate. For the unrestricted importation of other Schedule 6 ornamental finfish species, the probability would be very low.

EXPOSURE ASSESSMENT (E)

If iridoviruses entered Australia, the probability of susceptible animals in the ornamental finfish industry being exposed to a dose sufficient to cause infection would be low to moderate.

The probability of susceptible animals in Australian natural waters being exposed to a dose sufficient to cause infection would be extremely low.

PROBABILITY OF DISEASE ESTABLISHMENT (R + E)

The probability of iridoviruses associated with freshwater ornamental finfish becoming established in the ornamental finfish industry as a consequence of the unrestricted importation of gouramis and cichlids would be low to moderate (L–M). For other freshwater species and marine species, the probability would be very low (VL).

The probability of iridoviruses becoming established in natural waters as a consequence of the unrestricted importation of gouramis and cichlids would be extremely low (EL). For other freshwater species and marine species, the probability would be negligible (N).

CONSEQUENCE ASSESSMENT

The consequences of iridoviruses establishing in the ornamental finfish industry would be low (L), due primarily to the effects on cichlid and gourami breeding establishments.

If iridoviruses became established in natural waters, the consequences to native and introduced species, both wild and captive, would be negligible to low (N–L).

There is currently no evidence that iridoviruses carried by freshwater ornamental finfish would affect the survival of any vulnerable or endangered species in Australia or have any significant effect on the environment.

UNRESTRICTED RISK ESTIMATE FOR IMPORTATION OF ORNAMENTAL FINFISH

From Figure 1.1 (risk evaluation matrix):

- probability of establishment in the ornamental finfish industry from gouramis and cichlids = L–M
- significance of consequences = L
- importation risk for iridoviruses = unacceptable (‘no’ in Figure 1.1).

That is:

- the risk associated with the unrestricted importation of gouramis and cichlids does not meet Australia’s ALOP; and
- risk management measures are warranted for gouramis and cichlids.

4.2.4 SPRING VIRAEMIA OF CARP VIRUS (SPRING VIRAEMIA OF CARP)

Geographic distribution

Spring viraemia of carp virus (SVCV) has been spreading to many regions within continental Europe since 1929 (Wolf 1988, OIE 1997b) and is reported to have been introduced into the United Kingdom in 1988, almost certainly with imported live fish. In 1998, SVCV was detected in goldfish and koi carp imported to the United Kingdom from China, suggesting that the virus occurred outside Europe (Hill 1998).

SVC typically occurs at water temperatures below 18°C, predominantly in the spring (Fijan 1999).

Host range and prevalence

Under natural conditions, SVCV infects many cyprinid species, of which only goldfish (*Carassius auratus*) is listed on Schedule 6. Guppies (*Poecilia reticulata*) are susceptible to experimental infection (Ahne 1973 reviewed in Fijan 1999).

Haenen and Davidse (1993) reported that SVCV was not pathogenic for rainbow trout. SVCV is a rhabdovirus but is serologically unrelated to the salmonid rhabdoviruses, VHSV and IHNV (reviewed in Fijan 1999).

Serological surveys show that virus-neutralising antibodies to SVCV can be detected in fish from up to 95% of carp farms in some European countries (reviewed in Fijan 1999).

Detection methods

Diagnosis is based on isolation and immunological identification of the virus in cell culture or the detection of viral antigen in infected fish tissue (OIE 1997b). The virus may be readily isolated from diseased carp during an epizootic and from survivors for a few weeks after an outbreak of disease (Wolf 1988). It is thought that inapparent infection may be common, as some carp farms in Germany have a large percentage of serologically positive, apparently healthy fish (Wizigmann et al 1980 cited in Fijan 1999).

Goldfish are usually quite resistant to clinical disease but can be sub-clinically infected (BJ Hill pers. comm.).

Stability of disease agent

The virus is stable at pH 7–10 and in tap water at 10°C. It can survive in mud at 4°C for 42 days, in stream water at 10°C for 14 days and after drying at 4–21°C for 21 days (reviewed in Fijan 1999).

Susceptibility of host species in Australia

Cyprinids in Australia, including wild carp, would be susceptible to infection with SVCV. There is little information on the susceptibility of Australian native species. Infection trials have shown gudgeon and golden perch to be refractory to SVC (BJ Hill pers. comm.). There are no cyprinids native to Australia. Given overseas experience that cyprinid fish species are the only natural hosts for SVCV, it is very unlikely that native species would be susceptible to infection.

Transmission

SVCV is transmitted horizontally via virus in faeces and, possibly, in urine and gill mucous. The gills are the site of virus entry and primary replication (reviewed in Fijan 1999). There is circumstantial evidence that vertical transmission may also occur. Parasitic fish lice (*Argulus foliaceus*) and leeches (*Pisciola geometra*) may play a role in natural transmission (reviewed in Wolf 1988).

Release assessment

In addition to information presented on release assessment in Section 1.5, the following key points are relevant to the likelihood of SVCV entering Australia via the importation of ornamental finfish.

- The pathogen has been reported in Europe and China.
- Of the Schedule 6 species, natural infection has only been reported from goldfish.
- Methods for detecting the agent in fish require a high level of technical expertise and SVCV occurrence may therefore be under-reported. Sacrifice of the fish is required for definitive diagnosis.
- Goldfish are usually resistant to the disease but can be sub-clinically infected with SVCV.

Exposure assessment

In addition to information presented on exposure pathways (Section 1.6), if the disease agent entered Australia, the following key points would be relevant to the establishment of SVCV in the ornamental finfish industry.

- Goldfish are susceptible to infection and comprise a major component of the ornamental finfish industry in Australia.
- Infected fish may not always show signs of disease and may be supplied to end-users.
- SVCV may be transmitted horizontally. There is some evidence that transmission also occurs vertically and via parasite vectors.

In addition to information presented on exposure pathways (Section 1.6), if the disease agent entered Australia, the following key points would be relevant to the establishment of SVCV in Australian natural waters.

- Goldfish have a significant probability of entering and surviving in Australian natural waters.
- Susceptible host fish species are present in Australian natural waters.

There is a moderate probability of SVCV causing infection in the ornamental finfish industry in Australia. If the agent entered Australia, the probability of infection in natural waters would be expected to be only one level of probability lower than that for the ornamental fish industry.

Consequence assessment

Effects on commercially significant species

SVC is listed as a notifiable disease by the OIE (OIE 1997b), primarily affects common carp and can cause high rates of mortality and serious economic losses in carp aquaculture (Fijan 1999). Losses due to SVC vary from year to year, with mortalities, when they occur, of around 30% (Fijan 1999). If established in Australia, SVCV would be expected to have serious effects on the culture of koi carp and possibly goldfish. Any impact would be likely to affect production at a local or regional level, rather than a 'whole industry' level.

Ecological and environmental effects

SVCV is closely associated with farmed cyprinids overseas and does not affect non-cyprinid fish. The susceptibility of Australian native species to SVCV is not known; however, based on overseas experience, the host range of the agent and because there are no cyprinids native to Australia, there is no reason to consider that SVCV would cause significant disease in species native to Australia.

Unrestricted risk estimate

For the unrestricted importation of goldfish, the probability of SVCV establishing in the ornamental finfish industry would be low to moderate. The consequences of establishing in the ornamental finfish industry would be low to moderate. Thus, for SVCV, the risk associated with the unrestricted importation of goldfish would not meet Australia's ALOP and implementation of specific risk management measures would be warranted.

A summary of the risk assessment is shown at Box 4.4. Appropriate risk management measures are discussed in Chapter 5.

Box 4.4
Risk assessment — spring viraemia of carp virus

RELEASE ASSESSMENT (R)

The unrestricted probability of spring viraemia of carp virus (SVCV) entering Australia as a consequence of the importation of goldfish would be low to moderate. For other freshwater species the probability would be extremely low, and for marine species the probability would be negligible.

EXPOSURE ASSESSMENT (E)

If SVCV entered Australia, the probability of susceptible animals in the ornamental finfish industry being exposed to a dose sufficient to cause infection would be moderate.

The probability of susceptible animals in Australian natural waters being exposed to a dose sufficient to cause infection would be low.

PROBABILITY OF DISEASE ESTABLISHMENT (R + E)

The unrestricted probability of SVCV becoming established in the ornamental finfish industry as a consequence of the importation of goldfish would be low to moderate (L–M). For other freshwater species, the probability would be extremely low (EL) and for marine species, the probability would be negligible (N).

The probability of SVCV becoming established in natural waters as a consequence of the importation of goldfish would be low (L). For other freshwater species and marine species, the probability would be negligible (N).

CONSEQUENCE ASSESSMENT

The consequences of the of SVCV establishing in the ornamental finfish industry would be low to moderate (L–M), due primarily to effects on koi carp farming.

If SVCV became established in natural waters, the consequences to native and introduced species, both wild and captive, would be negligible to low (N–L).

While the effect on the environment cannot be discounted, there is no reason to expect that the establishment of SVCV would affect the survival of any vulnerable or endangered species in Australia or have any significant effect on the environment.

UNRESTRICTED RISK ESTIMATE FOR IMPORTATION OF ORNAMENTAL FINFISH

From Figure 1.1 (risk evaluation matrix):

- probability of establishment in the ornamental finfish industry from goldfish = L–M
- significance of consequences in the ornamental finfish industry = L–M
- importation risk for SVCV = unacceptable ('no' in Figure 1.1).

That is:

- the risk associated with the unrestricted importation of goldfish does not meet Australia's ALOP; and
- risk management measures are warranted for goldfish.

4.2.5 *AEROMONAS SALMONICIDA*, TYPICAL (FURUNCULOSIS) AND ATYPICAL STRAINS

Exotic strains of *A. salmonicida* are considered in this section. Because goldfish ulcer disease (GUD) is present in Australia and is not the subject of mandatory controls nationwide, no further consideration is given to the GUD biovar of 'atypical' *A. salmonicida*.

Geographic distribution

'Typical' *A. salmonicida* has a wide distribution but has not been reported in Australia, New Zealand, or South America (reviewed in Hiney and Olivier 1999). However, Shotts (1994) reported the agent's presence in North and South America, Europe, Asia and Africa. 'Atypical' strains of *A. salmonicida* have been reported in various parts of the world including Canada, the United States, Japan, central and northern Europe (including the Nordic countries), Australia, South Africa, the Mediterranean, Yugoslavia and Italy (Wiklund and Dalsgaard 1998). Hiney and Olivier (1999) observed that there appears to be a strong correlation between strains of 'atypical' *A. salmonicida* and their geographical region of origin.

Host range and prevalence

'Typical' *A. salmonicida* is reported from both salmonids and non-salmonids, and causes several diseases including furunculosis of salmonids. Bernoth (1997) in her review of this pathogen listed several non-salmonid hosts, including ornamental cyprinids (probably koi carp), minnow (*Phoxinus phoxinus*), stickleback (*Culaea inconstans*) and paddlefish (*Polyodon spathula*) from freshwater; and wrasse (*Labrus bimaculatus* and *Ctenolabrus rupestris*), coalfish (*Pollachius virens*) and Atlantic cod (*Gadus morhua*) from marine waters. Of the species listed on Schedule 6, 'typical' *A. salmonicida* non-experimental infection has only been reported from *Labrus bimaculatus*, a marine coldwater wrasse (Labridae).

There is little information on the role of non-salmonid carriers in the epidemiology of 'typical' *A. salmonicida* infection of salmonids. In a study of cleaner wrasse, Hjeltnes et al (1995) concluded that the transmission of *A. salmonicida* from wrasse to salmonids under cage culture conditions would be a rare event. Wrasse are in the family Labridae, all species of which are included on Schedule 6.

The reported host range for 'atypical' *A. salmonicida* is wide. Of Schedule 6 species, 'atypical' *A. salmonicida* has been isolated from apparently healthy goldsinny wrasse (*Ctenolabrus rupestris*), a coldwater finfish species (Frerichs et al 1992) and clinically infected goldfish (*Carassius auratus*) (reviewed in Hiney and Olivier 1999).

A. salmonicida is usually isolated from temperate/coldwater species. Except for goldfish, temperate species are not commonly traded in the ornamental finfish industry in Australia.

Detection methods

Diagnosis of *A. salmonicida* is usually based on culture of bacteria recovered from internal organs (especially kidney) and from skin lesions if present. Problems may be encountered with culture of fastidious strains as well as contamination by opportunistic pathogens (Hiney and Olivier 1999). 'Typical' subspecies are, on the whole, quite homogeneous in genetic and biochemical profile (Hiney and Olivier 1999).

Covert infection with 'atypical' *A. salmonicida* may occur. The finding in Australia in 1974 of the GUD biovar is thought to have followed from the importation of sub-clinically infected goldfish (Humphrey and Ashburner 1993). Similarly, 'typical' *A. salmonicida* present at extremely low levels in carrier fish may also be difficult to detect (Shotts 1994).

The American Fisheries Society recommends using IFAT on tissues and culture of bacteria recovered from intestinal material and kidney tissue to detect 'typical' *A. salmonicida* in asymptomatic fish (Shotts 1994). Standard serological tests for 'typical' *A. salmonicida* could be modified and used for detecting 'atypical' strains (Hiney and Olivier 1999). Stress testing based on heat treatment and injection of immunosuppressants is more sensitive but may take up to 18 days to complete (Hiney et al 1997). *A. salmonicida*-specific enrichment media have been developed and there are several PCR-based tests (both for pure culture and direct detection in tissues) with varying degrees of sensitivity (Byers et al

1997 1998, Carson 1998, CRC 1998). None of these tests is commercially available.

Certain Gram-negative bacteria have been shown to enter a viable but non-culturable (VBNC) state in low nutrient environments. However, the validity of tests used in experiments to determine cell viability has recently been questioned (Morgan et al 1992).

The information presented above is based on work on 'typical' *A. salmonicida* infection of salmonids. The validity of these methods in non-salmonids is undetermined.

Stability of disease agent

'Typical' *A. salmonicida* can remain infective for many months and viable for up to six months in marine sediment. The relationship between bacteria in the environment and occurrence of disease has not been established (Hiney and Olivier 1999). The agent's ability to persist in the external environment in an infective state was considered a major determinant in the spread of disease between Atlantic salmon sea cage sites (Rose et al 1990). However, Rose et al (1990) stated that 'typical' *A. salmonicida* has a limited potential to survive in seawater, whereas its survival in freshwater sediment is greatly enhanced. Morgan et al (1992) concluded that the transport of *A. salmonicida* bacteria in freshwater is of little significance in the spread of disease over long distances.

There is little information on the persistence of 'atypical' strains of *A. salmonicida* in the environment (outside a living host). Evelyn (1971) reported that a strain isolated from flounder survived better in seawater than in fresh water. Wiklund and Dalsgaard (1995) described the persistence of two strains from the Baltic Sea causing ulceration in flounder (*Platichthys flesus*). These agents survived for less than 14 days in sterilised brackish water. This period increased to 63 days when sterile sediment was added. The two strains remained viable more readily at 4°C than at 15°C. Wiklund and Dalsgaard (1995) concluded that 'atypical' *A. salmonicida* shed from ulcers of diseased flounders may persist in the bottom sediment of brackish water environments for an extended (unspecified) period.

Susceptibility of host species in Australia

Several finfish species in Australian waters are known to be susceptible to infection with *A. salmonicida*, including several species of introduced salmonids, goldfish and silver perch (which are susceptible to the GUD biovar). Worldwide, 'typical' and 'atypical' strains have been isolated from species in many fish taxa.

Transmission

Whittington and Cullis (1988) reported 10-day LD_{50} values of 7.4 x 10^3 CFU for Atlantic salmon, 3.0 x 10^2 CFU for brown trout, 3.7 x 10^2 CFU for brook trout, and 6.4 x 10^3 CFU for rainbow trout, using the GUD biovar of *A. salmonicida* present in Australia. Bath and abrade/bath doses were 1.8 x 10^6, 2 x 10^5, 2 x 10^6 and 2.1 x 10^5 for Atlantic salmon, brown trout, rainbow trout and brook trout, respectively. A bacterial dose of 10^2 x 10^3 CFU/mL over a three-day bath exposure did not induce infection in Atlantic salmon. However, extended periods of exposure to 10^2 CFU/mL for three weeks resulted in some mortality.

The virulence of strains of 'atypical' *A. salmonicida* varies. Reported values of LD_{50} based on parenteral exposure include $10^{1.7}$–10^3 CFU in Atlantic salmon for strains isolated from Atlantic salmon, 10^3 cfu in eels using an agent of eel origin, 10^4 CFU in goldfish using a goldfish isolate and 10^6 CFU using cod, flounder, turbot and minnow isolates in the hosts of origin (reviewed in Hiney and Olivier 1999). These LD_{50} values are, on the whole, moderate and therefore AQIS has assumed that infected fish (alive or dead) entering the aquatic environment could well contain a sufficient number of viable bacteria to infect a susceptible host.

The mode of transmission and route of entry of 'typical' or 'atypical' strains of *A. salmonicida* are not known (Hiney and Olivier 1999). In several cases, the establishment of disease has been linked to the transfer of infected live fish (as reported for the spread of the GUD biovar in Australia through infected goldfish) (Hiney and Olivier 1999). The probability of cross-species transmission is difficult to estimate because scientific opinion on this issue differs. Hiney and Olivier (1999) argued that there was little if any cross infection of strains between different host species under natural or aquaculture conditions. For example, these authors stated that there was no record of 'atypical' strains from goldfish affecting farmed or wild salmonids. In mass mortality of carp (*Cyprinus carpio*) and tilapia (*Oreochromis mossambicus*) in a reservoir in India, no cohabiting fish such as species of *Puntius, Rasbora, Esomus*, or *Garra* were affected (Reddy et al 1994) and there was no evidence that these apparently healthy fish were clinically infected with the disease agent.

On the other hand, reports of experimental cross-infection of salmonids and non-salmonids with the GUD biovar of *A. salmonicida* suggest that cross-species infection may be significant (Carson and Handlinger 1988). Bucke (1980) reported that a goldfish isolate was virulent in Atlantic salmon, brook and rainbow trout. The GUD biovar in Australia may cause disease in wild silver perch (*Bidyanus bidyanus*) and goldfish. A strain, reportedly identical to the GUD biovar, has been isolated from sablefish (*Anoplopoma fimbria*) and ling cod in Canada (reviewed in Hiney and Olivier 1999).

Moribund fish or apparently healthy carrier fish shedding the organism may contaminate water. Horizontal transmission of 'typical' *A. salmonicida* occurs between and within fish populations (Hiney and Olivier 1999). It is generally accepted that 'typical' *A. salmonicida* is transmitted in the apparent absence of a known animal vector, via water. Mechanical transmission via contaminated nets (McCarthy 1977), ectoparasitic sea lice (Wiklund et al 1992) and transfer via aerosol (Wooster and Bowser 1996) have also been proposed as mechanisms for disease transmission. Wrasse stocked in salmon cages (as cleaner fish) become infected with 'typical' *A. salmonicida* probably after ingesting dead infected salmon (Treasurer and Laidler 1994).

Daly et al (1994) demonstrated transmission of carp erythrodermatitis (CE) by bath challenge with *A. salmonicida* '*nova*'. CE is a disease of cultured carp in Europe and is part of the infectious dropsy of carp (IDC) complex (Noga 1996). IDC may manifest as an acute disease (caused by spring viraemia of carp virus) or as a chronic disease caused by 'atypical' *A. salmonicida*.

Vertical transmission of *A. salmonicida* has not been shown to occur under natural conditions (Shotts 1994). There was no evidence of vertical transmission of 'typical' *A. salmonicida* in carrier broodfish and in eggs from artificially infected broodstock tested five days after incubation (McCarthy 1977). The authors concluded that vertical transmission is not significant in the epidemiology of furunculosis in the field.

The spread of 'typical' *A. salmonicida* within a region is well documented. For example, furunculosis was first reported in Norway in 1964, after the importation of live rainbow trout from Denmark. The disease spread to several farms and to wild fish in a nearby river. It was eradicated at several sites, the last being disinfected in 1969. In 1985, furunculosis was discovered in marine fish farms following importation of salmonid smolts from Scotland. By the end of 1992, 550 farms were infected. The rapid spread of the disease was attributed to several factors, including escape of farmed fish, possibly transport of fish between farms, and natural movement of wild fish in the sea (Johnsen and Jensen 1994).

Release assessment

In addition to information presented on release assessment in Section 1.5, the following key points are relevant to the likelihood of exotic strains of *A. salmonicida* entering Australia via the importation of ornamental finfish.

- Exotic strains of *A. salmonicida* have a wide host range and occur in many countries. The normal host range of individual subspecies is not well defined.
- *A. salmonicida* is predominantly a pathogen of coldwater/temperate fish species, however, the majority of species on Schedule 6 and imported are tropical species. Of the species on Schedule 6, 'typical' *A. salmonicida* has only been isolated from clinically infected wrasse cohabiting with farmed salmonids and 'atypical' strains have only been reported from clinically infected goldfish (GUD biovar) and covertly infected goldsinny wrasse. As such, *A. salmonicida* is not expected to have a high prevalence in coldwater ornamental species. The agent's prevalence in other species is expected to be significantly lower.
- The agent may be detected relatively easily in overtly diseased fish; however, isolation from non-sterile sites such as the gut or skin where contaminants are likely, isolation from asymptomatic carriers, and

the isolation of fastidious strains, may be more difficult. As such, the prevalence of infection with *A. salmonicida* may be underestimated. To diagnose infection with *A. salmonicida,* tested fish must normally be sacrificed.

- Apparently healthy fish may be infected with *A. salmonicida* and may be included in goldfish and wrasse shipments exported to Australia. The pathogen would be at low titre in such fish.

Exposure assessment

In addition to information presented on exposure pathways (Section 1.6), if the disease agent entered Australia, the following key points would be relevant to the establishment of exotic strains of 'typical' and 'atypical' *A. salmonicida* in the ornamental finfish industry.

- Goldfish are susceptible to the agent and comprise a major component of the ornamental finfish industry in Australia.
- *A. salmonicida* has a direct life cycle. Infection may be readily transferred and moderate LD_{50} values have been reported for 'typical' and 'atypical' strains of *A. salmonicida.*
- Some infected fish may appear healthy and may be supplied to end-users. Overt disease, particularly with 'atypical' stains, may occur and thereby reduce the likelihood of infected fish being supplied to end-users.
- Susceptible animals in the marine ornamental finfish industry are less likely to be exposed to the agent than susceptible animals in the freshwater sector.

In addition to information presented on exposure pathways (Section 1.6), if the disease agent entered Australia, the following key points would be relevant to the establishment of exotic strains of 'typical' and 'atypical' *A. salmonicida* in Australian natural waters.

- Goldfish are associated with significant pathways by which infected fish may enter and survive in Australian natural waters.
- The GUD biovar is reported to have established in Australian feral fish via infected goldfish entering natural waters.
- *A. salmonicida* may readily persist in water and sediment outside the host fish.
- Susceptible host species would be present in Australian waters.

The probability of exotic strains of *A. salmonicida* causing infection in the freshwater and marine ornamental finfish industries in Australia is considered to be moderate and low, respectively. If the agent entered Australia, the probability of infection in natural waters would be expected to be only one level of probability lower than the probability of establishment in the ornamental fish industry.

Consequence assessment

Effects on commercially significant species

Of the fish included on Schedule 6, *A. salmonicida* has been isolated from species of *Carassius, Labrus* and *Ctenolabrus* (in the latter two species, in fish penned with farmed salmonids). The infectivity and pathogenicity of these isolates for aquatic animals in Australia are unknown. It is difficult to estimate the probability of natural cross-species transmission of infection with *A. salmonicida*.

Infection with 'typical' *A. salmonicida* has caused significant disease in farmed Atlantic salmon but is of little pathogenic or economic significance in other finfish. The significance of this disease in salmonids has decreased greatly in recent years with the adoption of effective management strategies; however, furunculosis due to 'typical' *A. salmonicida* is still one of the economically significant diseases of farmed salmonids in northern Europe and North America.

Experience in Europe shows that management and veterinary strategies can be used to prevent clinical disease but infection will still occur. Vaccines are available commercially in Europe and Canada. Oil adjuvant vaccines appear to be effective in controlling outbreaks of disease, however, they also have adverse effects, including the development of lesions in the carcase, increased cost of production and reduced growth rate (Lillehaug et al 1996, Midtlyng 1996). The use of vaccines may also mask the presence of infection and vaccination provides only a limited period of protection, hence, there is current research interest in the development of an oral vaccine that could be used to boost immunity (A McVicar pers. comm.).

If disease due to *A. salmonicida* became established in Australia, control measures similar to those used overseas could be implemented. This would necessitate the use of antibiotics, a use that would have a direct cost and could also harm the product image of Australian salmon, reducing the price premium that Australian salmon attracts. The establishment of antibiotic resistant strains of *A. salmonicida* would add to costs and limit the effectiveness of control measures. The introduction of practices, such as 'all in-all out' management, would add to the cost of production, especially for Atlantic salmon farms using out-of-season smolts. Attempts could be made to eradicate disease if it was detected in an isolated locality; however, it is unlikely that disease in wild fish or at multiple sites could be eradicated.

ABARE (1994) reported that reduced fish survival, loss of product and increased costs could threaten the viability of the Australian salmonid industry in the event that furunculosis became established throughout Australia. Effective strategies for the management and prevention of furunculosis have been adopted in countries affected by this disease since ABARE conducted this study. A McVicar (pers. comm.) advised, 'because of the success of control, furunculosis has now dropped well down the ranking in importance of diseases…currently affecting the Scottish salmon farming industry'. If disease due to typical *A. salmonicida* were to become established in Australia, it is likely that similar management measures would be adopted. The impact of establishment may be lower than that predicted by ABARE, but establishment would result in increased costs and reduced profitability for the salmonid farming industry.

The establishment of disease due to 'typical' *A. salmonicida* in wild freshwater salmonids would be expected to affect the recreational fishery (primarily trout angling) at a local/regional level. Although it is likely that the disease could not be eradicated from wild salmonids, experience in the United Kingdom suggests that the initial high impact would eventually be reduced as salmonids developed resistance to the pathogen (A McVicar pers. comm.). The adoption of management strategies to prevent the spread of disease to additional freshwater catchments would be expected to reduce the impact on the recreational sector at the national level.

Carp erythrodermatitis caused by an 'atypical' strain of *A. salmonicida* is not associated with heavy mortality but may cause skin ulceration and subsequent scarring which reduces the marketability of the fish (Richards and Roberts 1978). Carp exposed by bath to sublethal doses were protected from subsequent challenge for at least five months (Daly et al 1994). Evenberg et al (1988) reported that vaccines based on concentrated, detoxified culture supernatant protected carp against subsequent challenge with lethal doses of the bacterium.

Based on experience overseas, the establishment of 'typical' or 'atypical' *A. salmonicida* in non-salmonid fish would not be expected to have significant consequences at a regional or national level. Perhaps the most significant aspect of infection establishing in non-salmonids would be the potential for these fish to serve as a reservoir of the pathogen for freshwater salmonids.

Taking into account the expected effects on the farmed and the recreational salmonid sectors, AQIS concludes that the establishment of disease due to 'typical' *A. salmonicida* in Australia would have moderate to high consequences. Taking into account the capacity of some 'atypical' strains of *A. salmonicida* to cause disease and mortality in farmed salmonids overseas, the consequences of the establishment of additional 'atypical' strains of *A. salmonicida* in Australia would be low to moderate.

Ecological and environmental effects

A search of the literature indicated that infection with 'typical' *A. salmonicida* is of little pathogenic or economic significance in non-salmonid finfish, including native fish, overseas. Non-salmonid fish in fresh water would be more likely to be infected with atypical strains than with the typical strain of *A. salmonicida* (A McVicar pers. comm.).

It has been suggested that the establishment of *A. salmonicida* (typical or atypical strains) would threaten the survival of native freshwater species in Australia. For non-salmonid freshwater species, the most common hosts of *A. salmonicida* infection overseas are members of the Family Cyprinidae. There is little evidence that Australian native fish, none of which is closely related to the Family Cyprinidae, would be particularly susceptible to infection with 'typical' or 'atypical' strains of *A. salmonicida*. While Australian experience of infection with *A. salmonicida* is limited, 'atypical' strains occur here, including the GUD biovar in southern Australia (excluding Tasmania) and *A. salmonicida* in greenback flounder in Tasmania. An 'atypical' strain of *A. salmonicida* was detected (by IFAT), but not isolated, in roach with ulcerative dermatitis in a Victorian lake (cited by Whittington et al 1995).

A single case of disease due to the GUD biovar of *A. salmonicida* was reported in a native fish (silver perch) at a farm where goldfish had been infected. However, the presence of the GUD variant of *A. salmonicida* in Australia has had little consequence other than for the specific premises affected. It has not discernibly affected wild fish or the environment and appears of no significance for the status of vulnerable or endangered native species. Similarly, the presence of 'atypical' strains of *A. salmonicida* in Tasmania and Victoria has not been associated with disease under natural conditions and has had little consequence for farmed or wild salmonids or native finfish.

It could be argued that the entry and establishment of 'typical' *A. salmonicida* or more virulent 'atypical' strains would have greater consequence for the environment and for native fish. The finfish species listed by Environment Australia as vulnerable and/or endangered under the *Endangered Species Protection Act 1992* (Appendix 2) belong to 13 genera. Several factors have led to the current status of these species. The more important contributing factors include predation (including by introduced salmonid species such as brown trout) and degradation of habitat. From first principles, it could be argued that the establishment of a pathogen that had its main pathogenic effects on introduced salmonid species (such as brown trout) could have positive consequences for vulnerable species such as the galaxids, through a reduction in the population of key predators.

However, overseas experience shows that the presence of *A. salmonicida* has had no significant effect on populations of wild non-salmonid fish. Therefore, while the effect of establishment of additional, more virulent strains of *A. salmonicida* should not be discounted, there is no reason to expect that this would affect the survival of any vulnerable or endangered species in Australia or have any significant effect on the natural environment.

Unrestricted risk estimate

For the unrestricted importation of goldfish, the probability of an exotic strain of 'typical' or 'atypical' *A. salmonicida* establishing in natural marine and fresh waters would be very low and low, respectively. The consequences of establishing in natural waters would be of moderate to high or moderate significance, depending on the strain. Thus, for exotic strains of 'typical' or 'atypical' *A. salmonicida*, the risk associated with the unrestricted importation of goldfish would not meet Australia's ALOP and the implementation of specific risk management measures would be warranted.

A summary of the risk assessment is shown in Box 4.5. Appropriate risk management measures are discussed in Chapter 5.

Box 4.5

Risk assessment — *Aeromonas salmonicida* (‘typical’ and ‘atypical’ strains)

RELEASE ASSESSMENT (R)

The probability of exotic strains of *A. salmonicida* entering Australia as a consequence of the unrestricted importation of *Ctenolabrus* and *Labrus* spp originating from waters shared by cage-cultured salmonids would be moderate to high. For goldfish and *Ctenolabrus* and *Labrus* spp not originating from waters shared by cage-cultured salmonids, the probability would be moderate. For other temperate species the probability would be very low and for all other species the probability would be negligible.

EXPOSURE ASSESSMENT (E)

If *A. salmonicida* entered Australia, the probability of susceptible animals in the freshwater ornamental finfish industry being exposed to a dose sufficient to cause infection would be moderate. The probability of susceptible animals in the marine ornamental finfish industry being exposed to a dose sufficient to cause infection would be low.

The probability of susceptible animals in Australian natural marine and fresh waters being exposed to a dose sufficient to cause infection would be very low and low, respectively.

PROBABILITY OF DISEASE ESTABLISHMENT (R + E)

The probability of an exotic strain of *A. salmonicida* becoming established in the freshwater ornamental finfish industry as a consequence of the unrestricted importation of goldfish would be moderate (M). For other temperate species, the probability would be very low (VL). For *Ctenolabrus* and *Labrus* spp originating from waters shared by cage-cultured salmonids, the probability would be low (L). For all other species the probability would be negligible (N).

The probability of *A. salmonicida* becoming established in natural waters as a consequence of the importation of goldfish would be low (L). For other temperate freshwater species, the probability would be extremely low (EL). For other freshwater species and all marine species, the probability would be negligible (N).

CONSEQUENCE ASSESSMENT

The consequences of exotic strains of *A. salmonicida* (‘typical’ and ‘atypical’) establishing in the ornamental finfish industry would be negligible (N).

If ‘typical’ *A. salmonicida* became established in Australian natural waters, the consequences to native and introduced species, both wild and captive, would be moderate to high (M–H), due primarily to effects on the farmed and the recreational salmonid sectors. Taking into account the capacity of some ‘atypical’ strains of *A. salmonicida* to cause disease and mortality in farmed salmonids overseas, the consequences of the establishment of additional ‘atypical’ strains of *A. salmonicida* in Australian natural waters would be moderate (M).

While the effect on the environment cannot be discounted, there is no reason to expect that the establishment of ‘typical’ or ‘atypical’ strains of *A. salmonicida* would affect the survival of any vulnerable or endangered species in Australia or have any significant effect on the natural environment.

UNRESTRICTED RISK ESTIMATE FOR IMPORTATION OF ORNAMENTAL FINFISH

From Figure 1.1 (risk evaluation matrix):

- probability of establishment of an exotic strain in natural waters from goldfish = L
- significance of consequences in natural waters = M–H or M (depending on the strain)
- importation risk for exotic strains of ‘typical’ or ‘atypical’ *A. salmonicida* = unacceptable (‘no’ in Figure 1.1).

That is:

- the risk associated with the unrestricted importation of goldfish does not meet Australia’s ALOP; and
- risk management measures are warranted for goldfish.

4.2.6 *YERSINIA RUCKERI,* HAGERMAN STRAIN (ENTERIC REDMOUTH DISEASE)

The preferred serotyping scheme for *Yersinia ruckeri* is that devised by Romalde et al (1993) which comprises serotypes O1 to O4. Serotype O1 is subdivided into O1a and O1b. Serotype O1a (formerly Type 1) is the 'Hagerman strain', the most common and virulent of the serotypes (Inglis et al 1993, Austin and Austin 1993).

The IRA addresses the risk associated with serotype O1a, the 'Hagerman strain', of *Y. ruckeri.*

Geographic distribution

Y. ruckeri was first described from the Hagerman Valley, Idaho, United States in the early 1950s. Since then, the agent has progressively extended its range in North America. Wobeser (1973) considered that the movement of inapparently infected fish was the probable source of disease outbreaks outside Idaho (Stevenson and Daly 1982). By the 1980s, the disease had spread through most of Europe where it is of increasing importance to fish farming operations (Vigneulle 1990).

Y. ruckeri has now been reported from Australia, Canada, United States, and most of Europe, as well as Turkey, New Zealand, South Africa, Venezuela and India (Horne and Barnes 1999, Meier 1986). Most of these reports of yersiniosis have been for coldwater fish species, mainly salmonids.

Host range and prevalence

Y. ruckeri has been isolated from many freshwater and marine finfish species, earthworms, and several mammals including humans (reviewed in Horne and Barnes 1999). It has also been reported in the faeces and gastrointestinal tract of birds (Bangert et al 1988, Bruno 1990), in water, sewage sludge and aquatic invertebrates (Collins et al 1996). Yersiniosis primarily affects farmed freshwater fish; however, infection of farmed and wild fish in marine waters has been reported (Romalde et al 1994). *Y. ruckeri* has been isolated from non-salmonid finfish including eel, pike, perch, gudgeon and saithe. It has also been cultured from goldfish originating in Ireland (Bruno 1990).

The Hagerman strain of *Y. ruckeri* has been reported from a range of species including carp (*Cyprinus carpio*) (Fuhrmann et al 1984), goldfish (*Carassius auratus*) (McArdle and Dooley-Martyn 1985) and sole (*Solea solea*) (Michel et al 1986) (reviewed in Horne and Barnes 1999). Goldfish and the freshwater sole, *Achirus fasciatus* are listed on Schedule 6.

Detection methods

Y. ruckeri can be isolated from kidney, liver and spleen tissue and can be identified using standard culture and biochemical characterisation (Horne and Barnes 1999). Isolation from faeces is unreliable as fish shed the pathogen in faeces intermittently. The detection of covert infections may be enhanced by culturing samples from the distal intestine (Bruno 1990). Busch and Lingg (1975) concluded that the organism would be difficult to isolate using classical methods, especially if sampling was limited to the kidney and spleen; sampling of the liver and lower intestine would be required for accurate diagnosis. The API 20E system may be used to identify isolates; however, additional tests are required for confirmation. Rapid diagnostic tests based on ELISA are available commercially. PCR-based tests can be used to detect *Y. ruckeri* under experimental conditions.

Rodgers described the development of a selective, differential medium (ROD) for the isolation of *Y. ruckeri* from carrier and clinically infected rainbow trout and river water (Furones et al 1993).

Presumptive diagnosis of *Y. ruckeri* can be made by FAT of tissue smears of kidney and liver or on smears prepared from plate culture (reviewed in Horne and Barnes 1999). Definitive identification is achieved by examining specific biochemical characteristics using classical methods (Furones et al 1993). Immunodiagnostic methods such as ELISA are used commercially.

Stability of disease agent

Long-term survival of *Y. ruckeri* in the aquatic environment at a range of temperatures and salinities has been documented (reviewed in Horne and Barnes 1999). The agent survived more than three months in river, lake and estuarine environments and maintained its virulence in the viable but non-culturable state (Romalde et al 1994). *Y. ruckeri* may be shed from faeces by wild or farmed fish, aquatic invertebrates and birds; and the ability of the organism to persist in an infective state in the aquatic environment is significant (Romalde et al 1994). *Y. ruckeri* may survive for several months in sediments, potentially providing a reservoir of infection in salmonid farms (Bruno 1990).

Romalde et al (1994) reported that during the first fifteen days after bacterial cells had been added to different environments, the number of culturable bacterial cells increased by 1 log unit in water microcosms and 2 to 3 log units in sediment systems. The number of culturable bacteria was shown to be greater at 6°C than at 18°C. Each strain studied survived better in river than in estuarine environments.

Susceptibility of host species in Australia

Y. ruckeri has been isolated from a wide range of finfish hosts. Strains of *Y. ruckeri*, other than the Hagerman strain, are routinely isolated from salmonid finfish in Australia. Given the wide host range overseas, it is expected that finfish species (including introduced salmonids) in Australia would be susceptible to infection with the Hagerman strain of *Y. ruckeri* should it enter the Australian aquatic environment.

Transmission

LD_{50} values based on intraperitoneal injection range from 30 cells (Furones et al 1993) to 10^6 cells (Romalde and Toranzo 1993). Yersiniosis may be transmitted horizontally via water (the agent has been transmitted to trout by waterborne challenge) or vertically. The first outbreak of ERM reported in Venezuela may have been caused by imported rainbow trout eggs (Furones et al 1993).

Hunter et al (1980) demonstrated the transmission of the pathogen from carrier steelhead trout (*Oncorhynchus mykiss*) to healthy fish. The authors noted that the carrier fish shed pathogens in response to heat stress. Carrier fish may shed large numbers of *Y. ruckeri* into water via faeces and cause outbreaks of clinical disease in trout within 3–5 days. This is particularly so in farms with poor husbandry, or where the fish are stressed (Bruno 1990). The pathogen was found to localise in the lower intestine of 50–75% of rainbow trout surviving disease, 60–65 days after infection (Horne and Barnes 1999). These survivors could transmit disease to susceptible fish more than 102 days after infection. Expression of disease is strongly associated with stress (Horne and Barnes 1999). Detection of *Y. ruckeri* by conventional culture of rectal swabs from carrier Atlantic salmon, even in groups of fish that have previously suffered an outbreak of clinical disease, has been found to be difficult (B Munday pers. comm.). This suggests that the number of organisms actually excreted by carriers is relatively low. Consequently, it is unlikely that goldfish would shed many bacteria as they do not become clinically affected.

The importation of minnows for use as bait and activities of piscivorous birds have been suggested as routes for intercontinental transfer of the disease (Furones et al 1993, Michel et al 1986). Michel et al (1986) suggested that the isolation of *Y. ruckeri* from imported minnows provides a clear example of international transfer of a pathogen through hosts that were not suspected of harbouring the agent. This hypothesis may explain the sudden outbreaks of yersiniosis in Europe in 1981, as several previously proposed explanations, including the uncontrolled introduction of ornamental fish, were not considered convincing (Michel et al 1986).

In a survey, most rainbow trout farms infected with ERM in England and Wales used river water, while those free of ERM sourced their water from boreholes or springs. The few cage sites surveyed had ERM. This suggested that water or fish borne spread is more important than spread via birds (Rodgers 1992).

The spread of *Y. ruckeri* amongst farmed salmonids is commonly associated with the introduction of inapparently infected live salmonids to farms. *Y. ruckeri* has been diagnosed in Canadian salmon in which inapparent infection commonly occurs (Cornick 1990). Serious epizootics in salmon have been traced to the introduction of carrier fish from infected sources (Cornick 1990). Vaccination does not prevent infection of some fish in a population that is exposed to infection. The transfer of vaccinated and apparently healthy carrier fish is a significant route for transmission of ERM to free areas (Bruno 1990).

Release assessment

In addition to information presented on release assessment in Section 1.5, the following key points are relevant to the likelihood of *Y. ruckeri* (Hagerman strain) entering Australia via the importation of ornamental finfish.

- *Y. ruckeri* has a wide host and geographical range.
- *Y. ruckeri* is predominantly a pathogen of temperate, freshwater fish species. The majority of Schedule 6 finfish species imported are from tropical waters. Of species listed on or closely related to species listed on Schedule 6, *Y. ruckeri* has only been isolated from goldfish and sole (*Solea solea*) (both isolations being single, incidental findings).
- The agent may readily be detected in sick fish; however, detection in inapparently infected fish may be difficult. As such, the prevalence of *Y. ruckeri* infection may be under-estimated. Sacrifice of the fish would be needed for detection.
- Apparently healthy fish may be infected with *Y. ruckeri* although the agent would be present in very low titres in carrier fish. Carrier fish may be included in shipments of goldfish and freshwater sole (*Achirus* spp) for export to Australia.

Exposure assessment

In addition to information presented on exposure pathways (Section 1.6), if the disease agent entered Australia, the following key points would be relevant to the likelihood of *Y. ruckeri* (Hagerman strain) becoming established in the ornamental fish industry.

- The agent has been isolated from goldfish in a single incidental finding. Goldfish comprise a major component of the ornamental fish industry in Australia.
- *Y. ruckeri* has a direct life cycle. Horizontal and possibly vertical transmission is reported for the disease agent. *Y. ruckeri* is readily released in infective doses from infected fish via faeces. Very few bacteria are likely to be shed by goldfish as they do not become clinically affected.
- In the event that imported goldfish are infected with the agent, they may appear healthy and may be supplied to end-users.

In addition to information presented on exposure pathways (Section 1.6), if the disease agent entered Australia, the following key points would be relevant to the establishment of *Y. ruckeri* (Hagerman strain) in Australian natural waters.

- Goldfish can carry this disease agent and have a significant probability of entering and surviving in Australian natural waters.
- Prolonged survival of the pathogen in the environment is reported.
- There is documented evidence on the spread of yersiniosis in other parts of the world.
- Finfish species present in Australian waters would be susceptible to infection.

The probability of *Y. ruckeri* (Hagerman strain) causing infection in the ornamental finfish industry in Australia is considered to be low. If the agent entered Australia, the probability of infection in natural waters would be expected to be only one level of probability lower than that for the ornamental fish industry.

Consequence assessment

Effects on commercially significant species

In countries where disease due to highly pathogenic strains of *Y. ruckeri* (enteric redmouth, ERM) is endemic in salmonids, mortality rates of 10–15% are not uncommon (Horne and Barnes 1999). Mortality rates as high as 70% have been recorded in epizootics in fish that have not been vaccinated or treated. However, ERM is amenable to prevention, control and treatment through husbandry measures, immunisation, and the use of antimicrobials.

Vaccination is currently considered to be effective in protecting up to 90% of treated fish. Targeted vaccination by immersion and oral routes would be expected to protect 95–97% of fish in the population (Smith 1996). Vaccination has reduced the number of isolates identified by the Aberdeen Laboratory from fourteen a year in 1989 to three in 1998 (D Bruno pers. comm.).

Vaccination against ERM in England and Wales, as reported in 1991, cost each farm an average of UK£2495 (range UK£399–UK£11,700) (Rodgers 1992). If ERM were to become established in Australia, the cost of treatment would be expected to be as high.

Infection with the strains of *Y. ruckeri* found in Australia only becomes apparent when parr are moved or otherwise stressed and after smolts are transferred to sea. Losses from yersiniosis in Australia have been insignificant in economic terms, the development and registration of vaccines have not been warranted to date. Disease can be prevented by effectively managing stress, and reducing stocking rates. Such strategies would also tend to reduce the probability of establishment and the consequences of establishment of *Y. ruckeri* (Hagerman strain), if any were to enter the aquatic environment.

The five species of salmonids found in Australia would be susceptible to infection with *Y. ruckeri* (Hagerman strain).

Ecological and environmental impacts

The extent to which clinical disease would be expressed in aquacultured fish would be influenced by the presence of stressors. The establishment of exotic strains of *Y. ruckeri* (Hagerman strain) in wild fish species would be expected to be of minor significance, unless exceptional levels of stress affected the fish. The susceptibility of Australian native species to *Y. ruckeri* (Hagerman strain) is not known; however, based on overseas experience, there is no reason to consider that the agent would cause significant disease in native Australian species.

Unrestricted risk estimate

For the unrestricted importation of goldfish, the probability of *Y. ruckeri* (Hagerman strain) establishing in natural waters would be very low. The consequences of establishing in natural waters would be low to moderate. Thus, for *Y. ruckeri* (Hagerman strain), the risk associated with the unrestricted importation of goldfish would meet Australia's ALOP and the implementation of specific risk management measures would not be warranted.

A summary of the risk assessment is shown in Box 4.6.

Box 4.6

Risk assessment — *Yersinia ruckeri* (Hagerman strain)

RELEASE ASSESSMENT (R)

The probability of *Y. ruckeri* (Hagerman strain) entering Australia as a consequence of the unrestricted importation of goldfish and *Achirus* spp would be low. For other temperate, freshwater species the probability would be very low and for tropical freshwater species the probability would be extremely low. The probability for marine species would be negligible.

EXPOSURE ASSESSMENT (E)

If *Y. ruckeri* (Hagerman strain) entered Australia, the probability of susceptible animals in the ornamental finfish industry being exposed to a dose sufficient to cause infection would be low.

The probability of susceptible animals in Australian natural waters being exposed to a dose sufficient to cause infection would be very low.

PROBABILITY OF DISEASE ESTABLISHMENT (R + E)

The probability of *Y. ruckeri* (Hagerman strain) becoming established in the ornamental fish industry as a consequence of the unrestricted importation of goldfish and *Achirus* spp would be low (L). For other temperate, freshwater species the probability would be very low (VL). The probability for tropical freshwater species would be extremely low (EL) and the probability for marine species would be negligible (N).

The probability of *Y. ruckeri* (Hagerman strain) becoming established in natural waters as a consequence of the unrestricted importation of goldfish would be very low (VL). For other freshwater species and marine species, the probability would be negligible (N).

CONSEQUENCE ASSESSMENT

The consequences of *Y. ruckeri* (Hagerman strain) establishing in the ornamental finfish industry would be negligible (N).

If *Y. ruckeri* (Hagerman strain) became established in natural waters, the consequences to native and introduced species, both wild and captive, would be low to moderate (L–M), due primarily to the effects on salmonid aquaculture.

While the effect on the environment cannot be discounted, there is no reason to expect that the establishment of *Y. ruckeri* (Hagerman strain) would affect the survival of any vulnerable or endangered species in Australia or have any significant effect on the natural environment.

UNRESTRICTED RISK ESTIMATE FOR IMPORTATION OF ORNAMENTAL FINFISH

From Figure 1.1 (risk evaluation matrix):

- probability of establishment in natural waters from goldfish = VL
- significance of consequences in natural waters = L–M
- importation risk for *Y. ruckeri* (Hagerman strain) = acceptable (‘yes’ in Figure 1.1).

That is:

- the risk associated with the unrestricted importation of goldfish meets Australia’s ALOP; and
- risk management measures are not warranted.

4.2.7 *CRYPTOBIA* (*TRYPANOPLASMA*) *BORRELI* (CRYPTOBIOSIS)

Geographic distribution

C. borreli is a common parasite of farmed carp in Europe (reviewed in Woo and Poynton 1995) in which it causes sleeping sickness. It may be present in North America (Lom and Dyková 1992).

Host range and prevalence

C. borreli is a parasite of coldwater cyprinids including goldfish (reviewed in Woo and Poynton 1995). Prevalence in farmed carp (*Cyprinus carpio*) and grass carp (*Ctenopharyngodon idella*) may be as high as 70–100% (Lom and Dyková 1992). In addition to carp and goldfish, *C. borreli* infections have also been recorded in rudd, tench, roach, minnows and gobies (Lom and Dyková 1992).

Detection methods

The agent may be detected by oil-immersion microscopy of blood smears (reviewed in Woo and Poynton 1995). Detection of the parasite in blood of fish in the chronic phase of infection, when parasite numbers are low, can be improved by concentrating the agent using haematocrit tube centrifugation of blood samples. An ELISA may be used to detect *C. borreli* antigen (reviewed in Woo and Poynton 1995).

In goldfish, heavy parasitaemia occurs 16–18 days post-infection and infection usually results in death (Lom and Dyková 1992). In fish that survive, chronic infection, associated with mortality in some fish, may last for up to two months. Surviving fish are immune to reinfection, but are persistently infected.

Clinical signs include anaemia (pallor of the gills) and ascites. Pathological changes include glomerulitis, tubulonephrosis of the kidney and focal necrosis of the liver, in acute infections.

In experiments where cloned parasites were injected intramuscularly into common carp, Steinhagen et al (1989) recorded a prepatent period of four and eight days (depending on the size of the fish) at 20°C. Chronic infections occurred more commonly in fish >25 grams in weight.

Stability of disease agent

No data were found on the stability of *C. borreli* outside a living host.

Susceptibility of host species in Australia

C. borreli is primarily a pathogen of coldwater cyprinids. Introduced cyprinids in Australia, including goldfish, koi carp, roach and tench are expected to be susceptible to *C. borreli*. There are no cyprinids native to Australia. The susceptibility of Australian native fish to *C. borreli* is not known; however, based on overseas experience, there is no reason to consider that this pathogen would cause significant disease in these species.

Transmission

C. borreli is normally transmitted via the freshwater leeches (*Hemiclepsis marginata* and *Piscicola geometra*) (reviewed in Woo and Poynton 1995). The parasite develops in the crop of the leech and infects a new host fish when the leech feeds (Kruse et al 1989).

Langdon (1990b) referred to a *Piscicola* sp in a list of fish pathogens in Australia. A search of the current scientific literature revealed no further records of *Piscicola* or *Hemiclepsis* spp in Australia.

Direct transmission has not been demonstrated with *C. borreli.* However, direct transmission without a vector has been shown to occur with *C. salmositica,* another haematozoic species of *Cryptobia* (reviewed in Woo and Poynton 1995).

Release assessment

In addition to information presented on release assessment in Section 1.5, the following key points are relevant to the likelihood of *C. borreli* entering Australia via the importation of ornamental finfish.

- The pathogen has only been reported from Europe and possibly North America.
- Of the Schedule 6 species, the agent has only been reported from goldfish.
- The agent may be readily detected and sacrifice of the fish is not required. Given this ease of detection and the agent's highly pathogenic nature, if present

in other countries, it would be expected to have been detected.

- Fish surviving *C. borreli* infection may be apparently healthy carriers of infection and may be included in shipments for export to Australia. However, as the agent causes rapid mortality in naive goldfish, there is only a very small likelihood that carrier states will be present.

Exposure assessment

In addition to information presented on exposure pathways (Section 1.6), if the disease agent entered Australia, the following key points would be relevant to the establishment of *C. borreli* in the ornamental finfish industry.

- Goldfish are susceptible to the agent and comprise a major component of the ornamental finfish industry in Australia.
- *C. borreli* has an indirect life cycle that requires a leech vector for transmission of infection. A suitable vector species has not been identified in Australia.
- The parasite is unlikely to proliferate or survive for extended periods under aquarium conditions.

In addition to information presented on exposure pathways (Section 1.6), if the disease agent entered Australia, the following key points would be relevant to the establishment of *C. borreli* in Australian natural waters.

- Goldfish have a significant probability of entering and surviving in Australian natural waters.
- *C. borreli* has an indirect life cycle that requires a leech vector for transmission of infection. A suitable vector species has not been identified in Australia.
- Susceptible host fish species are present in Australian natural waters.

The probability of *C. borreli* causing infection in the ornamental finfish industry in Australia is negligible. If the agent entered Australia, the probability of infection in natural waters would be expected to be only one level of probability lower than that for the ornamental finfish industry.

Consequence assessment

Effects on commercially significant species

High level parasitaemia normally occurs, causing diffuse degenerative changes, anaemia, ascites and high level mortality, particularly in first year carp (Barckhausen-Kiesecker 1996, Dyková and Lom 1979). *C. borreli* has the potential to be a serious pathogen of cyprinid aquaculture in Europe (Lom and Dyková 1992). The establishment of this pathogen would be expected to affect farms growing koi carp and goldfish; however, it is likely that effects would be felt at the farm/regional level rather than at the ‘whole industry’ level.

No treatment is available for *C. borreli* infections, although there is potential for development of a vaccine (Woo and Poynton 1995).

Ecological and environmental impacts

C. borreli is primarily a pathogen of coldwater cyprinids. Introduced cyprinids in Australia, including goldfish and koi carp, roach and tench are expected to be susceptible to *C. borreli*. There are no cyprinids native to Australia. The susceptibility of Australian native species to *C. borreli* is not known; however, based on overseas experience, there is no reason to consider that the agent would cause significant disease in species native to Australia.

Unrestricted risk estimate

For the unrestricted importation of ornamental finfish, the probability of *C. borreli* establishing in the ornamental finfish industry would be negligible. The consequences of establishment would be low to moderate. Thus, for *C. borreli*, the risk associated with the unrestricted importation of ornamental finfish would meet Australia’s ALOP and the implementation of specific risk management measures would not be warranted.

A summary of the risk assessment is shown in Box 4.7.

Box 4.7

Risk assessment — *Cryptobia (Trypanoplasma) borreli*

RELEASE ASSESSMENT (R)

The probability of *C. borreli* entering Australia as a consequence of the unrestricted importation of goldfish would be low. For other freshwater species the probability would be extremely low, and for marine species the probability would be negligible.

EXPOSURE ASSESSMENT (E)

If *C. borreli* entered Australia, the probability of susceptible animals in the ornamental finfish industry being exposed to a dose sufficient to cause infection would be negligible.

The probability of susceptible animals in Australian natural waters being exposed to a dose sufficient to cause infection would be negligible.

PROBABILITY OF DISEASE ESTABLISHMENT (R + E)

The probability of *C. borreli* becoming established in the ornamental finfish industry as a consequence of the unrestricted importation of ornamental finfish would be negligible (N).

The probability of *C. borreli* becoming established in natural waters as a consequence of the importation of ornamental finfish would be negligible (N).

CONSEQUENCE ASSESSMENT

The consequences of *C. borreli* establishing in the ornamental finfish industry would be low to moderate (L–M), due primarily to effects on koi carp and goldfish production establishments.

If *C. borreli* became established in natural waters, the consequences to native and introduced species, both wild and captive, would be low (L).

While the effect on the environment cannot be discounted, there is no reason to expect that the establishment of *C. borreli* would affect the survival of any vulnerable or endangered species in Australia or have any significant effect on the natural environment.

UNRESTRICTED RISK ESTIMATE FOR IMPORTATION OF ORNAMENTAL FINFISH

From Figure 1.1 (risk evaluation matrix):

- probability of establishment in the ornamental finfish industry = N
- significance of consequences = L–M
- importation risk for *C. borreli* = acceptable (‘yes’ in Figure 1.1).

That is:

- the risk associated with the unrestricted importation of ornamental finfish meets Australia’s ALOP; and
- risk management measures are not warranted.

4.2.8 *SPHAEROSPORA RENICOLA* AND *S. CARASSII* (SPHAEROSPORIASIS)

Geographic distribution

Sphaerospora renicola is present in Europe, Israel, and the former Soviet Union (reviewed in Humphrey 1995, Lom and Dyková 1992). *S. carassii* was originally described from Japan and now occurs in several European countries, the former USSR and Hungary (Molnar 1979).

Host range and prevalence

Sphaerospora spp are considered to be relatively host specific (Lom and Dyková 1995). *S. renicola* and *S. carassii* infect *Carassius* species (Lom and Dyková 1992, Molnar 1979). *S. renicola* is primarily a pathogen of European carp (*Cyprinus carpio*) although goldfish exposed to infected carp may be infected (Lom and Dyková 1995). *Carassius carassius, C. auratus gibelio, Cyprinus carpio* and *Rutilus rutilus* may be infected with *S. carassii* (Molnar 1979). None of these species is listed on Schedule 6. However, the Prussian carp (*C. auratus gibelio*), the wild or eastern European form of the goldfish (*C. auratus auratus*), is listed on Schedule 6.

Proliferative kidney disease (PKD) is an important disease of farmed rainbow trout in Europe. Morphologically, the aetiological agent of PKD appears to be a *Sphaerospora* species. On morphological grounds alone, it is possible that *S. renicola* is the causative agent of PKD (Lom and Dyková 1995).

Detection methods

Specific identification is by detecting and characterising mature spores in tissue wet mounts or histological sections (Lom and Dyková 1995). Immature spores may be identified using electron microscopy. Serological techniques have also been used under experimental conditions.

Stability of disease agent

Spores of myxosporean species can retain their normal appearance and, presumably, infectivity for extended periods in cold water (Lom and Dyková 1995). Hoffman et al (1962) demonstrated the viability of *Myxobolus cerebralis* spores 22 months after storage.

Susceptibility of host species in Australia

S. renicola and *S. carassii* only occurs in coldwater cyprinids. There are several coldwater cyprinids in Australian natural waters including wild populations of goldfish and common carp which would be susceptible to *S. renicola* and *S. carassii*. The susceptibility of Australian native species to *S. renicola* and *S. carassii* is not known; however, from overseas experience, there is no reason to consider that this pathogen would cause significant disease in these species.

Transmission

From information on the life cycle of myxosporean species (*Myxobolus cerebralis, M. cotti*, and *M. pavlovskii*) it is likely that *S. renicola* and *S. carassii* would require an intermediate host. Actinosporeans released from the intermediate host are the infective stage for susceptible fish (El-Matbouli et al 1992). Nonetheless, Lom and Dyková (1995) suggested that, given the contradictory findings on the life cycle of these parasites, transmission via actinosporeans may alternate with direct transmission.

It has been suggested that myxosporean spores require an extended period in water to mature, as a prerequisite to becoming infectious. This process may require an intermediate host (Lom and Dyková 1995).

Release assessment

In addition to information presented on release assessment in Section 1.5, the following key points are relevant to the likelihood of *S. renicola* and *S. carassii* entering Australia via the importation of ornamental finfish.

- *S. renicola* and *S. carassii* have only been recognised in coldwater cyprinids in Europe, the former Soviet Union and Japan where cyprinid aquaculture is common.
- *S. renicola* and *S. carassii* have been reported from goldfish.
- The majority of Schedule 6 finfish species imported are from tropical waters.
- Relatively easy methods for detecting the agent in fish are available. Sacrifice of the fish would be necessary for detection.

- Infected fish may not always show signs of disease and thus may be included in shipments for export to Australia.

Exposure assessment

In addition to information presented on exposure pathways (Section 1.6), if the disease agent entered Australia, the following key points would be relevant to the establishment of *S. renicola* and *S. carassii* in the ornamental finfish industry.

- Goldfish are susceptible to the agent and comprise a major component of the ornamental fish industry in Australia.
- There is evidence that *S. renicola* and *S. carassii* have indirect life cycles requiring an intermediate host that may or may not be present in Australia.
- Given the requirement for an intermediate host, *S. renicola* and *S. carassii* are unlikely to proliferate or survive for extended periods under aquarium conditions.

In addition to information presented on exposure pathways (Section 1.6), if the disease agent entered Australia, the following key points would be relevant to the establishment of *S. renicola* and *S. carassii* in Australian natural waters.

- Goldfish have a significant probability of entering and surviving in Australian natural waters.
- Myxosporean spores may survive for extended periods in cold water.
- Susceptible host fish species are present in Australian natural waters.

The probability of *S. renicola* and *S. carassii* causing infection in the ornamental fish industry in Australia is very low. If the agent entered Australia, the probability of infection in natural waters would be expected to be only one level of probability lower than that for the ornamental fish industry.

Consequence assessment

Effects on commercially significant species

S. renicola and *S. carassii* are serious pathogens of cultured carp in the Northern Hemisphere. Cultured carp may incur 5–15% losses due to swim-bladder inflammation (SBI) caused by *S. renicola* (Lom and Dyková 1992). *S. carassii* was originally described in Japan and infects *Carassius auratus*, *Cyprinus carpio* and *Rutilus rutilus*. The agent causes branchial and renal sphaerosporosis. Heavy infections are usually accompanied by high mortalities (Waluga 1983).

The establishment of *S. renicola* or *S. carassii* in Australia would be expected to affect farms producing koi carp and goldfish. Effects would be felt at the farm or regional level rather than the 'whole industry' level. *Sphaerospora* spp have been isolated from goldfish in Australia but the species are not known.

Myxosporean spores readily persist in the aquatic environment, but disinfectants such as calcium hydroxide can be used to kill spores at the bottom of ponds (reviewed in Lom and Dyková 1995).

At present, AQIS considers that there is insufficient evidence on which to conclude that *S. renicola* causes PKD in salmonids**.**

Ecological and environmental impacts

The susceptibility of native fish species to *S. renicola* and *S. carassii* is not known; however, based on overseas experience and given that these agents are predominantly pathogens of coldwater cyprinids, there is no reason to consider that these agents would cause significant disease in species native to Australia.

Unrestricted risk estimate

For the unrestricted importation of ornamental finfish the probability of *S. renicola* and *S. carassii* establishing in the Australian ornamental fish industry or in natural waters would be negligible to extremely low. The consequences of establishment would be low. Thus, for *S. renicola* and *S. carassii*, the risk associated with the unrestricted importation of ornamental finfish would meet Australia's ALOP and the implementation of specific risk management measures would not be warranted.

A summary of the risk assessment is shown in Box 4.8.

Box 4.8

Risk assessment — *Sphaerospora renicola* and *S. carassii*

RELEASE ASSESSMENT (R)

The probability of *S. renicola* and *S. carassii* entering Australia as a consequence of the unrestricted importation of goldfish would be low to moderate. For other freshwater temperate species the probability would be very low and for other species the probability would be negligible.

EXPOSURE ASSESSMENT (E)

If *S. renicola* or *S. carassii* entered Australia, the probability of susceptible animals in the ornamental finfish industry being exposed to a dose sufficient to cause infection would be very low.

If *S. renicola* or *S. carassii* entered Australia, the probability of susceptible animals in Australian natural waters being exposed to a dose sufficient to cause infection would be extremely low.

PROBABILITY OF DISEASE ESTABLISHMENT (R + E)

The probability of *S. renicola* or *S. carassii* becoming established in the ornamental fish industry as a consequence of the unrestricted importation of goldfish and other freshwater temperate species would be very low (VL). For other freshwater species and marine species, the probability would be negligible (N).

The probability of *S. renicola* or *S. carassii* becoming established in natural waters as a consequence of the importation of goldfish would be extremely low (EL). The probability for other freshwater species and marine species, would be negligible (N).

CONSEQUENCE ASSESSMENT

The consequences of *S. renicola* or *S. carassii* establishing in the ornamental fish industry would be low (L), due primarily to effects on goldfish and koi carp production premises.

If *S. renicola* or *S. carassii* became established in natural waters, the consequences to native and introduced species, both wild and captive, would be low (L).

While the effect on the environment cannot be discounted, there is no reason to expect that the establishment of *S. renicola* or *S. carassii* would affect the survival of any vulnerable or endangered species in Australia or have any significant effect on the natural environment.

UNRESTRICTED RISK ESTIMATE FOR IMPORTATION OF ORNAMENTAL FINFISH

From Figure 1.1 (risk evaluation matrix):

- probability of establishment in the ornamental finfish industry or in natural waters = N–EL
- significance of consequences = L
- importation risk for *S. renicola* or *S. carassii* = acceptable (‘yes’ in Figure 1.1).

That is:

- the risk associated with the unrestricted importation of ornamental finfish meets Australia’s ALOP; and
- risk management measures are not warranted.

4.2.9 *TRYPANOSOMA DANILEWSKYI* (*CARASSII*) (TRYPANOSOMIASIS)

Geographic distribution

T. danilewskyi is a parasite of cyprinids found in Europe (reviewed in Woo and Poynton 1995) and India (Qadri 1962).

Host range and prevalence

T. danilewskyi is primarily a parasite of coldwater cyprinids such as common carp (*Cyprinus carpio*), tench (*Tinca tinca*) and goldfish (reviewed in Woo and Poynton 1995). The agent has also been reported from catfish (*Saccobranchus fossilis*) in India (Qadri 1962). Species infected experimentally include *Barbus conhus*, *Catostomus commersoni*, *Notropis cornutus*, *Etheostoma caeruleum, Ictalurus nebulosus* and *Danio malabaricus* (Woo and Black 1984). Of these species, only *D. malabaricus* is listed on Schedule 6.

Prevalence of infection may be as high as 100% in European carp (Lom and Dyková 1992).

Detection methods

The agent can be readily detected by light microscopy of blood when there is a high level parasitaemia (Woo and Poynton 1995). Taxonomic identification is based on characterisation of the agent in stained blood smears. Haematocrit tube centrifugation may be used to assist detection of the parasite in inapparently infected carrier fish (Woo and Poynton 1995).

In experimental infection of goldfish, the prepatent period was 5–11 days at 20–25°C and was >11 days at 28°C (Lom and Dyková 1992). Disease was not observed at temperatures <10°C. Higher parasitaemia was achieved in fish acclimatised at 20°C than in fish held at 10°C or 30°C (Woo et al 1983).

Surviving goldfish are persistently infected but without clinical signs of disease (Lom and Dyková 1992).

Stability of disease agent

No data were found on the stability of *T. danilewskyi* outside a live host**.**

Susceptibility of host species in Australia

T. danilewskyi is primarily a pathogen of coldwater cyprinids. Introduced cyprinids in Australia, including goldfish and koi carp, roach and tench are expected to be susceptible to infection. There are no cyprinids native to Australia. The susceptibility of Australian native species to *T. danilewskyi* is not known; however, based on overseas experience, there is no reason to consider that this pathogen would cause significant disease in these species.

Transmission

A leech vector is required for disease transmission (reviewed in Woo and Poynton 1995). In Europe, the vectors are *Piscicola geometra* and *Hemiclepsis marginata* (reviewed in Lom and Dyková 1992). Transmission probably occurs when an infected leech feeds on a susceptible host fish.

Langdon (1990b) referred to a *Piscicola* sp in a list of fish pathogens in Australia. A search of the current scientific literature revealed no further records of *Piscicola* or *Hemiclepsis* spp in Australia.

In experimental infection of goldfish, Woo (1981) reported mortality rates of 10% and 60%, using inocula of 3800 and 380,000 trypanosomes per fish, respectively.

Release assessment

In addition to information presented on release assessment in Section 1.5, the following key points are relevant to the likelihood of *T. danilewskyi* entering Australia via the importation of ornamental finfish.

- The pathogen has only been reported from Europe and India.
- Of the Schedule 6 species, natural infection has only been reported in goldfish. Experimental infection has been demonstrated with *Danio malabaricus*, a Schedule 6 listed species.
- Relatively easy methods for detecting the agent in fish are available. Sacrifice of the fish is not required for definitive diagnosis.
- The agent causes anorexia, anaemia and mortality in naive goldfish and therefore affected fish populations will be noticed and are unlikely to be

exported. However, fish surviving *T. danilewskyi* infection may appear healthy but carry low levels of the parasite.

Exposure assessment

In addition to information presented on exposure pathways (Section 1.6), if the disease agent entered Australia, the following key points would be relevant to the establishment of *T. danilewskyi* in the ornamental fish industry.

- Goldfish are susceptible to the agent and comprise a major component of the ornamental fish industry in Australia.
- Infected fish may not always show signs of disease.
- *T. danilewskyi* has an indirect life cycle requiring a leech vector; and a suitable vector species has not been identified in Australia.
- *T. danilewskyi* is unlikely to proliferate or survive for extended periods under aquarium conditions.

In addition to information presented on exposure pathways (Section 1.6), if the disease agent entered Australia, the following key points would be relevant to the establishment of *T. danilewskyi* in Australian natural waters.

- Goldfish may carry this disease agent.
- Goldfish have a significant probability of entering and surviving in Australian natural waters.
- Susceptible host fish species are present in Australian natural waters.
- *T. danilewskyi* has an indirect life cycle requiring a leech vector; and a suitable vector species has not been identified in Australia.

The probability of *T. danilewskyi* causing infection in the ornamental fish industry in Australia is negligible. If the agent entered Australia, the probability of infection in natural waters would be expected to be only one level of probability lower than that for the ornamental fish industry.

Consequence assessment

Effects on commercially significant species

T. danilewskyi is the only trypanosome known to cause significant disease in freshwater fish. It infects goldfish, tench, eels and a variety of ornamental fish when inoculated experimentally (reviewed in Woo and Poynton 1995). Infection causes anaemia and may lead to death. However, in the majority of cases the host recovers and is refractory to further infection (Lom and Dyková 1992). In goldfish, *T. danilewskyi* causes anaemia and anorexia (Islam and Woo 1991). *T. danilewskyi* may have some impact on koi carp and goldfish aquaculture production premises but such impact is not expected to be at a 'whole industry level'. The agent may have a small establishment-level impact on local eel aquaculture but this is only a minor industry in Australia.

Ecological and environmental effects

The susceptibility of native fish species to *T. danilewskyi* is not known. The agent is predominantly a pathogen of coldwater cyprinids. There are no cyprinids native to Australia. There is no reason to consider that these agents would cause significant disease in species native to Australia.

Unrestricted risk estimate

For the unrestricted importation of ornamental finfish, the probability of *T. danilewskyi* establishing would be negligible. The consequences of establishment would be negligible to low. Thus, for *T. danilewskyi*, the risk associated with the unrestricted importation of ornamental finfish would meet Australia's ALOP and the implementation of specific risk management measures would not be warranted.

A summary of the risk assessment is shown in Box 4.9.

Box 4.9

Risk assessment — *Trypanosoma danilewskyi* (*carassii*)

RELEASE ASSESSMENT (R)

The probability of *T. danilewskyi* entering Australia as a consequence of the unrestricted importation of goldfish would be low to moderate. For other freshwater species the probability would be very low, and for marine species the probability would be negligible.

EXPOSURE ASSESSMENT (E)

If *T. danilewskyi* entered Australia, the probability of susceptible animals in the ornamental finfish industry being exposed to a dose sufficient to cause infection would be negligible.

The probability of susceptible animals in Australian natural waters being exposed to a dose sufficient to cause infection would be negligible.

PROBABILITY OF DISEASE ESTABLISHMENT (R + E)

The probability of *T. danilewskyi* becoming established in the ornamental fish industry as a consequence of the unrestricted importation of ornamental finfish would be negligible (N).

The probability of *T. danilewskyi* becoming established in natural waters as a consequence of the importation of ornamental finfish would be negligible (N).

CONSEQUENCE ASSESSMENT

The consequences of *T. danilewskyi* establishing in the ornamental fish industry would be low (L), due primarily to effects on goldfish and koi carp production premises.

If *T. danilewskyi* became established in natural waters, the consequences to native and introduced species, both wild and captive, would be negligible to low (N–L).

While the effect on the environment cannot be discounted, there is no reason to expect that the establishment of *T. danilewskyi* would affect the survival of any vulnerable or endangered species in Australia or have any significant effect on the natural environment.

UNRESTRICTED RISK ESTIMATE FOR IMPORTATION OF ORNAMENTAL FINFISH

From Figure 1.1 (risk evaluation matrix):

- probability of establishment = N
- significance of consequences = N–L
- importation risk for *T. danilewskyi* = acceptable (‘yes’ in Figure 1.1).

That is:

- the risk associated with the unrestricted importation of ornamental finfish meets Australia’s ALOP; and
- risk management measures are not warranted.

4.2.10 *DACTYLOGYRUS VASTATOR* AND *D. EXTENSUS* (GILL FLUKE)

Geographic distribution

Dactylogyrus vastator is endemic to central Asia and has subsequently been introduced to Europe, Israel, and North America. *D. extensus* is endemic to Asia, central Europe, Israel, Japan and North America (reviewed in Cone 1995).

Host range and prevalence

Both *D. vastator* and *D. extensus* are parasites of carp and goldfish, causing significant disease in young pond-reared fish (reviewed in Cone 1995). Of the reported host species, only goldfish are listed on Schedule 6.

Detection methods

The pathogen can be observed microscopically in wet mounts of gill tissue. Sacrifice of fish is usually required for parasite detection, although with heavy infections, detection may be made from gill filament snips without sacrificing the fish. Specific identification is based on morphological characterisation of the adult fluke.

Stability of disease agent

Two types of *D. vastator* eggs are produced. One hatches normally but the other is a suspected diapause egg that survives the winter to infect fish the following spring (Paperna 1963a cited in Cone 1995).

Higher optimal temperatures have been reported for *D. extensus* that has spread to and become endemic in warmer climates (reviewed in Cone 1995).

Susceptibility of host species in Australia

Goldfish and koi carp are produced locally on a commercial scale and are known to be susceptible to this parasite. Given that these agents have only been reported from cyprinids overseas, it is unlikely that Australian native species will be susceptible to *D. vastator* and *D. extensus.*

Transmission

Completion of the life cycle of *D. vastator* takes approximately 11–13 days at 24–28°C (Paperna 1963a cited in Cone 1995). The eggs develop in 2–3 days and postoncomiracidium is sexually mature at 4–5 days.

Prost (1963 cited in Cone 1995) reported completion of the life cycle of *D. extensus* to take 8–9 days at 17–18°C. At 24–25°C, postoncomiracidia are sexually mature in 6–7 days.

Details on routes of infection/attachment by hatched larvae are not known.

Release assessment

In addition to information presented on release assessment in Section 1.5, the following key points are relevant to the likelihood of *D. vastator* or *D. extensus* entering Australia via the importation of ornamental finfish.

- The agents have a wide geographical distribution.
- *D. vastator* and particularly *D. extensus* are common parasites of goldfish.
- Adult stages can be readily detected microscopically. Sacrifice of fish is usually required for parasite detection, although with heavy infections, detection may be made from gill filament snips without sacrificing the fish.
- Low parasite loads on fish gills will likely go undetected. Infected fish will likely be inadvertently included in goldfish shipments destined for export to Australia.

Exposure assessment

In addition to information presented on exposure pathways (Section 1.6), if the disease agent entered Australia, the following key points would be relevant to the establishment of *D. vastator* and *D. extensus* in the ornamental fish industry.

- Goldfish are susceptible to the parasite and comprise a major component of the ornamental fish industry in Australia.

- Low level infestation of goldfish is common and will likely go undetected.
- *D. vastator* and *D. extensus* have direct life cycles.

In addition to information presented on exposure pathways (Section 1.6), if the disease agent entered Australia, the following key points would be relevant to the establishment of *D. vastator* or *D. extensus* in Australian natural waters.

- Goldfish have a significant probability of entering and surviving in Australian natural waters.
- *D. vastator* and *D. extensus* have direct life cycles and there may be a resistant diapause egg capable of surviving winter.
- Susceptible host fish species are present in Australian natural waters.

The probability of *D. vastator* or *D. extensus* causing infection in the ornamental fish industry in Australia is moderate. If the agent entered Australia, the probability of infection in natural waters would be expected to be only one level of probability lower than that for the ornamental fish industry.

Consequence assessment

Effects on commercially significant species

In carp and goldfish, *D. vastator* causes extensive degeneration of gill epithelium leading to respiratory failure and death of the fish. Affected gills undergo epithelial hyperplasia compromising gas exchange across the gills. Paperna (1963b cited in Cone 1995) found pond-reared carp longer than 35 mm were able to tolerate the parasite. *D. extensus* also occurs on the gills of carp and goldfish but is considered to be less pathogenic than *D. vastator*. Infection results in copious mucous production and localised damage.

D. vastator and *D. extensus* are expected to have significant impact on koi carp and goldfish aquaculture, however, any impacts are unlikely to be at the 'whole industry' level.

Adults and miracidia of *D. vastator* are sensitive to elevated salinity levels (reviewed in Cone 1995). Anthelmintics and other chemical treatment of the water as well as periodic drying of ponds can be used to control *D. vastator* in pond cultures (Cone 1995). Goven and Amend (1982) reported 95% efficacy with Trichlorofon against the parasite. *D. extensus* can be effectively controlled using Praziquantel (Schmahl and Mehlhorn 1985 from Cone 1995, Stoskopf 1993b).

Ecological and environmental effects

The susceptibility of native fish to *D. vastator* and *D. extensus* is not known; however, as these parasites are predominantly associated with aquacultured carp and goldfish, there is no reason to consider that these agents would cause significant disease in species native to Australia.

Unrestricted risk estimate

For the unrestricted importation of goldfish the probability of *D. vastator* or *D. extensus* establishing in the ornamental fish industry would be moderate. The consequences of establishment would be low to moderate. Thus, for *D. vastator* and *D. extensus*, the risk associated with the unrestricted importation of goldfish would not meet Australia's ALOP and the implementation of specific risk management measures would be warranted.

A summary of the risk assessment is shown in Box 4.10. Appropriate risk management measures are discussed in Chapter 5.

Box 4.10
Risk assessment — *Dactylogyrus vastator* and *D. extensus*

RELEASE ASSESSMENT (R)

The probability of *D. vastator* or *D. extensus* entering Australia as a consequence of the unrestricted importation of goldfish would be moderate to high. For other freshwater species the probability would be very low, and for marine species the probability would be negligible.

EXPOSURE ASSESSMENT (E)

If *D. vastator* or *D. extensus* entered Australia, the probability of susceptible animals in the ornamental finfish industry being exposed to a dose sufficient to cause infection would be moderate.

The probability of susceptible animals in Australian natural waters being exposed to a dose sufficient to cause infection would be low.

PROBABILITY OF DISEASE ESTABLISHMENT (R + E)

The probability of *D. vastator* or *D. extensus* becoming established in the ornamental fish industry as a consequence of the unrestricted importation of goldfish would be moderate (M). For other freshwater species, the probability would be very low (VL) and for marine species, the probability would be negligible (N).

The probability of *D. vastator* or *D. extensus* becoming established in natural waters as a consequence of the importation of goldfish would be low (L). For other freshwater species, the probability would be extremely low (EL) and for marine species the probability would be negligible (N).

CONSEQUENCE ASSESSMENT

The consequences of *D. vastator* or *D. extensus* establishing in the ornamental fish industry would be low to moderate (L–M), due primarily to effects on goldfish and koi carp production premises.

If *D. vastator* or *D. extensus* became established in natural waters, the consequences to native and introduced species, both wild and captive, would be low (L).

While the effect on the environment cannot be discounted, there is no reason to expect that the establishment of *D. vastator* or *D. extensus* would affect the survival of any vulnerable or endangered species in Australia or have any significant effect on the natural environment.

UNRESTRICTED RISK ESTIMATE FOR IMPORTATION OF ORNAMENTAL FINFISH

From Figure 1.1 (risk evaluation matrix):

- probability of establishment in the ornamental finfish industry from goldfish = M
- significance of consequences = L–M
- importation risk for *D. vastator* or *D. extensus* = unacceptable (‘no’ in Figure 1.1).

That is:

- the risk associated with the unrestricted importation of goldfish does not meet Australia’s ALOP; and
- risk management measures are warranted for goldfish.

4.2.11 *ARGULUS FOLIACEUS* AND *A. COREGONI* (FISH LICE)

Geographic distribution

A. foliaceus is present in Europe and Asia and *A. coregoni,* in Europe, Japan, China and North America (reviewed in Lester and Roubal 1995).

Host range and prevalence

A. foliaceus affects a wide range of freshwater fish including members of the Families Cyprinidae, Salmonidae, Gobiidae, Gasterosteidae, and Acipenseridae of temperate climates (reviewed in Lester and Roubal 1995). *A. coregoni* is primarily a parasite of salmonids although it affects cyprinids and other hosts. It generally occurs in colder waters than *A. foliaceus* (Lester and Roubal 1995).

Detection methods

Adult parasites are visible to the naked eye. Affected fish will initially attempt to dislodge the parasites by rubbing on tank sides or bottom (Lester and Roubal 1995). Eventually infected fish will stop feeding and become lethargic. Haemorrhagic spots are seen at the attachment/feeding sites and scale loss and fraying of fins may also occur. Taxonomic identification is based on morphological characterisation of adult parasites.

Stability of disease agent

During severe winters these parasites may over-winter as eggs (Heckmann 1993).

Susceptibility of host species in Australia

Goldfish, koi carp and freshwater salmonids would be susceptible to these parasites. The susceptibility of native fish species to *A. foliaceus* and *A. coregoni* is not known. However, the host range of these agents includes members of the family Gobiidae, members of which are native to Australia. These (and possibly other) native fish would be expected to be susceptible to infection.

Transmission

The life cycle of argulids is direct and contact between fish is not needed for transmission. Adult argulids can survive for several days independent of a host fish (Lester and Roubal 1995). Eggs are laid on inert objects and hatch after several months. *A. foliaceus* has three generations per year and *A. coregoni,* two generations. Hatching larvae of both species are parasitic.

Release assessment

In addition to information presented on release assessment in Section 1.5, the following key points are relevant to the likelihood of *A. foliaceus* or *A. coregoni* entering Australia via the importation of ornamental finfish.

- *A. foliaceus* and *A. coregoni* have a wide geographic distribution.
- *A. foliaceus* and *A. coregoni* are normally parasitic on temperate coldwater fish. Of the Schedule 6 species, the parasites have only been reported from goldfish.
- The adult parasites are readily detected in live fish, though low level infestations may go unnoticed. Infected fish may inadvertently be included in goldfish shipments destined for export to Australia.

Exposure assessment

In addition to information presented on exposure pathways (Section 1.6), if the disease agent entered Australia, the following key points would be relevant to the establishment of *A. foliaceus* or *A. coregoni* in the ornamental fish industry.

- Goldfish are susceptible to the agent and comprise a major component of the ornamental fish industry in Australia.
- *A. foliaceus* and *A. coregoni* have direct life cycles and can survive independently of the host fish for several days.

- Heavily infested fish would be detected and would be removed from consignments. Lightly infested fish may be undetected and supplied to end-users.

In addition to information presented on exposure pathways (Section 1.6), if the disease agents entered Australia, the following key points would be relevant to the establishment of *A. foliaceus* or *A. coregoni* in Australian natural waters.

- Goldfish are susceptible to *A. foliaceus* and *A. coregoni*.
- Goldfish have a significant probability of entering and surviving in Australian natural waters.
- Susceptible host fish species are present in Australian natural waters.

There is a moderate probability of *A. foliaceus* or *A. coregoni* causing infection in the ornamental fish industry in Australia. If the agent entered Australia, the probability of infection in natural waters would be expected to be only one level of probability lower than that for the ornamental fish industry.

Consequence assessment

Effects on commercially significant species

These cosmopolitan non-host-specific branchiuran parasites are found predominantly on the skin and gills of freshwater fish. Heavy infections may cause high rates of mortality, especially in young, farmed fish. Necrosis and ulceration may occur and predispose fish to secondary bacterial infection (reviewed in Humphrey 1995). Transmission of spring viraemia of carp virus (SVCV) via argulids is reported (Lester and Roubal 1995, Pfeil-Putzein and Baath 1978).

Mortalities normally occur only in heavy infections, when extensive skin damage interferes with osmoregulatory capacity (Lester and Roubal 1995).

If established in Australia, *A. foliaceus* and *A. coregoni* would be expected to affect farms growing freshwater salmonids and cyprinids. The consequences would be felt at a farm or regional level rather than a 'whole industry' level.

Insecticides are commonly used to treat infestation, however, the parasite readily develops resistance (Kabata 1985). Chemical treatments such as Trichlorofon may be used to control the disease in farmed fish (Inoue et al 1980). Other management practices may be used to control infestation of ponds, for example, changing the bottom substrate and introducing fish that feed on adult parasites (Lester and Roubal 1995).

Ecological and environmental effects

The susceptibility of native species to *A. foliaceus* or *A. coregoni* is not known although the reported host range of these parasites includes the Gobiidae, species of which are native to Australia. However, as these argulids are mainly of significance in aquaculture of temperate freshwater fish, there is no reason to consider that these parasites would cause significant disease in species native to Australia.

Unrestricted risk estimate

For the unrestricted importation of goldfish the probability of *A. foliaceus* or *A. coregoni* establishing would be moderate. The consequences of establishing in the ornamental finfish industry would be low to moderate. Thus, for *A. foliaceus* and *A. coregoni* the risk associated with the unrestricted importation of goldfish would not meet Australia's ALOP and the implementation of specific risk management measures would be warranted.

A summary of the risk assessment is shown in Box 4.11. Appropriate risk management measures are discussed in Chapter 5.

Box 4.11

Risk assessment — *Argulus foliaceus* and *A. coregoni*

RELEASE ASSESSMENT (R)

The probability of *A. foliaceus* or *A. coregoni* entering Australia as a consequence of the unrestricted importation of goldfish would be moderate. For other freshwater species the probability would be very low, and for marine species the probability would be negligible.

EXPOSURE ASSESSMENT (E)

If *A. foliaceus* or *A. coregoni* entered Australia, the probability of susceptible animals in the ornamental finfish industry being exposed to a dose sufficient to cause infection would be moderate to high.

The probability of susceptible animals in Australian natural waters being exposed to a dose sufficient to cause infection would be low to moderate.

PROBABILITY OF DISEASE ESTABLISHMENT (R + E)

The probability of *A. foliaceus* or *A. coregoni* becoming established in the ornamental fish industry as a consequence of the unrestricted importation of goldfish would be moderate (M). For other freshwater species, the probability would be very low (VL) and for marine species, the probability would be negligible (N).

The probability of *A. foliaceus* or *A. coregoni* becoming established in natural waters as a consequence of the importation of goldfish would be low (L). For other freshwater species, the probability would be extremely low (EL) and for marine species the probability would be negligible (N).

CONSEQUENCE ASSESSMENT

The consequences of *A. foliaceus* or *A. coregoni* establishing in the ornamental fish industry would be low to moderate (L–M), due primarily to effects on freshwater salmonid and cyprinid aquaculture.

If *A. foliaceus* or *A. coregoni* became established in natural waters, the consequences to native and introduced species, both wild and captive, would be very low (VL).

While the effect on the environment cannot be discounted, there is no reason to expect that the establishment of *A. foliaceus* or *A. coregoni* would affect the survival of any vulnerable or endangered species in Australia or have any significant effect on the natural environment.

UNRESTRICTED RISK ESTIMATE FOR IMPORTATION OF ORNAMENTAL FINFISH

From Figure 1.1 (risk evaluation matrix):

- probability of establishment in the ornamental finfish industry from goldfish = M
- significance of consequences in the ornamental finfish industry = L–M
- importation risk for *A. foliaceus* or *A. coregoni* = unacceptable (‘no’ in Figure 1.1).

That is:

- the risk associated with the unrestricted importation of goldfish does not meet Australia’s ALOP; and
- risk management measures are warranted for goldfish.

4.2.12 *LERNAEA ELEGANS* (ANCHOR WORM)

Geographic distribution

L. elegans has a worldwide distribution, including Europe, the former Soviet Union, central Asia, Japan and Israel (Schäperclaus 1991).

Host range and prevalence

The parasite has been reported from several commercial fish species including salmonids (steelhead, rainbow trout and peled), carp, and the ornamental species, goldfish, variegated cichlids (*Cichlasoma* spp) and Indian manyspines (*Nandus nandus*) (Schäperclaus 1991, Gun'kovskij and Khudolej 1989). Of these, goldfish and monga cichlids (*Cichlasoma nicaraguense*) are listed on Schedule 6.

In outbreaks of *L. elegans* infestations in Ukrainian salmonid fish farms, prevalence reached 100% in some ponds, and an average of 37 adult parasites per fish (Gun'kovskii and Khudolei 1989).

Detection methods

Adult parasites are visible to the naked eye and can be individually removed. The female pre-emergent stage may be much harder to detect. Fish will exhibit flashing behaviour at first though marked emaciation and weight loss will occur over time with heavy infestation (Schäperclaus 1991). Taxonomic identification is based on the morphologic characteristics of adult parasites.

Stability of disease agent

The parasite is absent or rare in waters with pH below 7 and salinity above 1.8%. Young females (both attached and free-living larval stages) and eggs can survive the winter (Schäperclaus 1991).

Susceptibility of host species in Australia

Several host species in Australian natural waters are expected to be susceptible to this parasite. The susceptibility of native species to the parasite is not known. However, based on the agent's wide host range and the fact that *L. cyprinacea* has been reported from a range of Australian native species, including *Maccullochella peeli*, *Gadopsis marmoratus*, *Macquaria ambigua*, *Bidyanus bidyanus* and *Galaxia* spp, indicates that many native finfish species may also be susceptible to *L. elegans. Maccullochella peeli mariensis* and six galaxids are listed by Environment Australia as vulnerable and/or endangered under the Endangered Species Protection Act.

Transmission

L. elegans has a direct life cycle lasting about 100 days at 14°C, 20 days at 24°C and 7–14 days at 28°C. It is generally a warm water parasite but trout can be infected when temperatures rise above 17°C (Schäperclaus 1991). The adult female has egg sacs containing approximately 200 eggs. Each egg hatches into a nauplius larvae which undergoes several moults through copepodid stages before attaching permanently as females to the fish host (Soulsby 1982).

The water supply was thought to be the source of the parasite in outbreaks on salmonid fish farms in the Ukraine, although *L. elegans* was also found on stocks of *Carassius* imported as feed (Gun'kovskij and Khudolei 1989).

Release assessment

In addition to information presented on release assessment in Section 1.5, the following key points are relevant to the likelihood of *L. elegans* entering Australia via the importation of ornamental finfish.

- *L. elegans* has a broad geographic range.
- Of the Schedule 6 listed species, the parasite has been reported from the monga cichlid and goldfish.
- The adult parasites are readily detected on live fish, although low level infestations may go unnoticed. Infected fish will likely be included in ornamental fish shipments destined for export to Australia.

Exposure assessment

In addition to information presented on exposure pathways (Section 1.6), if the disease agent entered Australia, the following key points would be relevant to the establishment of *L. elegans* in the ornamental fish industry.

- *L. elegans* has a broad host range including aquarium species such as goldfish.
- *L. elegans* has a direct life cycle and parasite numbers on farmed fish can increase rapidly when conditions are optimal.
- Very light infestations may go unnoticed. Infected fish may be transferred along the supply chain to end-users.

In addition to information presented on exposure pathways (Section 1.6), if the disease agent entered Australia, the following key points would be relevant to the establishment of *L. elegans* in Australian natural waters.

- Goldfish (and possibly poeciliids) are susceptible to *L. elegans* infestation.
- Goldfish and poeciliids have a significant probability of entering and surviving in Australian natural waters.
- Adult parasites as well as free-living larval stages and eggs can survive winter temperatures.
- Susceptible host fish species include cyprinids and salmonids which are present in Australian natural waters.

There is a moderate probability of *L. elegans* causing infection in the ornamental fish industry in Australia. If the agent entered Australia, the probability of infection in natural waters would be expected to be only one level of probability lower than the probability of establishment in the ornamental fish industry.

Consequence assessment

Effects on commercially significant species

Lernaeid copepods or anchor worms are important parasites of freshwater and marine fish species and may be fatal in low numbers, especially in young fish. In non-lethal infections, weight loss and local ulceration occurs and the fish may be unsightly. Outbreaks may occur in epidemic proportions. *L. elegans* is considered one of the most important parasites of commercial fish in North America and is reported to cause considerable damage to aquaculture in Japan and Israel (Schäperclaus 1991). At a salmonid farm in former Soviet Union, host mortality rates close to 100% were recorded. (Gun'kovskij and Khudolei 1989). *L. elegans* presents serious danger for hatchery-reared salmon (Gun'kovskij and Khudolej 1989).

Given the reported host range overseas, *L. elegans* may have a significant impact on freshwater salmonid aquaculture should the agent establish in the natural environment. Within the ornamental fish industry, koi carp and goldfish production premises may be seriously affected. However, impacts are unlikely to be at the 'whole industry' level.

Various dip and bath treatments are successful in treating infestation. These include salt, potassium permanganate, formalin and various insecticides (Schäperclaus 1991, Soulsby 1982).

Ecological and environmental effects

The susceptibility of native species to *L. elegans* is not known. The parasite is mainly a problem for aquaculture, aquarium fish and fish stocked in man-made lakes (reviewed in Lester and Roubal 1995). From the agent's wide host range, and the fact that *L. cyprinacea* has been reported from a range of Australian native species, including *Maccullochella peeli*, *Gadopsis marmoratus*, *Macquaria ambigua*, *Bidyanus bidyanus* and *Galaxia* spp, many native finfish species may also be susceptible to *L. elegans. Maccullochella peeli mariensis* and six species of *Galaxia* are listed by Environment Australia as vulnerable and/or endangered under the *Endangered Species Protection Act 1992*.

Unrestricted risk estimate

For the unrestricted importation of freshwater ornamental finfish the probability of *L. elegans* establishing in the ornamental finfish industry would be low to moderate or moderate. The consequences of establishing in the ornamental fish industry would be low to moderate. Thus, for *L. elegans* the risk associated with the unrestricted importation of freshwater ornamental finfish would not meet Australia's ALOP and the implementation of specific risk management measures would be warranted.

A summary of the risk assessment is shown in Box 4.12. Appropriate risk management measures are discussed in Chapter 5.

Box 4.12
Risk assessment — *Lernaea elegans*

RELEASE ASSESSMENT (R)

The probability of *L. elegans* entering Australia as a consequence of the unrestricted importation of goldfish and monga cichlids would be moderate. The probability for freshwater ornamental fish would be low to moderate. For marine species the probability would be negligible.

EXPOSURE ASSESSMENT (E)

If *L. elegans* entered Australia, the probability of susceptible animals in the ornamental finfish industry being exposed to a dose sufficient to cause infection would be moderate.

The probability of susceptible animals in Australian natural waters being exposed to a dose sufficient to cause infection would be low.

PROBABILITY OF DISEASE ESTABLISHMENT (R + E)

The probability of *L. elegans* becoming established in the ornamental fish industry as a consequence of the unrestricted importation of goldfish and monga cichlids would be moderate (M). The probability for other freshwater ornamental finfish would be low to moderate (L–M). For marine species, the probability would be negligible (N).

The probability of *L. elegans* becoming established in natural waters as a consequence of the importation of goldfish and poeciliids would be low (L). For other freshwater species, the probability would be extremely low (EL) and for marine species the probability would be negligible (N).

CONSEQUENCE ASSESSMENT

The consequences of *L. elegans* establishing in the ornamental fish industry would be low to moderate (L–M), due primarily to effects on koi carp and goldfish production premises.

If *L. elegans* became established in natural waters, the consequence to native and introduced species, both wild and captive, would be low (L).

There is some evidence to suggest that the establishment of *L. elegans* would affect vulnerable or endangered species in Australia. However, given that there are no reports of *L. cyprinacea* seriously affecting the survival of vulnerable or endangered species in Australia, there is no reason to expect that *L. elegans* would have such impact.

UNRESTRICTED RISK ESTIMATE FOR IMPORTATION OF ORNAMENTAL FINFISH

From Figure 1.1 (risk evaluation matrix):

- probability of establishment in the ornamental finfish industry from goldfish and monga cichlids and from other freshwater fish = L–M
- significance of consequences in the ornamental finfish industry = L–M
- importation risk for *L. elegans* = unacceptable (‘no’ in Figure 1.1).

That is:

- the risk associated with the unrestricted importation of freshwater ornamental finfish does not meet Australia’s ALOP; and
- risk management measures are warranted.

4.3 Risk assessments for low priority disease agents

The following disease agents were identified in Section 4.1 to be of lower priority for specific risk assessment:

- pike fry rhabdovirus (PFR)
- viral encephalopathy and retinopathy virus (VERV)
- *Chlamydia/Rickettsia* spp
- *Edwardsiella ictaluri*
- *Pseudomonas anguilliseptica*
- *Acanthamoeba* spp
- *Henneguya* spp
- *Ergasilus sieboldi*

4.3.1 PIKE FRY RHABDOVIRUS

Pike fry rhabdovirus (PFR) has not been reported in any Schedule 6 listed species. Natural PFR infection has been reported in pike (*Esox lucius*), grass carp (*Ctenopharyngdon idella*), tench (*Tinca tinca*), white bream (*Blicca bjoerkna*) and stone moroko (*Pseudorasbora parva*) (reviewed in Humphrey 1995). Grass carp, tench, white bream and stone moroko are coldwater cyprinids not closely related to cyprinids listed on Schedule 6, namely goldfish, bitterling (*Rhodeus amarus* and *R. sericeus*) and white clouds (*Tanichthys albonubes*). The likelihood of the agent being present in these imported ornamental finfish is extremely low.

Significant disease due to PFR has only been observed in pike (McAllister 1993).

Should the disease establish in Australia, no significant impact to the ornamental finfish industry is expected. Considering the host range of the agent and given that there are no Esocidae or Cyprinidae native to Australia, the agent is not expected to have a significant impact on any commercial fish species or native Australian finfish, including threatened and endangered species, should the agent establish in Australian natural waters.

Conclusion

For PFR, the unrestricted importation of ornamental finfish is considered to meet Australia's ALOP, due primarily to the agent not being reported from any Schedule 6 listed or closely related species and the negligible consequences associated with agent establishment in Australia.

4.3.2 VIRAL ENCEPHALOPATHY AND RETINOPATHY VIRUS

Strains of viral encephalopathy and retinopathy virus (VERV) are associated with at least 19 species representing 10 families of estuarine and marine species including Japanese parrotfish (*Oplegnathus fasciatus*), turbot (*Scophthalmus maximus*), striped jack (*Pseudocaranx dentex*), red spotted grouper (*Epinephelus akaara*), halibut (*Hippoglossus hippoglossus*), European sea bass (*Dicentrachus labrax*) and barramundi (*Lates calcarifer*) (OIE 1997b). Susceptible species include several species maricultured as food fish. As stated in Section 4.1, the importation of these or closely related species poses a higher risk. Pink ling (*Genypterus blacodes*), a maricultured food fish belonging to the Family Ophidiidae, is listed on Schedule 6. A few other species of marine food fish such as tiger puffers (*Takifugu rubripes*) and silver trevally (*Pseudocaranx dentex*) belonging to families with members represented on Schedule 6, are also farmed as food fish on a commercial scale overseas. VERV has not been reported from strictly freshwater species.

The virus has been detected in Australia in association with mass mortality in hatchery-raised larval and juvenile barramundi (Munday et al 1992). There are no federal-level controls over the movement of aquatic animals or non-viable product on account of this agent in Australia, although New South Wales, Western Australia and South Australia impose movement restrictions on live barramundi with respect to VERV; and fingerlings are required to test negative for VER before entry into those States. Different strains of VERV have been reported from overseas but the relative pathogenicity of these strains compared to strains endemic in Australia or their host specificity is not known. Should exotic strains of VERV establish in Australia, species such as silver trevally (*Pseudocaranx dentex*) and a number of species closely related to the above susceptible species may be affected. The severity of any potential impacts, including on endangered and threatened species, is not known.

Conclusion

For VERV, the unrestricted importation of ornamental finfish would meet Australia's ALOP, due primarily to the agent not being reported from any Schedule 6 listed or closely related species. The higher risk posed by fish from stock maricultured as food fish would be addressed by risk management measures recommended for high-priority disease agents. These measures are discussed in Chapter 5.

4.3.3 *CHLAMYDIA* SPP AND *RICKETTSIA* SPP

The only rickettsial disease agent to be characterised, *Piscirickettsia salmonis*, has only been reported from salmonids (reviewed in Lannan et al 1999). Other rickettsia-like organisms have been reported from a range of finfish species including members of the Cichlidae, Serranidae and Callionymidae. Of the species from which rickettsia-like organisms have been reported, only the dragonet (*Callionymus lyra*) (Davies 1986) is listed on Schedule 6. *Callionymus lyra* is a coldwater marine finfish. Likelihood of disease establishment via the importation of marine ornamental finfish was determined to be significantly less than those posed by freshwater species (Section 1.6).

Much like the rickettsias, the single genus within the Chlamidiales, *Chlamydia*, is poorly characterised or speciated. Epitheliocystis, the only fish disease associated with this group, has been reported from a wide range of finfish species (Lannan et al 1999), including barramundi and leafy sea-dragons in Australia (reviewed in Lannan et al 1999). It has been reported that different morphological forms of *Chlamydia* cause epitheliocystis in different finfish families and that cross-infection between families is unlikely (reviewed in Inglis et al 1993). Of the species from which epitheliocystis has been reported, only the goatfish (*Upeneus mollucensis*), a marine finfish, is listed in Schedule 6. As above, the likelihood of establishment via the importation of marine ornamental finfish was determined to be less than that posed by freshwater species (Section 1.6).

The main diseases of significance reported in finfish associated with *Rickettsia* spp and *Chlamydia* spp is piscirickettiosis and epitheliocystis. Piscirickettiosis is a serious disease affecting salmonid aquaculture. Epitheliocystis causes serious mortality and has been reported in Australia. Should exotic *Rickettsia* spp and *Chlamydia* spp establish in Australia, there is no evidence to suggest that they would have significant impact on native species, including endangered and threatened species.

Conclusion

For *Chlamydia* spp and *Rickettsia* spp exotic to Australia, the unrestricted importation of ornamental finfish is considered to meet Australia's ALOP, due primarily to the agents only being reported from two marine finfish species listed on Schedule 6 and because the likelihood of disease establishment via the importation of marine ornamental finfish was determined to be less than those posed by freshwater species.

4.3.4 *EDWARDSIELLA ICTALURI*

E. ictaluri has been recovered from a range of species including diseased *Puntius conchonis* (Humphrey et al 1986) and *Danio devario* (Waltman et al 1985) which are Schedule 6 listed species.

E. ictaluri is reported to be a significant problem only in catfish aquaculture in the United States and catfish are not commercially significant finfish species in Australia. Based on overseas experience, the agent is not expected to have a significant impact on the ornamental finfish industry. Should *E. ictaluri* establish in Australia, there is no evidence to suggest that it would have significant impact on native species, including endangered and threatened species.

Conclusion

For *E. ictaluri*, the unrestricted importation of ornamental finfish is considered to meet Australia's ALOP, due primarily to the lack of significant consequences should *E. ictaluri* establish in Australia.

4.3.5 *PSEUDOMONAS ANGUILLISEPTICA*

P. anguilliseptica has been reported from Finland, France, Japan, Malaysia, the Netherlands, Scotland, and Taiwan (reviewed in Daly 1999, Haenen and Davidse 1997, Subasinghe and Shariff 1992). Of the families represented on Schedule 6, *P. anguilliseptica* has only been reported to occur naturally in grouper (*Epinephelus tauvina,* Serranidae) and barramundi (*Lates calcarifer,* Centropomidae), although goldfish are reported to be susceptible to experimental challenge (reviewed in Daly 1999). *Lates* and *Epinephelus* spp are not listed on Schedule 6.

The agent was first identified as the cause of 'Sekiten-byo' or red-spot disease of Japanese eels, when it resulted in great losses of cultured fish (Daly 1999). A severe outbreak was reported in Scotland in 1981 when 67,000 cultured elvers (96% of stock) died (Stewart et al 1983). Since then, production losses in salmonid and eel aquaculture have been reported from several European countries. Should *P. anguilliseptica* establish in Australia, the agent may have some impact on the local eel aquaculture operations. Its potential impact on other native species, including endangered and threatened species, is unknown.

Conclusion

For *P. anguilliseptica*, the unrestricted importation of ornamental finfish is considered to meet Australia's ALOP, due primarily to the agent not being reported from any Schedule 6 listed or closely related species.

4.3.6 *ACANTHAMOEBA* SPP

Acanthamoeba is a large group of freshwater, free-living amoebae, some species of which are opportunistic pathogens of vertebrates. *Acanthamoeba* spp have been found infecting various freshwater fishes, including goldfish (Dyková et al 1996), common carp and blue tilapia (*Oreochromis aureus*) (Lom and Dyková 1992). Of 29 ornamental fish species screened for the presence of amoebae in internal organs, five goldfish and a swordtail (*Xiphophorus helleri*) were found to be positive (Dyková et al 1996). Goldfish and swordtails are listed on Schedule 6. *Acanthamoeba* spp have been recorded in Australia, although there are no reports of *Acanthamoeba* associated with disease in fish (P O'Donoghue pers. comm.).

Taylor (1977) attributed severe losses of blue tilapia to *A. polyphaga*. Mortality in catfish (*Silurus glanis*) averaging 30% has been attributed to a combination of factors, including *Acanthamoeba*-like amoebae (Nash et al 1988). *Acanthamoeba* spp are reported to cause granulomatous inflammatory lesions in internal organs of goldfish (Dyková at al 1996). Though the agent is not in general recognised as a serious pathogen in aquarium fish, granulomatous inflammatory changes are the most common among the internal lesions diagnosed in aquarium fish (Dyková et al 1996).

Based on overseas experience, there is no evidence to suggest that the agent would have significant impact on native species, including endangered and threatened species.

Conclusion

For *Acanthamoeba* spp, the unrestricted importation of ornamental finfish is considered not to meet Australia's ALOP, due primarily to likely impact on ornamental finfish production, particularly goldfish. Risk management measures are discussed in Chapter 5.

4.3.7 *HENNEGUYA* SPP

There is a mounting body of evidence that myxosporeans have complex life cycles requiring invertebrate intermediate hosts (reviewed in Lom and Dyková 1995). In further support of this, Gratzek (1993) stated that infections in fish due to *Henneguya* spp are considered to be self-regulating under aquarium conditions.

Henneguya cameronnensis has been reported from the catfish, *Synodontis batessi*. Although this species is not listed on Schedule 6, three species in the same genus are. These fish are not grown in open, pond culture in Australia and are therefore not associated with significant pathways by which *Henneguya* spp may establish in Australia via the importation of ornamental finfish.

Henneguya spp have been associated with serious losses in catfish and salmonids under aquaculture conditions (Gratzek 1993). None of the species of *Henneguya* reported from Schedule 6 species is associated with significant disease problems. *Henneguya* spp have been reported from Australia. Should exotic *Henneguya* spp infecting Schedule 6 fish species establish in Australia, there is no evidence to suggest that they would have significant impact on native species, including endangered and threatened species.

Conclusion

For *Henneguya* spp, the unrestricted importation of ornamental finfish is considered to meet Australia's ALOP, due primarily to the negligible likelihood of their establishment in the ornamental finfish industry or natural waters.

4.3.8 *ERGASILUS SIEBOLDI*

E. sieboldi is a copepod gill ectoparasite of a very wide range of coldwater species in Europe and the former USSR (Lester and Roubal 1995). In Germany, of 79 freshwater species, 39 have been recorded as hosts for *E. sieboldi* (Schäperclaus 1991). In addition to tench, *E. sieboldi* has also been reported from several salmonids, clupeids, perches, pikes, cyprinids and catfishes (Schäperclaus 1991). Goldfish would be the most likely Schedule 6 species of concern.

E. sieboldi is a serious pest causing severe gill damage of tench (*Tinca tinca*) in Europe (Wootton 1989). The agent's wide geographic distribution within Europe and high incidence of infestation have caused serious problem for lake fisheries (Schäperclaus 1991). Adult parasites on fish gills can be readily detected with the naked eye. Anti-parasitic treatment used for the management of other crustacean ectoparasites would be effective against this agent. The potential impact on native species, including endangered and threatened species, should *E. sieboldi* establish in Australia, is not known.

Conclusion

For *E. sieboldi*, the unrestricted importation of ornamental finfish would not meet Australia's ALOP. However, management measures imposed on ectoparasites determined to be of high priority for risk assessment would also reduce the risk associated with *E. sieboldi* to an acceptable level. These measures are discussed in Chapter 5.

Chapter 5
Risk management

5.1 General principles of risk management

THIS CHAPTER CONSIDERS THE RISK management measures that will be required to address the quarantine risks associated with disease agents of ornamental finfish. The risk assessment for the unrestricted importation of ornamental finfish (see Chapter 4) showed that the risk associated with the establishment of some disease agents would not meet Australia's appropriate level of protection (ALOP). The next step in the IRA was to consider how risk management measures could be implemented to reduce the risk to a level that would meet the ALOP.

If the risk from the proposed importation of a commodity is determined to be greater than Australia's ALOP — that is, the risk associated with the unrestricted importation is unacceptable — implementation of risk management measures must be considered, consistent with Section 70 of Quarantine Proclamation (QP) 1998:

> In deciding whether to grant a permit to import a thing into Australia, a Director of Quarantine… must consider whether, if the permit were granted, the imposition of conditions on it would be necessary, to limit the quarantine risk to a level that would be acceptably low.

Such consideration of measures is consistent with Australia's international obligations under the World Trade Organization (WTO) Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement).

The risk management measures chosen must not only meet Australia's ALOP, but must also restrict trade as little as possible. In developing these measures, Australia must consider matters such as practicability and ease of implementation, cost of compliance, cost-effectiveness and impact on trade, subject to the overriding requirement that measures reliably achieve the ALOP. Additionally, under Article 4 of the SPS Agreement, if an exporting country or other party can objectively demonstrate that measures other than those initially proposed by Australia would deliver the level of protection we require, the alternative measures should be acceptable.

Quarantine measures must be specified and applied in a way that does not discriminate between the commodities of different exporting countries, taking into account differences in assessed risk associated with commodities from each source. Similarly, measures applied to limit risk from imported commodities must not be more restrictive than measures applied to address similar risks from domestic commodities. Furthermore, quarantine measures imposed by Australia must not make arbitrary or unjustified distinctions in the acceptable level of quarantine risk from imported commodities (considering both the likelihood and consequences of establishment of the disease) if such distinctions restrict trade; that is, quarantine risk must be managed consistently.

Consistent with the SPS Agreement, Australia's policy is to adopt international standards if their use will meet our ALOP. As noted in Chapter 1, relevant international standards, including for several diseases considered in this risk analysis, have been determined by the Office International des Epizooties (World Organisation for Animal Health, OIE). For importing countries that are free of specified diseases and are sourcing fish from countries or regions that are not free of those diseases, the OIE recommends, as a minimum risk-management measure, that the fish be clinically healthy and originate from a premises, region or country subject to official health surveillance and free from diseases notifiable to the OIE.

Section 5.2 describes the general measures available for managing quarantine risks. Sections 5.3 and 5.4, respectively, describe the risk management measures proposed for the disease agents identified in Section 4.1.2 as requiring assessment with high priority (group 1) and lower priority (group 2). Section 5.5 describes non-regulatory options recommended by the Australian Quarantine and Inspection Service (AQIS).

5.2 Available quarantine measures

Quarantine measures aim to reduce the likelihood that the importation of ornamental finfish would lead to the introduction and establishment of exotic disease agents in Australia. There are two principal methods of achieving this outcome:

- reducing the likelihood of disease agents entering Australia in imported ornamental finfish, by imposing conditions on the population from which the fish are sourced and/or on the fish to be exported; and
- reducing the likelihood that susceptible host species in Australia would be exposed to imported ornamental finfish or derived waste likely to transmit disease, by imposing conditions on the imported fish and/or on the materials imported with them.

The existing post-arrival quarantine procedures for all freshwater ornamental finfish imported to Australia (see Section 1.4.3) were introduced in 1986, with some subsequent amendments to better meet industry needs and to address new disease concerns. Four factors indicate that there may be a need for a higher level of quarantine security (than currently provided) as a risk management option:

- evidence that there is a need for more consistent quarantine practices across all States and Territories;
- certain species of ornamental finfish being more likely than other species to transmit disease agents to susceptible fish;
- the fact that relatively little is known of some of the disease agents associated with ornamental finfish; and
- the fact that disease agents have been isolated from imported ornamental finfish; Humphrey (1995) lists such agents and Section 1.6 of this report discusses disease agents thought to have been introduced through trade in ornamental finfish.

Measures can be applied in the country of origin before export and/or in Australia after import to modify the level of risk. Factors relevant to the identification of appropriate risk management measures are discussed in Chapter 1.

5.2.1 PRE-EXPORT MEASURES

Section 1.6 discusses general factors affecting the prevalence of disease agents in imported ornamental finfish. Possible pre-export risk management measures include:

- restrictions on the source of the fish;
- restrictions on specific species;
- prophylactic/therapeutic treatment;
- inspection and clearance; and
- certification as to disease status at consignment, premises or region/country level.

Restrictions on the source of the fish

The source of imported ornamental finfish may affect the prevalence of disease agents in the fish. AQIS may require that certification be provided attesting to the source of the fish, including details of any associated fish species, their geographical location and whether they were wild-caught or farmed. In particular, requiring that ornamental finfish destined for export had not been associated with food fish aquaculture production facilities (particularly those of salmonids and carp) would reduce the likelihood of entry of exotic disease agents of significance to similar industries in Australia.

Such a requirement may be difficult to enforce as the actual origin of ornamental finfish is often difficult to determine due to the degree of transhipment through different countries associated with trade in such fish. Such a requirement would not represent a significant impediment to trade.

Restrictions on specific species

As a measure against the introduction of disease agents carried by specific ornamental finfish species, AQIS could place additional conditions on the importation of relevant host species. This would include several marine ornamental finfish species currently farmed as food fish overseas (such as pink ling) where prevalence of disease agents is expected to be higher than in wild-caught animals, representing a higher probability of introducing disease agents. To address the higher risk posed by these species, AQIS could require certification that imported fish are not sourced from food fish aquaculture operations.

Industry representatives have argued that restrictions on particular ornamental finfish would result in an increased level of smuggling of species difficult to obtain through legal channels. AQIS needs to make a judgment with regard to comparative risks posed by restrictions on legal trade compared to potential increases in risk from illegal activities (to the extent that the latter can be modified by AQIS policing borders).

Prophylactic/therapeutic treatment

Treatment may be applied to fish prior to export to address the risks posed by certain disease agents, particularly ectoparasites. AQIS could specify the treatment regimen for chemotherapeutants on fish for export to ensure that the chemotherapeutants are applied at an appropriate dose rate and duration. This would minimise the risk of resistance developing and likelihood of interference with procedures such as ad hoc testing which may be carried out during post-arrival quarantine detention.

Inspection and clearance

Inspection of fish is performed in many countries using a program approved by the appropriate certifying authority with the objective of affirming that each consignment meets the requirements of the importing country. Fish with visible lesions or evidence of septicaemia would be rejected, while fish with chronic low-grade infection would normally pass inspection. Therefore, while inspection will not detect all infected animals, it will provide for the removal of animals with gross lesions, which are often associated with higher titres of disease agents.

There are significant commercial incentives for exporters to include only apparently healthy fish in consignments for export; amongst other reasons, the need to avoid significant losses of fish en route, to satisfy importer expectations that consignments are healthy and to encourage repeat orders.

To further reduce risk, AQIS could require that all consignments be inspected for signs of diseased fish prior to clearance.

Certification

Certification is generally used to provide assurances when post-arrival inspection of imported fish cannot readily confirm that a particular measure has been implemented. Certification may also be used as a complement or an alternative to measures such as testing or quarantine detention on arrival.

Certifying authorities must have systems in place to support the issuance of accurate, valid certification. Such systems may include monitoring and surveillance programs, legislated provisions for the notification of disease outbreaks, animal disease control measures, competent animal health services with laboratory support, systems for inspection of fish, and a legislative system to support the issuing of certificates, with appropriate sanctions to discourage the issuing of false statements.

Importing countries have the right to take appropriate steps to verify that certificates are accurate and certification systems reliable. Before approving the importation of commodities for which certification is an important part of the risk management arrangements, an appropriate evaluation of the certifying authority may need to be made. AQIS would normally approve countries with a history of exporting animals/products that comply with Australia's quarantine requirements. This includes countries that regularly export items to Australia which are subject to similar levels of quarantine control, such as live animals, genetic material and animal products in commercial volumes. For countries where a similar level of detail and history of established trade is not available, AQIS may conduct a specific evaluation. Animal Quarantine Policy Memorandum 1999/41 provides draft guidelines for the approval of countries to export animals (including fish) and their products to Australia.

Certification can be used to provide assurances that regions or countries are free of particular disease agents. For diseases listed by the OIE, countries provide regular annual reports and emergency reports (as required) of disease status. Before accepting assurances about freedom from disease (on a regional or country basis), AQIS may require an exporting country to present a submission to support such claims. The submission should include the structure of and the results from ongoing surveillance and monitoring systems for disease agents of fish, and details of controls in place to prevent disease agents entering the country or disease-free region. AQIS would formally evaluate the submissions of exporting countries, having regard to the epidemiology of the disease agents and the likely effectiveness of any control programs.

The emergence of a previously unknown disease agent or syndrome is more likely to be detected in countries with structured monitoring and surveillance systems designed for the target population. The reporting of new agents or syndromes may mean that AQIS has to adopt additional or alternative risk management measures to maintain consistency with Australia's ALOP.

Certification forms the basis of the international standard for trade in live fish. AQIS may require, in accordance with provisions in the OIE *International Aquatic Animal Health Code* (OIE 1997a), that each consignment be accompanied by an animal health certificate from the certifying authority attesting to the health of the fish in the consignment and the health status of the premises. The certifying authority would also need to certify that the premises of export are currently approved for export to Australia.

5.2.2 POST-IMPORT MEASURES IN AUSTRALIA

Managing post-arrival disease risk is primarily aimed at reducing to an acceptably low level the likelihood that susceptible host species in Australia would be exposed to imported ornamental finfish or derived waste likely to transmit disease.

Risk management measures that may be applied to consignments of imported fish include:

- inspection at the border;
- quarantine detention on arrival in Australia;
- prophylactic/therapeutic treatment;
- testing of imported fish; and
- treatment of waste.

Inspection at the border

Imported ornamental finfish are usually stressed on arrival, due mainly to deterioration in water quality in transport bags and the variability of external environmental conditions during transport. Such stress is a predisposing factor in the manifestation of clinical disease, either on arrival in Australia or within a short period, depending on characteristics of any disease agents present, susceptibility of the host fish and the environment in which the fish are being held.

Visual inspection at the border will aid detection of unhealthy fish. However, in most instances it will be difficult to distinguish between fish suffering from an infectious disease and fish suffering from transport stress. Certain behaviour patterns or the presence of external lesions (sometimes pathognomonic) may lead to the suspicion that a disease agent is involved. Visual inspection at the border and appropriate disposal of unhealthy consignments would encourage best practice by exporters.

Inspection would also give AQIS early warning of problem shipments and alert AQIS to the possibility of similarly affected fish from the same country, zone or premises. Action could then be taken at the earliest opportunity to make a specific diagnosis. An early diagnosis would enable a quick response to the problem.

To decrease the likelihood of disease agent entry into Australia, AQIS may require that all consignments of ornamental finfish be inspected at the border and that only consignments of fish without clinical signs of disease be accepted.

Quarantine detention on arrival in Australia

The main objective of post-arrival quarantine detention is to provide a secure environment to allow for the observation of imported fish for clinical signs of disease, and for designated procedures to be carried out.

As a result of deliberations at the recent 'FAO/NACA/OIE Second Training Workshop on Quarantine, Health Certification, and Information Systems for Responsible Movement of Live Aquatic Animals in Asia–Pacific', a period of quarantine detention is one of the approaches supported by member countries of NACA in the context of developing regional technical guidelines for trade in live fish.

The diagnosis of disease in fish under quarantine (resulting from either a disease agent and/or physiological changes due to transport stress) may depend on observation of clinical signs and abnormal fish behaviour, and an inspection of specific lesions, mortality/morbidity patterns and necropsy/laboratory results. The quarantine period determined would need to take into account the expected time for clinical signs to appear. The presence of disease agents in fish not showing clinical signs (ie carrier fish) would not be detected in quarantine except via specific testing regimens or by the use of sentinel fish (of species likely or known to show clinical signs).

Quarantine also provides an opportunity for the:

- testing and/or treatment for specific disease agents;
- collection of information on the general health status of consignments, with a view to modifying risk management measures once a more complete data set is obtained;
- safe disposal of potentially contaminated sick and dead fish, transport water and packaging materials; and
- secure holding of fish in the event of notification of a disease outbreak in the source premises, region or country at around the time of export of the consignment.

Consignments for which the morbidity/mortality rate is considered to be within normal limits would be released at the end of the quarantine period. A consignment with an unacceptable morbidity/mortality rate would be released from quarantine only after AQIS is satisfied with the health status of the consignment. A specific testing or treatment program, or an extension of the quarantine period, would inspire further confidence in the health status of the consignment.

A minimum quarantine period of between one and three weeks (depending on the fish species and their associated diseases) would allow for the:

- increased likelihood of disease detection through the development of clinical signs due to any disease agents already present;
- results of any diagnostic testing to be available; and
- efficacy of any treatments to be ascertained.

Prophylactic/therapeutic treatment

ADSI (1999) reported on the use of chemotherapeutants in the ornamental finfish industry. The precise extent of their use, both therapeutically and prophylactically, by the industry is not known (due to the lack of specific data). The opinion of some industry members was that if chemotherapeutants were not used, resultant high rates of mortality would make the import trade commercially non-viable (ADSI 1999). The consultants considered that this indicated that the use of chemotherapeutants was clearly widespread. The consultants believed that the use of a chemotherapeutant in the absence of any specific diagnosis could be questioned and that currently the use of chemotherapeutants represents a 'shotgun' approach with little or no specificity. Industry sources acknowledge that such practices do exist but point out that such an approach represents worst practice in the industry and that most industry members take a more responsible approach.

AQIS is particularly concerned about two issues arising from ADSI (1999) — firstly, the potential for chemotherapeutants to mask clinical signs of disease and, secondly, their potential to interfere with accurate diagnosis of disease. Either of these possibilities makes it less likely that disease agents will be detected during post-arrival quarantine detention. The lack of formally registered chemotherapeutants in many countries for use on ornamental finfish also needs to be addressed.

AQIS may require that fish under quarantine detention be treated with chemotherapeutants only with AQIS permission and only as a result of specific disease agents being suspected or confirmed following diagnostic testing, or prophylactically for specific disease agents.

Testing of imported ornamental finfish on arrival

Testing of fish in quarantine detention may take two forms:

- ad hoc testing of a specific consignment to discover the cause of higher than normal morbidity/mortality during transport or post-arrival quarantine detention; and
- routine sampling of consignments of specific species of ornamental finfish or fish from specific sources, to determine whether such consignments are associated with unwanted disease agents that warrant additional risk management measures.

As well as disease agents of ornamental finfish, AQIS would target those agents pathogenic to other species that are likely to be carried by ornamental finfish but unlikely to exhibit as clinical signs in such finfish. AQIS may require sampling to be done on transport water and/or on sick and dead fish, and on sentinel fish if these are used.

Waste treatment

As discussed in Section 1.6, the disposal of waste from import premises may provide a pathway for disease agents to become established in Australia. Such waste includes sick and dead fish, transport water and packaging materials. The safe disposal of such waste by incineration (disposal through biohazard waste disposal companies) or adequate sterilisation (using chlorination or equivalent) would significantly reduce the risk by minimising the amount of potentially infected material released into the industry or into Australian natural waters.

The waste from ornamental finfish subject to quarantine detention on arrival is disposed of under AQIS supervision and presents negligible risk.

5.2.3 CONCLUSIONS

In general terms, the importation of live animals presents a higher probability of disease agent introduction than product, due primarily to the fact that the imports may be introduced directly into the national animal population. Also, there is increased risk because live animals may carry higher titres of disease agents than product, and continue to produce the agents over time.

Where sufficient information on disease agent epidemiology is known, risk management measures such as restrictions on source, testing and treatment may be used to mitigate specific risk factors.

With regard to ornamental finfish species, far less is known of the diseases and their epidemiology compared to those of farmed food fish or terrestrial animals. Where there are such significant gaps in knowledge, a more general approach needs to be taken, and baseline risk management applied to all imported ornamental finfish. For ornamental finfish, AQIS believes that the most practical baseline risk management measure which could be applied to mitigate the risks would be mandatory post-arrival quarantine detention.

The imposition of post-arrival quarantine detention as a mandatory import requirement for all ornamental finfish will reduce the likelihood of disease agent introduction as it will allow the observation of all fish, a determined level of testing and/or treatment to be carried out with security, and the safe disposal of all waste. Mandatory quarantine detention will also improve AQIS–industry information exchange, facilitating the resolution of issues relating to quarantine procedures, use of chemotherapeutants and investigation of unexpected morbidity and/or mortality levels in imported fish.

Post-arrival quarantine detention for a minimum of three weeks for goldfish and one week for all other finfish listed on Schedule 6 will be conducted in approved private facilities under quality assurance (QA) arrangements agreed with AQIS. However, a longer minimum quarantine period may be applied against specific disease agents. Quarantine security will be maintained over procedures in quarantine premises, including the disposal of sick and dead fish, transport water, packaging materials and other waste.

AQIS will require, in accordance with provisions in the OIE *International Aquatic Animal Health Code* (OIE 1997a), that each consignment be accompanied by an animal health certificate from the competent authority attesting to the health of the fish in the consignment and the health status of the source population. The competent authority would also need to certify that the premises of export/exporter are currently approved for export to Australia and that the fish had not been kept in water in common with farmed food fish.

All consignments will be visually inspected on arrival in Australia to identify overtly diseased consignments and to ensure that the fish are of species listed on Schedule 6.

In addition to the above baseline requirements, AQIS will apply the following risk management measures either singly or in combination to address specific disease concerns:

- health certification from the competent authority that the source of the fish be free of specified disease agents;
- treatment either of the source population of the fish, or of the fish for export, to address the likelihood that unwanted disease agents are present;
- testing of imported ornamental finfish during quarantine detection, either on an ad hoc or routine basis, to validate certification provided by overseas competent authorities and/or to provide additional data to improve the targeting of risk management measures on imports generally;
- treatment of imported ornamental finfish during quarantine detention by appropriate means, if the presence of specific disease agents is suspected or confirmed following diagnostic testing; and
- post-arrival quarantine detention for longer than the minimum period required.

As Australia is required to be least trade-restrictive in its approach to quarantine risk management, equivalent approaches to managing identified risk may be accepted, either generally or on a case-by-case basis.

5.3 Risk management for high-priority disease agents (group 1)

This section considers the risk management measures that could be applied to address the quarantine risks associated with individual high-priority (group 1) disease agents. On the basis of the risk assessment in Chapter 4, it was shown that for the unrestricted importation of ornamental finfish, the risk associated with the establishment of some of the group 1 disease agents does not meet Australia's ALOP. These disease agents are:

- goldfish haematopoietic necrosis virus (GFHNV);
- iridoviruses of freshwater ornamental finfish;
- spring viraemia of carp virus (SVCV);
- *Aeromonas salmonicida* ('typical' strains and exotic 'atypical' strains);
- *Dactylogyrus vastator* and *D. extensus*;
- *Argulus foliaceus* and *A. coregoni*; and
- *Lernaea elegans.*

The next step in the import risk analysis (IRA) was to consider for each disease how risk management measures could be implemented to reduce the risk to a level that would meet the ALOP.

5.3.1 GOLDFISH HAEMATOPOIETIC NECROSIS VIRUS

Risk assessment conclusions

In Chapter 4, AQIS concluded that, for the unrestricted importation of goldfish, the probability of the establishment of GFHNV in the ornamental finfish industry would be low. The consequences of establishment in the goldfish industry would be of low to moderate significance.

Therefore, for GFHNV, the risk associated with the unrestricted importation of goldfish does not meet Australia's ALOP and the implementation of risk management measures is warranted (see Box 4.1).

Key risk factors

1. GFHNV is associated only with goldfish, which are a Schedule 6 listed species widely traded in the ornamental finfish industry and which are associated with significant pathways by which diseases may enter Australian natural waters.
2. GFHNV has been reported from Japan and possibly from the United States. The actual origin of ornamental finfish may be difficult to determine due to the high levels of transhipment through different countries which occurs in the international trade of ornamental finfish.
3. Heavily infected material (waste and water) may be concentrated at quarantine premises.

Risk management measures

The following risk management measures would reduce the risk of GFHNV becomong established via the importation of ornamental finfish into Australia.

- *Health status*
  - certification attesting to the health of the source population of goldfish.
- *Inspection prior to export*
  - inspection of fish for clinical signs of disease prior to export to Australia.
- *Inspection of fish on arrival in Australia*
- *Post-arrival quarantine detention*
- *Ad hoc sampling of consignments*
  - to validate the health certification.
- *Waste disposal*
  - safe disposal of sick and dead fish, transport water and packaging materials.

Health status of the population from which the imported fish are derived

GFHNV has been reported from Japan and possibly from the United States. Goldfish imported into Australia originate mainly from China, Singapore, Malaysia and Indonesia. The apparent freedom from GFHNV of fish originating from these countries would need to be validated by assessing the type and level of surveillance and monitoring upon which any claims of freedom are based. Certification by a competent authority that the disease has not been reported in the premises, region or country of origin would significantly reduce the risk associated with the importation of goldfish. This measure would substantially address risk factors 1 and 2.

Pre-export inspection

As the disease is more likely to manifest after a period of stress such as that associated with transport, pre-export visual inspection of individual shipments by competent authority inspectors would provide only a minimal degree of risk reduction. This measure would address risk factors 1 and 2 to a minor degree.

Inspection on arrival in Australia

Given the stress associated with transport and because goldfish are affected by the disease agent, inspection of imported goldfish at the border would significantly reduce the risk associated with this agent. Affected shipments may be detained in quarantine or destroyed. This measure would substantially address risk factors 1 and 2.

Post-arrival quarantine detention

Given the stress associated with transport and given that goldfish are affected by the agent, a three-week period of post-arrival quarantine for goldfish would significantly reduce the risk. This measure would substantially address risk factors 1 and 2.

Ad hoc sampling

Ad hoc sampling for GFHNV would serve the purpose of validating exporting countries' certification on health status of source populations. This measure would significantly reduce the risk associated with goldfish importation. This measure would substantially address risk factors 1 and 2.

Safe disposal of waste

The safe disposal of waste would substantially address risk factor 3.

Conclusions

To mitigate the risk of GFHNV becoming established in Australia via the importation of ornamental finfish, AQIS would permit the importation of these fish subject to the conditions shown in Box 5.1.

For GFHNV, the implementation of these measures singly would reduce risk but not to the extent required to meet Australia's ALOP. Implementation of all the measures listed in Box 5.1 would meet Australia's ALOP.

Box 5.1

Risk management measures for goldfish haematopoietic necrosis virus

PRE-EXPORT REQUIREMENTS

- Certification in line with the OIE standard from the competent authority of the exporting country and, in addition, certification that goldfish were sourced from a GFHNV-free country, region or premises.

POST-IMPORT MEASURES

- Goldfish are visually inspected at the border.
- Goldfish are quarantined on arrival for a minimum period of three weeks.
- Ad hoc sampling of goldfish is undertaken to validate health certification.
- Sick and dead goldfish, transport water and packaging are disposed of safely.

5.3.2 IRIDOVIRAL DISEASES OF FRESHWATER ORNAMENTAL FINFISH

Risk assessment conclusions

In Chapter 4 AQIS concluded that, for the unrestricted importation of gouramis and cichlids, the probability of establishment of iridoviruses in the ornamental fish industry would be low to moderate. The consequences of establishment would be of low significance.

Therefore, for iridoviruses, the risk associated with the unrestricted importation of gouramis and cichlids does not meet Australia's ALOP and the implementation of risk management measures is warranted (see Box 4.3).

Key risk factors

1. Exotic iridoviruses of freshwater ornamental finfish are associated with gouramis and cichlids, which are Schedule 6 listed finfish widely traded in the ornamental finfish industry.

2. Exotic iridoviruses of freshwater ornamental finfish have been reported from the United States, South America, Singapore and the United Kingdom. The actual origin of ornamental finfish may be difficult to determine due to the high levels of transhipment through different countries which occurs in the international trade of ornamental finfish.
3. Heavily infected material (waste and water) may be concentrated at quarantine premises.

Risk management measures

The following risk management measures would reduce the risk of exotic iridoviruses of freshwater ornamental finfish becoming established via the importation of ornamental finfish into Australia:

- *Health status*
  – certification attesting to the health of the source population of gouramis and cichlids.
- *Inspection prior to export*
  – inspection of fish for clinical signs of disease prior to export to Australia;
- *Inspection of fish on arrival in Australia*
- *Post-arrival quarantine detention*
- *Ad hoc sampling of consignments*
  – to validate the health certification.
- *Waste disposal*
  – safe disposal of sick and dead fish, transport water and packaging materials.

Health status of the population from which the imported fish are derived

The disease agents have a wide geographic distribution including Asia. Due to the degree of transhipment in the international trade in ornamental finfish, it is not sufficient to treat the country of export as the country of origin. However, certification by a competent authority that the disease agent has not been reported in the premises, region or country of origin would significantly reduce the risk associated with the importation of susceptible species. This measure would substantially address risk factors 1 and 2.

Pre-export inspection

As the disease is more likely to manifest itself after a period of stress such as that associated with transport, pre-export visual inspection of individual shipments by competent authority inspectors would provide only a minimal degree of risk reduction. This measure would address risk factor 1 to a minor degree.

Inspection on arrival in Australia

Given the stress associated with transport and because gouramis and cichlids are affected by the agent, inspection of imported gouramis and cichlids at the border would significantly reduce the risk associated with this agent. Affected shipments may be detained in quarantine or destroyed. This measure would substantially address risk factor 1.

Post-arrival quarantine detention

Given the stress associated with transport and given that gouramis and cichlids are affected by the agent, a two-week period of post-arrival quarantine detention for gouramis and cichlids would significantly reduce the risk. This measure would substantially address risk factors 1 and 2.

Ad hoc sampling

Ad hoc sampling for exotic iridoviruses of freshwater ornamental finfish would serve the purpose of validating exporting countries' certification on the health status of source populations. This measure would significantly reduce the risk associated with gourami and cichlid importation, and would substantially address risk factor 1.

Safe disposal of waste

The safe disposal of waste would substantially address risk factor 3.

Conclusions

To mitigate the risk of exotic iridoviruses of freshwater ornamental finfish becoming established in Australia via the importation of ornamental finfish, AQIS would permit the importation of these fish subject to the conditions shown in Box 5.2.

For exotic iridoviruses of freshwater ornamental finfish, the implementation of these measures singly would reduce risk but not to the extent required to meet Australia's ALOP. Implementation of all the measures listed in Box 5.2 would meet Australia's ALOP.

Box 5.2
Risk management measures for exotic iridoviral diseases of freshwater ornamental finfish

PRE-EXPORT REQUIREMENTS

- Nil.

POST-IMPORT MEASURES

- Gouramis and cichlids are visually inspected at the border.
- Gouramis and cichlids are quarantined on arrival for a minimum period of two weeks.
- Sick and dead gouramis and cichlids, transport water and packaging are safely disposed of from importer premises.

5.3.3 SPRING VIRAEMIA OF CARP VIRUS

Risk assessment conclusions

In Chapter 4, AQIS concluded that, for the unrestricted importation of goldfish, the probability of establishment of SVCV in the ornamental finfish industry would be low to moderate. The consequences of establishment in the ornamental finfish industry would be of low to moderate significance.

Therefore, for SVCV, the risk associated with the unrestricted importation of goldfish does not meet Australia's ALOP and implementation of risk management measures is warranted (see Box 4.4).

Key risk factors

1. SVCV is associated with goldfish, which are a Schedule 6 listed species widely traded in the ornamental finfish industry and which are associated with significant pathways by which diseases may enter Australian natural waters.
2. Goldfish may be subclinically infected with SVCV.
3. SVCV primarily affects cultured carp.
4. SVCV has been reported from Europe and China. However, the actual origin of ornamental finfish may be difficult to determine due to the high levels of transhipment through different countries which occur in the international trade of ornamental finfish.
5. Heavily infected material (waste and water) may be concentrated at quarantine premises.

Risk management measures

The following risk management measures would reduce the risk of SVCV becoming established via the importation of ornamental finfish into Australia:

- *Health status*
  - certification attesting to the health of the source population of goldfish, and
  - certification that fish have not been kept in water shared with farmed carp.
- *Inspection prior to export*
- *Inspection of fish on arrival in Australia*
- *Post-arrival quarantine detention*
- *Ad hoc sampling of consignments*
  - to validate the health certification.
- *Waste disposal*
  - safe disposal of sick and dead fish, transport water and packaging materials.

Health status of the population from which the imported fish are derived

SVCV has been reported only from Europe and China, the latter (which has claimed freedom from SVC for a large part of its territory) being one of the important sources of goldfish to Australia. Any claims to freedom from this disease agent may need to be validated by assessing the type and level of surveillance and monitoring on which the claims are based. Certification by a competent authority that the disease agent is absent from the premises, region or country of origin and that the fish have not shared water with farmed carp would significantly reduce the risk associated with goldfish importation. This measure would substantially address risk factors 1, 2, 3 and 4.

Pre-export inspection

As disease due to SVCV is not likely to manifest itself in goldfish unless under extreme stress, pre-export visual inspection of individual shipments by competent authority inspectors is not likely to provide any risk reduction. This measure would address risk factors 1 and 2 to a minor degree.

Inspection on arrival in Australia

Given the stress associated with transport and because goldfish may be affected by the agent, inspection of imported goldfish at the border may reduce the risk associated with this agent to a minor degree. Affected shipments may be quarantined or destroyed. This measure would address risk factors 1 and 2 to a minor degree.

Post-arrival quarantine detention

Given the stress associated with transport and given that goldfish may be affected by the agent, a three-week period of post-arrival quarantine detention will reduce the risk. However, as goldfish are generally resistant to this disease and because the stresses associated with transport and holding procedures may not induce clinical signs, this measure would only partially address risk factors 1 and 2.

Ad hoc sampling

Ad hoc sampling for SVCV will serve the purpose of validating exporting countries' certification on the health status of source populations. This measure would significantly reduce the risk associated with goldfish importation, and would substantially address risk factors 1 and 2.

Safe disposal of waste

The safe disposal of waste would substantially address risk factor 5.

Conclusions

To mitigate the risk of SVCV becoming established in Australia as a result of the importation of ornamental finfish, AQIS would permit this importation subject to the conditions shown in Box 5.3.

For SVCV, the implementation of these measures singly would reduce risk but not to the extent required to meet Australia's ALOP. Implementation of all the measures listed in Box 5.3 would meet Australia's ALOP.

Box 5.3
Risk management measures for spring viraemia of carp virus

Pre-export requirements

- Certification in line with the OIE standard from the competent authority of the exporting country and, in addition, certification that goldfish were sourced from an SVCV-free country, region or premises.
- Certification from the competent authority of the exporting country that the fish had not been kept in water in common with farmed carp.

POST-IMPORT MEASURES

- Goldfish are visually inspected at the border.
- Goldfish are quarantined on arrival for a minimum period of three weeks.
- Ad hoc sampling is undertaken to validate health certification.
- Sick and dead goldfish, transport water and packaging are disposed of safely.

5.3.4 *AEROMONAS SALMONICIDA*

Risk assessment conclusions

In Chapter 4, AQIS concluded that, for the unrestricted importation of goldfish, the probability of the establishment of an exotic strain of *A. salmonicida* in natural waters would be low. The consequences of establishment in natural waters would be of moderate to high significance, or moderate significance, depending on the strain.

Therefore, for exotic strains of *A. salmonicida*, the risk associated with the unrestricted importation of goldfish does not meet Australia's ALOP and the implementation of risk management measures is warranted (see Box 4.5).

Key risk factors

1. *A. salmonicida* is associated with goldfish, which are a Schedule 6 listed species widely traded in the ornamental finfish industry and which are associated with significant pathways by which diseases may enter Australian natural waters.
2. Goldfish may be asymptomatic carriers of *A. salmonicida*.
3. *A. salmonicida* has a broad geographic range which is not well defined, but which includes the Americas, Europe, Asia and Africa. The actual origin of ornamental finfish may be difficult to determine due to the high levels of transhipment through different countries which occurs in the international trade of ornamental finfish.
4. *A. salmonicida* is expected to be more prevalent in waters associated with salmonid aquaculture. *A. salmonicida* susp *salmonicida* has been reported from carp.
5. *A. salmonicida* may survive independently of the fish host for prolonged periods.
6. Heavily infected material (waste and water) may be concentrated at quarantine premises.

Risk management measures

The following risk management measures would reduce the risk of *A. salmonicida* becoming established via the importation of ornamental finfish into Australia.

- *Health status*
  - certification attesting to the health of the source population of goldfish, and
  - certification that goldfish have not been kept in water in common with farmed salmonids or carp.
- *Inspection prior to export*
  - inspection of goldfish for signs of disease prior to export to Australia;
- *Inspection of goldfish on arrival in Australia*
- *Post-arrival quarantine detention*
- *Ad hoc sampling of consignments*
  - to validate health certification.
- *Waste disposal*
  - safe disposal of sick and dead fish, transport water and packaging materials.

Health status of the population from which the imported fish are derived

Exotic strains of *A. salmonicida* have a wide distribution. However, the agent has not been reported from any of the major source countries of goldfish to Australia; namely, China, Singapore, Malaysia and Indonesia. However, this apparent freedom from the disease agent, and the freedom of any other countries that goldfish may originate from, may need to be validated by assessing the type and level of surveillance and monitoring on which the claims are based. Certification by a competent authority that the disease agent has not been reported in the premises, region or country of origin, and that the fish have not been kept in water in common with farmed salmonids or carp will significantly reduce the risk associated with goldfish importation. This measure would substantially address risk factors 1, 2, 3 and 4.

Pre-export inspection

As *A. salmonicida* does not usually cause overt disease in goldfish (other than with the goldfish ulcer disease biovar), and because fish will have lower stress levels prior to shipment compared to the levels on arrival in

Australia, pre-export visual inspection of individual shipments by competent authority inspectors would not provide a significant risk reduction. This measure would address risk factors 1, 2, 3 and 4 to a minor degree.

Inspection on arrival in Australia

As disease due to *A. salmonicida* does not usually cause overt disease in goldfish (other than with the goldfish ulcer disease biovar), but because fish are likely to have higher stress levels on arrival in Australia, inspection of imported goldfish at the border would address risk factors 1, 2, 3 and 4 to a minor degree.

Post-arrival quarantine detention

Given the stress associated with transport and because goldfish may be affected by the agent, a three-week period of post-arrival quarantine detention will reduce the risk. However, as goldfish do not usually show overt disease, this measure would only partially address risk factors 1, 2, 3 and 4.

Ad hoc sampling

Ad hoc sampling for *A. salmonicida* will serve the purpose of validating exporting countries' certification on the health status of source populations. This measure would substantially address risk factors 1 and 2.

Safe disposal of waste

Given that the agent can survive independently of a live host fish for prolonged periods, the safe disposal of waste would substantially address risk factors 5 and 6.

Conclusions

To mitigate the risk of *A. salmonicida* becoming established in Australia as a result of the importation of ornamental finfish, AQIS would permit the importation of these fish subject to the conditions shown in Box 5.4.

For exotic strains of *A. salmonicida*, the implementation of these measures singly would reduce risk but not to the extent required to meet Australia's ALOP. Implementation of all the measures listed in Box 5.4 would meet Australia's ALOP.

Box 5.4

Risk management measures for *Aeromonas salmonicida*

PRE-EXPORT REQUIREMENTS

- Certification in line with the OIE standard from the competent authority of the exporting country and, in addition, certification that goldfish were sourced from an *A. salmonicida*-free country, region or premises.
- Certification from the competent authority of the exporting country that the fish had not been kept in water in common with farmed salmonids or carp.

POST-IMPORT MEASURES

- Goldfish are visually inspected at the border.
- Goldfish are detained in quarantine for a minimum period of three weeks.
- Ad hoc sampling is undertaken to validate health certification.
- Sick and dead goldfish, transport water, and packaging are disposed of safely.

5.3.5 *DACTYLOGYRUS VASTATOR* AND *D. EXTENSUS*

Risk assessment conclusions

In Chapter 4 AQIS concluded that, for the unrestricted importation of goldfish, the probability of the establishment of *Dactylogyrus vastator* or *D. extensus* in the ornamental fish industry would be moderate, and the probability of establishment in the natural environment would be low. The consequences of establishment would be of low to moderate significance.

Therefore, for *D. vastator* and *D. extensus*, the risk associated with the unrestricted importation of goldfish does not meet Australia's ALOP and the implementation of risk management measures is warranted (see Box 4.10).

Key risk factors

1. Both parasites are associated with goldfish, which are a Schedule 6 listed species widely traded in the ornamental finfish industry and which are associated with significant pathways by which diseases may enter Australian natural waters.
2. Both parasites are gill parasites and infestation will not be detected by visual inspection unless infestation is severe enough to cause behavioural changes.
3. Both parasites are prevalent on cultured carp.
4. Both parasites have a broad geographic distribution including Asia. The actual origin of ornamental finfish may be difficult to determine due to the high levels of transhipment through different countries which occurs in the international trade of ornamental finfish.
5. Eggs of the parasite as well as larval stages may survive independently of the fish host.
6. Heavily infected material (waste and water) may be concentrated at quarantine premises.

Risk management measures

The following risk management measures would reduce the risk of *D. vastator* and *D. extensus* becoming established via the importation of ornamental finfish into Australia.

- *Health status*
  - certification attesting to the health of the source population of goldfish, and
  - pre-export treatment of goldfish.
- *Inspection prior to export*
  - inspection of goldfish prior to export to Australia.
- *Inspection of goldfish on arrival in Australia*
- *Post-arrival quarantine detention*
  - quarantine detention of goldfish on arrival in Australia, and
  - treatment of goldfish in quarantine.
- *Ad hoc sampling of consignments*
  - to validate health certification.
- *Waste disposal*
  - safe disposal of sick and dead fish, transport water and packaging materials.

Health status of the population from which the imported fish are derived

The agents have a wide geographic distribution including Asia, the main source of goldfish imported to Australia. Certification by a competent authority that the disease agents are absent from the premises, region or country of origin, and that the fish have not been kept in water in common with farmed carp will significantly reduce the risk associated with goldfish importation. This measure would substantially address risk factors 1, 2, 3 and 4.

Pre-export treatment

Several chemotherapeutants are available for effective treatment of adult gill flukes of fish caused by *D. vastator* and *D. extensus*. However, reinfection before arrival in Australia may occur and therefore treatment accompanied by adequate safeguards to prevent reinfection should be undertaken. This measure would substantially address risk factors 1 and 2.

Pre-export inspection

Pre-export visual inspection of individual shipments by competent authority inspectors will detect heavily infected fish but may not detect those with very low levels of infection. This measure would address risk factors 1, 2, 3 and 4 to a minor degree.

Inspection on arrival in Australia

Given the stress associated with transport and because goldfish are affected by the agents, inspection of imported goldfish at the border will reduce the risk associated with these agents to a minor degree. This measure would moderately address risk factors 1, 2, 3 and 4.

Post-arrival quarantine detention

Given the stress associated with transport and that goldfish are affected by the agents, a period of observation during quarantine detention would allow time for close observation of behavioural changes associated with moderate to heavy gill fluke infestations. This measure would substantially address risk factors 1, 2, 3 and 4.

Treatment in quarantine

Adult *D. vastator* and *D. extensus* are amenable to treatment with several chemotherapeutants including sodium chloride dips or baths. Prophylactic treatments or therapeutic treatment after confirming parasite presence will significantly reduce risk. Appropriate water disposal and tank sterilisation procedures would be required to ensure life-cycle stages independent of the fish host do not survive. This measure would substantially address risk factors 1, 2, 3 and 5.

Ad hoc sampling

Ad hoc sampling for the agent will serve the purpose of validating exporting countries' certification on the health status of source populations. This measure would substantially address risk factors 1 and 2.

Safe disposal of waste

Because eggs and larval stages of these parasites can survive for some time independently of the host fish, the adequate sterilisation of transport and effluent water would substantially address risk factors 5 and 6.

Conclusions

To mitigate the risk of *D. vastator* and *D. extensus* becoming established in Australia as a result of the importation of ornamental finfish, AQIS would permit the importation of these fish subject to the conditions shown in Box 5.5.

For *D. vastator* and *D. extensus*, the implementation of these measures singly would reduce risk but not to the extent required to meet Australia's ALOP. Implementation of all the measures listed in Box 5.5 would meet Australia's ALOP.

Box 5.5
Risk management measures for *Dactylogyrus vastator* and *D. extensus*

PRE-EXPORT REQUIREMENTS

- Certification in line with the OIE standard from the competent authority of the exporting country.
- Certification that goldfish in export shipments have been treated for *D. vastator* and *D. extensus,* and that adequate precautions have been taken to prevent reinfection.

POST-IMPORT MEASURES

- Imported goldfish are inspected at the border.
- Imported goldfish are quarantined on arrival for a minimum period of one week.
- Goldfish are treated with approved chemotherapeutants if the presence of either parasite is indicated.
- Sick and dead goldfish, transport water and packaging are disposed of safely.

5.3.6 *ARGULUS FOLIACEUS* AND *A. COREGONI*

Risk assessment conclusions

In Chapter 4 AQIS concluded that, for the unrestricted importation of goldfish, the probability of the establishment of *Argulus foliaceus* or *A. coregoni* would be moderate. The consequences of establishment in the ornamental finfish industry would be of low to moderate significance.

Therefore, for *A. foliaceus* and *A. coregoni* the risk associated with the unrestricted importation of goldfish does not meet Australia's ALOP and the implementation of risk management measures is warranted (see Box 4.11).

Key risk factors

1. Both parasites are associated with goldfish, which are a Schedule 6 listed species widely traded in the ornamental finfish industry and which are associated with significant pathways by which diseases may enter Australian natural waters.
2. Goldfish become clinically infected, although extremely low-level infestations may go undetected by visual inspection.
3. Both parasites are prevalent on cultured carp and salmonids.
4. Both parasites have a broad geographic distribution in temperate regions of the world including Asia. The actual origin of ornamental finfish may be difficult to determine due to the high levels of transhipment through different countries which occurs in the international trade of ornamental finfish.
5. Life-cycle stages of the parasites, including the adult stage, can survive independently of the fish host.
6. Heavily infected material (waste and water) may be concentrated at quarantine premises.

Risk management measures

The following risk management measures would reduce the risk of *A. foliaceus* or *A. coregoni* becoming established via the importation of ornamental finfish into Australia.

- *Health status*
  - certification attesting to the health of the source population of goldfish, and
  - pre-export treatment of goldfish.
- *Inspection prior to export*
  - inspection of goldfish prior to export to Australia.
- *Inspection of goldfish on arrival in Australia*
- *Post-arrival quarantine detention*
  - quarantine detention of goldfish on arrival in Australia, and
  - treatment of goldfish in quarantine.
- *Ad hoc sampling of consignments*
  - to validate health certification.
- *Waste disposal*
  - safe disposal of sick and dead fish, transport water and packaging materials.

Health status of the population from which the imported fish are derived

The agents have a wide geographic distribution including Asia, the main source region for goldfish imported to Australia. Certification by a competent authority that the disease agents are absent from the premises, region or country of origin and that the fish have not been kept in water in common with cultured carp or salmonids will significantly reduce the risk associated with goldfish importation. This measure would substantially address risk factors 1, 2, 3 and 4.

Pre-export treatment

Several chemotherapeutants are available for effective treatment of fish lice caused by *A. foliaceus* or *A. coregoni.* However, reinfection before arrival in Australia is likely and therefore treatment accompanied by adequate safeguards to prevent reinfection should be undertaken. This measure would substantially address risk factors 1, 2, 3 and 4.

Pre-export inspection

Pre-export visual inspection of individual shipments by competent authority inspectors will detect infected fish but not those with extremely low levels of infections. This measure would address risk factors 1, 2, 3 and 4 to a minor degree.

Inspection on arrival in Australia

Given the stress associated with transport and because goldfish are affected by the agents, inspection of imported goldfish at the border may reduce the risk associated with these agents to a minor degree. This measure would moderately address risk factors 1, 2, 3 and 4.

Post-arrival quarantine detention

Given the stress associated with transport and given that goldfish may be affected by the agent, a period of quarantine detention will allow time for close observation to detect the presence of adult parasites on fish. This measure would substantially address risk factors 1, 2, 3 and 4.

Treatment in quarantine

Adult *A. foliaceus* or *A. coregoni* are amenable to treatment with several chemotherapeutants. Prophylactic treatments or therapeutic treatment with approved chemicals will significantly reduce risk. Appropriate water disposal and tank sterilisation procedures would be required to ensure life-cycle stages that live independently of the fish host do not survive.
This measure would substantially address risk factors 1, 2, 3 and4.

Ad hoc sampling

Ad hoc sampling for the agent will serve the purpose of validating exporting countries' certification on the health status of source populations. This measure would substantially address risk factors 1 and 2.

Safe disposal of waste

The safe disposal of waste would substantially address risk factors 5 and 6.

Conclusions

To mitigate the risk of *A. foliaceus* and *A. coregoni* becoming established in Australia as a result of the importation of ornamental finfish, AQIS would permit the importation of these fish subject to the conditions shown in Box 5.6.

For *A. foliaceus* and *A. coregoni*, the implementation of these measures singly would reduce risk but not to the extent required to meet Australia's ALOP. Implementation of all the measures listed in Box 5.6 would meet Australia's ALOP.

Box 5.6
Risk management measures for *Argulus foliaceus* and *A. coregoni*

PRE-EXPORT REQUIREMENTS

- Certification in line with the OIE standard from the competent authority of the exporting country.
- Certification from the competent authority of the exporting country that the fish had not been kept in water in common with farmed carp or salmonids.

POST-IMPORT MEASURES

- Goldfish are inspected at the border.
- Goldfish are quarantined on arrival for a period of one week.
- Goldfish are treated with approved chemotherapeutants if parasite presence is confirmed.
- Sick and dead goldfish, transport water and packaging are disposed of safely.

5.3.7 *LERNAEA ELEGANS*

Risk assessment conclusions

In Chapter 4 AQIS concluded that, for the unrestricted importation of freshwater ornamental finfish, the probability of the establishment of *Lernaea elegans* in the ornamental finfish industry would be low to moderate or moderate. The consequences of establishment in the ornamental finfish industry would be of low to moderate significance.

Therefore, for *L. elegans*, the risk associated with the unrestricted importation of freshwater ornamental finfish does not meet Australia's ALOP and the implementation of risk management measures is warranted (see Box 4.12).

Key risk factors

1. *L. elegans* is associated with freshwater species listed on Schedule 6.
2. Extremely low-level infestations of *L. elegans* may go undetected.
3. The parasite is commonly found on cultured carp and salmonids.
4. *L. elegans* has a broad geographic distribution including Asia. The actual origin of ornamental finfish may be difficult to determine due to the high levels of transhipment through different countries which occurs in the international trade of ornamental finfish.
5. Eggs of the parasite as well as larval stages may survive independently of the fish host.
6. Heavily infected material (waste and water) may be concentrated at quarantine premises.

Risk management measures

The following risk management measures would reduce the risk of *L. elegans* becoming established as a result of the importation of ornamental finfish into Australia.

- *Health status*
  - certification attesting to the health of the source population of fish.
- *Pre-export treatment of goldfish*
- *Inspection prior to export*
- *Inspection of fish on arrival in Australia*
- *Post-arrival quarantine detention*
  - quarantine detention of goldfish on arrival in Australia, and
  - treatment of goldfish in quarantine.
- *Ad hoc sampling of consignments*
  - to validate health certification.
- *Waste disposal*
  - safe disposal of sick and dead fish, transport water and packaging materials.

Health status of the population from which the imported fish are derived

The agent has a wide geographic distribution including Asia. Certification by a competent authority that the disease agent is absent from the premises, region or country of origin, and that the fish have not been kept in water in common with farmed carp or salmonids, will significantly reduce the risk associated with the importation of susceptible species. This measure would substantially address risk factors 1, 2, 3 and 4.

Pre-export treatment

Several chemotherapeutants are available for effective treatment of anchor worm (*L. elegans*). However, reinfection before arrival in Australia is likely and therefore treatment accompanied by adequate safeguards to prevent reinfection should be undertaken. This measure would substantially address risk factors 1, 2, 3 and 4.

Pre-export inspection

Pre-export visual inspection of individual shipments by competent authority inspectors will detect heavily infected fish but not those with extremely low levels of infections. This measure would address risk factors 1, 2, 3 and 4.

Inspection on arrival in Australia

Given the stress associated with transport and because freshwater finfish are affected by the agent, inspection of these fish at the border may reduce the risk associated with this agent to a minor degree. Affected shipments may be detained in quarantine or destroyed. This measure would substantially address risk factors 1, 2, 3 and 4.

Post-arrival quarantine detention

Given the stress associated with transport and given that freshwater finfish may be affected by the agent, a period of quarantine detention on arrival will allow time for close observation to detect the presence of adult parasites on fish. This measure would substantially address risk factors 1, 2, 3 and 4.

Treatment in quarantine

Adult *L. elegans* are amenable to treatment with several chemotherapeutants, and, if only a few fish are involved, the parasites may also be removed by hand. Prophylactic or therapeutic treatment will significantly reduce risk. Appropriate water disposal and tank sterilisation procedures would be required to ensure that life-cycle stages independent of the fish host do not survive. This measure would substantially address risk factors 1, 2, 3 and 4.

Ad hoc sampling

Ad hoc sampling for the agent will serve the purpose of validating exporting countries' certification on the health status of source populations. This measure would substantially address risk factors 1, 2, 3 and 4.

Safe disposal of waste

The safe disposal of waste would substantially address risk factors 5 and 6.

Conclusions

To mitigate the risk of *L. elegans* becoming established in Australia as aresult of the importation of ornamental finfish, AQIS would permit the importation of these fish subject to the conditions shown in Box 5.7.

For *L. elegans*, the implementation of these measures singly would reduce risk but not to the extent required to meet Australia's ALOP. Implementation of all the measures listed in Box 5.7 would meet Australia's ALOP.

Box 5.7

Risk management measures for *Lernaea elegans*

PRE-EXPORT REQUIREMENTS

- Certification in line with the OIE standard from the competent authority of the exporting country.
- Certification from the competent authority of the exporting country that the fish had not been kept in water in common with farmed carp or salmonids.

POST-IMPORT MEASURES

- Imported freshwater finfish are inspected at the border.
- Freshwater fish are quarantined on arrival for a minimum period of one week.
- Freshwater fish are treated if infection is indicated.
- Sick and dead freshwater fish, transport water and packaging are disposed of safely.

5.4 Risk management for lower priority disease agents (group 2)

Chapter 4 identified two lower priority (group 2) disease agents that require risk management: viral encephalopathy and retinopathy virus (VERV) and *Ergasilus sieboldi*. This section considers the risk management measures that could be applied to address the quarantine risks associated with these disease agents.

5.4.1 VIRAL ENCEPHALOPATHY AND RETINOPATHY VIRUS

Risk assessment conclusions

In Chapter 4 AQIS concluded that, for VERV, the unrestricted importation of ornamental finfish would meet Australia's ALOP (mainly because the agent has not been reported from any species listed on Schedule 6 or other closely related species). AQIS also concluded that the higher risk posed by fish from stock maricultured as food fish would be addressed by baseline risk management measures as well as specific risk management measures recommended for high-priority disease agents.

Risk management measures

General restrictions on the importation of Schedule 6 listed species sourced from waters shared by food fish aquaculture operations would address the risk associated with fish from maricultured stock.

5.4.2 *ACANTHAMOEBA* SPP

Risk assessment conclusions

In Chapter 4 AQIS concluded that, for *Acanthamoeba* spp, the unrestricted importation of ornamental finfish would not meet Australia's ALOP. However, AQIS believes that management measures imposed on all imported ornamental fish would reduce the risk associated with *Acanthamoeba* spp to an acceptable level.

Risk management measures

Risk management measures imposed on all imported ornamental fish, including inspection on arrival and post-arrival quarantine detention, would reduce the risk associated with *Acanthamoeba* spp to an acceptable level.

5.4.3 *ERGASILUS SIEBOLDI*

Risk assessment conclusions

In Chapter 4 AQIS concluded that, for *Ergasilus sieboldi*, the unrestricted importation of ornamental finfish would not meet Australia's ALOP. However, AQIS believes that management measures for ectoparasites determined to be of high priority for risk assessment would reduce the risk associated with *E. sieboldi* to an acceptable level.

Risk management measures

Risk management measures imposed on ectoparasites determined to be of high priority for risk assessment would reduce the risk associated with *E. sieboldi* to an acceptable level.

Risk management recommendations for addressing the risk posed by gill flukes (*D. vastator* and *D. extensus*) would also address the risk posed by *E. sieboldi.*

5.5 Non-regulatory options

In addition to the above regulatory risk management measures, AQIS recommends the following non-regulatory measures to be pursued at all possible levels including, where relevant, by incorporation into the Pet Industry Joint Advisory Council Code of Practice for Aquarium Operators (PIJAC 1998).

- Public education on the release of ornamental fish into natural waters.
- Increased education on improving husbandry practices at ornamental finfish farms, public aquaria and wholesaler/retailer premises to minimise disease spread and exposure of natural waters to live/dead fish, water or other waste materials.

- Recommendations to States and Territories on the regulation of ornamental finfish farms, wholesalers/retailers and public aquaria, with the objective of minimising disease spread and exposure of natural waters to live/dead fish, water or other waste materials.
- Recommendations to the National Registration Authority for Agricultural and Veterinary Chemicals on registration of chemotherapeutants for use in the ornamental finfish industry. To this end, AQIS will work with the authority to consider registration of additional chemicals for such use.

Detailed action plans based on the above recommendations will be developed by AQIS in consultation with the Department of Environment and Heritage and State and Territory governments.

Chapter 6
General conclusions

6.1 Outcome of the risk analyses

THIS REPORT DEALS WITH THE IDENTIFICATION, assessment and management of quarantine risks associated with the importation of live ornamental finfish from all countries. In parallel, a risk analysis on the importation of non-viable salmonids and non-salmonid marine finfish was also carried out. This chapter sets out the general conclusions of this report, notes the conclusions of the parallel risk analysis and explains how the two reports together address the outcome of the World Trade Organization (WTO) salmon case (see Section 1.1).

This import risk analysis (IRA) considers the disease and pest risks to Australian animals and the environment associated with the importation into Australia of live ornamental (aquarium) finfish as listed in Schedule 6, Part II of the *Wildlife Protection (Regulation of Exports and Imports) Act 1982* (hereafter referred to as Schedule 6). Schedule 6 includes all freshwater and marine ornamental finfish species that may be imported into Australia without being subject to the provisions of the *Wildlife Protection (Regulation of Exports and Imports) Act 1982*. The IRA does not address the pest risks posed by the fish species themselves, as this was addressed by Environment Australia and its predecessor organisations when the species were placed onto Schedule 6.

The objective of the Australian Quarantine and Inspection Service (AQIS) is to adopt quarantine policies which provide the animal and plant health safeguards required by government policy in the least trade-restrictive way. Wherever appropriate, measures are based on relevant international standards. In developing quarantine policies, the disease risks associated with importations are analysed using a structured, transparent and science-based process of import risk analysis. In conducting this risk analysis and in forming conclusions, AQIS has utilised the expertise of its scientific staff and those of the national offices, scientific experts both in Australia and overseas, and comment from stakeholders on the scientific aspects of the analysis.

As prescribed in the *Quarantine Act 1908*, the Director of Animal and Plant Quarantine may permit the entry of commodities on an unrestricted basis or subject to compliance with conditions, which are normally specified on a permit. A risk analysis provides the scientific and technical basis for quarantine policies that determine whether an import may be permitted and, if so, the conditions to be applied. The matters to be considered when deciding whether to issue a permit include the quarantine risk and whether the imposition of conditions would be necessary to limit the quarantine risk to a level that would be acceptably low, consistent with Australian government policy.

These risk analyses provide the scientific and technical basis for AQIS to permit the importation of live ornamental finfish, and non-viable salmonids and non-salmonid marine finfish. In keeping with the scope of the *Quarantine Act 1908*, only the factors relevant to the evaluation of quarantine risk (ie the risk associated with the entry, establishment and spread of unwanted pests and diseases) are considered in the risk analyses.

6.1.1 IMPORT RISK ANALYSIS ON LIVE ORNAMENTAL FINFISH

The risk analysis on live ornamental finfish concluded that the importation of live ornamental finfish on Schedule 6 should be permitted, subject to risk management measures to mitigate the probability of entry and establishment in Australia of diseases of quarantine concern. Diseases of quarantine concern, those identified as requiring specific risk management, include goldfish haematopoietic necrosis virus, iridoviruses of freshwater ornamental finfish, spring viraemia of carp virus, *Aeromonas salmonicida* ('typical' strains and exotic 'atypical' strains), *Dactylogyrus vastator* and *D. extensus, Argulus foliaceus* and *A. coregoni,* and *Lernaea elegans*.

Live animals generally present greater risk than product and there are significant gaps in knowledge of the diseases of ornamental finfish species. Accordingly, AQIS will apply baseline risk management measures to all ornamental finfish imported. The measures for goldfish recognise the higher risks presented by that species.

As warranted by the conclusions of the risk analysis, each consignment of ornamental finfish must be accompanied by:

- an animal health certificate from the competent authority attesting to the health of the fish in the consignment and the health status of the souce population;
- certification from a competent authority that the premises of export/exporter are currently approved for export to Australia; and
- certification from a competent authority attesting that the fish had not been kept in water in common with farmed food fish;

and each consignment must be subject to:

- visual inspection of all fish on arrival to identify overtly diseased consignments and to ensure that the fish are of a species listed on Schedule 6;
- post-arrival quarantine detention for a minimum period in approved private facilities under quality assurance arrangements agreed with AQIS (the minimum period of quarantine will be three weeks for goldfish and one week for all other Schedule 6 listed finfish); and
- quarantine security over procedures in quarantine premises, including the disposal of sick and dead fish, transport water, packaging materials and other waste.

In addition to these baseline requirements, AQIS will apply the following risk management measures either singly or in combination, to address specific disease concerns associated with the importation of ornamental finfish:

- health certification from the competent authority that the source of the fish was free of specified disease agents;
- treatment either of the source population of the fish or of the fish for export, to address the likelihood that unwanted disease agents may be present;
- testing of imported fish during quarantine detention, either on an ad hoc or routine basis, to validate the certification provided by overseas competent authorities, and/or to provide additional data to improve the targeting of risk management measures on imports generally;

- treatment of imported fish during quarantine detention by appropriate means if the presence of specific disease agents is suspected or confirmed following diagnostic testing; and
- post-arrival quarantine detention greater than the minimum required (eg due to concerns over the risks posed by iridoviruses, the minimum quarantine period for gouramis and cichlids will be two weeks).

Equivalent approaches to managing identified risk may be accepted generally or on a case-by-case basis. Parties seeking to use alternative risk reduction measures to those listed in the new conditions — for example, an extended period of quarantine detention or a specified testing regimen — should provide a submission for consideration by AQIS. Such proposals should include supporting scientific data that clearly explain the degree to which alternative measures would reduce risk.

The implementation of these conditions will provide for the continued importation of ornamental finfish. The new importation conditions are more restrictive than the current conditions in that health certification is required for each consignment and post-arrival quarantine will be applied to all imports of live ornamental finfish.

Under previous conditions for the importation of live ornamental freshwater finfish listed on Schedule 6, AQIS required that:

- the pre-export premises for freshwater finfish were approved by AQIS;
- each consignment of freshwater fish was accompanied by an exporter's certificate attesting to the health of the fish in the consignment and that, for goldfish, the farms of origin were free from goldfish ulcer disease;
- each consignment of goldfish was accompanied by a health certificate from the appropriate government authority that the goldfish had been examined and showed no clinical evidence of disease, and that they originated either from a country free from spring viraemia of carp or from premises at which there had been no evidence of spring viraemia of carp for the three months before export; and
- the freshwater fish were held in post-arrival quarantine of two weeks (four weeks for gouramis) in approved premises, during which time they could be subjected to tests and treatment required by AQIS.

The established trade in live ornamental finfish will be permitted to continue under transitional arrangements until the new conditions are fully implemented.

6.1.2 IMPORT RISK ANALYSIS ON NON-VIABLE SALMONIDS AND NON-SALMONID FINFISH

The IRA for non-viable salmonids and non-salmonid finfish concluded that the importation of non-viable finfish should be permitted, subject to risk management measures to reduce the probability of entry and establishment of specified diseases to an acceptably low level. The diseases of concern are those identified in the risk analysis as requiring risk management to meet Australia's appropriate level of protection (ALOP). For eviscerated, commercially-harvested, market-size salmonids,[1] the disease agents that require specific risk management are:

- infectious haematopoietic necrosis virus (IHNV);
- infectious salmon anaemia virus (ISAV) (for Atlantic salmon);
- *Aeromonas salmonicida* (not for wild, ocean-caught Pacific salmon);
- *Renibacterium salmoninarum*; and
- *Myxobolus cerebralis* (for rainbow trout).

As these diseases are either not reported in New Zealand or (for *M. cerebralis*) occur at extremely low prevalence in New Zealand Pacific salmon, these measures would not apply to imports of Pacific salmon from New Zealand.

1 AQIS will not generally permit the importation of juvenile salmonids and sexually mature adult salmonids (spawners) as this would present an unacceptably high quarantine risk for certain disease agents.

For whole, round, commercially-harvested, market-size non-salmonid finfish, the disease agents that require specific risk management are:

- aquatic birnaviruses (aquabirnaviruses);
- infectious pancreatic necrosis virus (IPNV);
- viral haemorrhagic septicaemia virus (VHSV);
- red sea bream iridovirus;
- *Aeromonas salmonicida*; and
- *Photobacterium damsela piscicida*.

For *A. salmonicida*, risk management applies to all farmed (but not to wild-caught) non-salmonid marine finfish species. For all other disease agents, risk management applies only to the susceptible species specified in Chapter 7 of the IRA on non-viable salmonids and non-salmonid finfish (AQIS 1999).

Measures affecting the importation of non-viable salmonids and non-salmonid marine finfish into Australia

As this analysis considers the risks associated with the establishment of individual disease agents, the status of each exporting country (or source of fish if not exported from the country of origin) with respect to the diseases of concern will determine the risk management measures to be applied to fish exported from that country.

Exporting countries may provide an official statement of freedom from one or more of the disease(s) of concern, based on the results of a program of monitoring and surveillance of the health of farmed fish that is recognised by AQIS. A competent authority that is recognised by AQIS should provide this statement.

If the exporting country does not provide certification attesting to the freedom of source populations from the disease(s) of concern, countries may still export non-viable salmonids and non-salmonid marine finfish to Australia by complying with the following risk management measures, as appropriate to the health status of relevant fish populations in the exporting country. The implementation of these measures would mitigate the risk of establishment in Australia of diseases of quarantine concern and so maintain consistency with Australia's ALOP.

Measures for non-viable salmonids

The starting point of the risk analysis for salmonid products is the product that is traded internationally; ie eviscerated salmon. Non-viable salmonid fish may be imported subject to the following risk management measures:

- the fish must be derived from a population for which there is a documented system of health monitoring and surveillance administered by a competent authority;
- the fish must not be derived from a population slaughtered as an official disease control measure;
- for countries in which infectious salmon anaemia (ISA) occurs[2] Atlantic salmon must not come from a farm known or officially suspected of being affected by an outbreak of ISA;
- the fish must not be juveniles or sexually mature salmonids (spawners);
- the fish must be processed in premises approved by and under the control of a competent authority;
- the head and gills must be removed and internal and external surfaces thoroughly washed;
- the product must be free of visible lesions associated with infectious disease;
- the fish must be subjected to an inspection and grading system supervised by a competent authority; and
- consignments exported to Australia must be accompanied by official certification confirming that the exported fish fully meet Australia's import conditions.

2 As at July 1999, ISA has been reported from Scotland, Norway and Canada.

Product derived from non-viable salmonids meeting these conditions will be released from quarantine if imported in consumer-ready form.

In this risk analysis, the following products are considered to be ‘consumer-ready’:

- cutlets — including central bone and external skin but excluding fins— of less than 450g in weight;
- skinless fillets — excluding the belly flap and all bone except the pin bones of any weight;
- skin-on fillets — excluding the belly flap and all bone except the pin bones — of less than 450g in weight; and
- eviscerated, headless ‘pan-size’ fish of less than 450g in weight; and
- product that is processed further than the stage described above.

Imported head off, gilled and gutted salmonids or skin-on salmonid product of greater than 450g in weight (ie not consumer-ready) must be processed to consumer-ready form in premises approved by AQIS before release from quarantine.

These conditions cover the importation of uncooked salmonids from any country that meets Australia’s quarantine requirements. Previously, cooked (smoked or canned) salmonids or salmonid roe could be imported. The former conditions for smoked salmonids will be withdrawn, but imports under these conditions will be permitted until further notice. The conditions for salmonid roe (AQIS currently requires washing and pasteurisation of such products) will be maintained pending validation of the time/temperature of the thermal treatments currently required. The conditions for canned salmon remain unchanged.

Measures for non-viable non-salmonid marine finfish

For non-viable, non-salmonid marine finfish, the starting point of the risk analysis is the product that is traded internationally; ie whole, round (uneviscerated) fish. AQIS is introducing new restrictions that reflect quarantine risk associated with this commodity. Non-viable non-salmonid marine finfish may be imported subject to one of the following groups of risk management measures.

OPTION 1 (no import permit required):

- the fish must be processed in a premises approved by and under the control of a competent authority;
- the fish must be eviscerated;
- the fish must be individually sorted and packaged to facilitate inspection
- the fish must be subjected to an inspection system supervised by a competent authority;
- the head and gills must be removed and internal and external surfaces thoroughly washed;
- the product must be free from visible lesions associated with infectious disease; and
- consignments exported to Australia must be accompanied by official certification confirming that the exported fish meet Australia’s import conditions in full.

OPTION 2 (no import permit required):

- AQIS will not require an official health certificate for consumer-ready product that has been processed further than the stage described above.
  (For the purpose of these policies, consumer ready-product is product that is ready for the householder to cook/consume; as for salmonids, above.)

OPTION 3 (import permit required):

- if neither option 1 nor option 2 applies, an importer must obtain a permit from AQIS before importing fish;
- the application for the permit should provide details of the finfish species to be imported (scientific and common names), the waters in which the fish were farmed (if applicable) and harvested and the intended end use of the imported fish; and
- AQIS will assess the application in light of the quarantine risks it presents; if the delegate concludes that the proposed importation is consistent with Australia’s ALOP, a permit for the importation of single or multiple consignments during a specified timeframe would ordinarily be granted.

The importation of non-salmonid marine finfish products will be permitted to continue in the interim under the existing conditions, pending the completion of administrative arrangements to provide for implementation of the new policies. As the opportunity arises, AQIS may conduct technical consultations with exporting countries to confirm compliance with the new policies.

This risk management regime is generally more restrictive than that applied previously (historically, the importation of non-salmonid marine finfish into Australia was not the subject of specific quarantine measures). Under previous conditions the importation of non-salmonid freshwater finfish was not the subject of specific quarantine measures; however, this is under review and will be the subject of a specific IRA (as foreshadowed in Animal Quarantine Policy Memorandum 1998/23).[3]

Measures for non-viable non-salmonid marine finfish from New Zealand

AQIS will not require an import permit for non-viable marine finfish caught in or adjacent to New Zealand's Exclusive Economic Zone (EEZ) by fishers approved/registered under controls administered by a government authority of New Zealand. However, consignments of such fish would have to be accompanied by official certification stating that:

- the fish or fish from which the product was derived were caught in New Zealand's EEZ or in adjacent international waters; and
- the consignment is product of New Zealand.

6.2 Addressing the findings of the WTO report

As stated in Chapter 1, the WTO found in November 1998 that Australia had not complied with its obligations under the WTO Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement) with regard to the measures applying to salmon. In short, the key findings were:

1. Australia's IRA on uncooked wild-caught Pacific salmon from Canada did not fulfil all the requirements of the SPS Agreement in relation to a risk analysis, and there was no risk analysis to support the restrictions on the importation of other uncooked salmon products; and
2. there were arbitrary or unjustifiable distinctions in the level of protection applied by Australia in relation to salmon and other fish, and these distinctions resulted in a disguised restriction on international trade.

AQIS conducted accelerated risk analyses on non-viable salmonids and non-viable non-salmonid marine finfish and on live, ornamental finfish to address the WTO findings. The reports of the risk analyses together address the WTO findings.

6.2.1 WTO FINDING OF INADEQUATE RISK ANALYSIS

AQIS has ensured that the measures to be applied to the importation into Australia of non-viable salmonids, non-viable non-salmonid marine finfish and live ornamental finfish are based on risk analyses that are consistent with the provisions of the *Quarantine Act 1908* and meet international obligations by adopting the following approach:

- the risk analyses contain a scientific evaluation of disease risks associated with the probability and consequences of establishment of individual pathogens;
- the scientific validity of the risk analyses was strengthened by making arrangements for

3 AQIS (Australian Quarantine and Inspection Service) (5 March 1998), Animal Quarantine Policy Memorandum 1998/23, Work program for aquatic animal quarantine policy review.

independent scientific experts to review draft papers and advise AQIS on the accuracy of scientific information and the rigour and balance of the analyses;

- the risk analyses were conducted in accordance with relevant international standards,[4] which were taken into account as appropriate throughout the analyses;
- for each pathogen, the unrestricted risk of establishment was compared with Australia's appropriate level of protection (ALOP). Where it was concluded that the unrestricted risk would be consistent with the ALOP, AQIS will permit importation and will not require disease-specific risk management measures against that pathogen;
- for each pathogen, where AQIS concluded that the unrestricted risk would not meet the ALOP, AQIS considered the effect of applying disease-specific risk management measures. Where AQIS judged that the implementation of disease-specific measures against that pathogen would have the effect of reducing risk to meet the ALOP, AQIS will permit importation subject to appropriate disease-specific measures;
- for each pathogen, the trade-restrictive effects of available measures were considered, and (where options are available) the least trade-restrictive option available was adopted;
- AQIS has taken into account the presence or absence of pathogens in countries in determining the measures to be applied for individual pathogens, including, as appropriate, the existence of populations that have a low prevalence of disease. AQIS has also undertaken to consider submissions from exporting countries regarding the absence of specified diseases from populations that are the subject of monitoring and surveillance of fish health;
- the analyses are broad in scope to cover quarantine issues relevant to the entire range of measures applied to the importation of aquatic species that carry the diseases of concern; and
- AQIS has undertaken to apply the principles of equivalence and national treatment in considering the systems countries use to provide guarantees on fish health or other measures.

6.2.2 WTO FINDING OF INCONSISTENCY

The level of protection applied to the importation of aquatic animals (finfish) and their products will be made consistent through the implementation of the conclusions of the two risk analyses, thus addressing the second WTO finding, regarding inconsistency.

AQIS has ensured consistency in the level of protection applied to non-viable salmonids, non-viable non-salmonid finfish and live ornamental finfish by adopting the following approach to the risk analyses.

- The risk analyses are based on a scientific evaluation of quarantine risk arising from the probability and consequences of establishment of individual pathogens.
- In examining the consequences of establishment, AQIS assumed that the consequences would be similar regardless of the pathway of pathogen entry and establishment. Measures were thus applied to bring the probability of establishment of pathogens into consistency by applying measures as appropriate to the different commodities.
- AQIS compared the effect of measures that could be used to mitigate the probability of establishment of each pathogen via the different imported commodities, with the objective of ensuring that, for all disease agents, importation would only be permitted if the measures applied to imported goods would have the effect of reducing risk to meet Australia's ALOP.
- For each disease agent, trade-restrictive effects of available measures were considered, and (where appropriate) the least trade-restrictive option available was adopted.

4 The international standards used were Section 1.4 of the OIE *International Animal Health Code* (1999 edition, in press), as adopted by the International Committee of the OIE in May 1999; the OIE *International Aquatic Animal Health Code* (1997a)and the OIE *Diagnostic Manual for Aquatic Animal Diseases* (1997b).

A key consideration in the risk analyses was the comparison of probability of establishment (before and after the application of risk management) via the different pathways presented by the importation of live finfish in contrast to the importation of non-viable finfish. The pathways and, therefore, the risk management options are quite different for these two groups of commodities; thus, the comparison of the effect of risk management presents some complexities.

As stated in Chapter 1, Section 1.7, the importation of live fish and viable products (eg eyed ova) presents, in general, greater quarantine risk than the importation of non-viable finfish and their products. This relates to the propensity for infectious agents to persist and multiply in live fish, and the fact that live fish will be introduced into an aquatic environment (albeit in most cases a closed system, such as an aquarium), where they become part of the national animal population. In recognition of the greater quarantine risks associated with viable fish and genetic material, Australia does not permit the importation of live salmonids or their genetic material into Australia. In respect of live fish, only ornamental finfish on Schedule 6 of the *Wildlife Protection (Regulation of Exports and Imports) Act 1982* may be imported into Australia.

Non-viable products imported for human consumption would not generally be introduced into the aquatic environment, so the opportunity for transmission of infectious organisms would be greatly reduced. The commercial processing of imported fish in Australia could generate a significant volume of solid or liquid waste at the premises' point of discharge. For historical reasons, many fish processing plants are located near or on waterways. Large-scale discharge (deliberate or accidental) into the aquatic environment of untreated waste from imported fish would increase the risk of establishment of pathogens, if present in imported product.

Imported non-viable fish or products that are used for fishing bait, or for feeding to farmed fish, would enter the aquatic environment. For certain pathogens, the quarantine risks associated with this practice may be at least as high as those associated with the importation of live fish and gonadal products.

In reaching a consistent outcome to the risk analyses, AQIS has taken into account the differing probabilities of entry and establishment of pathogens via the pathways associated with the different commodities and the factors relevant to these pathways.

6.3 Next steps: implementation of the conclusions of the risk analyses

With effect from the publication of AQIS's findings, these conditions apply to countries that wish to export live ornamental finfish and aquatic products to Australia. The necessary arrangements are being set in place for formal recognition of:

- the competent authorities of exporting countries in relation to fish health and control of fish processing plants and live fish exporting premises; and
- the system for monitoring and surveillance of health of populations from which live ornamental finfish and aquatic products for export to Australia are sourced.

6.3.1 RECOGNITION OF THE COMPETENT AUTHORITY

In some countries (such as New Zealand) a single government agency may be responsible for all functions relating to animal health and import/export regulation; in others, responsibility may lie with different government agencies that may be at national or subnational level, or to a government authorised body.

For some countries there is an established history of exporting a range of terrestrial animals and fish and their products to Australia. In some cases, based on the established trade, AQIS has recognised the competence of authorities to approve and control fish export premises and provide health certification in respect of live fish exported to Australia. In some cases, AQIS has conducted a specific evaluation of veterinary services and has recognised the competence of veterinary authorities to provide export certification for products of terrestrial animals.

AQIS has not conducted a formal assessment of competent authorities for fish health in many countries. However, given the ornamental finfish associated risks identified in this import risk analysis (IRA), the established trade in live ornamental finfish will be permitted to continue under transitional arrangements until the new conditions are fully implemented.

For other countries that do not have an established history of trade, AQIS may need to conduct a specific evaluation of the competent authority(ies) for fish health, the approval and control of fish export premises and the systems for monitoring and surveillance of fish health. Animal Quarantine Policy Memorandum 1999/41 provides guidelines for the approval of countries to export animals (including fish) and their products to Australia. The requirements set out in that memorandum are based on the provisions of the Office International des Epizooties (World Organisation for Animal Health, OIE) *International Aquatic Animal Health Code* (OIE 1997a, Chapter 1.4.3 Evaluation of competent authority).

6.3.2 SYSTEMS FOR MONITORING AND SURVEILLANCE OF FISH HEALTH

AQIS will base its assessment of systems for monitoring and surveillance of fish health on the provisions of the OIE *Diagnostic Manual for Aquatic Animal Diseases* (OIE 1997b, Chapter 1.1 General information), although the provisions relate to fish diseases listed by the OIE. Australia is free of many serious pathogens that are not listed by the OIE, and government policy is to maintain freedom from these pathogens. It is important to ensure that the system of monitoring and surveillance of the health of fish in exporting countries is sufficiently comprehensive to address the issues of concern in this risk analysis. Accordingly, in conducting its assessment, AQIS will also take into account relevant general provisions of the OIE *International Animal Health Code* (1998) contained in Chapter 1.4.5, Surveillance and monitoring of animal health.

In considering 'minimum requirements' for disease surveillance by exporting countries, Australia has an obligation to consider the principles of equivalence and national treatment in the SPS Agreement. It would be inconsistent with our international obligations if Australia were to require countries to conduct significantly more intensive surveillance to demonstrate the absence of specified diseases than that deemed sufficient to support Australia's claims to freedom from the same diseases (all other technical issues being equal).

6.4 Summary

The risk analyses have been conducted according to an accelerated timetable necessitated by the WTO decision on implementation of the WTO findings on salmon. AQIS has completed these analyses within three months from 23 April 1999, when the Australian Government announced that the risk analyses would be accelerated.

The findings of the risk analyses are based on a comprehensive analysis of relevant scientific literature and discussions with experts in fish health and quarantine in Australia and overseas. AQIS took several steps to ensure the scientific validity of the risk analyses, including considering the reports of consultancies (most of which were commissioned in 1998) on identified gaps in the information relating to these risk analyses. AQIS also made arrangements for 14 independent scientists (in Australia or overseas) to review one or both of the draft reports as they were being prepared. AQIS asked the independent reviewers to advise on:

- the completeness and accuracy of scientific information in the IRA reports;
- the balance and objectivity with which scientific information was treated;
- the extent to which the exercising of professional judgment in the report was supported by and consistent with relevant scientific information; and
- the consistency of professional judgments on scientific issues that were common to each risk analysis report (where appropriate).

AQIS did not ask the independent reviewers to advise on factors pertaining to the 'correctness' of the decision (that may include, for example, opinions or judgments about Australia's ALOP). These matters are the responsibility of the Australian Government, having regard to the broad range of quarantine decisions and precedents within AQIS's purview.

To ensure that the process fulfilled the Australian Government's commitment to an open and consultative approach to IRA, AQIS held public meetings in five capital cities and two meetings of key stakeholders in Canberra. AQIS also made each chapter of the draft reports available to the public for comment; however, the public had only a very short time to review the later chapters of the draft report due to the decision to complete the risk analyses by 6 July 1999.

In the course of the risk analyses, AQIS received 35 submissions on scientific issues (a list of scientific submissions on the risk analysis on live ornamental finfish is in Appendix 3). AQIS considered all scientific issues raised in the submissions of respondents and sought the advice of the independent scientific reviewers on significant points in the submissions. For each risk analysis, AQIS reviewed each part of the report in the light of stakeholder submissions.

The scientific information reviewed in these reports is comprehensive and up to date, and the independent scientific reviewers have agreed that the scientific analysis is accurate, objective and balanced. On this basis, the conclusions in the risk analyses will be incorporated (where appropriate) into legal instruments and procedures for the importation of non-viable salmonids and non-salmonid marine finfish and live ornamental finfish in accordance with the conditions set out in these reports.

Appendix 1
Fish species (Schedule 6)

Schedule 6 of the *Wildlife Protection (Regulation of Exports and Imports) Act 1982*, updated as at 1 January 1998.

Schedule 6, section 22

Live animals and live plants, the import of which is not prohibited by paragraph 22 (b) and in relation to which section 9 applies

PART I — LIVE SPECIMENS

A live fish of a genus, species or subspecies specified in Part II.

A live brine shrimp of the species *Artemia salina*.

A live plant, the introduction of which into Australia is in accordance with the *Quarantine Act 1908*.

PART II — FISH

Division 1 — Freshwater fish (Class Pisces)

GENUS, SPECIES OR SUBSPECIES	COMMON NAME
Abramites hypselonotus	headstander
Acanthophthalmus spp	loach, kuhlii
Aequidens maronii	keyhole
Aequidens pulcher	acara, blue
Anostomus spp	headstander
Aphyocharax spp	tetras, bloodfin
Aphyosemeion spp	killie fish
Apistogramma spp	cichlid, dwarf
Aplocheilus spp	panchax
Apteronotus albifrons	knife fish, black ghost
Apteronotus leptorhynchus	long nose brown ghost knife fish
Arnoldichthys spilopterus	Arnold's or redeye characin
Astronotus ocellatus	oscar
Astyanax fasciatus mexicanis	'jordani' (only albino form) fish, blind cave
Aulonocara nyassae	(length 5 cm and over) cichlid, African peacock
Aulonocara spp	cichlids, African

GENUS, SPECIES OR SUBSPECIES	COMMON NAME
Bagrichthys hypselopterus	(only males) catfish, black lancer
Balantiocheilus melanopterus	shark, silver
Barbodes everetti	barb, clown
Barbodes fasciatus	barb, striped
Barbodes hexazona	barb, tiger
Barbodes lateristriga	barb
Barbodes pentazona	barb, banded
Bedotia geayi	rainbow, Madagascar
Benthochromis tricoti	benthochromis tricoti
Betta spp	fighting fish
Boehlkea fredcochui	tetra, Chochui's blue
Botia macracantha	loach, clown
Brachydanio albolineatus	danio, pearl
Brachydanio frankei	danio, leopard
Brachydanio kerri	danio, kerr's
Brachydanio nigrofasciatus	danio, spotted
Brachydanio rerio	danio, zebra
Brachygobius spp	bumble bee fish
Brochis spp	catfish, armoured and catfish, blue
Brycinus longipinnis	tetra, African
Campylomormyrus cassaicus	double-nose elephant nose
Campylomormyrus rhynchophorus	double-nose elephant nose
Capoeta arulius	barb, longfin
Capoeta oligolepis	barb, checker
Capoeta partipentazona	barb, tiger
Capoeta semifasciolatus	barb, golden
Capoeta tetrazona	barb, tiger
Capoeta titteya	barb, cherry
Carassius auratus	goldfish

GENUS, SPECIES OR SUBSPECIES	COMMON NAME
Carnegiella spp	hatchet fish
Chalinochromis brichardi	(only bridled morph of 5cm & over) cichlid, Lake Tanganyika
Chalinochromis spp	cichlids, Lake Tanganyika
Chanda spp	perchlets
Chilodus punctatus	headstander, spotted
*Chilotilapia rhoadesii*** [1]	(length 5 cm and over) Rhoadesii
Cichlasoma nicaraguense	(length 5 cm and over) cichlid, Nicaraguan
Coelurichthys microlepis	tetra, croaking
Colisa chuna	gourami, honey dwarf
Colisa fasciata	gourami, giant dwarf
Colisa labiosa	gourami, thick-lipped
Colisa lalia	gourami, dwarf
Copeina arnoldi	tetra, splash and characin, jumping
Copeina guttata	red-spotted copeina
Corydoras spp	cat, armoured
Corynopoma riisei	(only males) characin, swordtail
Crenicara filamentosa	checkerboard lyretail
Crenicara maculata	(length 5 cm & over) cichlid, checkerboard
Cyathopharnx furcifer	thread fin furficer
Cyprichromis leptosoma	cyprichromis, yellowtail
Cyrtocara moorii	
Danio devario	danio, bengal
Danio malabaricus	danio, giant
Dermogenys pusillus	half beak
Dianema urostriata	catfish, stripe tailed
Epalzeorhynchus kallopterus	flying fox
Epalzeorhynchus siamensis	siamese flying fox
Epiplatys spp	killie fish

1 ** denotes added species

GENUS, SPECIES OR SUBSPECIES	COMMON NAME
Eretmodus cyanostictus	dwarf goby cichlid
Eretmodus maculatus	cichlid, Tanganyikan clown
Esomus malayensis	barb, flying
Farlowella acus	catfish, twig
Gasteropelecus spp	hatchet fish
*Gnathochromis permaxillaris***	
Gnathonemus macrolepidotus	elephant nose
Gnathonemus petersi	elephant nose
Gymnocorymbus ternetzi	tetra, black widow
Gyrinocheilus aymonieri	catfish, sucking-Asia
Hasemania nana	tetra, silver tip
Helostoma rudolfi	gourami, pink kissing
Helostoma temminckii	gourami, green kissing
Hemigrammus spp	tetra
Hemiodopsis sterni	hemiodopsis, striped
Hemigrammopetersius caudalis	yellow-tail congo tetra
Homaloptera orthogoniata	lizard fish (Indonesia)
Hyphessobrycon spp	tetra
Inpaichthys kerri	blue emperor tetra
Iodotropheys sprengerae	cichlid, African
Julidochromis spp	cichlid, dwarf
Kryptopterus bicirrhis	catfish, glass
Kryptopterus macrocephalus	catfish, poormans glass
Labeo bicolor	shark, redtail
Labeo erythrurus	shark, red fin
Labeo frenatus	shark, rainbow
Labeo variegatus	shark, variegated
Laetacara curviceps	curviceps
Laetacara dorsigerus	cichlid
Laubuca laubuca	Indian hatchet fish
Leiocassis siamensis	(only males) catfish, Siamese or bumble bee
Lepidarchus adonis	tetra, flagtail or adonis
Leporinus arcus	leporinus, lipstick
Leporinus fasciatus	leporinus, banded

GENUS, SPECIES OR SUBSPECIES	COMMON NAME
Leporinus maculatus	leporinus, spotted
Leporinus multifasciatus	leporinus, multi-banded
Loricaria filamentosa	catfish, whiptail
Macrognathus aculeatus	eel, spiny
Macropodus opercularis	(only males of length 6cm and over) paradise fish
Megalamphodus spp	tetras
Melanochromis auratus	auratus
Melanochromis simulans	auratus
Mesonauta festivus	(albino prohibited) festivum
Metynnis spp	(length 4cm and over) silver dollars
Moenkhausia spp	tetra
Monodactylus argenteus	angel, Malayan mono batfish
Monodactylus sebae	mono, African
Morulius chrysophekadion	shark, black
Myleus rubripinnis	(only males of length 8cm and over) red hook
Nannacara anomala	acara, golden dwarf
Nannacara aureocephalus	cichlid, golden head
Nannacara taenia	cichlid, dwarf lattice
Nannostomus spp	pencil fish
Nematobrycon spp	tetra, emperor
Neolamprologus brichardi	Burundi, Princess of
Neolamprologus cylindricus	cichlid, Tanganyikan
Neolamprologus leleupi	(only yellow morph of length 5cm and over) cichlid, lemon
Neolamprologus meeli	(length 5cm and over) cichlid, African
*Neolamprologus mustax***	(length 5cm and over) mustax, mask lamprologus
Neolamprologus ocellatus	(length 5cm and over) cichlid, African
Ophthalmotilapia spp	threadfin cichlid, blacknosed
Oryzias latipes	medaka, golden

GENUS, SPECIES OR SUBSPECIES	COMMON NAME
Osteochilus hasselti	barb, bony lipped
Osteochilus vittatus	barb, bony lipped
Otocinclus arnoldi	catfish, sucker
Oxygaster oxygastroides	barb, glass
Pantodon buchholzi	butterfly fish
Papiliochromis altispinosa	cichlid, Bolivian butterfly
Papiliochromis ramirezzii	ram
Paracheirodon axelrodi	tetra, cardinal
Paracheirodon innesi	tetra, neon
Paracyprichromis nigripinnis	blue neon cyprichromis
Parauchenipterus fisheri	(only males of length 7cm and over) woodcat
Parosphromenus deissneri	(only males of length 4cm and over) licorice gourami
Pelvicachromis pulcher	kribensis
Pelvicachromis subocellatus	kribensis
Pelvicachromis taeniatus	kribensis
Petitella georgiae	false rummy nose
Petrochromis trewavasae	(length 5cm and over) white-spotted peerrochromis, threadfin chichlid**
Phenacogrammus interruptus	tetra, congo
Pimelodella pictus	cat, pictus
Pimelodus ornatus	cat, pictus
Poecilia latipinna	mollie, sailfin
Poecilia reticulata	guppy
Poecilia sphenops	mollie, black
Poecilia velifera	mollie, yucatan sailfin
Poecilocharax weitzmani	(only males) shining tetra
Prionobrama filigera	bloodfin, glass
Pristella maxillaris	pristella
Pseudogastromyzon myersi	sucker, dwarf stone
Pterophyllum spp	angel fish
Puntius asoka	barb, asoka
Puntius bimaculatus	barb, two spot
Puntius conchonius	barb, rosy

GENUS, SPECIES OR SUBSPECIES	COMMON NAME
Puntius cumingi	barb, cummings
Puntius filamentosus	barb, black spot
Puntius lineatus	barb, striped
Puntius nigrofasciatus	barb, ruby
Puntius ticto	barb, ticto
Puntius vittatus	barb, kooli
Rasbora argyrotaenia	rasbora, silver
Rasbora borapetensis	rasbora, red tail
Rasbora caudimaculata	rasbora, red tail
Rasbora dorsiocellata	rasbora, emerald eye
Rasbora dusonensis	rasbora, yellow tail
Rasbora einthoveni	rasbora, blue line
Rasbora elegans	rasbora, two spot
Rasbora hengelii	rasbora, harlequin
Rasbora heteromorpha	rasbora, harlequin
Rasbora kalochroma	rasbora, clown
Rasbora leptosoma	rasbora, copper striped
Rasbora maculata	rasbora, dwarf spotted
Rasbora pauciperforata	rasbora, red line
Rasbora sarawakensis	rasbora, Sarawak
Rasbora steineri	rasbora, gold line
Rasbora taeniata	rasbora, blue line
Rasbora trilineata	scissortail, black
Rasbora vaterifloris	rasbora, flame
Rhodeus amarus	bitterling
Rhodeus sericeus	bitterling
Semaprochilodus insignis	prochilodus
Semaprochilodus taeniurus	prochilodus, flagtail
Spathodus erythrodon	cichlid, blue spotted goby
Sphaerichthys osphronemoides	gourami, chocolate
Sturiosoma panamense	(only females of length 8cm and over) catfish, armoured
Symphysodon spp	discus
Synodontis decorus	(only males of length 10cm and over) catfish

GENUS, SPECIES OR SUBSPECIES	COMMON NAME
Synodontis multipunctatus	catfish, African
Synodontis nigriventris	cat, upside-down
Tanganicodus irsacae	goby cichlid
Tanichthys albonubes	white cloud
Telmatherina ladigesi	rainbow, celebes
Thayeria spp	tetra, hockeystick
Thoracocharax spp	hatchet fish
Toxotes jaculator	archer fish
Trichogaster leeri	gourami, pearl
Trichogaster microlepis	gourami, moonbeam
Trichogaster trichopterus	gourami, golden; gourami, opaline; gourami, blue
Trichopsis pumilus	gourami
Trichopsis vittatus	gourami
Trinectes maculatus	flounder, freshwater
Triportheus spp	fish false hatchet
Tropheus spp	cichlids, African
Xiphophous helleri	swordtail
Xiphophorus maculatus	platy
Xiphophorus variatus	platy, variegated

Division 2 — Marine fish (Class Pisces)

FAMILY	GENUS, SPECIES OR SUBSPECIES	COMMON NAME
Acanthuridae	All species of the family Acanthuridae	Surgeonfish
Anomalopidae	All species of the family Anomalopidae	Flashlight fish
Apogonidae	All species of the family Apogonidae	Cardinal fish
Balistidae	All species of the family Balistidae	Triggerfish
Blennidae	(species listed below) *Cirripectes stigmaticus* *Ecsenius axelrodi* *Ecsenius bicolor* *Ecsenius graveri* *Ecsenius melarchus* *Ecsenius midas* *Ecsenius pulcher* *Lipophrys nigriceps* *Meiacanthus astrodorsalis* *Meiacanthus grammistes* *Meiacanthus ovalauensis*	Blennies
Brotulidae	All species of the family Brotulidae	Eel-pouts
Bythitidae	All species of the family Bythitidae	Cusk eels
Callionymidae	All species of the family Callionymidae	Dragonets
Carangidae	*Alectis* spp	Trevally
Carapidae	All species of the family Carapidae	Pearlfish
Centriscidae	All species of the family Centriscidae	Razor fish
Chaetodontidae	All species of the family Chaetodontidae	Butterfly fish
Cirrhitidae	All species of the family Cirrhitidae	Hawk fish
Dasyatidae	*Taeniura lymma*	Stingrays
Ephippididae	All species of the family Ephippididae	Batfish
Gobiidae	(species listed below) *Gobiodon* spp *Lythrypnus* spp *Nemateleotris* spp *Ptereleotris* spp *Signigobius* spp *Valenciennea strigata*	Gobies
Grammidae	All species of the family Grammidae	Grammas
Heterodontidae	*Heterodontidae zebra*	Bullhead sharks
Holocentridae	All species of the family Holocentridae	Squirrel fish
Labridae	All species of the family Labridae	Wrasses
Lobotidae	*Lobotes* spp	Jumping cod
Lutjanidae	(species listed below) *Macolor* spp *Symphorichthys* spp	Sea perches

FAMILY	GENUS, SPECIES OR SUBSPECIES	COMMON NAME
Malacanthidae	All species of the family Malacanthidae	Blanquillos
Monocentrididae	All species of the family Monocentrididae	Pineapple fish
Mugiloididae	All species of the family Mugiloididae	Weevers
Mullidae	All species of the family Mullidae	Goatfish
Muraenidae	All species of the family Muraenidae	Moray eels
Ostraciidae	All species of the family Ostraciidae	Box fish
Pegasidae	All species of the family Pegasidae	Seamoths
Pempherididae	All species of the family Pempherididae	Sweepers
Pholidichthyidae	All species of the family Pholidichthyidae	Convict blennies
Plesiopidae	All species of the family Plesiopidae	Longfins
Plotosidae	*Plotosus lineatus*	Eel-tailed catfish
Pomacanthidae	All species of the family Pomacanthidae	Angel fish
Pomacentridae	All species of the family Pomacentridae	Damsel fish
Priacanthidae	All species of the family Priacanthidae	Bullseyes
Pseudochromidae	All species of the family Pseudochromidae	Dottybacks
Scaridae	All species of the family Scaridae	Parrotfish
Scolopsidae	*Scolopsis bilineatus* *Scolopsis (Nemipterus) bleekeri*	Spine-cheeks Spine-cheeks
Scorpaenidae	*Brachirus* spp *Dendrochirus* spp *Pterois* spp *Rhinopias* spp	Scorpion fish
Serranidae	(species listed below) *Anthias* spp *Cromileptes* spp	Rock cods
Siganidae	*Siganus (Lo)* spp	Rabbit fish
Syngnathidae	All species of the family Syngnathidae	Pipe fish
Tetraodontidae	*Canthigaster* spp	Puffer fish
Zanclidae	All species of the family Zanclidae	Tangs

Appendix 2
Vulnerable and endangered finfish species

The finfish species listed by Environment Australia as vulnerable and/or endangered under the *Endangered Species Protection Act 1992*.

SPECIES	COMMON NAME	FAMILY	ORDER	TYPE
Brachionichthys hirsutus	Spotted-hand fish	Brachionichthyidae (anglerfishes)	Lophiiformes (anglerfishes)	Endangered
Chlamydogobius micropterus	Elizabeth Springs goby	Gobiidae (perch-likes)	Perciformes (perch-likes)	Endangered
Galaxias fontanus	Swan galaxias	Galaxiidae (salmons, pikes and smelts)	Salmoniformes (salmons, pikes and smelts)	Endangered
Galaxias fuscus	Barred galaxias			Endangered
Galaxias johnstoni	Clarence galaxias			Endangered
Galaxias pedderensis	Pedder galaxias			Endangered
Maccullochella ikei	Clarence River cod	Percichthyidae (perch-likes)	Perciformes (perch-likes)	Endangered
Maccullochella macquariensis	Trout cod			Endangered
Maccullochella peeli mariensis	Mary River cod			Endangered
Melanotaenia eachamensis	Lake Eacham rainbow fish	Melanotaeniidae (silversides)	Atheriniformes (silversides)	Endangered
Scaturiginichthys vermeilipinnis	Red-finned blue-eye	Pseudomugilidae (silversides)	Atheriniformes (silversides)	Endangered
Carcharodon carcharias	Great white shark	Lamnidae (mackerel sharks)	Lamniformes (mackerel sharks)	Vulnerable
Carcharias taurus	Grey nurse shark	Odontaspididae (mackerel sharks)	Lamniformes (mackerel sharks)	Vulnerable
Craterocephalus fluviatilis	Murray hardyhead	Atherinidae (silversides)	Atheriniformes (silversides)	Vulnerable
Galaxias tanycephalus	Saddled galaxias			Vulnerable
Galaxiella pusilla	Dwarf galaxias	Galaxiidae (salmons, pikes and smelts)	Salmoniformes (salmons, pikes and smelts)	Vulnerable
Nannoperca obscura	Yarra pygmy perch	Percichthyidae (perch-likes)	Perciformes (perch-likes)	Vulnerable
Nannoperca oxleyana	Oxleyan pygmy perch			Vulnerable
Nannoperca variegata	Ewens pygmy perch			Vulnerable
Prototroctes maraena	Australian grayling	Retropinnidae (salmons, pikes and smelts)	Salmoniformes (salmons, pikes and smelts)	Vulnerable
Pseudomugil mellis	Honey blue-eye	Pseudomugilidae (silversides)	Atheriniformes (silversides)	Vulnerable

Appendix 3
Scientific submissions received by AQIS

Veterinary Pathology Services	15 March 1999
Riverside Aquarium and Cichlid Centre	12 April 1999
Australian Institute of Veterinary and Animal Sciences	12 April 1999
AQIL Consultancy	23 April 1999
Riverside Aquarium and Cichlid Centre	27 April 1999
Tasmanian Department of Primary Industries, Water and Environment	3 May 1999
Victorian Department of Natural Resources and Environment	10 May 1999
Len Ashburner	9 May 1999
Pet Industry Joint Advisory Council	10 May 1999
CSIRO Division of Marine Research	12 May 1999
CSIRO Australian Animal Health Laboratory	21 May 1999

Abbreviations and acronyms

ABARE	Australian Bureau of Agricultural and Resource Economics
ADVS	Aquaculture Development and Veterinary Services
AFFA	Agriculture, Fisheries and Forestry — Australia
AFMA	Australian Fisheries Management Authority
ALOP	appropriate level of protection
AQIS	Australian Quarantine and Inspection Service
AQUAPLAN	Aquatic Animal Health Plan
BIV	Bohle iridovirus
BKD	bacterial kidney disease
BOD	biological oxygen demand
BRS	Bureau of Resource Sciences later termed the Bureau of Rural Sciences
CE	carp erythrodermatitis
CFU	colony forming units
CRC	Cooperative Research Centre
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DPIE	Department of Primary Industries and Energy
DPIF	Department of Primary Industries and Fisheries
EA	Environment Australia
ELISA	enzyme-linked immunosorbent assay
EM	electron microscopy
ENV	erythrocytic necrosis virus
ERM	enteric redmouth
EU	European Union
FAO	Food and Agriculture Organization
FAT	fluorescent antibody test
GATT	General Agreement on Tariffs and Trade
GFHNV	goldfish haematopoietic necrosis virus
GUD	goldfish ulcer disease
HVHN	herpes viral haematopoietic necrosis
ID	infectious dose
IDC	infectious dropsy of carp
IFAT	indirect fluorescent antibody test

IHN	infectious haematopoietic necrosis
IHNV	infectious haematopoietic necrosis virus
IPN	infectious pancreatic necrosis
IPNV	infectious pancreatic necrosis virus
IRA	import risk analysis
NTF	National Task Force on Imported Fish and Fish Products
OIE	Office International des Epizooties (World Organisation for Animal Health)
PCR	polymerase chain reaction
PFR	pike fry rhabdovirus
PFU	plaque forming units
PIJAC	Pet Industry Joint Advisory Council
PKD	proliferative kidney disease
PKX	proliferative kidney disease agent
QA	quality assurance
QP	quarantine proclamations
Quarantine Act	*Quarantine Act 1908*
RSIV	red sea bream iridovirus
RVC	*Rhabdovirus carpio*
SBI	swimbladder inflammation
SD	standard deviation
SPS Agreement	WTO Agreement on the Application of Sanitary and Phytosanitary Measures
SVC	springviraemia of carp
SVCV	springviraemia of carp virus
TABV	Tasmanian aquatic birnavirus
VBNC	viable but non-culturable
VEN	viral erythrocytic necrosis
VER	viral encephalopathy and retinopathy
VERV	viral encephalopathy and retinopathy virus
VHS	viral haemorrhagic septicaemia
VHSV	viral haemorrhagic septicaemia virus
WTO	World Trade Organization

Glossary of terms

Aetiology	The cause of a disease or the study of such causes.
Appropriate level of protection (ALOP)	Annex A of the SPS Agreement states that the appropriate level of protection is the level of protection deemed appropriate by the Member establishing a sanitary or phytosanitary measure to protect human, animal or plant life or health within its territory. Note: many Members refer to this concept as the 'acceptable level of risk'.
Aquaculture	The growing of aquatic animals and plants in water.
Aquatic Code	The OIE International Aquatic Animal Health Code, 1997.
Biodiversity	A measure of the variety of the Earth's animal, plant and microbial species; of genetic differences within species and of the ecosystems that support those species.
Biofilm	A thin film of bacteria that forms on a surface and is difficult to remove.
Biological oxygen demand	The amount of organic pollution in the water, measured as the amount of oxygen taken up from a sample containing a known amount of oxygen kept at 20°C for five days. A low BOD indicates little pollution while a high BOD indicates increased activity of heterotrophic microorganisms and thus heavy pollution.
Brackishwater fish	Fish inhabiting water with a salinity of between 4 parts per thousand and 30 parts per thousand.
Carrier fish	An apparently healthy fish that is infected with a pathogenic agent and capable of transmitting the specific disease to another individual.
Chemotherapeutant	A substance or chemical used to treat an infection or disease by producing a toxic effect upon the target pathogen.
Clinical disease	Presence of infection with observable clinical signs in the affected host.
Clinical signs	Any evidence of disease observed by a clinician.
Commensal	An organism, usually the one that benefits, in a commensalism. Hence, commensal bacteria are those that live within another animal species without normally causing disease.
Commensalism	The association between two organisms of different species that live together and share nutrient resources, one species benefiting and the other being unharmed by the association.
Competent authority	The National Veterinary Services or other authority of a country having the responsibility and competence for aquatic animal health measures within the country and for export certification.

Consequence assessment	An assessment of the adverse consequences that would result from the establishment of a disease in a previously free country.
Disinfect	To use a chemical or physical process to cause the demise and removal of organisms that may cause infection and/or disease.
Endemic disease	A disease that is present within a defined region or country.
Epidemiology	The investigation of disease, other related events, and production in animal populations and the making of inferences from the investigation in an attempt to improve the health and productivity of the populations.
Epizootic	An occurrence of a disease in excess of its anticipated frequency.
Evisceration	Removal of the viscera (does not include brain and gills).
Exotic disease	A disease that is not present within a defined region or country.
Export certification	Official certification that accompanies goods in international trade.
Exposure assessment	An assessment of the probability of susceptible hosts being exposed to pathogens in a dose sufficient to cause infection.
Finfish	For the IRA on non-viable marine finfish (AQIS 1999), the term 'finfish' includes members of the Teleostomi (bony fishes). It does not include sharks, rays or invertebrates.
Fish product	Non-viable fish or parts of fish.
Foodfish	Fish species used for human consumption.
Freshwater fish	Fish inhabiting water with salinity less than 4 parts per thousand dissolved salts.
Hazard	In the context of this import risk analysis, a hazard is a biological agent that may have an adverse effect.
Hazard identification	In the context of this import risk analysis, hazard identification is the process of identifying the biological agents that could be carried by the commodity being considered in the risk analysis.
Health surveillance and monitoring system	Systematic process of investigating the health status of a given population.
Hobbyist	An unlicenced person who collects ornamental fish for the purposes of keeping for display, breeding, selling, swapping or trading.
Host	Species that the pathogen of interest can infect.
Idiopathic diseases	Diseases for which the aetiology has not been defined.
Import risk analysis	The process through which quarantine policy is developed or reviewed, incorporating risk assessment, risk management and risk communication.
Incidence	The number of new cases or outbreaks of a disease that occur in a population at risk in a particular geographical area within a defined period of time.
Index case	The first case of infection in a population previously free of the disease agent.

ID_{50}	The median infective dose of a pathogen (ie the dose at which 50% of the test units become infected).
Marine fish	Fish inhabiting the sea or marine waters (water with salinity of 30 parts per thousand dissolved salts).
Metazoan	Multicellular animals with cells organised into tissues and possessing nervous tissue.
Morbidity	The amount of disease in a population (commonly defined in terms of incidence or prevalence).
Mortality	A measure of the number of deaths in a population.
Native species	Species that originated in Australia (ie not introduced).
Non-salmonid marine finfish	In this import risk analysis, this includes finfish, except salmonids, that are caught or cultured in brackish or marine waters.
Non-viable	Dead; incapable of propagation.
Notifiable diseases (OIE)	The list of transmissible diseases that are considered to be of socioeconomic and/or public health importance within countries and that are significant in the international trade of aquatic animals and aquatic animal products. Diseases notifiable to the OIE were previously known as listed diseases.
Ornamental finfish	Finfish that are not typically used as a food source for humans or livestock, commonly kept as pets or displayed: can be of freshwater or marine origin.
Pathogen	An organism that causes disease.
Pathway	The route by which a disease agent entering Australia may take before it infects a susceptible individual of an animal population in Australia.
Prevalence	The total number of cases or outbreaks of disease that are present in a population at risk, in a particular geographical area, at one specified time.
Probability	The likelihood of an event occurring.
Propagule	The unit, or number of individuals, involved in an invasion event.
Propagule pressure	The effect on the probability of successful invasion of increasing or decreasing the size and the number of propagules.
Public aquarium	Facilities open to the general public displaying fish of marine, brackish, and fresh water aquatic animals.
Protozoan	Unicellular heterotrophic, generally non-photosynthetic, eukaryotes, lacking cell walls. Protozoans are often now classified with algae and other simple eukaryotes in a separate kingdom, Protista.
Quarantine detention	The isolation and observation of fish in a place of sanitary security. Quarantine measures Actions taken to manage the risk associated with diseases or pests associated with imported commodities such as ornamental finfish.

Quarantine risk	The combination of the likelihood the importation will lead to the introduction, establishment or spread of a disease or a pest in Australia, the likelihood that harm will result (to humans, animals, plants, the environment or economic activities) and the likely extent of any such harm.
Regionalisation	The recognition of a part of a country or countries having a different pest or disease status, due to epidemiological reasons or because of sanitary controls.
Release assessment	An assessment of the probability of viable pathogens being present in the
Risk assessment	The processes of identifying and estimating the risks associated with the importation of a commodity and evaluating the consequences of taking those risks (OIE International Animal Health Code).
Risk management	The identification, documentation and implementation of the measures that can be applied to reduce the risks and their consequences (OIE International Animal Health Code).
Sanitary (quarantine) measure	Measures such as those described in chapters on risk management of these import risk analyses, which are used to protect animal life or health from risks arising from pests and diseases.
Subclinical disease	Presence of infection without observable clinical signs in the affected host.
Salmonid fish (salmonids)	Species of finfish that belong to the families Salmonidae and Plecoglossidae.
SPS Agreement	The WTO Agreement on the Application of Sanitary and Phytosanitary Measures.
$TCID_{50}$	A measure of infectivity for viruses, ie the dose at which 50% of tissue cultures become infected and show degeneration.
Unrestricted risk estimate	An estimate of the risk associated with the importation of a commodity in the absence of quarantine measures.
Zoning	*see* Regionalisation.

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