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An assessment of the risk of exotic disease introduction and spread among Australian Barramundi farms from the importation of Barramundi products

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In submitting this report, the researcher has agreed to FRDC publishing this material in its edited form.

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Abbreviations

ABARES - Australian Bureau of Agricultural and Resource Economics and Sciences

ABFA - Australian Barramundi Farmers Association

ABS - Australian Bureau of Statistics

BICON – Australian Biosecurity Import Conditions

DAF QLD - Department of Agriculture and Fisheries Queensland

DAFWA - Department of Agriculture and Food Western Australia

DAWR - Department of Agriculture and Water Resources

DELWP - Department of Environment Land, Water and Planning Victoria

DPI NSW - Department of Primary Industries New South Wales

FAO - Food and Agriculture Organization of the United Nations

FSANZ - Food Standards Australia and New Zealand

FRDC - Fisheries Research and Development Corporation

HTISC - Harmonised Tariff Item Statistical Code

IFIS - Imported Food Inspection Scheme

IGAB - Intergovernmental Agreement on Biosecurity

ISKNV - Infectious spleen and kidney necrosis virus

NACA - Network of Aquaculture Centers in Asia-Pacific

OIE - World Organisation for Animal Health

PBD - Pot belly disease

PIRSA - Department of Primary Industry and Regions South Australia

RSIVD - Red sea bream iridoviral disease

SDS - Scale drop syndrome

Executive Summary

Background

The current research project has been conducted by a research team from the School of Animal and Veterinary Sciences at Charles Sturt University, with expertise in risk assessment and aquatic animal health and diseases. The research team was approached by the Australian Barramundi Farmers Association (ABFA) to conduct an assessment of the potential risk posed to the Australian Barramundi industry (aquaculture, wild catch and recreational, including indigenous) by the importation of Barramundi commodities from overseas. This project addresses the Aquatic Animal Health and Biosecurity Subprogram of the Fisheries Research and Development Corporation (FRDC) by enhancing the knowledge of potential risks to the industry that is an essential step for any risk management strategy in the future.

In 1999, an import risk analysis for salmonids and non-salmonids marine finfish was conducted by the Australian Government (Kahn S.A et al., 1999). However, this risk analysis did not specifically assess the potential risk of disease introduction and spread posed by the importation of Barramundi products. Some of the hazards included in this risk analysis and identified as requiring risk management strategies, such as Red sea bream iridoviral disease (RSIVD), affect Barramundi. Since then, there have been reports of emerging significant diseases in aquaculture species from around the world, such as Scale drop syndrome (SDS) and Pot belly disease (PBD) affecting Barramundi in South East Asian countries. This raised concerns from the industry on the potential risk of the introduction and spread of these significant diseases into Australia and justifies the need for an assessment of the risk posed by these hazards to the Australian Barramundi industry.

In 2014-2015, according to the Australian Bureau of Agriculture and Resource Economics and Sciences (ABARES), the production value of Australian farmed Barramundi was estimated at $37.1 million AUD with a production of 3,772 tonnes annually (Savage, 2015). The value of the wild-catch was estimated to be $9.9 million AUD with 1,073 tonnes produced (Savage, 2015). A total of 268 license holders for Barramundi farms were registered in 2014-2015, however, it must be noted that not all of these license holders are currently producing (Savage, 2015) or are producing small volumes. According to ABFA, the 10 ABFA members produce over 90% of the farmed barramundi produced in Australia. Their reported production based on farm data was 6,000 tonnes in 2016 (valued at $60 million AUD) with production scaled to reach over 10,000 tonnes by 2018 (valued at $100 million AUD) and with growth projected to reach 20,000 tonnes by 2025 (valued at $200 million AUD) (Executive Officer, ABFA 2017, pers. comm.). These sectors of the industry as well as recreational and Indigenous fishers, are all at risk of being exposed to hazards potentially introduced by imported Barramundi products, which could pose significant consequences.

Objectives

The overall aim of this project is to assess the potential risk of introduction and spread of exotic diseases affecting the Barramundi industry in Australia, including the aquaculture industry, wild catch and recreational fisheries, including indigenous, through the importation of Barramundi products from overseas.

Specifically this research project aims to:

- Identify biological hazards, described as pathogens causing infectious diseases that could enter Australia with imported Barramundi products.
- Identify pathways of pathogen entry into Australia (entry assessment) and estimate the likelihood of these pathways to occur.
- Identify pathways of the Barramundi industry in Australia being exposed with the pathogens released into the country with imported Barramundi products (exposure assessment) and estimate the likelihood of these pathways to occur.

- Describe the potential spread scenarios after the first Barramundi sector of the industry has been exposed with the pathogens of interest, estimate the likelihood of these scenarios to occur and describe direct and indirect impacts (consequence assessment).
- Estimate the risk of disease entry and spread and provide recommendations on risk mitigation strategies.
- Identify of gaps of information to accurately estimate the risks.

Methodology

This study followed the World Organization for Animal Health framework for import risk analysis (World Organization for Animal Health (OIE), 2009) and used a literature review and expert consultation process to gather information to inform the assessment of the risk posed by the importation of Barramundi products into Australia. The literature review focused on general information on Barramundi biology and production in Australia and worldwide, diseases affecting Barramundi, import and export markets and biosecurity import regulations. The consultation process was conducted with experts from Australia and South East Asia, with government, industry and private aquatic animal health consultants invited to participate. The consultation process was based on the completion of a semi-qualitative questionnaire and a follow-up interview. The aim of the expert consultation process was to inform the risk assessment, in relation to hazards, pathways and likelihoods. A qualitative assessment of the pathways and likelihood of introduction, exposure and spread of exotic diseases into the Barramundi industry in Australia from Barramundi products imported from overseas was then conducted, including a hazard identification, entry, exposure and consequence assessment and overall risk estimation.

Results

Four exotic disease agents were identified as hazards to be considered in this assessment, including:

1) Red sea bream iridoviral disease (RSIVD);

2) Infectious spleen and kidney necrosis virus (ISKNV);

3) Scale drop syndrome (SDS);

4) Pot belly disease (PBD).

In addition, exotic strains of *Vibrio* spp. and *Streptococcus* spp., pathogens that are present in Australia, were also identified as hazards.

Participating experts estimated a *Moderate* likelihood of entry for all disease agents considered hazards in this assessment. Following introduction, experts estimated a *Moderate* likelihood of exposure to wild catch and recreational/Indigenous Barramundi and a *Low* likelihood for farmed Barramundi. However, these estimates had a significant level of uncertainty, with the lack of accurate data on prevalence and the epidemiology of the disease being important factors contributing to this uncertainty. The highest risk of exposure was posed by processing and household waste being used as bait, with a lower risk posed by waste discarded at garbage tips and being carried by birds to aquatic environments. Establishment and spread of these disease agents was considered likely to occur, with the impact of the spread to the Barramundi industry being described as significant to extremely significant for the four exotic diseases. The impact posed by the exotic strains of *Vibrio* spp. and *Streptococcus* spp., although considered lower than the exotic diseases, was estimated to be significant. Experts only provided an overall estimate of the impact; however, all experts considered this impact to be very high. These impacts could include direct biological consequences for the affected fish (e.g. morbidity and mortality), subsequent economic consequences due to production loss and costs of disease control (e.g. vaccination for those diseases with an available vaccine), and a decrease of value of domestic and export markets. In addition, the impact of these diseases could also include potential environmental consequences for those diseases that are not host specific. Control measures, such as vaccination or depopulation, would be limited at farm-level, with eradication of the diseases at a country level being practically not possible if diseases are spread among

wild populations. The high vaccine and labour costs and logistics required for vaccination would compromise the success of any control strategy for these diseases.

When the likelihoods of entry, exposure and spread is combined with the potential impact posed by the diseases considered in this assessment, the overall risk of introduction and establishment of RSIVD, ISKNV, Scale drop syndrome and Pot belly disease with the importation of Barramundi products is estimated to be *Moderate*. This risk is considered to be *Low* and *Very Low* for *Streptococcus* spp. and *Vibrio s*pp., respectively. Despite the reported uncertainty around the estimates provided by experts, this assessment suggests that the risk posed by the importation of products for the Australian Barramundi industry is not negligible and further research to reduce this uncertainty and to be able to accurately estimate this risk, is warranted.

Activities conducted in this study identified significant gaps of information affecting the ability to accurately estimate the risk of disease introduction with the importation of Barramundi products. The lack of specific information on the country of origin and the volumes of imported Barramundi and on the epidemiology of some of the hazards included in this assessment are the main areas to be considered. Given the existent uncertainty and the lack of scientific information in relation to these diseases, the precautionary principle (Morton and Routledge, 2016) should be adopted when making decisions about importing Barramundi products, with a review of existing preventive biosecurity and disease control measures needed.

Recommendations

Recommendations arising from this research project are summarized as follow:

- For imported Barramundi products to have a specific international HTISC number. To accurately estimate the animal health risk posed by the importation of Barramundi products from overseas, specific information on country of origin and volumes of Barramundi imported is required.

- Further research on the aetiology and epidemiology of Scale drop syndrome and Pot belly disease in countries where these diseases are present, is required to better understand the risk these diseases pose to the Barramundi industry in Australia.

- For any further risk assessments to include seafood safety and zoonotic risk. Food safety and public health was outside the scope of this study, however, we consider this area to be a priority for Australia.

- Fish labelling systems to be reviewed to identify potential issues in relation to domestic and imported product differentiation. As an example, the use of forensic trace elements analysis as a regulatory tool could be used to ensure correct product labelling.

- Increase awareness of the risk of disease transmission posed by fish waste used as bait. Information on the potential risk of disease transmission posed by the use of waste of fish for human consumption as bait to be disseminated among commercial and recreational fishers.

- The current risk assessment for importing barramundi into Australia is generic, outdated and should be updated in line with potential emerging risks and changing international trade.

- Until a comprehensive risk assessment is conducted and required data is collected, the lack of scientific information and the uncertainties around the importation of Barramundi products justify the use of the precautionary principle in decision making and the need to take action to mitigate the risk in relation to products imported.

Keywords

Risk; Australia; *Lates calcarifer;* Barramundi; import; disease.

1. Introduction

There have been a number of studies in the past evaluating the importation of fish and seafood products from overseas. For example, in a FRDC funded project (2010/222) the composition, value and utilisation of imported seafood in Australian trade were investigated in order to enable informed discussions about specific volumes, values and the interaction between overseas and domestic produce; however, the risk of disease transmission was outside the scope of that study. In other projects, including project numbered 2009/072 and 2008/104 the risk of disease introduction associated with domestic translocation of bait and berley products within Australia and the risk associated with stocking Barramundi into Hazelwood Cooling Pondage in Churchill Victoria were assessed; however, in this case the risk posed by imported products from overseas was not included. In 1999, two projects were carried out by the Australian Quarantine and Inspection Services. One investigated pathways of exposure of aquatic animals to aquatic animal products intended for human consumption and the other one was an import risk analysis for salmonids and non-salmonid marine finfish. Since then, there have been several cases of emerging deadly diseases in aquaculture species from around the world, such as Scale drop syndrome, in South East Asian countries, which demands conducting an updated risk assessment study. Current importation policy is mainly based on the 1999 import risk analysis and the more limited international trade arrangements that were in place at the time, support the principle that an updated risk analysis is required.

The Australian Barramundi Farmers Association had concerns about the potential risk associated with the importation of Barramundi products, especially from South East Asia. The current study aimed to conduct an initial assessment of the potential risks posed by these imports. Results from this study will assist decision-makers to determine the areas for further research in this field and a review of current importation policies for sustainable Barramundi farming, the ecology and those commercial, recreational and Indigenous fishers who access the wild stocks in the country.

2. Objectives

The overall aim of this project is to assess the potential risk of introduction and spread of exotic diseases affecting the Barramundi industry in Australia, including the aquaculture industry, wild catch commercial, Indigenous and recreational fisheries and the ecosystem, through the importation of Barramundi products from overseas.

Specifically this research project aims to:

- Identify biological hazards, described as pathogens causing infectious diseases that could enter Australia with imported Barramundi products.
- Identify pathways of pathogen entry into Australia (entry assessment) and estimate the likelihood of these pathways to occur.
- Identify pathways of the Barramundi industry and ecosystem in Australia being exposed with the pathogens released into the country with imported Barramundi products (exposure assessment) and estimate the likelihood of these pathways to occur.
- Describe the potential spread scenarios after the first Barramundi sector of the industry has been exposed with the pathogens of interest, estimate the likelihood of these scenarios to occur and describe direct and indirect impacts (consequence assessment).
- Estimate the risk of disease entry and spread and provide recommendations on risk mitigation strategies.
- Identify gaps of information to accurately estimate the risks.

3. Method

3.1 Ethics

The study proposal was submitted to the Faculty of Science Ethics in Human Research Committee at Charles Sturt University and approved on the 19th July 2016 (protocol number 400/2016/22).

3.2 Literature review

The aim of the literature review was to gather information to support the assessment of the risk of disease introduction and spread among Australian Barramundi farms and the broader ecosystem from the importation of *Lates calcarifer* products. The literature review focused on general information on Barramundi biology and production in Australia and worldwide, diseases affecting Barramundi, import and export markets and biosecurity import regulations.

3.2.1 Search strategy

Research and publication portals and online information within Australian state and federal government websites (Department of Agriculture and Water Resources (DAWR); Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES), Department of Agriculture and Fisheries Queensland (DAFQLD), Northern Territory Government, NSW Department of Primary Industries (NSW DPI), Department of Primary Industry and Regions South Australia (PIRSA), Department of Agriculture and Food Western Australia, Department of Environment (DAFWA), Department of Land, Water and Planning Victoria (DELWP), Agriculture Victoria, Australian Bureau of Statistics (ABS), Food Standards Australia and New Zealand (FSANZ) were searched for published and grey literature.

International data was sourced from Food and Agriculture Organization of the United Nations (FAO), OIE World Organisation for Animal Health and Network of Aquaculture Centers in Asia-Pacific (NACA).

Literature was sourced from scientific publications using the following search terms anywhere in the title or abstract - Barramundi, *Lates calcarifer*, seabass, Asian seabass, disease, pathogens, farming, production, trade, risk. The Primo Search, Wiley Online Library and Science Direct databases and Google Scholar were searched. Bibliographies of retrieved articles were also searched for relevant literature.

In addition grey literature was sourced from relevant websites and through reports provided to the researchers.

3.3 Expert consultation process

A formal expert consultation process was conducted with experts from Australia and South East Asia. Representatives from Commonwealth and national government departments, the Barramundi industry, seafood importers, aquaculture departments within tertiary and government institutions and aquatic animal health private consultants were contacted. The aim of the expert consultation process was to inform the risk assessment, in relation to hazards, pathways and likelihoods.

Participating experts were asked to complete a semi-qualitative questionnaire that focussed on pathogens affecting Barramundi and the risk that they pose to the Australian Barramundi industry, followed by a 1h telephone interview. The objective of the follow up interview was to expand upon the information provided in the semi-qualitative questionnaire and to discuss any additional aspects relevant to the research aims.

3.3.1 Development of semi-qualitative questionnaire

A review of available literature was conducted to identify hazards that could be introduced with imported Barramundi products. The OIE list of fish diseases and the list of diseases considered in the 1999 Import Risk Analysis on non-viable salmonids and non-salmonid marine finfish (Kahn S.A et al., 1999) were initially used. To identify additional emerging diseases affecting Barramundi, a subsequent literature search (section 4.1) was conducted. Endemic pathogens were included to investigate the potential for more pathogenic /virulent overseas strains entering Australia. A list of exotic and endemic diseases/pathogens with potential for introduction and spread among Australian Barramundi, was then developed to be used in the expert semi-qualitative questionnaire.

Participants were asked to review the list in terms of completeness and accuracy of information, provide comment, and to indicate if the disease/pathogen should be included in an import risk assessment of Barramundi.

For those diseases/pathogens that the participant indicated should be included in an import risk assessment, a qualitative evaluation of the risk posed by each of these diseases/pathogens was to be completed in relation to:

a. likelihood of being introduced into Australia with imported Barramundi products,
b. likelihood of exposure of the Australian Barramundi industry: farm, wild catch and recreational,
c. likelihood of spread of the pathogen once introduced to the Barramundi sector- farm, wild catch and recreational,
d. impact of the spread of the pathogen.

Experts were provided with tables with descriptors for the qualitative estimates (Tables 1 and 2). Responses were entered onto a provided template (Appendix A).

Table 1 Qualitative estimates of likelihood

Likelihood	Probability range		
Negligible	0	to	0.000001
Extremely low	0.000001	to	0.001
Very low	0.001	to	0.05
Low	0.05	to	0.3
Moderate	0.3	to	0.7
High	0.7	to	1

Table 2 Qualitative estimate of impact

Impact	Description
Insignificant	when the impact is not causing a distinguishable variation or effect at the specific level
Minor significance	when the impact is identifiable but reversible at the specific level
Significant	when the impact is serious and affecting economic viability, but reversible at the specific level
Extremely significant	the impact is extremely serious, affects the economic viability and is irreversible at a specific level

3.3.2 Development of follow up interview

Following completion and return of the semi-qualitative questionnaire, a suitable time was arranged with each participant to conduct the follow up telephone interview. A set of semi-structured questions (Appendix B) was used with responses recorded on an electronic recording device. Responses were then transcribed.

The structure of the follow up interview expanded upon the semi-qualitative questionnaire, focussing on the reasoning behind the expert's responses and any gaps in information. Factors influencing the introduction, exposure and spread of pathogens; such as the age of fish affected, the survival of the pathogen in products, the relative risk of introduction among products, host specificity and potential pathways of exposure were discussed. Experts were also asked to comment on the pathogens that they consider to pose the highest risk to the Barramundi industry both within Australia and throughout South East Asia. If required, prompting would occur to ensure that Iridovirus, Scale drop syndrome, Asian strains of streptococcus, Pot belly disease and Vietnamese Barramundi disease were discussed.

3.3.3 Identification of experts

Aquatic animal health experts in Australia and South East Asia were identified through consultation with the Department of Agriculture and Water Resources (DAWR), through public internet searches and through the researchers existing knowledge of experts within the aquatic animal health field. Factors considered in the selection of experts were the relevance of any formal qualifications, knowledge and experience in the areas of aquatic animal health and/or biosecurity; Australian and South East Asian aquaculture; Australian and South East Asian trade or relevant Australian government legislation and policy.

3.3.4 Recruitment of experts

Contact details were obtained through publically available sources and through existing professional contacts and networks of the researchers. An introductory email was sent to potential participants containing a brief outline of the research and a Participant Information Sheet as an attachment (Appendix C). Interested persons were asked to contact a member of the research team in the first instance.

3.4 Risk assessment approach

A qualitative assessment of the pathways and likelihood of introduction, exposure and spread of exotic diseases into the Barramundi industry in Australia from Barramundi products imported from overseas was conducted using the World Organization for Animal Health (OIE) framework on risk analysis (OIE, 2009). This assessment has focused on the identification of hazards, the factors to be considered when estimating the likelihood of introduction of these hazards, the pathways of exposure of the Australian Barramundi industry and the potential spread of the diseases caused by these hazards once introduced into Australia. In conducting this assessment, gaps of information were identified and discussed.

i) Hazard identification process:

A review of publicly available documentation and a consultation with the Animal Biosecurity Branch of the Australian Commonwealth, Department of Agriculture and Water Resources (DAWR) were conducted to gather information on the country of origin of the imported Barramundi products and the volume of product imported. The initial list of potential hazards to be included in the risk assessment was created during the development of the semi-qualitative expert questionnaire (Section 4.1.9, Table 9). This list was then refined through the expert consultation process, to produce the final list of diseases to be included in the risk assessment.

ii) Risk assessment process:

Entry: The likelihood of the hazards identified entering into Australia through the importation of Barramundi products was qualitatively investigated though an initial consultation with the Animal Biosecurity Branch of the Australian Commonwealth DAWR and the Australian Barramundi Farmers

Association, the literature review and the expert consultation process. Importation of live Barramundi, which is prohibited by Australian biosecurity import conditions, is not considered in this assessment, with only Barramundi products for human consumption being considered. These products included chilled and frozen whole fish, eviscerated headless fish or fillets, with whole Barramundi being used as the reference product for estimating the likelihood of entry and other products being assessment comparatively. Information relevant for this step of the assessment, was in relation to type of product imported, the sources of these products and the inspection requirements for these products at the border.

Exposure and spread: The pathways of exposure of the Australian Barramundi industry to the hazards introduced with imported Barramundi products and spread of these pathogens were investigated through the literature review and the expert consultation process. The corresponding likelihoods of these pathways occurring were qualitatively estimated through the expert consultation process. Scenario trees were built to represent the exposure pathways with the spread pathways being qualitatively discussed. Experts were also asked to provide estimates of the likelihood of spread if these diseases were introduced into Australia and exposed Australian Barramundi and the potential impact of the establishment of these diseases for the Barramundi industry.

iii) Estimating the overall risk and identifying gaps of information:

The overall risk posed by the identified hazards was qualitatively discussed considering the likelihoods of entry, exposure and spread and the estimated impact of establishment of the diseases considered. During this process, the gaps of information and uncertainties were identified and discussed.

4. Results and Discussion

4.1 Literature review

4.1.1 Habitat and biology

Lates calcarifer (Bloch, 1970) belongs to the perch family, and is known commonly in Australia as Barramundi. Worldwide it has various names and is generally referred to as Asian seabass in the international literature (Schipp et al., 2007).

A tropical species, requiring water temperature of 20-30^{o}C, this large predatory fish is found in coastal waters, estuaries and lagoons. Barramundi tolerates a range of salinities and while preferring slow moving water, it can be found in waters adjacent to shore islands and reefs (Australian Barramundi Farmers Association, 2016). It is distributed widely, extending from the Arabian Gulf to China and Taiwan, to Papua New Guinea and across northern Australia. In Australia, it can be found in areas from the Ashburton River in Western Australia, throughout the Northern Territory, to the Maryborough River in Queensland.

A protandrous hermaphrodite, most Barramundi mature and function as males for one or more spawning season before undergoing sex inversion (Davis, 1987). Barramundi are a fecund species capable of producing up to 2.3 million eggs per kilo of body weight (Davis, 1984) reaching sexual maturity at two to three years of age.

Barramundi can be cultured in areas where the winter water temperature is more than 25^{o}C Broadly speaking, farming can be conducted using three methods; culture in purpose built fresh/salt/brackish water ponds, sea cage culture in offshore or estuarine waters, and indoor intensive production (recirculating or flow through).

Product is sold as fingerlings for outgrowing, fresh or frozen as plate fish, larger whole fish or fillets. There is also a small leather industry utilising the skin by product of the fishing industry and the swim bladders for production of fish maw.

4.1.2 Global production

Aquaculture of Barramundi commenced in Thailand in the 1970's expanding to other regions over ensuing decades. Production of Barramundi through aquaculture now occurs in Australia, the USA, areas of Europe, the Middle East, Pacific Islands and Micronesia, however the production in these areas is considerably lower than that of South East Asia. Production of Barramundi in South East Asia occurs primarily in cages in freshwater or brackish water ponds or in sea cages.

The Food and Agriculture Organization of the United Nations (FAO), report the 2014 global aquaculture production of Barramundi, excluding Australia, to be 68,141.38 tonnes (FAO, 2016b). Latest production figures obtained from the FishStatJ database (FAO, 2016a) show that the top producers in terms of volume were Malaysia, Thailand, Taiwan and Indonesia (Table 3). Wild capture, excluding Australia, for the same period totalled 100,736 tonnes (Table 4). Vietnam is a significant producer of Barramundi and exporter of Barramundi products; however, the FishStatJ database does not specifically report on Barramundi production, with data aggregated for marine fishes. Similarly, the Vietnam Association of Seafood Exporters and Producers (VASEP) only reports 'Other marine fish' as a category of export products, with no specific information on Barramundi (VASEP, 2016).

Table 3 Global Barramundi aquaculture production 2014, excluding Australia, reported in FishStatJ (FAO, 2016).

Rank	Country	Aquaculture area	Environment	Value US ($000)	Quantity (tonnes)
1	Malaysia	Asia - Inland waters	Freshwater	22	5.7
	Malaysia	Indian Ocean, Eastern	Brackishwater	110,087	26,752.8
	Malaysia	Pacific, Western Central	Brackishwater	16,705.22	3,687.1
	TOTAL			126,814	**30,445.6**
2	Thailand	Indian Ocean, Eastern	Brackishwater	5,331	1,228.0
	Thailand	Pacific, Western Central	Brackishwater	58,849	15,583.0
	TOTAL			64,180	**16,811.0**
3	Taiwan Province of China	Asia - Inland waters	Freshwater	27,260	7,448.6
	Taiwan Province of China	Pacific, Northwest	Brackishwater	15,947	4,133.0
	TOTAL			43,207	**11,581.6**
4	Indonesia	Pacific, Western Central	Brackishwater	15,541	3,071.3
	Indonesia	Pacific, Western Central	Marine	12,019	2,375.3
	TOTAL			27,561	**5,446.6**
5	Saudi Arabia	Indian Ocean, Western	Marine	20,200	2,525.0
6	Singapore	Pacific, Western Central	Marine	2,532	476.6
7	United States of America	America, North - Inland waters	Freshwater	2,400	400.0*
8	Cambodia	Pacific, Western Central	Marine	1,600	200.0*
9	Myanmar	Indian Ocean, Eastern	Marine	380	95.0
10	Brunei Darussalam	Pacific, Western Central	Brackishwater	594	75.3
11	Israel	Mediterranean and Black Sea	Brackishwater	572	60.0
12	Sri Lanka	Indian Ocean, Eastern	Brackishwater	61	17.7
13	Bulgaria	Europe - Inland waters	Freshwater	32	5.0
14	Vanuatu	Pacific, Western Central	Brackishwater	37	2.0*
					Total 68,141.38

* FAO estimate from available sources of information

Table 4 Global Barramundi capture 2014, excluding Australia, reported in FishStatJ (FAO, 2016)

Rank	Country	Fishing area	Quantity (tonnes)
1	Indonesia	Pacific, Western Central	87,491
	Indonesia	Indian Ocean, Eastern	10,308
	TOTAL		**97,799**
2	Malaysia	Pacific, Western Central	1,646
	Malaysia	Indian Ocean, Eastern	177
	TOTAL		**1,823**
3	Philippines	Pacific, Western Central	686
4	Papua New Guinea	Oceania - Inland waters	350*
	Papua New Guinea	Pacific, Western Central	20*
	TOTAL		**370***
5	Thailand	Pacific, Western Central	7
	Thailand	Indian Ocean, Eastern	27
	TOTAL		**34**
6	Singapore	Pacific, Western Central	24
			Total 100,736

* FAO estimate from available sources of information

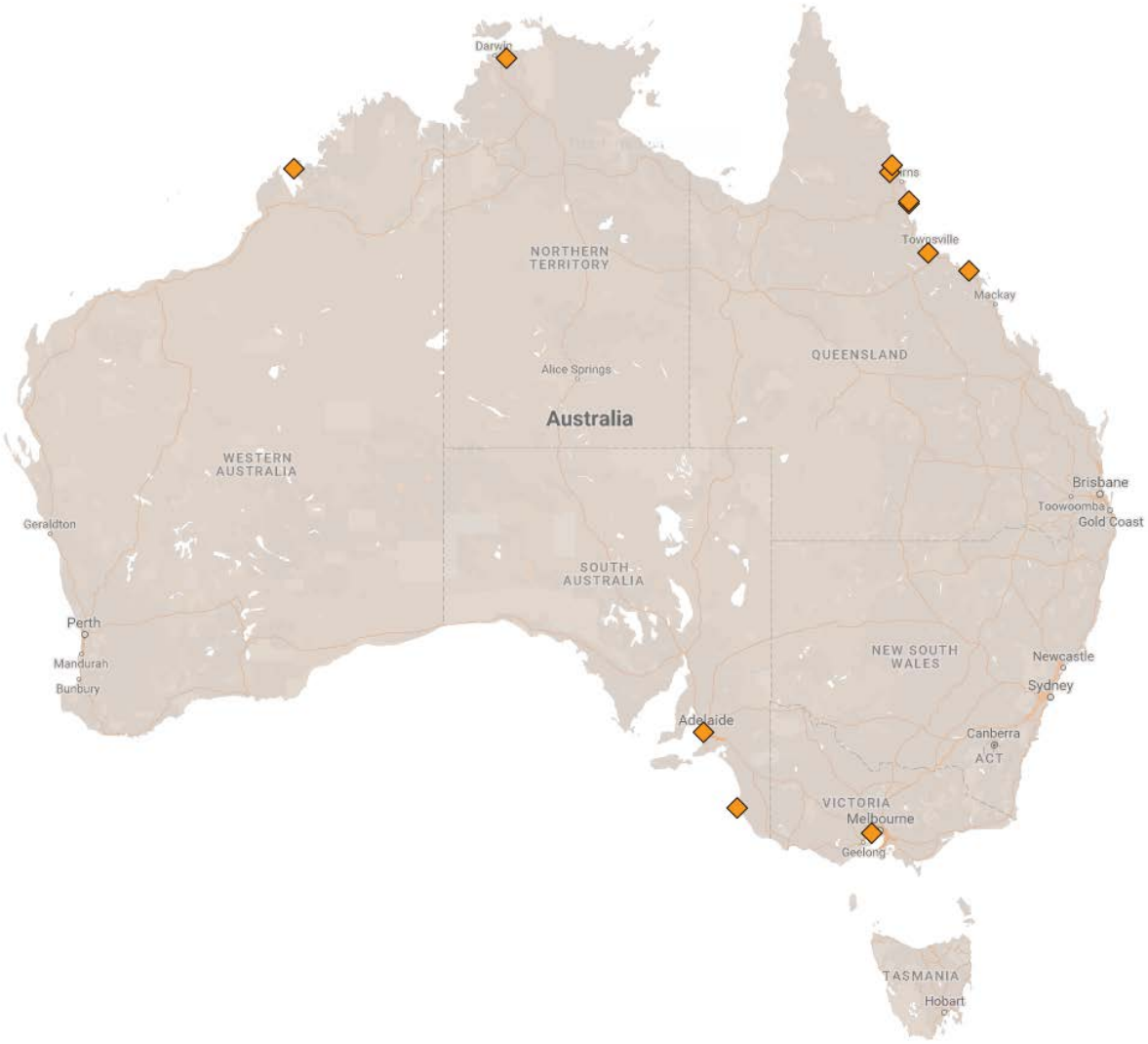
4.1.3 Overview of the Australian Barramundi industry

4.1.3.1 Production description

Barramundi is farmed in all mainland Australian States and the Northern Territory with the majority of production currently occurring in the northern areas of Western Australia, Northern Territory and Queensland. Commercial inshore gill net fisheries operate across Western Australia, Northern Territory and Queensland, with recreational fishing and Indigenous use of Barramundi also taking place across these states.

The Australian Barramundi Farmers Association currently represents ten active enterprises that account for an estimated 90+% of production. Current producing members of the ABFA are Barramundi Gardens; Daintree Salt Water Barramundi; GFB – Bowen; GFB – Kelso; Humpty Doo Barramundi; King Reef Seafoods; Mainstream Aquaculture; Marine Produce Australia; Pejo Enterprises and; Robarra (farm and hatchery); Bakers Creek Marine Farm (Executive Officer, ABFA 2017, pers. comm.). The locations of these enterprises are presented in Figure 1.

Figure 1 Location of members of Australian Barramundi Farmers Association farms



4.1.3.2 Australian Barramundi aquaculture production

In 2014-2015, according to the Australian Bureau of Agriculture and Resource Economics and Sciences (ABARES), the production value of Australian farmed Barramundi was estimated at $37.1 million AUD with a production of 3,772 tonnes annually (Savage, 2015). Queensland was the major producer, accounting for close to 3,000 tonnes (Savage, 2015). The value of the wild-catch was estimated to be $9.9 million AUD with 1,073 tonnes produced (Savage, 2015). In North Queensland, Western Australia and the Northern Territory production occurs primarily in outdoor fresh or saltwater ponds and sea cages. In southern Queensland and other southern other states, recirculation systems are used. Licences are required to breed, hatch or culture Barramundi. These are managed at a state level by relevant authorities. A total of 268 license holders for Barramundi farms were registered in 2014-2015, however, it must be noted that not all of these license holders are currently producing (Savage, 2015) or are producing small volumes. According to ABFA, the 10 ABFA members produce over 90% of the farmed barramundi produced in Australia. Their reported production based on farm data was 6,000 tonnes in 2016 (valued at $60 million AUD) with production scaled to reach over 10,000 tonnes by 2018 (valued at $100 million AUD) and with growth projected to reach 20,000 tonnes by 2025 (valued at $200 million AUD) (Executive Officer, ABFA 2017, pers. comm.). These sectors of the industry as well as recreational and Indigenous fishers, are all at risk of being exposed to hazards potentially introduced by imported Barramundi products, which could pose significant consequences.

4.1.3.3 Annual consumption

Australians consume approximately 20,000 tonnes of Barramundi each year, of which around 40% is Australian product (farmed 33% and wild caught 7%), with the balance imported (Executive Officer Australian Barramundi Farmers Association, 2014). The fish is sold primarily fresh or frozen as whole plate size fish (350–500 g or larger up to 800g), or as fillets (from fish 2 to 3 kg).There is also a small domestic trade in plate size live fish for restaurants specializing in live seafood products (Rimmer M.A, 2016). A lack of accurate trade data on imported barramundi makes it impossible to definitively assess volumes of imported fish and in what form it is coming into Australia.

4.1.4 Main import and export market for Barramundi products

Barramundi does not have an international Harmonised Tariff Item Statistical Code (HTISC) number, making it difficult to obtain accurate import and export data. The Australian Fisheries Statistics is published annually by ABARES; however, data is aggregated and does not provide specific figures on Barramundi imports. Similarly Australian customs and the Australian Bureau of Statistics record Barramundi as “other fish”, “other fillets” or “other preparations”.

Currently, the predominant sources of imported Barramundi are Taiwan, Malaysia, Indonesia and Singapore with Myanmar, India, Papua New Guinea, Thailand and Vietnam also contributing to trade. However, given the lack of specific information on Barramundi importations, which are considered as an aggregated product, it is difficult to accurately identify the sources and volume of Barramundi imports.

An Australian market analysis undertaken in 2011, utilising field observations and trade interviews, reported commonly available imported Barramundi products to include:

- Chilled and frozen head on fish.
- Frozen headless “butterflied” fish.
- Chilled and frozen fillets (Skin on or skin off).
- Frozen portions.
- Retail packs of frozen raw Barramundi fillets in proprietary brands and supermarket home brands/private label.
- Imported Barramundi crumbed and packed in Australia (retail and food service packs) (Ruello, 2011).

In addition, non-eviscerated farmed Barramundi (i.e. whole unprocessed fish), can be imported from the Philippines and Taiwan provided it is accompanied by the appropriate import permits. However, despite

import restrictions, there are anecdotal reports that whole Barramundi has been imported into Australia from Indonesia and Malaysia (Australian Barramundi Farmers Association, 2014).

Fresh products are usually sold to wholesalers for processing and on selling, with supermarkets being the main receiver of frozen products (Ruello, 2011). Dried products such as fish maw (dried swim bladder), are also listed for trade on various seafood export websites (e.g. Ali Baba https://www.alibaba.com/). Intercompany trading also occurs in response to supply and demand.

Barramundi is not included in the list of species approved for live import, and as such, live Barramundi cannot be imported into Australia. This restriction includes importation for use as an aquarium species (DAWR, 2016).

4.1.5 Importation of bait, berley and feed products

The importation of pet fish food is permitted with an import permit. Import requirements include heating to a minimum of 85 ˚C for a period of not less than 15 minutes, or heating to a minimum of 80 ˚C for a period of not less than 20 minutes or in the case of it not being treated prior to import, the product must be subjected to gamma irradiation at 50 kGy (5 Mrad) on arrival to Australia. Irradiation at 50 kGy at a facility approved by the Department of Agriculture is mandatory even if the product has been irradiated before shipment to Australia (i.e. at an overseas gamma irradiation facility). This product cannot be used in any other external aquatic environment including pond-based commercial aquaculture systems. The importation of finfish (all species excluding family Salmonidae) for use as baitfish and aquaculture feed, where the country of origin is other than New Zealand, is subject to import permit applications being assessed against the import conditions. The information available through the Australian Biosecurity Import Conditions (BICON) system does not provide specific detail on required treatment (DAWR, 2017).

Seafood intended for human consumption cannot be imported for use as bait. It is, however, possible that the end use of such product may be as bait by recreational fishers. This poses a risk to not only the wild Barramundi population, but also particularly in the case of pathogens capable of spreading to new hosts in multiple environments, a more widespread risk (Department of Agriculture, 2015). It must be noted that reports on berley and bait generally use the classification of finfish, making any definitive statements on the use of Barramundi and / or Barramundi products difficult (Kewagama Research, 2002, Department of Agriculture, 2015).

4.1.6 Movement of Barramundi within Australia

While there are restrictions placed on the movement of live Barramundi within Australia, translocation does occur and must be considered in the context of disease spread. The movement of live fish is managed by state and territory authorities, with some variation in policy evident. For example, in Western Australia, Barramundi brought from interstate must be sourced from a licensed hatchery and health tested for nominated diseases. Barramundi sourced from wild stocks within Western Australia and moved from one drainage basin to another must also be health tested (Thorne, 2002). Queensland follows a similar process with health certification being a requirement for movement to non-restricted areas with additional testing for nodavirus required for movement to restricted areas (DAF Qld, 2011). Victoria allows the translocation of health tested fingerling (older than 42 days) but no eggs or larvae can be transported (Agriculture Victoria, 2015). Although testing at state level is only undertaken for nominated diseases, it involves histological tests, which could detect tissue abnormalities due to other diseases (M. Landos 2017, pers. comm.) The National policy guidelines for translocation of live aquatic organisms (1999) are being revised to assist the development and revision of translocation policies across all states and territories (Animal Health Australia, 2016). The aim of this policy revision is to increase consistency across states and territories.

4.1.7 Australia's biosecurity policies and import legislation

Imported Barramundi / Barramundi products, must comply with Australian biosecurity and food safety requirements. The management of biosecurity risk is underpinned by the Biosecurity Act of 2015 (Federal Register of Legislation, 2016a). Depending on the type of Barramundi product imported, goods may be permitted entry; subject to import conditions; or require an import permit. Tables 5 – 7 below provide a summary of the import conditions of imported finfish (including Barramundi) products as detailed in BICON (https://bicon.agriculture.gov.au/BiconWeb4.0.).

In addition to mitigating for potential biosecurity risk, imported Barramundi is subject to the Imported Food Control Act 1992 (Federal Register of Legislation, 2016b) and the Imported Food Control Regulations 1993 (Federal Register of Legislation, 2015). These underlie the Imported Food Inspection Scheme (IFIS), a risk based border inspection program. All imported food must comply with the relevant standards as set out in the Australia New Zealand Food Standards Code. This code is developed and managed by the Food Standards Australia New Zealand (FSANZ). FSANZ monitors worldwide food safety incidents and advises the Department of Agriculture and Water Resources of existing and new risk to human health and safety. Potential food imports are categorised based on FSANZ determinations as either risk foods which are assessed as posing a medium to high risk to public health, or surveillance foods, considered to pose a low risk. All consignments of risk food are inspected against a list of potential hazards whereas surveillance foods have a 5% chance of being randomly selected for inspection.

Despite the import permits required and the current import legislation and biosecurity policies, the recent outbreak of White Spot Disease in prawns in Queensland (outbreak.gov.au/current-responses-to-outbreaks/white-spot-disease) highlights the potential weaknesses of the system and the industry concerns about the effectiveness of the current inspection systems (Executive Officer, ABFA 2017 pers. comm.).

Table 5 Conditions for the importation of Barramundi / Barramundi products into Australia for which an import permit is not required.

Import permit not required
• ***Consumer ready***
Cutlets (including the central bone and external skin, and excluding fins), each weighing no more than 450 grams, or
Skinless fillets (excluding the belly flap and all bone except the pin bones) of any weight, or
Skin-on fillets (excluding the belly flap and all bones except the pin bones) each weighing no more than 450 grams, or
Eviscerated, headless 'pan-size' fish, each weighing no more than 450 grams, or
Fish that is headless and eviscerated which has been salted, dried or smoked, of any weight, or
Products that are processed further than the stage described in points (1) to (5), including commercially canned products
• ***Not in a consumer-ready form-Personal use***
Eviscerated (or further processed) and in an amount of up to 5 kg or,
Able to be stored at room (or ambient) temperature, not requiring refrigeration or freezing before the package is opened and in an amount of up to 10 kg.
• ***Not in a consumer-ready form-Non-personal use-Finfish were not caught in international waters-Country of sourcing, processing and exporting with an approved competent authority-Eviscerated***
A statement that the fish were processed in a premises approved by and under the control of a competent authority
A statement that the fish were eviscerated.
A statement that the fish were subjected to an inspection system supervised by a competent authority.
A statement that the head and gills were removed and internal and external surfaces thoroughly washed.
A statement that the product is free from visible lesions associated with infectious disease.
• ***Not in a consumer-ready form-Non-personal use-Finfish were not caught in international waters Country of sourcing, processing and exporting with an approved competent authority-Not eviscerated-Farmed-Country of sourcing, processing and exporting is Taiwan-Accompanied by importer and less than 5kg***
Eviscerated (gutted) and gills removed or processed further than evisceration and gills removed.
For human consumption only.
• ***Not in a consumer-ready form-Non-personal use-Finfish were not caught in international waters-Country of sourcing, processing and exporting with an approved competent authority-Not eviscerated-Country of sourcing, processing and exporting is the Philippines-Accompanied by importer and less than 5kg***
Eviscerated (gutted) and gills removed or processed further than evisceration and gills removed.
For human consumption only.

Table 6 Conditions for the importation of Barramundi / Barramundi products into Australia for which an import permit is required.

Import permit required
• ***Not in a consumer-ready form-Non-personal use -Finfish were caught in international waters***
• ***Not in a consumer-ready form-Non-personal use-Finfish were not caught in international waters-Country of sourcing, processing and exporting with an approved competent authority -Not eviscerated-Farmed-Country of sourcing, processing and exporting is Taiwan-Not accompanied by importer and/or not less than 5kg-Standard permit conditions*** A statement identifying the fish species in the consignment (i.e. scientific name, including genus and species). A statement that that the fish were derived from an aquaculture facility subject to health surveillance and monitoring under the supervision of the Competent Authority. A statement that the fish were not derived from a population slaughtered as an official disease control measure. A statement that the fish were processed in a premises approved by and under the control of the Competent Authority. A statement that the product is free from visible lesions associated with infectious disease. A statement that the product is fit for human consumption.
• ***Not in a consumer-ready form-Non-personal use-Finfish were not caught in international waters-Country of sourcing, processing and exporting with an approved competent authority-Not eviscerated-Farmed-Country of sourcing, processing and exporting is Taiwan-Not accompanied by importer and/or not less than 5kg-Non-standard permit application***
• ***Not in a consumer-ready form-Non-personal use-Finfish were not caught in international waters-Country of sourcing, processing and exporting with an approved competent authority-Not eviscerated-Farmed-Country of sourcing, processing and exporting is the Philippines-Not accompanied by importer and/or not less than 5kg-Standard permit conditions*** A statement identifying the fish species in the consignment (i.e. scientific name, including genus and species). A statement that that the fish were derived from an aquaculture facility subject to health surveillance and monitoring under the supervision of the Competent Authority. A statement that the fish were not derived from a population slaughtered as an official disease control measure. A statement that the fish were processed in a premises approved by and under the control of the Competent Authority. A statement that the product is free from visible lesions associated with infectious disease. A statement that the product is fit for human consumption.
• ***Not in a consumer-ready form-Non-personal use-Finfish were not caught in international waters-Country of sourcing, processing and exporting with an approved competent authority-Not eviscerated-Farmed-Country of sourcing, processing and exporting is the Philippines-Not accompanied by importer and/or not less than 5kg-Non-standard permit application***
• ***Not in a consumer-ready form -Non-personal use-Finfish were not caught in international waters-Country of sourcing, processing and exporting with an approved competent authority-Not eviscerated-Not farmed***

Table 7 Barramundi / Barramundi products not permitted to be imported into Australia.

Not permitted. Must be exported or destroyed
• ***Not in a consumer-ready form -Non-personal use-Finfish were not caught in international waters-Country of sourcing, processing and exporting with an approved competent authority-Not eviscerated -Farmed-Country of sourcing, processing and exporting is other than Taiwan or the Philippines***
• ***Not in a consumer-ready form-Non-personal use-Finfish were not caught in international waters-Country is other than New Zealand, Cocos Island or a country with an approved competent authority***

4.1.8 International agreements and standards

The Australian government can enter into voluntary government to government certification arrangements. Imports accompanied by a recognised foreign government certificate may be inspected and tested at a reduced rate. With regards to the importation of finfish, Australia has foreign government certification arrangements with Thailand and Canada, noting that this relates only to the food standards component of the importation process, not associated biosecurity requirements. The DAWR list of all competent authorities is provided in Table 8.

Table 8 List of competent overseas authorities for importation of aquatic goods into Australia.

Country	Overseas authority
Bangladesh	Department of Fisheries
Brunei	Department of Fisheries of the Ministry of Industry and Primary Resources
Cambodia	Animal Health and Production Department; Ministry of Agriculture, Forestry & Fisheries; Ministry of Health Quarantine Service
China	State General Administration of the PRC for Quality Supervision, Inspection and Quarantine
	CIQ - Entry-Exit Inspection and Quarantine of the People's Republic of China
Fiji	Department of Fisheries of the Ministry of Fisheries and Forests; Ministry of Health
French Polynesia	Service du Développement Rural ; Ministry of Agriculture
Guam	Agricultural Development Services, Department of Agriculture
Hong Kong	Agriculture Fisheries and Conservation Department
India	Export Inspection Agency/Export Inspection Council
	Ministry of Commerce
	Livestock and Marine Products Inspection cum Certification Laboratory, Government of Kerala
	Animal Quarantine & Certification Services
	Department of Animal Husbandry, Dairying and Fisheries
	Ministry of Agriculture
Indonesia	Republic of Indonesia Ministry of Marine Affairs and Fisheries, Centre for Fish Quarantine
Iran	Ministry of Jihad-e Agriculture
Japan	Japanese Ministry of Agriculture, Forestry and Fisheries (MAFF)
	Authorised Certifying Agency on behalf of MAFF, Japan Frozen Foods Inspection Corporation (JFFIC)
	Ministry of Health, Labour and Welfare (MHLW)
Malaysia	Ministry of Health; Ministry of Agriculture; Department of Fisheries; Fisheries Research Institute (FRI); Marine Fisheries Department Sarawak (MFD)
Micronesia	Division of Agriculture, Department of Resources and Development
Myanmar	Ministry of Livestock and Fisheries; Department of Fisheries
Pakistan	Marine Fisheries Department (MFD), Ministry of Ports & Shipping
Papua New Guinea	Fisheries Inspection Service, National Fisheries Authority
Philippines	Bureau of Animal Industry (Department of Agriculture)
	Bureau of Fisheries and Aquatic Resources Quarantine Services (Department of Agriculture)
	Department of Fisheries
Samoa	Department of Agriculture and Fisheries, Office for Tokelau Affairs
Saudi Arabia	General Directorate of Laboratories and Quality Control at the Ministry of Commerce
	Department of Ministry of Agriculture (ADMA) [Human consumption end use]
Singapore	Agri-Food and Veterinary Authority
South Africa	The National Regulator for Compulsory Specifications (NRCS)
	Directorate of Animal Health, National Department of Agriculture
	Ministry of Environmental Affairs and Tourism
	National Department of Agriculture, Forestry and Fisheries, Directorate of Veterinary Services
Sri Lanka	Department of Animal Production and Health ; Department of Fisheries and Aquatic Resources
Taiwan	Bureau of Standards, Meteorology and Inspection (BSMI) [Human consumption only]
Thailand	Department of Fisheries (DOF) [Human consumption and animal feed (aquaculture and stockfeed) use]
USA	National Oceanic and Atmospheric Administration (NOAA), Seafood Inspection Program of the United States Department of Commerce (USDC) [for non-viable aquatic animal and animal products]
Vanuatu	Ministry of Agriculture, Livestock, Forestry, Fisheries & Biosecurity; Biosecurity Vanuatu
Vietnam	National Agriculture, Forestry and Fisheries Quality Assurance Department (NAFIQAD) of the Ministry of Agriculture and Rural Development (MARD) [Human consumption only]

4.1.9 Common diseases in Barramundi

Barramundi is susceptible to a number of viral, bacterial, fungal and protozoan diseases, affecting both wild and farm populations. The main sources of infection are through water, feed materials and other fish. The intensive production and associated economic importance places the Barramundi industry in a position where any disease incursion has potential for devastating consequences.

Australia is host to a number of endemic diseases/disease agents affecting Barramundi with significant mortalities reported (Schipp et al., 2007). While mandatory controls of movement of live fish within and between some Australian states and territories has restricted the distribution of significant diseases/disease agents, there is no restriction on the movement of non-viable non-salmonids throughout Australia.

The most recent assessment of risk on the importation of non-viable non-salmonid marine fish (including Barramundi) to Australia was undertaken by AQIS in 1999 (Kahn S.A et al., 1999). In this report, the criteria used to determine whether a disease agent required consideration was that the disease agent must be:

1. infectious; and,
2. (a) exotic to Australia, or (b) present in Australia but subject to official control; and
3. (a) OIE listed, and/or (b) would be expected to cause significant harm in Australia.

Since the report by Kahn et al (1999), there have been limited comprehensive studies on diseases of Barramundi. A study on gill diseases undertaken by Griffiths (2009) presented details of existing pathogens and highlighted the need for both the monitoring of existing pathogens and ongoing surveillance for new pathogens in wild ecosystems and aquaculture facilities. Similarly, an investigation by Gibson–Kueh (2012) presented details of existing and emerging diseases observed in Barramundi, highlighting Scale drop syndrome and Pot belly disease as two diseases warranting further investigation (Gibson-Kueh, 2012). The list of OIE diseases, infections and infestations is reviewed regularly and currently lists ten notifiable fish diseases, two of which; *Aphanomyces invadans* (epizootic ulcerative syndrome, EUS); and, Red sea bream iridoviral disease (RSIVD) have been reported in Barramundi.

While the risk of the introduction of exotic diseases is of considerable concern, the introduction of imported Barramundi also poses the real risk of more virulent strains of existing endemic diseases being introduced into Australia.

The Network of Aquaculture Centre in Asia–Pacific (NACA) produces an online quarterly report on aquatic animal diseases in the Asian–Pacific Region. The most recent publication (Oct - Dec 2015) reported the following aquatic diseases to which Barramundi are susceptible: *Aphanomyces invadans*, reported in India and Japan; RSIVD, reported in Japan and Korea; viral encephalopathy and retinopathy, reported in the Philippines and Japan; *Streptococcus* spp., reported in Myanmar; viral nervous necrosis (VNN), reported in Singapore; enteric septicaemia of catfish, reported in Vietnam; and, infectious spleen and kidney necrosis virus (ISKNV), reported in Singapore. Note that in some cases the disease was reported in a very limited zone, which may also include a quarantine area (NACA, 2016). Using information derived from various sources, such as The Network of Aquaculture Centre in Asia–Pacific (NACA), FAO data, and literature a table of diseases affecting non-salmonid finfish was developed (Table 9).

Table 9 List of major disease/disease agents affecting non salmonid finfish according to available literature.

Disease/disease agent	OIE Listed Aquatic Diseases (2016)*	Exotic / Endemic	Type
Infectious hematopoietic necrosis virus (IHNV)	✓	Exotic	Viral
Viral haemorrhagic septicaemia (VHS)	✓	Exotic	Viral
Red sea bream iridoviral disease (RSIVD)	✓	Exotic	Viral
Scale drop syndrome		Exotic	Viral
Viral erythrocytic necrosis (VEN)		Exotic	Viral
Infectious pancreatic necrosis (IPNV)		Exotic	Viral
Infectious spleen and kidney necrosis virus (ISKNV)		Exotic	Viral
Spring viraemia of carp virus (SVC)	✓	Exotic	Viral
Viral encephalopathy and retinopathy (VER) or Viral nervous necrosis (VNN)		Endemic	Viral
Epizootic haematopoietic necrosis	✓	Endemic	Viral
Lymphocystis		Endemic	Viral
Vibriosis/*Vibrio* spp.		Endemic	Bacteria
Bacterial haemorrhagic septicaemia/*Aeromonas hydrophila*		Endemic	Bacteria
Streptococcosis spp.		Endemic	Bacteria
Pot belly syndrome		Exotic	Bacteria
Nocardiosis/*Nocardia* spp.		Endemic	Bacteria
Streptococcosis/*Streptococcus iniae*		Endemic	Bacteria
Tenacibaculosis/*Tenacibaculum maritimum*		Endemic	Bacteria
Aeromonas salmonicida		Exotic	Bacteria
Enteric septicaemia of catfish/*Edwardsiella ictaluri*		Endemic	Bacteria
Columnaris disease/*Flexibacter columnaris, Flexibacter maritimus*		Endemic	Bacteria
Epitheliocystis/*Chlamydiaceae*		Endemic	Bacteria
Rickettsiaceae		Endemic	Bacteria
Pseudomonas anguilliseptica		Exotic	Bacteria
Francisellaceae spp.		Endemic	Bacteria
Epizootic ulcerative syndrome (EUS)/*Aphanomyces invadans*	✓	Endemic	Fungal
Cryptocaryon irritans		Endemic	Parasitic
Trichodina spp.		Endemic	Parasitic
Neobenedenia spp.		Endemic	Parasitic
Eimeria spp.		Endemic	Parasitic

*****Source - http://www.oie.int/animal-health-in-the-world/oie-listed-diseases-2016/

4.2 Expert consultation

Invitations to participate in the expert consultation process were extended to 23 experts. An additional 11 experts were provided through recommendations and/or referrals from this initial group, making the final number of experts contacted 34. A summary of expert type, location and level of participation is provided in Table 10.

Table 10 Summary of experts participating in the expert consultation process.

Expert type	Location
Experts involved in formal questionnaire and/or interview (n=7)	
Commonwealth Government Scientist.	Australia
Senior Principal Research Scientist – Fish Disease. BSc (Hons) PhD	
Consultant- Veterinary pathology.	Australia
Veterinary Pathologist. BVSc MSc PhD MACVSc	
Research and Development Site Manager SE Asia. BVMS MRCVS	Singapore
Barramundi producer. BAppSc	Australia
Commonwealth Government Scientist.	Australia
Science Officer Animal Biosecurity. PhD	
Consultant – Aquatic animal health veterinarian.	Australia
BVSc(HonsI) MANZCVS	
University Scientist - Fish pathologist.	Australia
Adjunct lecturer Aquatic Animal Health. BVSc MSc (Aquatic Veterinary Studies) PhD (Fish Pathology)	
Experts providing comment (n=6)	
Barramundi Producer. BSc	Australia
Consultant- aquaculture.	Australia
FRDC Aquatic Animal Health & Biosecurity Subprogram, DAWR Subcommittee on Aquatic Animal Health. National Aquaculture Council (NAC) Chair, (prev) BSc	
Barramundi Producer. BSc	Australia
Seafood importer.	Australia
Barramundi Producer / Seafood importer (prev).	Australia
Barramundi Producer / Australian Barramundi Industry representative. MSc	Australia
Experts contacted but unable to participate (n=11)	
University Scientist. PhD	Australia
Research and Development Aquaculture SE Asia. D.Sc	Philippines
University Scientist. PhD	Vietnam
Commonwealth Government Scientist. PhD	Australia
University Scientist. PhD	Australia
State aquaculture industry.	Australia
State aquaculture industry.	Australia
Research and Development Aquaculture SE Asia. MS	Philippines
University Scientist. PhD	Vietnam
National Government, Biologist. PhD	Thailand
University Scientist - PhD	Australia
Experts no response (n=10)	
University Scientist - PhD	Australia
Commonwealth Government Scientist.	Australia
University Scientist/Consultant. PhD	Thailand
Research and Development Aquaculture SE Asia. PhD	Philippines
National Government Scientist. PhD	Malaysia
National Government Scientist - Virology. PhD	Thailand
University Scientist - PhD	Vietnam
State Government Veterinarian	Australia
State Government Veterinarian	Australia
State Government Scientist. Veterinarian	Australia

4.3 Risk assessment

4.3.1 Hazard identification

The outcomes of the hazard identification process previously described is shown in Table 11. Experts refined the initial list provided in the questionnaire, considering the Barramundi susceptibility to the hazard and the status of the disease or presence of the hazard in Australia (in Barramundi or other fish). In addition, existence of more virulent strains of currently endemic diseases in Australia was also considered by experts. The table provides information on which diseases should be included in an import risk assessment for Barramundi products, the reasons for inclusion or non-inclusion and additional information to be considered.

Table 11 Outcomes of the hazard identification process – Disease agents considered in an Import Risk Assessment of Barramundi products.

Disease/disease agent	To be included in an Import Risk Assessment of Barramundi product	Additional information
Infectious hematopoietic necrosis virus (IHNV)	No	Not recorded in Barramundi
Viral haemorrhagic septicaemia (VHS)	No	Not recorded in Barramundi
Red sea bream iridoviral disease (RSIVD)	**Yes**	
Scale drop syndrome	**Yes**	
Viral erythrocytic necrosis(VEN)	No	Not recorded in Barramundi
Infectious pancreatic necrosis (IPNV)	No	Not recorded in Barramundi
Infectious spleen and kidney necrosis virus (ISKNV)	**Yes**	
Spring viraemia of carp virus (SVC)	No	Not recorded in Barramundi
Viral encephalopathy and retinopathy (VER) or Viral nervous necrosis (VNN)	No	Endemic
Epizootic haematopoietic necrosis	No	Endemic
Lymphocystis	No	Endemic
Vibriosis /*Vibrio* spp.	**Yes**	**Endemic. Exotic strain**
Bacterial haemorrhagic septicaemia/*Aeromonas hydrophila*	No	Endemic
Streptococcosis/ *Streptococcus* spp.	**Yes**	**Endemic. Exotic strain**
Pot belly syndrome	**Yes**	
Nocardiosis/*Nocardia* spp.	No	Endemic
Streptococcosis/*Streptococcus iniae*	No	Endemic
Tenacibaculosis/*Tenacibaculum maritimum*	No	Endemic
Aeromonas salmonicida	No	Not recorded in Barramundi
Enteric septicaemia of catfish/*Edwardsiella ictaluri*	No	Endemic
Columnaris disease/*Flexibacter columnaris, Flexibacter maritimus*	No	Endemic (refer *T. maritimum*.)
Epitheliocystis /*Chlamydiaceae*	No	Endemic
Rickettsiaceae	No	Not recorded in Barramundi
Pseudomonas anguilliseptica	No	Not recorded in Barramundi
Francisellaceae	No	Not recorded in Barramundi
Epizootic ulcerative syndrome (EUS)/*Aphanomyces invadans*	No	Endemic
Cryptocaryon irritans	No	Endemic
Trichodina spp.	No	Endemic
Neobenedenia spp.	No	Endemic
Eimeria spp.	No	Endemic

According to the hazard identification process, four hazards (RSIVD, Scale drop syndrome, ISKNV, Pot belly disease) that are considered exotic to Australia and two hazards (*Vibrio* spp., *Streptococcus* spp.) with potential different strains present in South East Asia should be considered further in the assessment.

4.3.2 Hazard descriptions

4.3.2.1 Red sea bream iridoviral disease (RSIVD)

Clinical signs: Red sea bream iridoviral disease (RSIVD) is characterised by lethargy, enlargement of the spleen, severe anaemia and petechiae of the gills and has resulted in mass mortalities in cultured fish populations. External changes are usually present in infected fish however covert infection is possible. On histopathological examination, infected cells are located in the spleen, heart, kidney, intestine and gill.

Etiology: The disease is caused by infection with Red sea bream iridovirus (RSIV) and Infectious spleen and kidney necrosis virus (ISKNV). Both viruses belong to the genus Megalocytivirus within the Iridoviridae family and whilst related, are considered to be distinct agents.

Geographical distribution: RSIVD has been reported in Japan, Chinese Taipei, China, Hong Kong, Rep. of Korea, Malaysia, Philippines, Singapore, and Thailand.

Host specificity: The virus is not host specific with over 30 aquatic species found to be susceptible. Infection can occur at any stage of development from juvenile to adult, however juveniles are considered to be most susceptible. It had been thought that RSIVD was restricted to marine fish, however there have been reports of RSIVD being identified in freshwater fish (Shinmoto et al., 2009). Survival of the virus outside the host is unknown (World Organisation for Animal Health (OIE), 2016).

Disease pattern: Transmission of the disease is horizontal via the water column, and whilst optimum replication of the virus is observed at water temperatures between 20 or 25°C (Nakajima and Sorimachi, 1994), most outbreaks are associated with temperatures over 25°C (World Organisation for Animal Health (OIE), 2016). Mortality ranges from 0 to 100% depending on host factors and it is unknown if RSIV can survive outside the host. RSIVD is highly contagious (DAFF, 2012). A recent study has suggested that infected fish appearing to have recovered from the disease may continue to hold the virus during colder periods creating the potential for the virus to re-emerge as a source of infection as the temperature increases (Jun et al., 2009).

Prevention: A formalin-inactivated vaccine is available however it is not effective for all fish species susceptible to the disease (Kurita and Nakajima, 2012).

Stability of the agent: RSIV is inactivated at 56°C for 30 minutes; sensitive to ether and chloroform; inactivated by formalin (0.1%) and stable in tissue at –80°C (World Organisation for Animal Health (OIE), 2016). It has also been shown to be stable to repeated freeze thaw cycles (Nakajima and Sorimachi, 1994). Both chloroform and ether treatment destroyed the infectivity of RSIV, which is consistent with the presence of a lipid membrane (Kurita and Nakajima, 2012).

4.3.2.2 Infectious spleen and kidney necrosis virus (ISKNV)

Clinical signs: Infectious spleen and kidney necrosis disease is characterised by changes in body colour, exophthalmos and abdominal distension. On histopathological examination, infected cells are located throughout the body with proliferation in the tissues of the spleen and kidney. (DAFF, 2012). ISKNV can cause symptomatic and asymptomatic infection (Jeong et al., 2008).

Etiology: ISKNV is in the genus Megalocytivirus, family Iridoviridae. ISKNV-like viruses produce similar clinical signs to ISKNV and are variations within the genus. The International Committee on Taxonomy of Viruses has concluded that the group of ISKNV/ turbot reddish body iridovirus (TRBIV) /RSIV are strains of the same viral species (de Groof et al., 2015).

Geographical distribution: The virus has been reported in China, Singapore, Taiwan, Hong Kong, across Southeast Asia and more recently, Japan (Tanaka et al., 2014, Jeong et al., 2008, Kurita and Nakajima, 2012).

Host specificity: The virus is not host specific.

Disease pattern: Transmission of the disease is horizontal via cohabitation, water, ingestion of excreta or cannibalism. The possibility of vertical transmission of iridovirus has been suggested and warrants further investigation (Jeong et al., 2008). There is recent evidence to suggest that the infected cells are leucocytes (Lee et al., 2009).

Stability of the agent: ISKNV is prone to inactivation by desiccation or heat at temperatures above 50 °C, but is stable in water at 4 °C for extended periods (DAFF, 2012).

4.3.2.3 Scale drop syndrome (SDS) (Scale Drop Disease)

Clinical signs: Affected fish are characterised by darkened bodies, necrotic dermis resulting in scale loss, tail and fin erosion, gill pallor, and exophthalmia. Behavioural changes can include lethargy, schooling disruption, and spiral swimming. Vasculitis is observed in all major organs with tissue degeneration, haemorrhages and necrosis further pathological symptoms observed (de Groof et al., 2015).

Etiology: The causative agent of Scale drop syndrome has been recently identified as Scale drop disease Virus, a member of the Megalocytivirus genus of the Iridoviridae family (de Groof et al., 2015).

Geographical distribution: Malaysia, Indonesia, Singapore and the straits of Malacca.

Host specificity: SDS affects juvenile and adult fish, with size ranging from 100gm to 5kg. It has been suggested that susceptibility has an inverse relationship to age with the possibility that maternal antibody protection occurs (Gibson-Kueh, 2012). To date, Scale drop syndrome has been found to affect Barramundi specifically (de Groof et al., 2015).

Disease pattern: Mortality is estimated to be between 40-50% (de Groof et al., 2015).

Stability of the agent: Unknown

4.3.2.4 Pot belly disease (PBD) (alternate name Big belly disease)

Clinical signs: Affected fish show as darkened and emaciated, with abdominal distensions (Gibson-Kueh, 2012). Histopathologically, severe necrotizing and ulcerative enteritis, progressing to perforation and peritonitis is observed. Other tissues affected include those in the peritoneum, spleen and kidney.

Etiology: The causative agent of Pot belly disease is unknown, however immunohistochemistry suggests an association with *Edwardsiella ictaluri* (Gibson-Kueh et al., 2004). Further investigation is required to establish origin.

Geographical distribution: Indonesia, Singapore and Malaysia.

Host specificity: To date, the disease has only been isolated from Barramundi and has been reported in fry from 3 weeks old through to adults. There are reports that PBD been observed in snapper fry farmed with Barramundi (Anonymous 2016, pers. comm.).

Disease pattern: Transmission patterns have not been clearly identified. Mortality of up to 80% has been reported. PBD often occurs concurrently with other diseases. Further investigation is required to establish modes of transmission (Gibson-Kueh, 2012).

Stability of the agent: Unknown

4.3.2.5. Vibriosis /Vibrio spp.

Clinical signs: Vibriosis results in hemorrhages and ulcerations of the skin, fin, and tail; hemorrhagic and degenerative changes of internal organs; and other systemic changes.

Etiology: Vibrios are gram-negative bacteria, ubiquitous in estuarine and marine ecosystems as well as aquaculture farms. Vibrios affecting non salmonid finfish include *Vibrio anguillarum, Vibrio ordalii* (endemic) and *Vibrio salmonicida* (Kahn S.A et al., 1999).

Geographical distribution: Ubiquitous.

Host specificity: Wide host range. Vibriosis often occurs as a concurrent infection.

Disease pattern: Can cause more than 50% mortality in fish culture environments and up to 100% in commercial systems. Infection can occur through the skin and through oral ingestion (Frans et al., 2011). Stress plays a significant role with chemical, biological and physical stress being associated with onset of disease.

Prevention: A formalin-killed *Vibrio* vaccine is used in the salmonid industry.

Stability of the agent: Some *Vibrio* spp. have been shown to survive in the marine environment for more than 14 months. (Kahn S.A et al., 1999).

4.3.2.6. Streptococcosis/*Streptococcus* spp.

Clinical signs: Associated with chronic and acute infection. Affected fish may exhibit erratic swimming (such as spiralling or spinning); loss of buoyancy control; lethargy; darkening; uni or bilateral exophthalmia; corneal opacity; haemorrhages, ascites; and ulcerations (Yanong and Francis-Floyd, 2002).

Etiology: Regarded as a complex of different diseases caused by different genera and species. (Toranzo et al., 2005). Warm water (*L. garvieae, S. iniae, S. agalactiae* and *S. parauberis*,) and cold water (*Lactococcus piscium* and *V.salmoninarum.*).

Geographical distribution: Ubiquitous.

Host specificity: Wide host range. Wild fish may serve as a reservoir for infection when cohabiting in sea cages (Jerry, 2013). Can affect all ages of fish, however larger fish are more susceptible.

Disease pattern: Streptococcosis spp. is transmitted horizontally.

Prevention: A vaccine is available, however variability in protection have been observed (Toranzo et al., 2005) and vaccination does not always provide cross-protection between different strains. Outbreaks usually take place when fish have been exposed to stress.

Stability of the agent: Certain strains can persist in the environment in the absence of an infected host.

4.3.3 Entry assessment

The qualitative estimates on the likelihood of entry provided by the experts were transformed into quantitative values using uniform distributions following the semi-quantitative methods previously used for import risk analysis (DAFF, 2004). Of the seven experts participating in the questionnaire and interview process, only four provided qualitative estimates of the likelihood of entry. An overall probability of entry for each disease agent when importing whole Barramundi was estimated combining all experts' estimates using a discrete probability. All experts were considered to have the same level of expertise. The outcomes of the likelihood of entry are presented in Table 12.

Table 12 Quantitative (median, 5% - 95%) and qualitative estimates of the likelihood of entry of the disease agents considered in this Import Risk Assessment according to the experts consulted.

Disease / Disease agent	Likelihood of entry (Median, 5% -95%)	Qualitative estimate
Red sea bream iridoviral disease (RSIVD)	0.437 (0.01 – 0.67)	Moderate (Very low – Moderate)
Infectious spleen and kidney necrosis virus (ISKNV)	0.502 (0.01 – 0.93)	Moderate (Very low – High)
Scale drop syndrome (SDS)	0.431 (0.01 – 0.67)	Moderate (Very low – Moderate)
Pot belly disease (PBD)	0.402 (0.0001 – 0.66)	Moderate (Very low – Moderate)
Vibriosis /*Vibrio* spp.	0.501 (0.10 – 0.94)	Moderate (Low – High)
Streptococcosis/*Streptococcus* spp.	0.300 (0.01 – 0.66)	Moderate (Very low – Moderate)

The estimated likelihood of entry for all disease agents is *Moderate*. All estimates have a significant level of uncertainty as seen in the wide ranges of the outcome distributions. A driver for this wide range is the differences in estimates provided by the Australian experts (Consultant aquatic animal health veterinarian; Consultant veterinary pathologist; Fish pathologist) compared to the expert from Singapore (Veterinarian Research Manager from Animal Health provider, with aquatic expertise), who provided much lower estimates. For Pot belly disease, one of the Australian experts estimated a negligible probability of being introduced into Australia, as he believed the disease was primarily a husbandry driven disease, due to feeding practices leading to digestion problems and overgrowth of bacteria, potentially causing peritonitis. However, other experts with extensive work with this disease suggest that it is being caused by an infectious agent, which is yet to be identified. A previous study has associated Pot belly disease with the presence of *Edwardsiella ictaluri* (Gibson-Kueh et al., 2004), although this does not seem to be the primary cause of the clinical presentation of the disease. As such, the negligible estimate was excluded from the calculations.

The main reasons for experts not providing likelihoods was the low confidence in their knowledge to be able to provide an estimate, due to the lack of information on the disease or disease agent and the number of unknown factors that could influence these likelihoods. This indicates that there is a significant level of uncertainty due to lack of accurate and scientific data for some of these diseases, such as the prevalence of the disease in countries of origin, the dynamics of the infection and the epidemiology of the disease. Despite the uncertainties reported by experts there is an agreement that the probability of entry of these disease agents through the importation of Barramundi products is not negligible and additional research is warranted. As previously mentioned, Australia has government certification arrangements with competent authorities of some countries, which provide assurance of disease freedom for specific exported products. One of the experts involved in the consultation, referred to issues recently identified by the Interim Inspector-General of Biosecurity (IIGB) in relation to competent authorities and disease freedom claims affecting other commodities, such as pork (DAFF, 2013), which could potentially pose a risk for Australia's free-disease status. Given these concerns, the IIGB Audit Report recommends a review process for approved countries to ensure exporting countries have appropriate procedures in place.

Contributing to the uncertainty on the likelihood of disease introduction is the lack of accurate information on country of origin, volumes and the form of imported Barramundi products. As previously indicated, Barramundi does not have an international HTISC number, with import data recorded by Australian customs and published by ABARES being aggregated. An estimation of the actual risk posed by imports cannot be conducted accurately unless specific records for Barramundi are kept.

4.3.4 Exposure assessment:

The likelihood of exposure was obtained similarly than the likelihood of entry and resulting quantitative and qualitative estimates are shown in Table 13. According to the participant experts, farmed Barramundi in Australia had a *Low* likelihood of being exposed to the disease agents from the imported Barramundi product, with this likelihood being estimated as *Moderate* for wild catch and recreational Barramundi. Similar estimates were obtained for all disease agents except for *Vibrio* spp. which had an estimated lower likelihood of exposure. However, the wide range of the output distributions obtained indicates there is very significant uncertainty on these estimates. Experts indicated that *Vibrio* spp. are a ubiquitous species and that they are only important as a secondary pathogen.

The potential pathways of exposure are represented in Figure 2. Experts agreed that if the disease agents considered in this assessment were introduced into Australia with the imported product, wild catch and recreational Barramundi could be exposed before farmed Barramundi. Experts identified processing waste as the most likely pathway of exposure, with the risk posed by household waste being considered lower, although not negligible. Experts identified the significant potential for processing waste (e.g. heads, frames) being sold or given away for use as crab bait, which if infected, would pose a risk for direct exposure of Barramundi and other susceptible fish. Similarly, household waste could also be used as bait. Another potential pathway of exposure from fish waste is for the liquid waste, if not processed or treated, going directly to the aquatic environment through the domestic sewerage system. Household solid waste disposed at garbage tips was also considered to pose an indirect risk of exposure. If the garbage tip is accessible by birds, then birds could act as mechanical vectors for the disease agents or carry infected waste to the aquatic environment.

In addition to waste, some experts discussed the potential of whole unprocessed fish to be disposed of when not sold, going directly to the garbage tip o used as bait. The use of disposed fish which are not fit for human consumption, for berley was also considered a risk.

All experts agreed that there is significant uncertainty in relation to the likelihood of exposure occurring, given the lack of information on the dynamics of infection for some of the disease agents. Understanding the agent (e.g. transmission), host (e.g. susceptibility) and environmental (e.g. stability) factors contributing to the occurrence of these diseases is crucial for estimating the risk of exposure and establishment in Australia. Although for some diseases, these factors are known to some extent, for others, such as Scale drop syndrome and Pot belly disease, there is very limited information available.

Figure 2 Potential pathways of exposure of Australian Barramundi to disease agents introduced via imported Barramundi for human consumption.

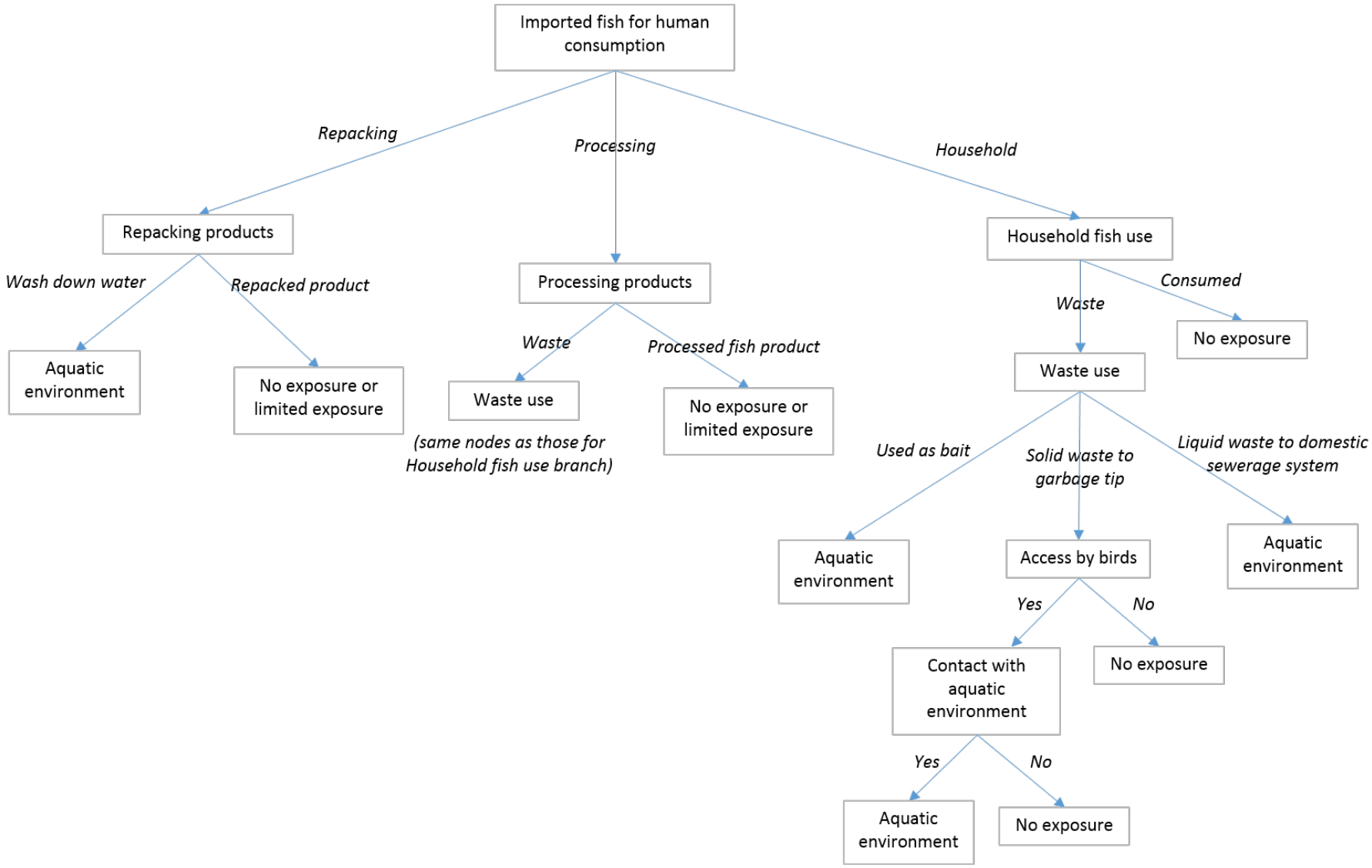


Table 13 Quantitative (median, 5% - 95%) estimates of the likelihood of exposure of the disease agents considered in this Import Risk Assessment to different Australian Barramundi populations, according to the experts consulted.

Disease / Disease agent	**Likelihood of exposure (Median, 5% -95%)**		
	FARM	WILD CATCH	RECREATIONAL
Red sea bream iridoviral disease (RSIVD)	0.050 (0.0002-0.280) *Low (Extremely low – Low)*	0.298 (0.0001-0.665) *Moderate (Extremely low – Moderate)*	0.300 (0.0002-0.656) *Moderate (Extremely low – Moderate)*
Infectious spleen and kidney necrosis virus (ISKNV)	0.050 (0.0001-0.617) *Low (Extremely low – Moderate)*	0.300 (0.0002-0.663) *Moderate (Extremely low – Moderate)*	0.298 (0.0002-0.660) *Moderate (Extremely low – Moderate)*
Scale drop syndrome (SDS)	0.050 (0.0002-0.270) *Low (Extremely low – Low)*	0.300 (0.0002-0.655) *Moderate (Extremely low – Moderate)*	0.300 (0.0002-0.654) *Moderate (Extremely low – Moderate)*
Pot belly disease (PBD)	0.050 (0.0002-0.631) *Low (Extremely low – Moderate)*	0.300 (0.0002-0.937) *Moderate (Extremely low –High)*	0.298 (0.0002-0.948) *Moderate (Extremely low – High)*
Vibriosis /*Vibrio* spp.	0.024 (0.0001-0.641) *Very Low (Extremely low – Moderate)*	0.174 (0.0001-0.962) *Low (Extremely low –High)*	0.170 (0.001-0.960) *Low (Extremely low – High)*
Streptococcosis / *Streptococcus* spp.	0.050 (0.0002-0.628) *Low (Extremely low – Moderate)*	0.300 (0.0002-0.936) *Moderate (Extremely low –High)*	0.300 (0.0002-0.946) *Moderate (Extremely low – High)*

4.3.5 Consequence assessment:

Experts were asked to provide their estimates of the likelihood of spread of the disease agents considered in this assessment and the potential overall impact to the Barramundi industry if these diseases were to be established in Australia (Table 14). All experts agreed that if exposure to a susceptible Barramundi to the disease agents considered in this assessment occurred, these agents were very likely to spread and establish within the Australian Barramundi industry and wider ecosystem. It was considered that spread was more likely to occur in farm settings due to the higher levels of stress, high stocking density and potential contacts among fish, than within wild catch and recreational Barramundi; however, the estimated likelihoods were considered at least *Moderate* for all populations and for all diseases. The widest range of estimates is seen for Pot belly disease, indicating the most significant disagreement among experts, with the non-Australian expert considering the likelihood of spread of this disease much lower than the Australian experts.

In relation to the impact of these diseases to the Australian Barramundi industry and wider ecosystem, all experts considered the impact of the establishment of Scale drop syndrome and Pot belly disease to be significant to extremely significant, with an effect of the economic viability of the industry, which in some instances could be irreversible. Australian experts also considered the impact of the establishment of RSIVD and ISKNV to be significant to extremely significant, with the non-Australian expert considering these diseases to have a minor significance due to the availability of vaccination. This was similar for *Streptococcus* spp., with Australian experts considering the impact of this disease to be higher than the non-Australian expert. The impact of *Vibrio* spp. was considered to be lower than the rest of diseases, due to being a secondary pathogen. The impact posed by the exotic strains of *Vibrio* spp. and *Streptococcus* spp., although considered lower than the exotic diseases, was estimated to be significant. Experts did not describe the type of impact, providing only an overall estimate of the impact to the industry; however, all experts considered the impact of these diseases to be very high. These impacts could include direct biological consequences for the affected fish (e.g. morbidity and mortality), subsequent economic consequences due to production loss and costs of disease control (e.g. vaccination for those diseases with an available vaccine), and a decrease of value of domestic and export markets. In addition, the impact of these diseases could also include potential environmental consequences, especially for those diseases that are not host specific. It is important to emphasize that if these diseases spread among wild catch and recreational Barramundi, populations with a higher likelihood of exposure than farmed Barramundi, control measures, such as vaccination or depopulation, would be limited at farm-level, with eradication of the diseases at a country level being practically not possible, with wild populations acting as reservoirs. Some experts considered that the high costs and logistics required for vaccination would compromise the success of any control strategy for these diseases.

4.3.6 Overall risk estimation:

To estimate the overall risk of these diseases to the Australian Barramundi industry, the Import Risk Analysis risk estimation methodology of the Department of Agriculture and Water Resources for combining descriptive likelihoods was used (DAFF, 2004). Initially the median output of the estimated likelihoods of entry and exposure were combined and the likely consequences were obtained. The likely consequences were estimated combining the median output of the estimated likelihood of spread and the potential impact of the establishment of the disease. To obtain the risk estimation the likelihood of entry and exposure was combined with the likely consequences. The process used for combining likelihoods and the overall risk estimation is shown in Table 15.

According to the expert estimates and only considering the median of the output distribution when combining all expert estimates and the likelihoods of entry, exposure and spread, the overall risk of introduction and establishment of RSIVD, ISKNV, Scale drop syndrome and Pot belly disease with the importation of Barramundi products is estimated to be *Moderate*. The risk posed by *Streptococcus* spp. and *Vibrio* spp. is estimated to be *Low* and *Very low*, respectively. Despite the reported uncertainty around the estimates provided by experts, this assessment suggest that the risk posed by the importation of Barramundi products for the Australian Barramundi industry is not negligible and further research to reduce this uncertainty and to be able to accurately estimate this risk, is warranted.

Table 14 Quantitative (median, 5% - 95%) estimates of the likelihood of spread of the disease agents considered in this Import Risk Assessment to different Australian Barramundi populations, according to the experts consulted.

Disease / Disease agent	**Likelihood of spread (Median, 5% -95%)**		
	FARM	WILD CATCH	RECREATIONAL
Red sea bream iridoviral disease (RSIVD)	0.560 (0.323-0.934) *Moderate (Moderate – High)*	0.429 (0.101-0.674) *Moderate (Low – Moderate)*	0.432 (0.104-0.671) *Moderate (Low – Moderate)*
Infectious spleen and kidney necrosis virus (ISKNV)	0.566 (0.322-0.938) *Moderate (Moderate – High)*	0.436 (0.104-0.673) *Moderate (Low – Moderate)*	0.431 (0.099-0.678) *Moderate (Low – Moderate)*
Scale drop syndrome (SDS)	0.699 (0.095-0.976) *Moderate (Low – High)*	0.300 (0.070-0.657) *Moderate (Low – Moderate)*	0.300 (0.077-0.648) *Moderate (Low – Moderate)*
Pot belly disease (PBD)	0.300 (0.0002-0.969) *Moderate (Extremely low – High)*	0.405 (0.0001-0.670) *Moderate (Extremely low – Moderate)*	0.405 (0.0001-0.662) *Moderate (Extremely low – Moderate)*
Vibriosis /*Vibrio* spp.	0.602 (0.326-0.954) *Moderate (Moderate – Moderate)*	0.497 (0.320-0.680) *Moderate*	0.497 (0.320-0.683) *Moderate*
Streptococcosis / *Streptococcus* spp.	0.698 (0.338-0.962) *Moderate (Moderate – High)*	0.438 (0.011-0.673) *Moderate (Low – Moderate)*	0.428 (0.011-0.676) *Moderate (Low – Moderate)*

Table 15 Estimation of the overall risk posed by the disease agents considered in an assessment of the risk of disease introduction with the importation of Barramundi products.

Disease / Disease agent	**Likelihood of entry x exposure**			**Likelihood of spread x impact = Likely consequences**	**Overall risk**
	FARM	WILD CATCH	RECREATIONAL		
Red sea bream iridoviral disease (RSIVD)	*Moderate x Low = LOW*	*Moderate x Moderate = LOW*	*Moderate x Moderate = LOW*	*Moderate x Significant – Extremely significant = HIGH*	MODERATE RISK
Infectious spleen and kidney necrosis virus (ISKNV)	*Moderate x Low = LOW*	*Moderate x Moderate =LOW*	*Moderate x Moderate =LOW*	*Moderate x Significant – Extremely significant = HIGH*	MODERATE RISK
Scale drop syndrome (SDS)	*Moderate x Low = LOW*	*Moderate x Moderate =LOW*	*Moderate x Moderate =LOW*	*Moderate x Significant – Extremely significant = HIGH*	MODERATE RISK
Pot belly disease (PBD)	*Moderate x Low = LOW*	*Moderate x Moderate =LOW*	*Moderate x Moderate =LOW*	*Moderate x Significant – Extremely significant = HIGH*	MODERATE RISK
Vibriosis /*Vibrio* spp.	*Moderate x Very Low = VERY LOW*	*Moderate x Low =LOW*	*Moderate x Low =LOW*	*Moderate x Minor Significant – Significant = LOW*	VERY LOW RISK
Streptococcosis / *Streptococcus* spp.	*Moderate x Low = LOW*	*Moderate x Moderate =LOW*	*Moderate x Moderate =LOW*	*Moderate x Significant – Significant = MODERATE*	LOW RISK

5. Conclusion and recommendations

The current research project investigated those factors influencing the risk of disease introduction through the importation of Barramundi products into Australia, the potential pathways of exposure to native Barramundi and the likelihood of these pathways occurring. The study conducted did not intend to conduct a comprehensive import risk assessment but to provide an insight into the potential animal health risks, the gaps of information and recommendations for further research. This study followed the OIE framework for import risk analysis (World Organization for Animal Health (OIE), 2009) and used a literature review and expert consultation process to gather information to inform the assessment of the risk posed by the importation of Barramundi products into Australia. Due to the preliminary nature of this study and the limited number of experts providing likelihood estimates, results obtained should be interpreted with caution.

Findings from this study indicate that there are four exotic disease agents that could pose a risk to the Barramundi industry in Australia and the wider ecosystem with the importation of Barramundi products from overseas, these being: 1) Red sea bream iridoviral disease (RSIVD); 2) Infectious spleen and kidney necrosis virus (ISKNV); 3) Scale drop syndrome; 4) Pot belly disease. In addition, exotic strains of *Vibrio* spp. and *Streptococcus* spp., pathogens that are present in Australia, were also identified as hazards. According to the experts participating in the study, the overall risk of introduction and establishment of RSIVD, ISKNV, Scale drop syndrome and Pot belly disease with the importation of Barramundi products is estimated to be *Moderate*. This risk is considered to be *Low* and *Very Low* for *Streptococcus* spp. and *Vibrio* spp., respectively. The overall risk considers the likelihood of entry, exposure and spread and the impact due to this introduction. Experts agreed that the impact of all these diseases would be very high if introduced into the country, including, direct biological and economic consequences, domestic and export market consequences and environmental consequences. Introduction of these diseases into the wild was a concern due to the lack of effective control measures available to eradicate the diseases. In addition, experts considered that the high vaccine and labour costs and logistics required for vaccination in Australia would compromise the success of any control strategy for these diseases at farm level.

The data gathering processes identified significant gaps of information affecting the ability of accurately estimate the risk of disease introduction with the importation of Barramundi products. The main area lacking accurate information is in relation to the country of origin and the volumes of imported Barramundi. Barramundi does not have an international HTISC number, with the imports information being aggregated with other fish. Although it is known that the main markets for exporting Barramundi to Australia are in South East Asia, the fact that it comes as an aggregated product makes it difficult to identify the specific countries and volumes. Another area of lack of information is in relation to some of the disease agents identified as hazards. As previously suggested by Gibson-Kueh (2012), to accurately assess the risk posed, further research in better understanding the aetiology and epidemiology of Scale drop syndrome and Pot belly disease is required.

Although there is significant uncertainty around the expert estimates, this assessment suggest that the risk posed by the importation of Barramundi products for the Australian Barramundi industry is not negligible and should not be underestimated. Further research to reduce this uncertainty and to be able to accurately estimate this risk, is warranted. Furthermore, given the existent uncertainty and the lack of scientific information in relation to the diseases, the precautionary principle (Morton and Routledge, 2016) should be adopted when making decisions about importing Barramundi products, with a review of existing preventive biosecurity and disease control measures needed.

Recommendations arising from this research project are summarized as follow:

- For imported Barramundi products to have a specific international HTISC number. To accurately estimate the animal health risk posed by the importation of Barramundi products from overseas, specific information on country of origin and volumes of Barramundi imported is required.

- Further research on the aetiology and epidemiology of Scale drop syndrome and Pot belly disease in countries where these diseases are present, is required to better understand the risk these diseases pose to the Barramundi industry in Australia.

- For any further risk assessments to include seafood safety and zoonotic risk. Food safety and public health was outside the scope of this study, however, we consider this area to be a priority for Australia.

- Fish labelling systems to be reviewed to identify potential issues in relation to domestic and imported product differentiation. As an example, the use of forensic trace elements analysis as a regulatory tool could be used to ensure correct product labelling.

- Increase awareness of the risk of disease transmission posed by fish waste used as bait. Information on the potential risk of disease transmission posed by the use of waste of fish for human consumption as bait to be disseminated among commercial and recreational fishers.

- The current risk assessment for importing barramundi into Australia is generic, outdated and should be updated in line with potential emerging risks and changing international trade.

- Until a comprehensive risk assessment is conducted and required data is collected, the lack of scientific information and the uncertainties around the importation of Barramundi products justify the use of the precautionary principle in decision making and the need to take action to mitigate the risk in relation to the products imported.

6. Extension and Adoption

The final report will be distributed among interested stakeholders, including the Australian Barramundi Farmers Association and the relevant aquatic animal health government departments.

This study will be presented, if approved by FRDC, to the Australasian Scientific Conference on Aquatic Animal Health in July 2017.

7. Appendices

Appendix A: Semi-qualitative questionnaire

An assessment of the risk of exotic* disease introduction and spread among Australian Barramundi farms and the broader ecosystem from the importation of Lates calcarifer products
Expert Consultation - Initial questionnaire

Your name:
Organisation:
Position:

Note- you will not be individually identified in any reports/publications.

Table A Qualitative estimates of likelihood (Q2a,b,c)

Likelihood	Probability range		
Negligible	0	*to*	0.000001
Extremely low	0.000001	*to*	0.001
Very low	0.001	*to*	0.05
Low	0.05	*to*	0.3
Moderate	0.3	*to*	0.7
High	0.7	*to*	1

Below is a list of pathogens that are exotic to Australia with potential for introduction and spread among Australian Barramundi, sourced from literature.

1. In the first instance please,
   a. review the list with reference to completeness and accuracy of information
   b. indicate if the disease/pathogen should be included in an import risk assessment of barramundi
2. For those diseases/pathogens that should be included in an import risk assessment, please,

Qualitatively evaluate the risk posed by each of this pathogen in relation to:

a. likelihood of being introduced into Australia with imported Barramundi products, ((refer table A)
b. likelihood of exposure of the Australian barramundi industry: farm, wild catch and recreational, (refer table A)
c. likelihood of spread of the pathogen once introduced to the barramundi sector- farm, wild catch and recreational, and (refer table A)
d. impact of the spread of the pathogen (refer Table B)

Justification of your estimates will be discussed during the phone semi-structured interview

Table B Qualitative estimates of impact (Q2d)

Impact	Description
Insignificant	when the impact is not causing a distinguishable variation or effect at the specific level
Minor significance	when the impact is identifiable but reversible at the specific level
Significant	when the impact is serious and affecting economic viability, but reversible at the specific level
Extremely significant	the impact is extremely serious, affects the economic viability and is irreversible at a specific level

Disease /Agent		Type	Comment	a. Likelihood of introduction	b. Likelihood of exposure			c. Likelihood of spread			d. Impact of spread
					Farm	Wildcatch	Recreational	Farm	Wildcatch	Recreational	
Example: Disease /agent A				*Very low*	*Low*	*High*	*Extremely low*	*Low*	*Low*	*Moderate*	*Significant*
Infectious hematopoietic necrosis virus (IHNV) / Novirhabdovirus	Exotic	Viral									
Viral haemorrhagic septicaemia (VHS) / Rhabdovirus viral haemorrhagic septicaemia virus (VHSV)	Exotic	Viral									
Red sea bream iridoviral disease (RSIVD) / Red sea bream iridovirus	Exotic	Viral									
Scale drop syndrome	Exotic	?									
Viral erythrocytic necrosis(VEN) / Erythrocytic necrosis virus	Exotic	Viral									
Infectious pancreatic necrosis (IPNV) / Aquabirnavirus	Exotic	Viral									
Infectious spleen and kidney necrosis virus (ISKNV) / Megalocytivirus, family Iridoviridae	Exotic	Virus									
Spring viraemia of carp virus (SVC)	Exotic	Viral									
Viral encephalopathy and retinopathy (VER) or viral nervous necrosis (VNN) / Nervous necrosis virus Betanodavirus	Endemic	Viral									
Epizootic haematopoietic necrosis / Iridovirus	Endemic	Viral									
Lymphocystis / Iridovirus	Endemic	Viral									
Vibriosis / Vibrio spp	Exotic	Bacteria									
Bacterial haemorrhagic septicaemia / Aeromonas hydrophila	Exotic	Bacteria									
Streptococcosis spp	Exotic	Bacteria									
Pot belly disease	Exotic	Bacteria									
Nocardiosis / Nocardia spp	Endemic	Bacteria									
Streptococcosis / Streptococcus iniae	Endemic	Bacteria									
Tenacibaculosis / Tenacibaculum maritimum	Endemic	Bacteria									
Aeromonas salmonicida	Exotic	Bacteria									
Enteric septicaemia of catfish / Edwardsiella ictaluri	Endemic	Bacteria									
Columnaris disease / Flexibacter columnaris, Flexibacter maritimus	Endemic	Bacteria									
Epitheliocystis / Chlamydiaceae	Endemic	Bacteria									
Rickettsiaceae	Endemic	Bacteria									
Pseudomonas anguilliseptica	Exotic	Bacteria									
Francisellaceae	Endemic	Bacteria									
Epizootic ulcerative syndrome /Aphanomyces invadans	Endemic	Fungal									
Cryptocaryon irritans	Endemic	Parasitic									
Trichodina spp	Exotic	Parasitic									
Neobenedinia spp	Exotic	Parasitic									
Eimeria	Exotic	Parasitic									
Other diseases not listed:											

*please note that where endemic diseases are included, consider the potential for more pathogenic/virulent overseas strains entering

Appendix B: Semi-structured follow-up interview

Follow-up interview:

1. Discuss the list of pathogens to identify any gaps of information: Which diseases should or should not be included in an IRA of Barramundi products coming into Australia.

   For those that should not be included, why? (e.g. not present in the exporting country / endemic in Australia (same strain))

2. Discuss the pathogens they believe are posing the highest risk to the Barramundi industry in Australia and why.

For Australian experts:

3. In relation to new or emerging diseases, such as, Iridovirus, Scale drop syndrome, Asian strains of streptococcus, Pot belly disease and Vietnamese Barramundi disease, what is your opinion or current knowledge of the occurrence of these diseases in SE Asian countries and Saudi Arabia?

4. In relation to likelihoods of exposure, what did you consider when providing these estimates? (pathways, product)

5. Which Barramundi product did you consider when estimating the likelihood of introduction that you provided on the questionnaire? Would this likelihood change according to the product imported?
   If yes, what is the relative risk of disease introduction among these products?

- Whole fish
- Headed, gutted
- Fillets
- Fresh vs. frozen

Is this relative risk going to be different according to the disease?

6. If the infected product is introduced into Australia (for human consumption), what are the potential pathways of exposure of the Australian Barramundi industry sectors (farm, wildcatch, recreational).
   Contemporary farm practices?

7. If native Barramundi gets exposed to these diseases (this might differ by disease) how likely is that the pathogen will establish? We need to consider infection after exposure, spread to other fish and establishment of the infection.

8. In relation to the estimates provided how certain are you of these?

Appendix C: Participant Information Sheet

SCHOOL OF ANIMAL AND VETERINARY SCIENCES
FACULTY OF SCIENCE
Locked Bag 588
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Participant Information Sheet

An assessment of the risk of exotic disease introduction and spread among Australian Barramundi farms and the broader ecosystem from the importation of *Lates calcarifer* products

Principal Investigators:
Dr Marta Hernandez-Jover, BVSc, MSc, PhD. Senior Lecturer Veterinary Epidemiology and Public Health
Email mhernandez-jover@csu.edu.au Ph 02 6933 2086
Dr Shokoofeh Shamsi, BVSc, PhD. Senior Lecturer in Veterinary Parasitology
Email sshamsi@csu.edu.au Ph 02 6933 4887

You are invited to participate in a research study investigating risk of exotic disease introduction and spread among Australian Barramundi farms and the broader ecosystem from the importation of Lates calcarifer products. Participants are required to be at least 18 years old.

The study is being conducted by Dr Marta Hernandez-Jover and Dr Shokoofeh Shamsi from the School of Animal and Veterinary Sciences Charles Sturt University.

Before you decide whether or not you wish to participate in this study, it is important for you to understand why the research is being done and what it will involve. Please take the time to read the following information carefully and discuss it with others if you wish.

What is the purpose of this study?
The overall aim of this project is to assess the potential risk of introduction and spread of exotic diseases affecting the Barramundi industry in Australia, including the aquaculture industry, wild catch commercial, indigenous and recreational fisheries, through the importation of Barramundi products from overseas.

Specifically, the purpose of the expert consultation is to gather information in relation to pathogens (hazards) exotic to Australia that could be introduced through the importation of Barramundi products and could pose a risk for the Barramundi industry. This information will then be used to inform the risk assessment.

Why have I been invited to participate in this study?
We are seeking the participation of aquatic animal health experts. You have been identified as having the level of experience and expertise in aquatic animal health to assist in this area of research.

What does this study involve?
If you agree to participate you will be asked to complete a questionnaire in relation to exotic pathogens and the risk that they pose to the Australian Barramundi industry. Following the return of this information to the researchers, you will be contacted to arrange a 1-h telephone (or face-to-face, if preferred) interview to discuss the outcomes of the questionnaire.

Are there any risks and benefits to me in taking part in this study?
There are no identified risks or individual benefits associated with participating in the research.

How is this study being paid for?
The project is being funded by the Fisheries Research and Development Corporation.

Will taking part in this study (or travelling to) cost me anything, and will I be paid?
You will encounter no costs nor are there any payments associated with participating in the research.

What if I don't want to take part in this study?
Participation in this research is entirely your choice. Only those people who give their informed consent will be included in the project. Whether or not you decide to participate is your decision and will not disadvantage you.

What if I participate and want to withdraw later?
If you do decide to participate you may withdraw from the project at any time without giving a reason. Completion of the questionnaire does not place you under any obligation to participate in the follow up interview. Your data will be destroyed if you choose to withdraw, unless you specifically direct us otherwise.

How will my confidentiality be protected?
Individuals will not be identified in any reports arising from the research.

The information that you provide through the questionnaire will be transferred to a database (excel) for analysis. Interviews will be recorded and transcribed in an electronic format. All electronic data will be stored in a password secured computer file.

All information collected by the researchers will be stored securely and only accessed by the researchers unless you consent otherwise, except as required by law. Data will be retained for at least 5 years at Charles Sturt University, School of Animal and Veterinary Sciences, Wagga Wagga.

What will happen to the information that I give you?
It is the intention of the researchers to undertake a risk assessment which will be forwarded to the Fisheries Research and Development Corporation in the form of a report. The outcomes of the study may also be published in an appropriate scientific journal. Individual participants will not be identified in any reports arising from the research.

What should I do if I want to discuss this study further before I decide?
If you would like further information please contact:

Dr Marta Hernandez-Jover, Charles Sturt University, School of Animal and Veterinary Sciences
Email mhernandez-jover@csu.edu.au Ph 02 6933 2086

Dr Shokoofeh Shamsi, BVSc, PhD. Senior Lecturer in Veterinary Parasitology
Email sshamsi@csu.edu.au Ph 02 6933 4887

Who should I contact if I have concerns about the conduct of this study?
Charles Sturt University's Faculty of Science Human Research Ethics Committee has approved this project. If you have any complaints or reservations about the ethical conduct of this project, you may contact the Executive Officer.

The Executive Officer
Faculty of Science Low Risk Human Ethics Committee
Charles Sturt University
Locked Bag 49
Dubbo NSW 2830
Tel: (02) 6885 7327
Email: scienceFHEC@csu.edu.au
Any issues you raise will be treated in confidence and investigated fully and you will be informed of the outcome.

What do I do next?
If you are interested in participating, please contact a member of the research team:

Dr Marta Hernandez-Jover
Email mhernandez-jover@csu.edu.au
Ph 02 6933 2086

Dr Shokoofeh Shamsi
Email sshamsi@csu.edu.au
Ph 02 6933 4887

Interested persons will then be sent a consent form to be completed and returned prior to commencement.
Thanks for taking the time to consider participating in this research.

This information sheet is for you to keep.

Appendix D: References

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