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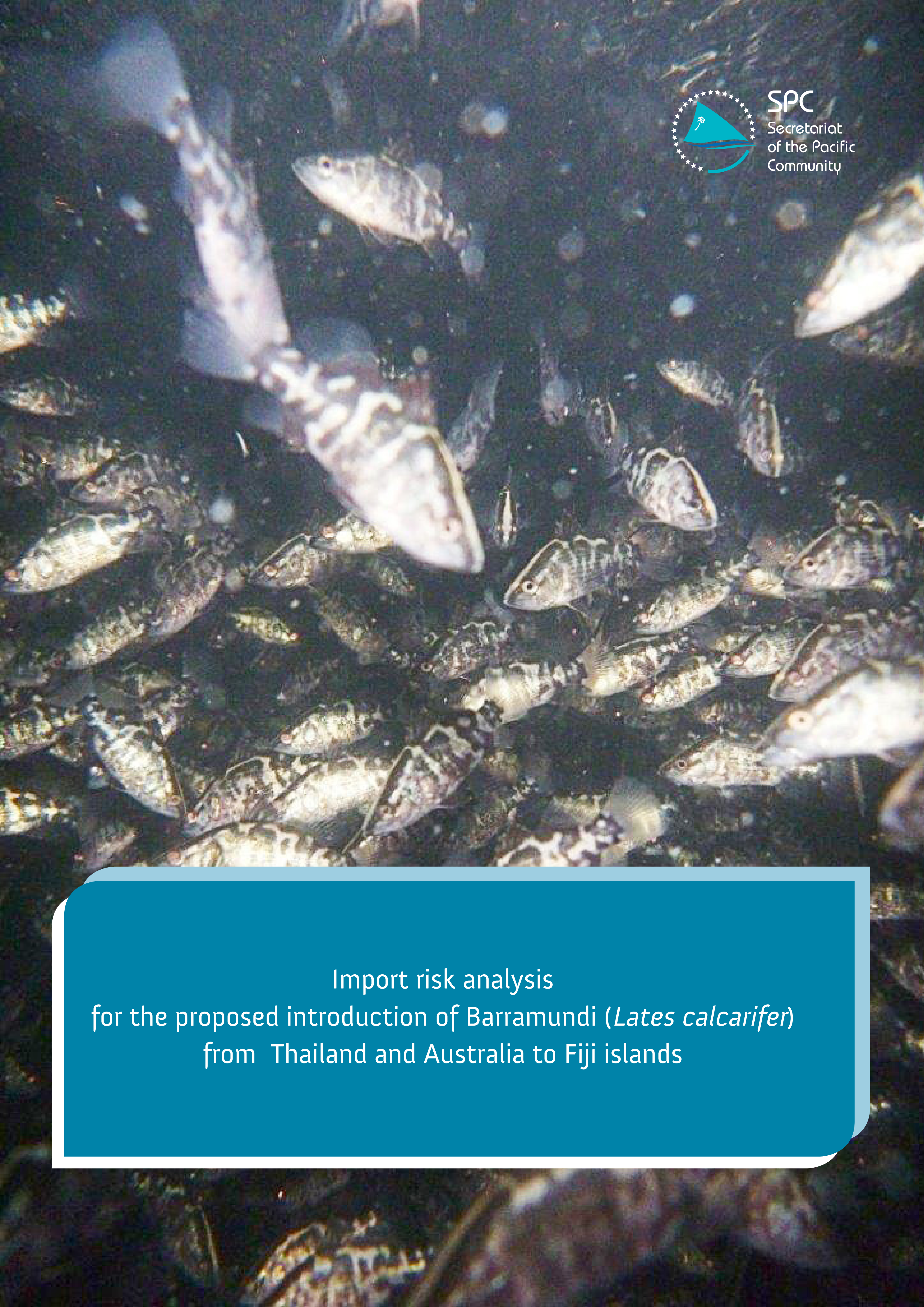

Import risk analysis for the proposed introduction of Barramundi (*Lates calcarifer*) from Thailand and Australia to Fiji islands

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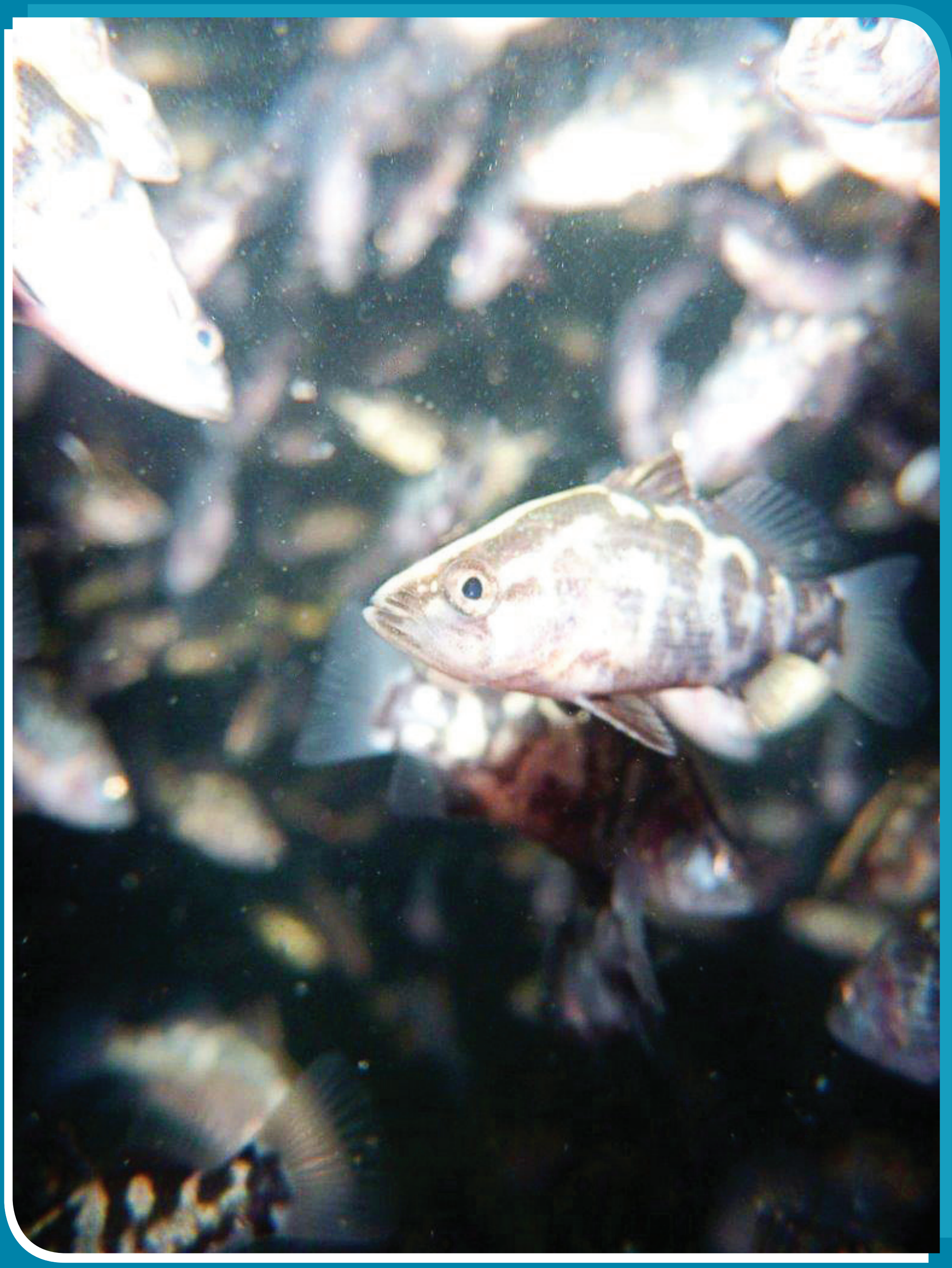
by the Secretariat of the Pacific Community

Secretariat of the Pacific Community, Noumea

Contents



C1. Introduction

1.1. General background information

The objective of this report is to undertake a risk analysis of the potential pathogen-related and ecological risks associated with the proposed introduction of the species *Lates calcarifer* (commonly known as barramundi or Asian sea bass) from Thailand or Australia to Fiji Islands for aquaculture purposes. This import risk analysis includes:

1. **a pathogen risk analysis** (section 8), which examines the potential risks of introducing pathogens with the specimens, either as opportunistic microorganisms or as real primary pathogens, and considers ways to minimise these risks; and
2. **an ecological risk analysis** (section 9), which considers the potential for the proposed species to become invasive in the receiving waters, as well as the nature of any potential ecological impacts of the species on the environment, and proposes ways to minimise these risks.

The primary concern about the proposed introduction of the barramundi specimens from Australia or Thailand is whether it is likely to introduce exotic diseases as well. It is noteworthy that the proposed countries of origin, Australia and Thailand, have stringent health requirements regarding product.World Organisation for Animal Health (OIE) that could affect barramundi: the red sea bream iridoviral disease (RSIVD) and the rethinopathy and encephalopathy viral disease (VNN); and Thailand is free of RSIVD and its proposed facility of origin.

The secondary concern is whether the species is likely to become invasive in Fijian waters. Previous experience of introducing this species into new environments (e.g. Vanuatu and French Polynesia) has shown that the species has a medium to high level of invasiveness. However, such experience has also shown that the species is less likely to be released to the natural environment, and that the consequences of any introduction can be reduced to an acceptable level if minimum biosecurity protocols are applied at farm level (site selection, basic infrastructures, biosecurity measures, water distribution and filtration systems, water management strategies, etc.).

The species has a complex life cycle and it must migrate to reach maturity. Due to these factors, its chances of escape, survival and reproduction in the wild are relatively low. The species has not been reported as invasive in any of the introductions implemented in the past (Food and Agriculture Organization's Database on Introductions of Aquatic Species (FAO DIAS): www.fao.org/fishery/dias/en).

Lastly, this risk analysis assesses the main ecological risks of the farming activity itself, such as the effects of: water effluents; use of chemical products; and use of artificial pellets. Correspondingly it proposes mitigation measures to keep these risks to an acceptable level.

1.2. Purpose of introducing Barramundi

The main purpose of introducing barramundi is to develop a small-scale aquaculture industry in Fiji Islands that is focused on the existing and increasing demand from the domestic market (import substitution). This enterprise will promote local employment and economic development. Supporting this potential, regional airlines have registered strong interest in making barramundi part of inflight meals. In addition, it is well known that all countries in the Melanesian Spearhead Group are currently importing relatively large volumes of Asian sea bass (plate size and fillets) from several Asian countries.

The proposed project would directly create over 40 jobs as well as indirectly sustaining a substantial number of jobs in supporting industries and numerous communities in the rural communities surrounding the regional towns of Ba and Lautoka in the Fijian Archipelago. It would expand the range of exports from Fiji Islands and generate hard currency receipts from sales to established export markets. The project would be developed in phases over five years. Its three main components are:

- a multi-species hatchery for production of fingerlings and post larvae (including broodstock after importation of initial stocks). The establishment of this hatchery is one of the main prerequisites for the approval of this transfer;

- the redevelopment of the existing lease to grow the seedstock to commercial size for local and export markets; and
- a processing/packing plant, where the product will be packed and frozen for the local and export markets.
- The majority of the production is aimed at the local market. In addition, there is extensive interest in exported live and/or fresh air-freighted product.

1.3. Project overview

Table 1 lists the key features of barramundi relevant to the proposed project, along with the main players and production goals in the project.

Table 1: Overview of the species and the proposed project

Species to be imported	*Lates calcarifer* (barramundi, Asian sea bass)
Proposed date of importation	Third trimester of the year 2013
Life cycle to be imported	>20 mm (recommended day-old fry)
Importer	Pacific Ocean Culture Fiji Ltd Name of the owner: Mr Paul Christian Ryan
State agency submitting the proposal	Ministry of Fisheries and Forests, Fiji Islands
Proposed exporter	Jeremy & Abby Muir Trading, Queensland (Australia) and Nam Sai Farms Ltd (Thailand)
Proposed source	Jeremy & Abby Muir Trading, Queensland (Australia) or Nam Sai Farms Ltd (Thailand)
Proposed number of shipments	4 shipments a year for a minimum period of 4 years
Volume	500,000 fry per shipment (50 boxes containing 10,000 fry in each box)
Proposed destination	Raviravi (ex-Fijiprawn Ltd.)

2. Background of the species proposed for introduction

2.1. Historical Background

Lates calcarifer, known as sea bass in Asia and as barramundi in Australia, is a large, euryhaline member of the family Latidae that is widely distributed in the Indo-West Pacific region from the Arabian Gulf to China, Taiwan/ROC, Papua New Guinea and northern Australia. Aquaculture of this species began in Thailand in the 1970s and rapidly spread throughout much of Southeast Asia.

Today barramundi is farmed throughout most of its range. Most production occurs in Southeast Asia, generally from small, coastal cage farms. Often these farms will culture a mixture of species in addition to barramundi, such as groupers (family Serranidae, subfamily Epinephelinae) and snappers (family Lutjanidae). In Australia, large-scale barramundi farms are being developed along the lines of the industrialised style of aquaculture in Europe. Where barramundi is farmed outside the tropics, recirculation production systems are often used (e.g. in southern Australia and in the northeastern United States of America).

Barramundi has been introduced for aquaculture purposes in three member countries and territories of the Secretariat of the Pacific Community: Vanuatu, Guam and French Polynesia. It is being successfully farmed on a commercial scale in Vanuatu (by the sister company of Pacific Ocean Culture (Fiji), which is proposing the introduction to Fiji Islands).

2.2. Biological Features

The barramundi has:

- body elongate, compressed, with a deep caudal peduncle;
- head pointed, with concave dorsal profile becoming convex in front of dorsal fin;
- mouth large, slightly oblique, upper jaw reaching to behind eye; teeth villiform, no canines present;
- lower edge of pre-operculum with a strong spine; operculum with a small spine and with a serrated flap above origin of lateral line;
- lower first gill arch with 16 to 17 gill rakers;
- scales large, ctenoid;
- dorsal fin with 7 to 9 spines and 10 to 11 soft rays; a very deep notch almost dividing spiny from soft part of fin; pectoral fin short and rounded, several short, strong serrations above its base; dorsal and anal fins both have scaly sheaths; anal fin rounded, with 3 spines and 7 to 8 short rays; caudal fin rounded; and
- colour in two phases, either olive brown above with silver sides and belly (usually juveniles) or green/blue above and silver below. No spots or bars present on fins or body.

2.3. Taxonomy

Kingdom: Animalia

Phylum: Chordata

Class: Actinopterygii

Order: Perciformes

Family: Latidae

Genus: *Lates*

Species: *L. calcarifer*

2.4. Habitat and biology

Barramundi live in freshwater, brackish and marine habitats including streams, lakes, billabongs, estuaries and coastal waters. They are opportunistic predators; crustaceans and fish are the main diet of adult barramundi.

The season of spawning varies within the range of this species.

- Barramundi in northern Australia spawn between September and March, with latitudinal variation in spawning season, presumably in response to varying water temperatures.
- In the Philippines, barramundi spawn from late June to late October.
- In Thailand, spawning is associated with the monsoon season, with two peaks during the northeast monsoon (August–October) and the southwest monsoon (February–June).

Spawning occurs near river mouths, in the lower reaches of estuaries, or around coastal headlands. Barramundi spawn after the full and new moons during the spawning season, and spawning activity is usually associated with incoming tides that apparently help to transport eggs and larvae into the estuary.

Barramundi are highly fecund; a single female (120 cm total length or TL) may produce 30–40 million eggs. Consequently, only a *small* number of broodstock is needed to provide an adequate number of larvae for large-scale hatchery production. The high fecundity rate is one important reason for the success of this species.

Larvae recruit into estuarine nursery swamps where they remain for several months before they move out into the freshwater reaches of coastal rivers and creeks. Juvenile barramundi remain in freshwater habitats until they are three to four years of age (60–70 cm TL) and reach sexual maturity as males. They then move downstream during the breeding season to participate in spawning. Because barramundi are euryhaline, they can be cultured in a range of salinities, from fresh to seawater.

When they are six to eight years old (85–100 cm TL), Australian barramundi change sex to female and remain female for the rest of their lives. Sex change in Asian populations of this species is less well defined and primary females are common.

Although some barramundi have been recorded as moving extensively between river systems, most of them remain in their original river system and move only short distances. This limited exchange of individuals between river systems has contributed to the development of genetically distinct groups of barramundi in northern Australia. There are six recognised genetic strains in Queensland, and a further 10 in the Northern Territory and Western Australia.

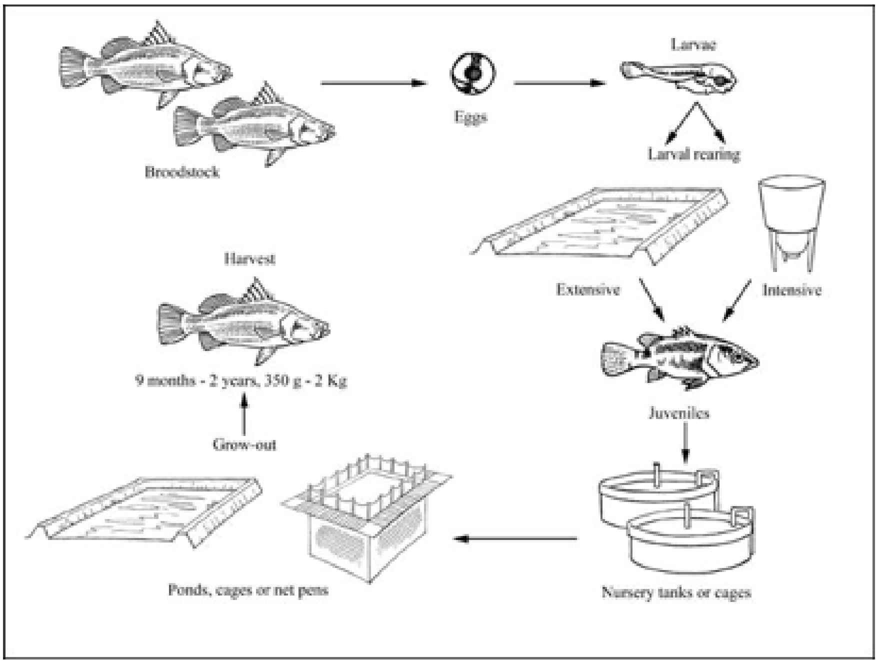


Figure 1: Barramundi production cycle

2.5. Production cycle

Figure 1 summarises the production cycle of the barramundi, from the collection and selection of broodstock, through the production of fry and fingerling to the on-growing techniques.

2.6. Common production systems

This section gives an overview of common production systems used through five stages of barramundi production: seed supply; rearing fingerlings; hatchery; nursery; and on-growing techniques.

Seed supply

While barramundi fingerlings are still collected from the wild in some parts of Asia, most seed supply comes through hatchery production. Hatchery production technology is now well established throughout the culture range of this species (see section 2.6.3 below).

Rearing fingerlings

Barramundi broodstock is held in floating cages or in concrete or fibreglass tanks. It is maintained in either fresh or seawater but must be placed in seawater (28–35% salinity) before the breeding season so that final gonadal maturation can take place. Barramundi show no obvious external signs of gonadal development and must be examined by cannulation to determine their gender and reproductive status, although milt can be expressed easily from male fish during the spawning season. Barramundi broodstock is usually fed with 'trash' fish or commercially available feeds.

Asian barramundi have been induced to spawn by manipulating environmental parameters (salinity and temperature) to simulate the migration to the lower estuary, and the tidal regime there at the time of natural spawning. The same techniques have proven unsuccessful with Australian populations of barramundi. Instead, they generally require hormonal induction to spawn; this method has been successful using a range of hormones at various doses, administered by techniques such as injection, slow-release cholesterol pellets and osmotic pumps. Spawning of barramundi is now generally induced using the leuteinising hormone-releasing hormone analogues.

At spawning, the sperm and eggs are released into the water column and fertilisation occurs externally. Barramundi eggs are 0.74–0.80 mm in diameter, with a single oil droplet of 0.23–0.26 mm in diameter. The eggs are collected from spawning tanks using fine-mesh (around 300 μm) egg collection nets through which tank water is diverted. If barramundi are spawned in cages, the cages are lined with a fine-mesh 'hapa' net that keeps the eggs inside the cage so that it is later easy to remove them and transfer them to the hatchery.

Fertilised eggs develop rapidly, hatching 12–17 hours after fertilisation at 27–30°C. Newly hatched larvae have a large yolk that is absorbed rapidly over the first 24 hours after hatching, and is largely exhausted by 50 hours after hatching. The oil globule is absorbed more slowly and persists for about 140 hours after hatching. The mouth and gut develop the day after hatching (day two) and larvae begin feeding from 45–50 hours after hatching.

Hatchery production

Barramundi are generally reared using 'green water' intensive techniques, in circular or rectangular concrete tanks or in circular canvas tanks with up to 26 m^3 capacity. A microalgal culture (usually *Tetraselmis* spp. or *Nannochloropsis oculata*) is added to the rearing tanks at densities ranging from $8–10\times10^3$ to $1–3\times105$ cells per ml. Intensively reared barramundi are fed on:

- rotifers (*Brachionus plicatilis*) from day two (where day one is the day of hatching) until day 12 (or as late as day 15); and
- brine shrimp (*Artemia* sp.) from day eight onwards.

Both rotifers and brine shrimp fed to barramundi are cultured on microalgae or commercial enrichment products to increase levels of highly unsaturated fatty acids. The freshwater cladocerans *Daphnia* and *Moina* have been used to supplement, or replace, brine shrimp as prey for intensively reared barramundi larvae. Overall survival for intensively reared barramundi larvae, from hatching to about 10 mm TL, generally ranges from 15–50 per cent. Compounded microdiets have been used to partly or totally replace brine shrimp in the intensive larval rearing of barramundi.

Barramundi fingerlings are also produced using extensive (pond-based) rearing procedures. Pond areas used for the extensive larval rearing of barramundi range from 0.05 to 1 ha and may be earthen or plastic lined. They are relatively shallow (less than 2 m deep) to promote maximum production of phytoplankton and to prevent stratification. Larval rearing ponds are managed by applying inorganic and organic fertilisers to produce a 'bloom' of suitable zooplankton along with the introduction of the newly hatched barramundi larvae. Barramundi larvae are stocked at densities of 400,000–900,000 larvae per hectare. Continued pond management focuses on supporting adequate zooplankton populations for the developing larvae, and continuing to meet water quality criteria. Barramundi are harvested from the ponds when they reach 25 mm TL or longer (about three weeks after stocking), and are then transferred to nursery tanks. The survival rate of extensively reared barramundi averages about 20 per cent, but is highly variable, ranging from 0 to 90 per cent. Production rates of up to 640,000 fish per hectare have been achieved in extensive rearing.

Nursery

Barramundi juveniles (1.0–2.5 cm TL) may be stocked in floating or fixed nursery cages in rivers, coastal areas or ponds, or put directly into freshwater or brackish water nursery ponds or tanks. The fish are fed on minced trash fish (4–6 mm) or on small pellets. Vitamin premix may be added to the minced fish at a rate of 2 per cent. This nursery phase lasts for 30 to 45 days; once the fingerlings have reached 5–10 cm TL they can be transferred to grow-out ponds.

Cannibalism can be a major cause of mortalities during the nursery phase and during early grow-out because barramundi will cannibalise fish that are up to 61–67 per cent of their own length. Cannibalism may start during the later stages of larval rearing and is most pronounced in fish less than about 150 mm TL; in larger fish, it is responsible for relatively few losses. Cannibalism is reduced by grading the fish at regular intervals (usually at least every seven to ten days) to ensure that the fish in each cage are similar in size.

On-growing techniques

Most barramundi culture is undertaken in net cages. Both floating and fixed cages are used; these range in area from 3×3 m up to 10×10 m, and in depth from 2–3 m. In Australia and the United States of America, a number of barramundi farms have been established using recirculation freshwater or brackish water systems with a combination of physical and biological filtration. These farms may be located in regions where barramundi could not otherwise be farmed because of consistently low temperatures (southern Australia, northeastern United States of America). The major advantage of such culture systems is that they can be sited near markets in these areas, thus reducing transport costs for the finished product.

The stocking densities used for cage culture generally range from 15 to 40 kg/m^3, although densities may be as high as 60 kg/m^3. Generally, higher densities reduce growth rates, but this effect is relatively minor at densities under about 25 kg/m^3. Barramundi farmed in recirculation production systems are stocked at a density of about 15 kg/m^3.

Barramundi are also farmed in earthen or lined ponds without cages; in Australia, this technique is called 'free ranging'. Juvenile barramundi (20–100 g) are cultured in brackish water ponds at 0.25–2.0 fish per square metre. In Asia, barramundi may be polycultured in brackish water ponds with tilapia (*Oreochromis* spp.) as a food source.

2.7. Main Producer Countries

Although barramundi has been introduced for aquaculture into a number of other countries, including Vanuatu, Guam and French Polynesia in the Pacific Island region as noted in section 2.1. However, only a few countries have reported production so far, including Australia and several Southeast Asian countries (see figure 2).

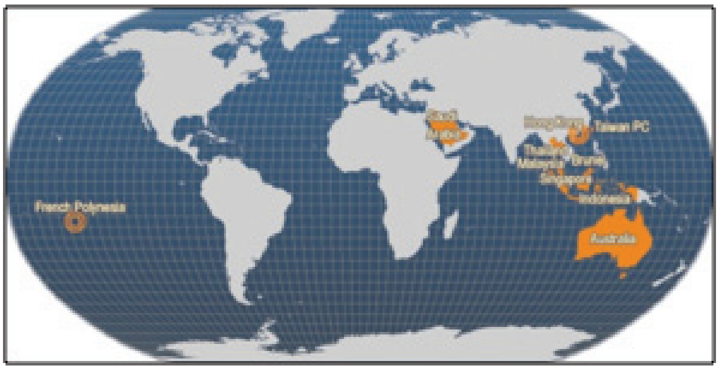


Figure 2: Main producer countries for barramundi. Source: FAO fisheries factsheets

2.8. Aquaculture attributes

Among the attributes that make barramundi an ideal candidate for aquaculture are that:

- it is a relatively hardy species that tolerates crowding and has wide physiological tolerances;
- the high fecundity of female fish provides plenty of material for hatchery production of seed;
- hatchery production of seed is relatively simple;
- barramundi feed well on pelleted diets, and juveniles are easy to wean to pellets; and
- barramundi grow rapidly, reaching a harvestable size (350 g – 3 kg) in six months to two years.

2.9. Market and trade

In Asia, most barramundi are marketed at 500–900 g, although small numbers of larger fish (1–3 kg) are also sold. In Australia, there are two main products from farmed barramundi:

- 'plate size' fish, which range from 350–500 g, although larger (banquet) fish may be up to 800 g; and
- fillet product fish, which are generally in the range of 2–3 kg.

Little effort has been given to developing value-added products for barramundi. In Australia, there are a few suppliers of smoked barramundi.

Throughout its cultured range, live barramundi is sold to restaurants that specialise in live seafood products, but this is a relatively small proportion of the total market for barramundi. The Australian Barramundi Farmers Association has adopted product quality standards to address the issue of highly variable product quality in the Australian market (for details, see its website www.abfa.org.au).

3. Description of the receiving facility

Quarantine – initial nursery stage: Introduced fingerling (longer than 20 mm) will be maintained within a closed tank system for a period of 14 days. For details on pre-border and post-border quarantine measures (e.g. water filtration systems for inlet and effluents), see section 8.8.

4. Proposed farming site and farming strategies

Pacific Ocean Culture (Fiji) Ltd, an entity incorporated in Fiji Islands, will redevelop and manage the property currently known as Raviravi or Fiji Prawns Ltd. It is an integrated enterprise that will focus on the sustainable production and export of finfish and marine prawn products in rural Viti Levu, Fiji Islands.

The exact location of the proposed site for the enterprise is shown in figure 3.

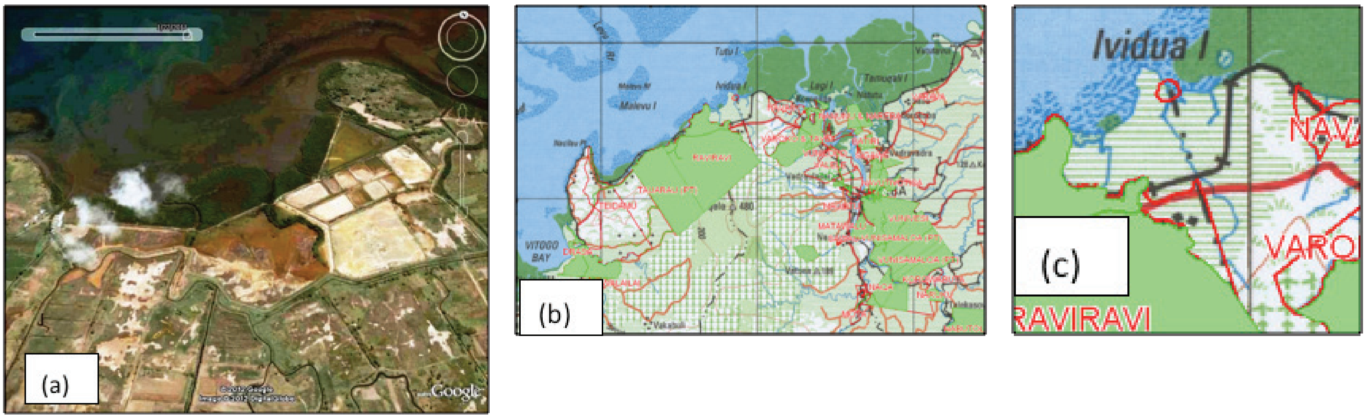


Figure 3: Site of proposed enterprise of Pacific Ocean Culture (Fiji) in Viti Levu from three perspectives: (a) satellite view; (b) map of area; and (c) map showing close-up view of site

There are three operational sections: the hatchery (initially a quarantined nursery for imported juveniles), where the larval stock is produced and grown for stocking; the farm, where the juveniles are grown out to market size; and the processing/packing plant, where the product is packed and shipped or air-freighted fresh for the export market.

The project will use the following farming strategies.

- **Quarantine – initial nursery stage:** Introduced fingerling (longer than 20 mm) will be maintained in a tank system for a period of 14 days. For details of pre-border and post-border quarantine measures (e.g. water filtration systems for inlet and effluents, quarantine operations), see section 8.8.
- **Hatchery:** The hatchery and nursery design will be modular, with an initial production capacity that is sufficient to initially provide animals for further grow-out to the farm. It will be a relatively high-technology facility that will produce larvae in a closely monitored environment. Operations will be divided into maturation, larvae, and algae or live feed production. Large indoor tanks using filtered water at a high-water exchange rate will be used, and larvae stocking densities will be high. An outdoor, broodstock programme will be established in small tanks adjacent to the hatchery unit, to develop objectives for finfish genetic improvement as a second step after the introduction.
- **Secondary nursery stage:** Small nursery ponds will maintain the stock in hapas (size between 1–3 m^3) for 1.5 to 2 months. Stocking densities will be around 20–30 kg/m^3. Hapas will be changed during the nursery stage while grading is taking place and new nets are prepared.
- **Grow-out:** The farm will be managed as a semi-intensive grow-out system, with direct stocking of juveniles to production in earthen ponds and floating cages. Stock will have highly digestible formulated diets, in order to maximise feed conversion ratios and growth rates. The farm inflow and pond inlets will be screened (500 microns). Stocking densities will be semi-extensive, varying from 0.5 to 2 animals per square metre. These low stocking densities will promote healthier fish and hence reduce health issues markedly. Pond outlets will be double-screened according to stock sizes and farm effluent screened.
- **Feeding:** Stock will have artificial diets that are highly digestible and species-specific.
- **General management practices:** The site has access to both fresh and seawater at both the farm and hatchery. Therefore, the proposal is to undertake culture in both systems, which will allow for treatment of parasites and other external pathogens with alternate culture water ('salt baths' or 'salinity changes').

Grading is of utmost importance in barramundi farming during all life stages and will be intensive during the early and nursery stages. Grading during the grow-out period will be less frequent.

It is anticipated that no chemical treatments will be required during grow-out periods and that they will be only a 'last resort' during nursery stages.

- **Processing and packing plant:** Fresh product will arrive from the farm live and in excellent condition and will be classified by hand. Product destined for the live market trade will be placed within purging tanks prior to departure. Microbiological tests will be undertaken in the laboratory before the product is shipped to ensure it is safe for customers.

5. Technical justification for the introduction

The main purpose of introducing barramundi is to develop a small-scale aquaculture industry in Fiji Islands focused on the existing and increasing demand from the domestic market (import substitution, as well as food and nutrition security). This enterprise will promote local employment and economic development. Notably, regional airlines have registered strong interest in including the product in their inflight meals. In addition, all countries in the Melanesian Spearhead Group are importing relatively large volumes of Asian sea bass (plate size and fillets) from Asian countries.

This project will expand and diversify seafood exports from Fiji Islands, while generating annual hard currency earnings from established exports markets in Australia, Asia and Pacific Island countries. On becoming fully operational in 2014, after initially importing seedstock and further redeveloping the existing hatchery infrastructure, the project will produce an estimated 200 MT of finfish per year .

According to the business plan submitted to The Fiji Ministry of Fisheries and Forests the project will be developed under current international codes of practice for responsible aquaculture and accepted industry best management practices. It will also implement comprehensive biosecurity measures, and will be fully compliant with aquaculture regulations of Fiji Islands. The project will implement environmentally balanced and responsible production practices, while further developing technology throughout the value chain.

The project will initially rebuild the proposed site and operate its entire lease. This 'first phase' will also include the reconstruction of a small hatchery (in year three) as well as a processing and packing plant. Subsequent expansion will use effective production technologies. Table 2 gives an overview of the first three years of project development.

As to the logistical question of how to get the product to its markets, exported products will be air-freighted from Nadi. Pacific Ocean Culture (Fiji) Ltd has consulted with other operators who have successfully achieved similar goals (i.e. Pacific Prawns, Tebara Meats/Navua Farm and Hunter Pearls). There appear to be no obstacles that cannot be overcome within the immediate future.

Table 2: The first phase of project development

Year	Main activities
Year one (a) First half (wet season)	Begin infrastructure redevelopment and purchase major equipment items. Import culture units and develop feed infrastructure. Collect local wild broodstock.
(b) Second half (dry season)	Import finfish/marine prawn juveniles as required in the production schedule. Continue reconstruction of additional grow-out ponds. Establish further feed infrastructure.
Year two (a) First half (wet season)	Invest in additional infrastructure and equipment. Establish hatchery production (dependent on initial import schedule of seed). Operate hatchery and produce seed for initial units of production. Investigate cooperative style of production throughout Fiji Islands.
(b) Second half (dry season)	Expand broodstock holding facility. Evaluate potential of further pond development in Viti Levu, Vanua Levu and especially outer islands to help address food security, poverty alleviation and employment issues.
Year three	Begin export of market-established product.

Furthermore, the Fiji-based company, Pacific Ocean Culture (Fiji), has a sister company Vate Ocean Gardens Ltd, based in the Republic of Vanuatu. For over seven years, Vate Ocean Gardens Ltd has directly supplied a growing domestic market as well as sending occasional exports to Australia and other countries within the Pacific Island region.

Lastly, the manager of the company, Mr Paul Christian Ryan, has 15 years of experience in the general development of aquaculture, including design, construction and operation of both marine and freshwater shrimp and fish production systems, processing, packing and export facilities. He has designed, built and managed farms, hatcheries and processing plants in Mozambique, Australia, Vanuatu, Denmark and Ghana (West Africa), and has effectively transferred technology and training in all these areas. He has additional industry experience as a consultant in Australia, South Africa, Tanzania and Europe. He has previously managed Teouma Prawns Ltd from first harvest for two years, and he is the current owner and manager of Vate Ocean Gardens Ltd.

6. Alternative strategies

The Fiji Ministry of Fisheries and Forests has identified the development and promotion of marine aquaculture in Fiji Islands as one of the country's key priorities. With this priority in view, the following are possible alternative strategies to the current proposal.

- Take the 'do nothing' option, which means continuing to rely on finfish exported from abroad to cover existing domestic and regional demand.
- Introduce other exotic finfish species, which could also diversify the mariculture sub-sector, improve food and nutrition security and provide alternative income-generating activities to capture fisheries. This strategy would inevitably raise the concerns associated with introducing any exotic species. In this context, it is significant that barramundi has many advantages. Section 2.8 has already covered its benefits from a farming point of view. In addition, from a marketing perspective, it is quite a popular fish in the country and within the region, there is a relatively high demand from tourists to Fiji Islands (mainly Australians), and this species can be commercialised either as plate fish and as fillets, which creates the potential for marketing to a wide range of customers.
- Domesticate local finfish species, which could be an outstanding option in the long term, given that domestication programmes for new species could last 20 to 25 years or longer.

7. Approaches to the risk analysis

Risk analysis is a structured process for determining what events can occur (identifying hazards), analysing the probability that each event will occur (determining likelihood), assessing the potential impact if it does occur (determining consequences), identifying the potential management options and communicating the elements and magnitude of identified risks. In simple terms, risk analysis is a way of working out how likely it is that an undesired event will occur and the consequences of such an event.

The risk analysis generally follows a repeatable and iterative process where we seek answers to the following questions.

- What can occur? (Hazard identification)
- How likely is it to occur? (Risk assessment: likelihood assessment through release assessment and exposure assessment)
- What would be the consequences of it occurring? (Risk assessment: consequence assessment and risk estimation; risk management; risk evaluation)
- What can be done to reduce either the likelihood or the consequences of it occurring? (Risk management: option evaluation, implementation, monitoring and review)

The entire process includes risk communication – that is, the communication of the risk to others in order to generate a change in management, regulation or operation.

7.1. Pathogen risk analysis

The general approach used in the pathogen risk analysis (section 8) follows that outlined by the OIE (2004) and the International Council for the Exploration of the Sea's code of conduct (2003). The pathogen risk analysis has been conducted as a 'generic' risk analysis for introduction of fingerling from Australia and Thailand to Fiji Islands. It includes:

- a preliminary hazard identification;
- a detailed hazard identification for those pathogens meeting the criteria for further consideration;
- risk assessment – possibilities that hazards might be released; and
- risk management measures – quarantine protocols (pre- and post-border).

7.2. Ecological risk analysis

The ecological risks of introducing *Lates calcarifer* from Australia and Thailand into Fiji Islands (section 9) were assessed by reviewing the applicable scientific literature and technical reports covering the ecology (habitat, life cycle, etc.) and the sites and strategies involved in farming the species, as well as other local species that could potentially be negatively impacted by the introduction.

In broad terms, the assessment examined:

- the potential for the species to establish sustaining local populations in the natural environment; and
- if a population of barramundi did become established in the wild, the possible effects of this.

7.3. Limitations of the risk analysis

The current proposal provides technical guidance on and assesses the risks involved in the proposed introduction, and recommends possible mitigation measures for both pathogen and ecological risks. However, this risk analysis should not be taken as the sole basis on which the Government of Fiji decides for or against approving the request to introduce the species. Because it does not contain detailed data on the aquatic animal health situation in the importing country (Fiji Islands), it cannot offer definitive conclusions as to the risk of introducing exotic pathogens. A precautionary approach, referring also to other sources of data, is therefore appropriate.

8. Pathogen risk analysis

8.1. Status of knowledge of pathogens

Common diseases affecting barramundi are well known and well documented, because it has been a popular choice of species for farming in various countries.

Table 3 lists common pathogens to which barramundi are susceptible, as well as common control measures in each case. Note that all of these diseases, apart from the OIE ones (i.e. VNN and RSIVD), are opportunistic diseases caused by ubiquitous pathogens; therefore they have been reported and observed in aquatic organisms of both the countries of origin (Thailand and Australia) and the country of destination (Fiji Islands).

Table 3: Common opportunistic and primary pathogens in barramundi

Disease	Agent	Type	Syndrome	Measures
Viral nervous necrosis (VNN)	*Lates calcarifer* encephalitis virus (LcEV) – a betanodavirus	Virus	Pale or dark colouration; erratic swimming behaviour; spiral swimming; bloating; 'fainting'; extensive vacuolation of the brain and spinal cord; generally encountered during hatchery phase	Screening of broodstock; low larval rearing densities; optimal larval nutrition; improved broodstock nutrition; improved hatchery hygiene
Red sea bream iridoviral disease (RSIVD)	Red sea bream iridovirus	Virus	Lethargic, severe anaemia, petechiae in the gills, and enlargement of the spleen	Introducing pathogen-free fish; implementing hygiene practices on farms; and avoiding practices that can decrease water quality and/or increase stress
Lymphocystis	Lymphocystis virus	Virus	Wart-like growths on skin and fins; generally only fatal if infection severe and associated with very poor environmental conditions	Removal of infected fish; improved environment
Vibriosis	*Vibrio harveyi*; Vibrio spp.	Bacteria	Marine fish with darkening; lethargy; anorexia; reddened ulcerations on body; reddened abdominal fluid; associated with nursery systems, poor environment and skin trauma	Improved environment; antibiotic treatment
Bacterial haemorrhagic septicaemia	*Aeromonas hydrophila; Aeromonas sobria; Aeromonas caviae; Aeromonas* spp.; *Pseudomonas* spp.	Bacteria	Freshwater fish with irregular reddened skin ulcerations; lethargy; anorexia; reddened abdominal fluid; pale gills; associated with poor environment and skin trauma	Improved environment; antibiotic treatment
Integumentary bacteriosis	*Aeromonas sobria; Aeromonas hydrophila; Vibrio harveyi; Vibrio alginolyticus*	Bacteria	Irregular reddened skin ulcerations; loss of scales; associated with poor environment and skin trauma	Improved environment; increased water exchange
Streptococcosis	*Streptococcus iniae*	Bacterium	Darkened fish; anorexia; pale gills; reddened abdominal fluid; reddened abdominal organs and inner wall	Antibiotic treatment; vaccination
Columnaris disease	*Flavobacterium columnare; Flavobacterium johnsoniae*; and *Flavobacterium* spp. (gliding forms) in fresh water *Tenacibaculum maritimum* in seawater	Bacteria	Pale skin patches on dorsal surface behind dorsal fin and on caudal peduncle; lethargy; most commonly occurs in nursery phase; in older juveniles a mouth form with erosion of skin around upper and lower jaws has been seen; associated with overstocking, tank rearing, poor hygiene and skin trauma	Treatment in potassium permanganate or copper baths may help in early disease; antibiotic treatment
Bacterial gill disease	Various bacteria, *Flavobacterium* spp., *Cytophaga* spp.	Bacteria	Swimming at water surface; gulping; rapid opercular movement; excess mucus on gills; white patches on gills; most commonly occurs in nursery phase	Improve water quality; treatment with salinity reversal, potassium permanganate or quaternary ammonium baths; increase water exchange; reduce stocking density
Bacterial peritonitis	Various Gram-negative and Gram-positive bacteria including *Vibrio* harveyi and *Aeromonashydrophila*	Bacteria	Darkened fish; lethargy; swollen abdomen; adhesions and bad smelling fluid in abdomen; abdominal fistulas; more common in recirculation systems	Cull affected fish; antibiotic treatment
Bacterial enteritis	Various Gram-negative bacteria	Bacteria	Acute disease in intensive larval rearing systems; anorexia; pin heads; darkened fish and death	Cull affected larval batch
Fin and tail rot	*Aeromonas* spp.; *Pseudomonas* spp.; *Vibrio* spp.; *Flavobacterium* spp.; *Cytophaga* spp.	Bacteria	Erosion of soft tissue in fins and tail; may extend to involve entire tail and caudal peduncle	Improve environment; reduce stocking density
Epitheliocystis	*Epitheliocystis* organism – a Chlamydia	Bacterium	Swimming at water surface; rapid opercular movements; disease rare but seen in marine fish and in recirculation systems	None known

Disease	Agent	Type	Syndrome	Measures
White spot	*Ichthyophthirius multifiliis* in fresh water *Cryptocaryon* irritans in marine	Protozoa	'Flashing'; rubbing skin on surfaces; anorexia; swimming at water surface; white spots on skin and fins	Treatment with salinity reversal, formalin baths or combinations; treatment in copper bath for marine fish
Chilodonelliasis	*Chilodonella* spp.; *Chilodonella hexasticha*	Protozoa	Swimming at water surface; rapid opercula movement; flared opercula; seen in poor environmental conditions and in weakened fish	Treatment with salt, formalin or potassium permanganate bath or combinations
Trichodiniasis	*Trichodina complex* spp.	Protozoa	Swimming at water surface; rapid opercular movements; excess gill mucus; typically follows cold water temperatures, high organic loads and high stocking densities	Increase water exchange; treatment with salt or formalin bath
Ichthyobodosis (costiasis)	*Ichthyobodo* necator	Protozoa	'Flashing'; rubbing skin on surfaces; opaque patches on skin; raised scales; swimming at water surface; rapid opercular movements; flared opercula	Treatment with salinity reversal; formalin or potassium permanganate bath
Piscinoodiniasis	*Piscinoodinium* spp.	Protozoa	Found in fresh water: In young fish – opaque patches or a greenish discolouration of the skin; patches of skin lifting of surface and ulcers In older fish – rapid opercular movements; excess gill mucus; dark green gill colour	Treatment with salt bath
Amyloodiniasis	*Amyloodinium ocellatum*	Protozoa	Found in marine conditions: In young fish – opaque patches or a green discolouration of the skin; patches of skin lifting of surface and ulcers In older fish – rapid opercular movements; excess gill mucus; dark green gill colour More common in broodstock and in raceways; associated with low water temperatures or rapid drops in temperature	Treatment with fresh water, copper, formalin or hydrogen peroxide bath
Red sore disease	*Epistylis* spp.	Protozoa	Skin ulcers in freshwater pond fish; raised fluffy surface and secondary bacterial infections	Reduce organic levels in water; treatment with formalin bath
Gill fluke	*Diplectanum* spp.; *Dactylogyrus* spp.	Monogenean trematodes	Rapid opercular movements; anorexia; white areas on gills	Treatment with salinity reversal, formalin, organo-phosphate or praziquantel bath
Skin fluke	*Neobenedenia melleni; Gyrodactylus* spp.	Monogenean trematodes	Marine fish with opaque cornea; white patches on skin; skin ulcers; associated with high salinity and cool water temperatures	Treatment in fresh water or hydrogen peroxide bath
Myxosporidiosis	*Henneguya* spp.; *Kudoa* spp.	Spore-forming protozoa	Disease uncommon but histologically spore cysts seen in gill filaments (Henneguya sp.) and brain (Kudoa sp.)	None known
Microsporidiosis	*Pleistophora* spp.	Spore-forming protozoa	Raised lumps on skin; soft white nodules in muscle	None known
Integumentary mycosis	*Saprolegnia* spp.; *Achlya* spp.	Fungi	Raised, fluffy growths on skin and fins; associated with low water temperatures and skin trauma	Salinity reversal and formalin baths; do not handle fish when water temperatures low
Branchiomycosis	*Brachiomyces* spp.; *Achlya* spp.	Fungi	Swimming at water surface; rapid opercular movements; white and red patches (mottled appearance) on gills; associated with cold water temperatures and high organic loads	No treatment known; reduce organic load and increase water exchange
Fish louse	*Argulus* spp.	Copepod	Disc-shaped parasite visible on skin; red foci; darkening	Treatment in organophosphate bath
Anchor worm	*Lernaea* spp.	Copepod	Thin body of female parasite visible on skin with small red ulcer where parasite penetrates skin	Treatment in organophosphate bath

8.2. Disease status in Australia and Thailand

Both Australia and Thailand are members of the OIE and accept the OIE list of notifiable aquatic animal diseases, which are described under the OIE code for aquatic animals (to assess the current aquatic health status of each country, go to: www.oie.int/animal-health-in-the-world). The Competent Authorities of both countries report on any notifiable aquatic animal diseases to other relevant national authorities and to the OIE, as required. The Ministry of Agriculture and Cooperatives in Thailand and the National Quarantine Agency in Australia are in charge of investigating, compiling, monitoring and reporting on aquatic animal diseases, through the information provided by provincial and district animal health officers.

These two countries are, therefore, an appropriate option as 'countries of origin', given their well-known aquatic health status, their stringent biosecurity measures and their strong reporting system. Equally, however, as section 8.8 will describe in detailed, strict pre-border mitigation protocols will be applied to the selected stock (the specimens to be transported) in order to ensure that all fry/fingerling transported are free of any OIE-listed diseases, as well as free of any relevant trans-boundary diseases for marine finfish organisms.

As to the OIE-listed diseases that could affect barramundi specifically (i.e. VNN and RSIVD):

- Australia is currently free of both pathogens – they have never been reported in the country; and
- Thailand is currently free of RSIVD (it has never been reported) and, although the country is not free of VNN, the Department of Fisheries in the Ministry of Agriculture and Cooperatives has declared the proposed facility of origin to be free of it (see annex 2 for a copy of the health certificate).

8.3. Disease status in Fiji Islands

The Ministry of Fisheries and Forests and the Biosecurity Authority of Fiji Islands are responsible for collecting, compiling and reporting on the health status of the aquatic animals being farmed in the country. Fiji Islands is a member of the OIE. Regarding relevant transboundary animal diseases, it accepts the OIE-listed diseases as notifiable, and the OIE as a body that sets sanitary and phytosanitary (SPS) standards under the World Trade Organization.

The Ministry of Fisheries and Forests, through the district and provincial officers, is in charge of compiling, analysing and reporting on animal diseases to the OIE and other relevant stakeholders. Much of the aquatic animal health status in Fiji Islands is unknown (to assess what is known of its current aquatic health status, go to: www.oie.int/animal-health-in-the-world). Therefore, quarantine and other pre-border and post-border risk management measures proposed in this document are quite conservative in order to achieve an appropriate level of protection.

In terms of its status in regard to OIE-listed diseases that could affect barramundi (i.e. VNN and RSIVD), Fiji Islands is 'theoretically' free of both pathogens; they have never been reported in marine finfish species in the country.

8.4. Preliminary hazard identification of main pathogens

In this analysis, a preliminary hazard identification has been undertaken to identify all relevant pathogens and diseases reported for barramundi. A pathogen or disease must meet the following criteria in order to be considered in this preliminary hazard identification.

- The potential pathogen or disease must be an identifiable biological agent or a disease believed to be produced by a single biological agent, and not as an opportunistic pathogen.
- The agent must have been recorded from barramundi as a cause of significant disease. Pathogens reported from any life cycle stage and any geographical locality are included.

The results of the preliminary hazard identification are presented in Table 4 below.

Table 4: Primary pathogens in barramundi

Disease	Agent	Type	Syndrome	Measures
Viral nervous necrosis (VNN)	*Lates calcarifer* encephalitis virus (LcEV) – a betanodavirus	Virus	Pale or dark colouration; erratic swimming behaviour; spiral swimming; bloating; 'fainting'; extensive vacuolation of the brain and spinal cord; generally encountered during hatchery phase	Screening of broodstock; low larval rearing densities; optimal larval nutrition; improved broodstock nutrition; improved hatchery hygiene
Red sea bream iridoviral disease (RSIVD)	Red sea bream iridovirus	Virus	Lethargic, severe anaemia, petechiae in the gills, and enlargement of the spleen	Introducing pathogen-free fish; implementing hygiene practices on farms; and avoiding practices that can decrease water quality and/or increase stress
Vibriosis	*Vibrio harveyi*; *Vibrio* spp.	Bacteria	Marine fish with darkening; lethargy; anorexia; reddened ulcerations on body; reddened abdominal fluid; associated with nursery systems, poor environment and skin trauma	Improved environment; antibiotic treatment
Bacterial haemorrhagic septicaemia	*Aeromonas hydrophila; Aeromonas sobria; Aeromonas caviae; Aeromonas* spp.; *Pseudomonas* spp.	Bacteria	Freshwater fish with irregular reddened skin ulcerations; lethargy; anorexia; reddened abdominal fluid; pale gills; associated with poor environment and skin trauma	Improved environment; antibiotic treatment
Columnaris disease	*Flavobacterium columnare; Flavobacterium johnsoniae*; and *Flavobacterium* spp. (gliding forms) in fresh water Tenacibaculum maritimum in seawater	Bacteria	Pale skin patches on dorsal surface behind dorsal fin and on caudal peduncle; lethargy; most commonly occurs in nursery phase; in older juveniles, a mouth form with erosion of skin around upper and lower jaws has been seen; associated with overstocking, tank rearing, poor hygiene and skin trauma	Treatment in potassium permanganate or copper baths may help in early disease; antibiotic treatment
White spot	*Ichthyophthirius multifiliis* in fresh water *Cryptocaryon irritans* in marine	Protozoa	'Flashing'; rubbing skin on surfaces; anorexia; swimming at water surface; white spots on skin and fins	Treatment with salinity reversal, formalin baths or combinations; treatment in copper bath for marine fish
Gill fluke	*Diplectanum* spp.; *Dactylogyrus* spp.	Monogenean trematodes	Rapid opercular movements; anorexia; white areas on gills	Treatment with salinity reversal, formalin, organo-phosphate or praziquantel bath
Skin fluke	*Neobenedenia melleni; Gyrodactylus* spp.	Monogenean trematodes	Marine fish with opaque cornea; white patches on skin; skin ulcers; associated with high salinity and cool water temperatures	Treatment in fresh water or hydrogen peroxide bath

8.5. Criteria for further consideration of pathogens

To be given further consideration in this analysis, a potential hazard (pathogen) must meet all of the following criteria.

1. The agent must have been reported **to infect, or is suspected of being capable of infecting barramundi at any live stage**.
2. The agent must be an **obligate pathogen**; it is not a ubiquitous free-living organism that is capable of becoming an opportunistic pathogen of barramundi under certain environmental or culture conditions.
3. The agent must **cause significant disease outbreaks** and associated losses in populations of barramundi or, if not a significant pathogen of barramundi, it must cause serious disease outbreaks in populations of other species of aquatic organisms.
4. It must be **plausible that the pathogen might be present in populations of barramundi in the stock of origin**.

Animal diseases notifiable to the OIE for finfish include:

- fish epizootic haematopoietic necrosis;
- infectious haematopoietic necrosis;
- spring viraemia of carp;
- viral haemorrhagic septicaemia;
- infectious salmon anaemia;
- epizootic ulcerative syndrome;
- gyrodactylosis (*Gyrodactylus salaris*);
- red sea bream iridoviral disease;
- Koi herpesvirus disease; and
- encephalopathy and retinopathy nodavirus disease.

Presently, the only two of the diseases listed above that have been reported to affect barramundi are:

1. **red sea bream iridoviral disease (RSIVD); and**
2. **encephalopathy and retinopathy nodavirus (VER and VNN)**

8.6. Pathogens not considered further

Taking into account the criteria for a pathogen to be considered in the preliminary hazard identification, along with the criteria for further consideration of pathogens, most of the viral, bacterial and parasitic pathogens described in section 8.2 (apart from the VNN virus – encephalopathy and retinopathy nodavirus – and the red sea bream iridovirus) could be considered as opportunistic and quite ubiquitous agents, which do not strictly meet these criteria. Some of these pathogens could cause serious mortality and morbidity in barramundi (e.g. the parasitic infestations caused by white spot when affecting juveniles), but in all cases their occurrence is closely related to specific stressing factors.

However, the mitigation and containment measures recommended in section 8.8 are designed to prevent the possible release of any pathogens through the introduction of barramundi to Fiji Islands, as well as to prevent possible exposure of the receiving environment to these pathogens.

8.7. Pathogens for further consideration

Encephalopathy and retinopathy nodavirus (VNN)

Introduction: The VNN disease is the most devastating viral infection among marine finfish. Outbreaks of VNN caused up to 70 per cent mortality in fry, up to 100 per cent mortality in 2.5–7.5 cm fish and less than 20 per cent mortality in fish longer than 15 cm. VER or VNN has been reported as a serious disease of larval and juvenile and sometimes older marine fish that occurs almost world-wide except for in Africa.

Hosts: To date, the disease has been reported in at least 30 fish species, with the greatest impact being in sea bass (*Lates calcarifer* and *Dicentrarchus labrax*), groupers (*Epinephelus akaara, E. fuscogutatus, E. malabaricus, E. moara, E. septemfasciatus, E. tauvina, E. coioides* and *Cromileptes altivelis*), jacks (*Pseudocaranx dentex*), parrotfish (*Oplegnathus fasciatus*), puffers (*Takifugu rubripes*), flatfish (*Veras permoseri, Hippoglossus hippoglossus, Paralichthys olivaceus, Scophthalmus maximus*) and cobia.

Clinical signs: Diseased fish swim in a darting, corkscrew manner. Some fish sink to the bottom then float to the surface again. Affected juvenile and broodstock fish develop a bloated belly. In addition, affected fish show lethargy, pale colouration and loss of appetite. Internal disease signs include pale livers, empty digestive tracts and intestines filled with greenish to brownish fluid.

Transmission: The virus propagates in the eye, brain and distal spinal cord of affected fish, causing marked vacuolations of the central nervous tissues which lead to vacuolating encephalopathy and retinopathy. Usually there is also vacuolation of the nuclear layers of the retina. It multiplies in the gonad, livers, kidney, stomach and intestine as well.

It has been demonstrated that the causative agent is vertically transmitted in some species, as reflected in the early occurrence of clinical disease. This finding has led to the successful control of VNN of larvae, where virus-carrying broodstock was eliminated by reverse-transcription polymerase chain reaction and fertilised eggs were disinfected by ozone. The mode of transmission/ introduction of the viruses, other than in gametes and by cohabitation, has not been demonstrated, but the possibilities include influent water, juvenile fish held on the same site, and carriage on utensils, vehicles, etc. It is possible that these small viruses are quite resistant to environmental conditions and therefore readily translocated by commercial activities.

Epidemiology: In general, younger fish have more severe lesions; older fish have less extensive lesions and these may show a predilection for the retina. The age at which disease is first noted and the period over which mortality occurs vary considerably. In general, the earlier the signs of disease occur, the greater the rate of mortality is. It is very rare for disease to occur at the juvenile stages in some species. In other species, however, mass mortalities are frequent at juvenile to young stages, indicating the age dependence of susceptibility, although a mortality rate of 100 per cent is rare.

Control measures: Vaccination using a recombinant capsid protein is still at the experimental stage but has proven effective. VNN-carrier broodstocks were also found to be a source of inoculum of the virus to their larvae.

Pre- and post-spawning screening of broodstocks for VNN is very important, and only VNN-negative broodstocks should be allowed to spawn, after which the fertilised eggs should be disinfected using ozone or iodine. These procedures are very effective in preventing the vertical transmission of the virus. Strict husbandry management in the hatchery phase is also very important in managing VNN infection. Betanodaviruses are quite resistant to some environmental parameters, thus it is highly possible that the virus could be easily translocated via contaminated rearing water and paraphernalia. Using non-recycled, chemically treated rearing water and decontaminating tanks after every hatching cycle can prevent VNN infection.

Other measures to help control VNN in larval finfish are to:

- disinfect eggs with iodine or ozone and hatchery paraphernalia with chlorine;
- rear each batch of larvae and juveniles in separate tanks supplied with UV or ozone sterilised water; and
- separate larvae and juveniles from broodstock fish.

In addition, it is important to reduce identified stress factors in the culture system; lowering larval stocking density in the tank may also help reduce the possibility of viral transmission. Rearing water temperature has been shown to influence disease development: higher mortality and earlier appearance of the disease signs have been observed at higher rearing water temperatures. This finding suggests that manipulation of water temperature will help reduce disease outbreaks.

Red sea bream iridovirus

Introduction: RSIVD is a significant cause of mortality among cultured marine fish. The causative agent is the red sea bream iridovirus. Overt infections have been recognised not only in red sea bream (*Pagrus major*), but also among other cultured marine fish, including barramundi. The first outbreak of RSIVD was recorded in cultured red sea bream in Shikoku Island, Japan in 1990. Since 1991, the disease has produced mass mortalities in cultured fish populations in the western part of Japan, mainly among juvenile red sea bream but also in some market-sized fish.

Clinic sings: Affected fish are lethargic, and exhibit severe anaemia, petechiae of the gills, and enlargement of the spleen. The disease is characterised by the appearance of enlarged cells stained deeply with Giemsa solution on microscopic observation of tissue sections of the spleen, heart, kidney, liver and gills of infected fish.

Transmission: RSIVD is mainly transmitted horizontally via the water. It has shown some weak cross-reactivity in indirect fluorescent antibody tests using polyclonal rabbit anti-RSIVD serum with the systemic ranaviruses resembling epizootic haematopoietic necrosis virus (or FV-3). Diagnostic methods, such as the observation of stained impression smears or tissue sections, an immunofluorescence test with anMAb, and a polymerase chain reaction, have been reported for RSIVD.

Control methods: Currently RSIVD is controlled by using hygiene practices at the farm (best management practices and biosecurity protocols, as mentioned above for the VNN infection). A commercial vaccine may soon be available for RSIVD in red sea bream. Vaccination for other marine fish species is at the experimental stage.

8.8. Mitigation strategies – Quarantine measures

Table 5 sets out the quarantine measures recommended for both the exporting country (pre-border measures) and the importing country (post-border measures) to minimise the risk of pathogens being introduced along with barramundi, as well as to minimise their impact if they are introduced.

Table 5: Recommended pre-border and post-border quarantine measures

Exporting country Pre-border quarantine measures	Importing country Post-border quarantine measures
• The shipment of barramundi fry/fingerling to be introduced into Fiji Islands should be of 'high' health status and have an ANIMAL HEALTH CERTIFICATE OR a CLEAR SANITARY CERTIFICATION issued by the Competent Authority in charge of Biosecurity and Aquatic Animal Health Management of the country of origin, and signed by an authorised Veterinary Officer. • The animal health certificate must conform to the principles of the OIE International Aquatic Animal Health Code 2005, Part 6, Section 6.1 Appendix 6.1.1, International Aquatic Animal Health Certificate for Live Fish and Gametes. • A detailed health checklist should be applied to each individual before it is transported from the facility of origin. • The facility of origin in the country of origin must demonstrate a proven track record of main diseases and pathogens of cultured barramundi stocks, including clinical signs, differential diagnosis, final diagnosis, mortalities and morbidities occurring in the specimens to be introduced. • The facility of origin will present the screening results for VNN and RSIVD for the stock to be introduced, following the *OIE manual of diagnostic tests for aquatic animals.* • The facility of origin will have evidence that it follows strict biosecurity protocols and an overall health management plan.	• The receiving facility must implement standardised and adapted quarantine measures operations to minimise the risk of pathogen exposure. (The quarantine protocol is described in annex 1; it has been adapted from the *FAO manual on quarantine protocols for the movement of alive aquatic organisms*.) • The stock will be received at the quarantine area of Pacific Ocean Culture (Fiji) that will have previously been approved by the Fiji Biosecurity Authority, the Competent Authority of Fiji Islands. • The facility will be on the Raviravi site, completely excluded from any day-to-day activities related to other culture species. • The intake and outlet waters will be separated and contained, as suggested within this import risk analysis, and in accordance with the Fiji Biosecurity Authority regulations in this respect, and with the FAO protocol for the quarantine of live aquatic organisms (see annex 1of this document). • The Fiji Competent Authority, either at the airport or at the quarantine area, will analyse and review the sanitary certification and related documentation provided by the Competent Authority of the country of origin. • The general health status of the specimens received will be checked when they are received into the quarantine area, and monitored weekly by Fiji Biosecurity Officers during a quarantine period of 14 days.

Exporting country Pre-border quarantine measures	Importing country Post-border quarantine measures
• The facility must provide the Government of Fiji with sufficient guarantees as to the high health status and reliable history of its stock. • During the week before transportation, the facility of origin will apply an external treatment to the stock, which is to be the same as or similar to the following: • Anti-parasitic treatment for external parasites control: one day formaldehyde (formalin) bath at 150 ppm an hour. • If possible, and if seen to be appropriate, a recognised expert will visit the production facility for an on-site inspection on behalf of the Government of Fiji to check that the protocols, diagnostic procedures, security, etc. are adequate to validate guarantees of good health status. • The facility of origin will separate the batch of the stock destined for export as early as possible from other stocks reared in the facility and will maintain them in tanks separate from the rest of the stocks. • The facility of origin will keep detailed records of the health status and mortality rates of each batch of barramundi fingerlings to be transported. It will make these records available to the Competent Authority responsible for health certification. TRANSPORTATION • The consignment must be exported direct to Fiji Islands in new, clean, sealed packaging containers that comply with the standards of the International Air Transport Association (IATA) preventing any leakage or entry of contamination. • The containers must be transported according to the recommendations set out in Chapter 5.4 of the OIE Aquatic Animal Health Code of 2009. • Any transshipment between freight vessels must be conducted in a manner that ensures no risk of contamination of the consignment. No water or food is to be exchanged during transport. • Consignments must not contain any undeclared feedstuffs, animal material, or any other aquatic organisms other than the species that is intended to be introduced for aquaculture. • Consignments will be inspected when they arrive. • If a consignment arrives in Fiji Islands without the correct certification or having failed to meet these requirements in any other way, the consignment may, at the discretion of the Fiji Biosecurity Authority, be retained in quarantine for additional testing and examination, returned to the country of origin or destroyed at the owner's expense • When they arrive, all consignments must enter quarantine in an aquaculture • -farming facility approved by the Fiji Biosecurity Authority (or an approved closed tank system) that has adequate water and disease monitoring systems and procedures in place. If other fish or aquaculture species are already present on the property, then the consignment is to be isolated in an area, pond or tank that has been previously approved by the Fiji Biosecurity Authority and that does not share water or feeding systems with the rest of the facility.	• Approximately 500,000 fry/fingerling will be introduced. These will be counted and measured at the Quarantine Facility, and later once again after they have acclimatised to the water temperature and water quality before they are released into the stocking tanks. • Before the stock are released into them, stocking tanks will be cleaned and disinfected with hypochlorite at 200 ppm or other disinfectant solution. • The specimens will be stocked in 2000 L circular plastic and fibreglass tanks. • Intake water will be sand filtered and then passed by a 500 micrometre cartridge filter. • The water outlet will be filtered by a 1 micrometre cartridge filter and disinfected by an UV filter before the stock are released; independent water inlets and outlets will be available for each tank at the quarantine area, for ease of filtration and disinfection treatments • The stock will be maintained during 14 days at the hatchery facilities; after this period, the general health status of the specimens will be checked before stoking them for culture in hapas and ponds. • The Quarantine Facility operators will follow a general health monitoring system, keeping a time-series record of health status, mortalities and morbidities, and disease outbreaks. • No animals will be removed from the receiving facility without prior permission from the Fiji Competent Authority. • If there is a serious mortality or disease outbreak, all animals will be destroyed and disposed of using an approved sanitary method and the facility will be fully disinfected before restocking.

9. Ecological risk analysis

9.1. Introduction

The aim of this proposal is to introduce domesticated strains of barramundi to Fiji Islands, in order to develop a technically feasible and economically viable aquaculture activity that is sustainable in the long term, using a strain that is easy to rear and that has suitable growth characteristics. The introduction of domesticated and improved strains is seen as a way of diversifying the aquaculture sector in the Fiji Islands.

Barramundi in particular is believed to offer substantial advantages over local finfish species available. For example, barramundi:

- is easy to work with due to its life cycle, feeding technologies, etc.;
- can be farmed with improved technologies that already exist – farming and feeding strategies are well known and easier to adopt than for other marine finfish species;
- has high growth rates and an efficient feed conversion ratio;
- has relatively high survival rates during larval rearing;
- has a relatively high tolerance to changes in water-quality parameters, such as salinity, temperature, oxygen and pH;
- is a high-value, in-demand species;
- has well-established market acceptance in the region and in country;
- offers various farming options from the range of culture systems developed;
- has the potential for a high stocking density;
- is a relatively hardy species, adaptable to a range of environments; and
- has many options for hatchery installation in a large number of potential land-based sites.

9.2. Potential invasiveness

In considering the question of whether the species might become invasive in Fijian waters, it is instructive to refer to the experience of other countries. When this species has been into new environments (e.g. Vanuatu, French Polynesia, Israel, United States of America) in the past, its theoretical level of invasiveness was medium to high. In practice, however, due to its complex life cycle and the need for individuals to migrate before they can reach maturity, it has not been reported as invasive following any of these introductions (FAO DIAS: www.fao.org/fishery/dias/en).

It is easy to reduce the likelihood of the species being released and establishing a permanent population in the natural environment, and to mitigate the consequences if such a release were to happen, by applying basic and simple biosecurity measures during transportation and at farm level (see section 9.4).

9.3. Qualitative assessment of risks

Tables 6, 7 and 8 set out a qualitative risk assessment of potential ecological impacts during construction and operations.

Table 6: Risk assessment and uncertainty for the probability of barramundi becoming established

Assessment parameter and relevant considerations	Risk estimate	Uncertainty estimate
Exotic species successfully colonises and maintains a viable population where it is introduced or where it escaped	Low	Relatively certain
Exotic species has high biological potential for dispersion (e.g. migratory habits, long larval stages, high fecundity, short generation time)	Medium	Very certain
Exotic species has high human-assisted potential for dispersion (e.g. human migration, transportation of fish)	Medium	Relatively certain
Final rating for probability of establishment	Medium	Relatively certain

Table 7: Risk assessment and uncertainty for the consequences of barramundi becoming established

Assessment parameter and relevant considerations	Risk estimate	Uncertainty estimate
Negative economic impact if exotic species becomes established	Medium	Relatively certain
Negative economic impacts due to the impact of the exotic species on commercially important species	Low	Relatively certain
Economic development associated with exotic species will adversely impact some stakeholders	Low	Relatively certain
Economic costs if exotic species becomes established (e.g. loss of trade, increased treatment and quarantine due to presence of new pathogen)	Low	Relatively certain
Costs of monitoring programme	Medium	Relatively certain
Costs of mitigation measures	Low	Relatively certain
Economic costs of eradication efforts, if necessary	Medium	Relatively certain
Environmental impact if exotic species becomes established	Medium	Relatively certain
Exotic species competes with important native species for food, space, mates and breeding sites	Low	Relatively certain
Exotic species preys on important native species	Medium	Relatively certain
Exotic species disrupts or modifies habitat or water quality	Low	Relatively certain
Exotic species reduces the size of the native species population to the extent that inbreeding occurs	Low	Relatively certain
Genetic impact of exotic species	Low	Relatively certain
Exotic species hybridises or breeds with local species	Low	Relatively certain
Hybridised exotic species are capable of reproducing either with other hybrids or with parental species	Low	Relatively certain
Final rating for consequence of establishment	Low	Relatively certain

Table 8: Risk assessment and uncertainty for the consequences of pathogen or parasite becoming established

Assessment parameter and relevant considerations	Risk estimate	Uncertainty estimate
Pathogen or parasite is introduced along with the alien species	Low	Relatively certain
Pathogen or parasite escapes from aquaculture facility into environment	Low	Relatively certain
Pathogen or parasite encounters susceptible species or habitat in the environment	High	Relatively certain
Ecological impacts of pathogen or parasite on local habitat	Medium	Relatively certain
Important species susceptible	Low	Relatively certain
Disease outbreak reduces competitive ability of indigenous species	Low	Relatively certain
Disease outbreak reduces the marketability of important species	Low	Relatively certain
Final rating for consequence of establishment	Low	Relatively certain

9.4. Mitigation measures

Barramundi has a medium to high potential for invasiveness, according to scientific literature. However, it is easy to minimise the probability and mitigate the consequences of releasing barramundi specimens into the wild by applying the following basic biosecurity measures during transportation and farming.

- All fish imported must be from authorised and licensed hatcheries.
- It is highly recommended that prophylactic treatments are used and stock is screened before transportation, in order to avoid any introduction and spread of exotic pathogens, pests and stock hitch-hikers.
- The consignment must be exported directly to Fiji Islands in new, clean, sealed packaging containers that comply with IATA standards preventing any leakage or entry of contamination.
- Any transshipment between freight vessels must be conducted in a manner that ensures no risk of contamination of the consignment. No water or food is to be exchanged during transport.
- Consignments must not contain any undeclared feedstuffs or animal material.
- Fry/fingerling should be transported from the airport to the approved Quarantine Facility in a closed tank system.
- When they arrive in Fiji Islands, all consignments must enter quarantine in an aquaculture-farming facility approved by the Fiji Biosecurity Authority (or an approved closed tank system) that has adequate water and disease monitoring systems and procedures in place.
- If other fish or aquaculture species are already present on the property then the consignment is to be isolated in an area, pond or tank that has been previously approved by the Fiji Biosecurity Authority and that does not share water or feeding systems with the rest of the facility.
- Transferred specimens should be maintained in the Quarantine Facility for a minimum period of 14 days before stocking them into the ponds.
- Tank material should be checked regularly to ensure its integrity.
- Ponds should be designed to withstand extreme weather.
- Site security should be ensured.
- The farm must be located in an area that does not flood during the rainy season.
- Earthen ponds should have dikes of 30 cm (minimum) from water level to prevent escapes when the water level rises.
- Water levels of earthen ponds must be controlled and maintained during heavy rains, to prevent flooding.
- The drainage of all earthen ponds, as well as the general farm drain, should have a grid system to prevent specimens from escaping into the natural environment.
- Any specimen that enters or leaves the farm either alive or dead must be reported to the facility responsible at that time.

According to the data provided by the Fiji Meteorological Service (2011–2012), the geographical area that has been selected for the enterprise (Raviravi) is subject to heavy rains and relatively prone to flooding during the rainy season. For this reason, the water-level control measures mentioned above in section 9.4 must be applied with extreme accuracy. In addition, we recommend the implementation of an **early warning system**, in collaboration with the Fiji Meteorological Service – Lautoka section, in order to most efficiently take action before floods allow specimens to escape from the ponds into the wild.

To conclude, developing and implementing a cost-effective, biosecure fish-farming protocol depends on technical, managerial and economic factors. Human or managerial factors are among the most important ones; in this regard, the company requesting this introduction has shown that the human resources in charge of quarantine and production will be adequately trained and monitored throughout these processes. The main measures that Pacific Ocean Culture (Fiji) will implement in order to ensure stringent biosecurity are:

1. aggressive methods for disease exclusion from culture systems (pathogen exclusion from water and carriers) and effective seed and broodstock screening;
2. appropriate environmental management;
3. effective health management (involving genetic selection, specific pathogen free/resistant stocks, stocking strategies, feed management); and
4. strict and proactive health monitoring and farm management strategies.

10. Conclusions and recommendations

Both parts of this risk analysis involve a moderate level of uncertainty but also offer some vital information in assessing the proposal to introduce barramundi to Fiji Islands.

First, for the pathogen risk analysis, there is sufficient accurate information on the general health status of the stock to be introduced, the sanitary status of the facility of origin and the countries of origin. Although there is a lack of information on aquatic animal diseases in Fiji Islands specifically, it is well known that the country is free of the two OIE-listed diseases affecting barramundi: RSIVD and VNN.

Second, the ecological risk analysis suggests that although there is a general paucity of country-specific and species-specific data to support the analysis, the potential social and economic benefits of introduction outweigh any potential negative effects. Based on past practices, it is recommended that Fiji Islands adopts a **conservative** level of protection, with a **medium** level of risk (i.e. an approach that offers a moderate level of protection).

It is emphasised that the quarantine measures and ecological risks mitigation measures identified in this risk analysis should not be taken as the sole basis on which the Government of Fiji decides for or against approving the request to introduce the species. Policy, legislation, technical capability and other relevant matters must also be considered before such a decision can be made.

Overall, though, the introduction of a species such as barramundi – which is in high demand in both domestic and export markets and is easy to rear either for restocking or aquaculture purposes – could lead to the development of economically viable activities in the country generally and in Raviravi area in particular. Decision-makers should balance the benefits against the risks in considering this proposed introduction.

Notably, according to the data provided by the Fiji Meteorological Service (2011–2012), the geographical area that has been selected for the enterprise (Raviravi) is subject to heavy rains and relatively prone to flooding during the rainy season. For this reason, the water-level control measures mentioned in the section 9.4 must be applied with extreme accuracy. In addition, we recommend the implementation of an early warning system, in collaboration with the Fiji Meteorological Service – Lautoka section, in order to most efficiently take action before floods allow specimens to escape from the ponds into the wild.

Annex 1: General quarantine protocol for the movement of live aquatic organisms

The following protocol has been adapted from the *FAO manual on quarantine protocols for the movement of alive aquatic organisms.*

A. Infrastructure and operations

A1. Period of quarantine

The period of holding the introduced or transferred specimens in the Quarantine Facility will depend on the various factors involved: the species to be introduced and its life cycle, pathogens that could be introduced and spread with the stock (including pathogens not considered further and pathogens for further consideration) and other possible imported stock hitch-hikers.

In defining the required quarantine period (using more or less conservative parameters), one of the most important considerations is whether pathogens could be introduced either through vertical transmission (from one generation to the next) or as 'hidden' pathogens, which could have long incubation periods or cause subclinical infections. Depending on the nature of the specimens, either the imported stock or the following generations (F1, F2 and so on) would be released after the quarantine process, which would include testing and monitoring the pathogens for further consideration, as described below.

In all cases, once the Competent Authority is satisfied that the introduced stock, the F1 or a subsequent generation is safe for limited release, the specimens can be released. In the case of vertically spread pathogens, it is advisable to maintain the parent stock at the facility. Once the F1 has been tested, parent stock should be destroyed and the Quarantine Facility thoroughly disinfected. An application to introduce or transfer an aquatic animal entails a commitment to maintain the animals under conditions of strict quarantine, sometimes even for a number of years. The quarantine period will need to take into account the life history of the aquatic animal being introduced or transferred. If a pathogen or infectious disease is detected at any point while the imported aquatic animals and their progeny are under quarantine, the supervising Quarantine Officer may require treatment and further testing. If the disease is of a serious and/or untreatable nature, destruction of all aquatic animals held in the facility should be ordered and complete disinfection of the building, water and all equipment should be required before permission to restock is granted.

A2. Standards of Construction

A2.1 Location of Quarantine Facilities

It is always advisable to avoid quarantine areas in the vicinity of private or government fish hatcheries, aquaculture facilities, watercourses or areas subject to frequent flooding. In cases when the quarantine area is located in the vicinity of another aquaculture facility, the water disinfection and filtration protocols described below, for inlet and outlet, should be followed very strictly.

A2.2 General Requirements

- Access to the Quarantine Facility should be through property owned or leased on a long-term basis by the operator and should be available to Quarantine Officers during normal business hours and at any other times that aquatic animals are entering or leaving the facility.
- The Quarantine Facility should be located within a single operational entity, if possible. Its structure should be **physically separated** from all other operations and dedicated solely to the holding of the shipment.
- **It should not share a building in which areas are used for different purposes and should not serve as an accessway to other buildings or activities.**

- The Quarantine Facility should not to be used for any purpose whatsoever other than as a place for the performance of quarantine.
- The Quarantine Facility should be weatherproof and maintained in a state of good repair.
- The Quarantine Facility should be a secure, lockable building that is surrounded by a lockable, person-proof security fence.
- The holding capacity of the Quarantine Facility should be commensurate with the proposed quantities of the species of aquatic animal for which a permit is granted.
- Provision must be made for the growth and maturation of the original parent stock and the holding of all F1 and subsequent generations, in case these measures are required.
- The Quarantine Facility should be equipped for the sterilisation of all equipment that comes in contact with aquatic animals or **tank water during the quarantine period.**
- **The Quarantine Facility should be equipped with back-up systems for essential components** (e.g. electricity, water circulation, aeration, temperature control, filtration) to maintain biosecurity and the health of stocks in the case of electrical or mechanical failures.

A2.3 Specific construction and Equipment Requirements

The Quarantine Facility should comply with the following specific construction and equipment requirements.

1. Windows should be screened to prevent the entry of insects.
2. **Floor and walls should be constructed of concrete, tiles or other impervious material so that they can be hosed down and disinfected while retaining all wastewater.** The floor should be sufficiently smooth and with sufficient grade to drain to an enclosed holding tank.
3. Floor-to-wall junctions and all gaps and cracks in the walls, floor and ceiling should be effectively sealed such that the quarantine area is capable of containing all leaks and floods that might occur.
4. Lighting should be of sufficient intensity to allow proper inspection of all aquatic animals.
5. Floor drainage with an insertable plug or other mechanism to prevent the accidental escape of aquatic animals or uncontrolled release of water should be installed. Drainage should be to an approved holding tank. The holding tank should be of suitable size to contain the total volume of all tanks used for the holding of aquatic animals.
6. Doors should be equipped with self-closing mechanisms to ensure that they remain closed after entry, or there should be a self-closing, insect-proof screendoor installed.
7. **Access to the Quarantine Facility should only be through a personnel entrance leading to a separate outer change room**, which contains facilities for staff and Quarantine Officers to wash their hands and change outer clothing before entering or leaving the quarantine area**.**
8. **A footbath containing disinfectant should be placed at the entrance door to the Quarantine Facility.**
9. **All holding tanks for aquatic animals should:**
    - **be identified with permanent numbers so that individual tank records can be correlated with them;**
    - **be fitted with lids or other approved coverings to prevent transmission of pathogens between adjacent tanks due to splash from the aeration/filter system, and to prevent the escape of aquatic animals;**
    - have water intake lines equipped with automatic shut-off valves;
    - be arranged in a manner that permits ready access for inspection purposes, including a minimum width of **75 cm for corridors** between rows of tanks or between tanks and walls;
    - **other than the aquatic animals, contain only sterilisable materials that do not interfere with inspection;**
    - have at least the front **transparent to provide good visibility of their contents**, and be stacked for adequate viewing; and
    - **each have their own set of equipment** – nets, buckets, beakers and other items associated with the tank use, to ensure that no equipment is shared between tanks.

10. As all aquatic animals within the facility should be considered to have the same quarantine status, the use of a **shared water recirculation** system is permissible but **not advisable**, as it may facilitate the spread of pathogens between tanks.
11. All entry and exit points for the Quarantine Facility should prominently display a quarantine sign that states '**Quarantine Area – Authorised People Only**'. Such signs should be highly visible and fixed permanently in place.
12. A suitable **wash-up trough should be located in the quarantine area for cleaning and disinfecting equipment.** An approved disinfectant should be available at the wash-up trough.
13. A designated refrigerator or **freezer should be provided solely for storing and preserving dead aquatic animals.** The refrigerator or freezer should be clearly identified as being for quarantine use only, be lockable and be located within the quarantine area.
14. **Equipment needed to disinfect all wastewater** (both the overseas transport water and all domestic waters used in the Quarantine Facility) should be supplied.
15. Secure storage facilities for food used for aquatic animals should be provided so that pests cannot contaminate or infest it.
16. A fully stocked first aid cabinet should be provided and maintained.
17. Amenities that should be provided for Quarantine Officers include access to a desk and chair, a telephone with a direct outside line, toilet facilities, hand-washing facilities (within the quarantine area) and a hygienic means of drying hands. Suitable arrangements for daily cleaning of amenities should also be made.

A3. Standards of operation

A3.1 Influent water

All influent water entering the Quarantine Facility should be from an approved water source certified to be free from biological material, including any possible infective agents.

Alternatively, water from other sources may be used; however, it should be **filtered** to remove suspended matter and then sterilised using a method approved by the Competent Authority before being used in the Quarantine Facility.

A3.2 Wastewater sterilisation and disposal

All wastewater to be discharged from the Quarantine Facility should be appropriately sterilised. Sterilised wastewater should not be discharged directly into natural waterways. Disposal of wastewater should also conform to any state and local government requirements. **Wastewater should be sterilised in accordance with one of the following methods.**

(a) Chlorination

1. Pass all water through an approved filter capable of removing suspended organic material before hypochlorite treatment.
2. Pass all water to a retention vessel, to which you add sufficient hypochlorite to achieve a minimum concentration of 200 parts per million (ppm).
3. Before the treatment period commences, bring the chlorinated effluent to a pH of between 5.0 and 7.0.
4. After adding hypochlorite, agitate wastewater for at least 10 minutes to mix hypochlorite thoroughly.
5. After a retention period of not less than 1 hour, measure the chlorine concentration using an approved method (e.g. commercially available chlorine test kit). Tanks not achieving a minimum chlorine concentration of 200 ppm will be treated again.
6. Neutralise the chlorine in the wastewater by adding sodium thiosulphate at a rate of 1.25 g (2.5 ml of 50 per cent sodium thiosulphate solution) per litre of treated wastewater, then agitate it for not less than 10 minutes before discharge.
7. Maintain chlorination records, noting: the amount of compound added, the volume of effluent, the time that the treatment period began, the pH at the start of the treatment period, the 1 hour post-treatment concentration, the amount of sodium thiosulphate added to achieve neutralisation and the residual chlorine concentration at discharge.
8. Do not discharge chlorinated water directly into adjacent waterways.

(b) Heat treatment

Prior to discharge, heat wastewater to at least 85°C for a minimum of 30 minutes. Water heating units should be approved by the Competent Authority and be fitted with temperature and flow recorders.

(c) Ultraviolet (UV) light radiation

As particles in the water may shade pathogens from the effects of UV light, all water to be treated should pass through an approved filter capable of removing suspended organic material prior to irradiation.

This method requires commercial UV water treatment units operating in the spectral range of 190–280 nm (254 nm recommended) and delivering doses of at least 130 mWs/cm^2. As UV bulbs will burn long after their effectiveness has waned, monitor the burning time of the UV lamp, and replace the lamp according to manufacturer's specifications.

A3.3 Disinfection of equipment

Before removal from the quarantine area, and before any restocking, all tanks and tank equipment must be thoroughly cleaned and disinfected with:

1. hypochlorite solution at 200 ppm concentration for 5 minutes; or
2. an approved iodophores solution containing iodine at 0.5 per cent available iodine for 5 minutes; or
3. another disinfection procedure approved by the supervising Quarantine Officer.

If possible, filter material should be disposed of by autoclaving followed by incineration or deep burial.

A3.4 Disposal of dead aquatic animals

Dead aquatic animals should only be disposed of as directed by the Competent Authority. **Aquatic animals that have died while under quarantine should held in an approved freezer** or an approved refrigerator, or preserved using another method as specified by the Competent Authority (or another officer in charge) until removed for laboratory examination or released for disposal by the supervising Quarantine Officer. Once their disposal has been approved, dead aquatic animals should be disposed of by sterilisation using an approved autoclave followed by incineration or deep burial.

A3.5 Disposal of packing materials

All containers (bags, boxes and cartons) used to hold aquatic animals during transit should be disinfected using the methods of disinfection specified under section 3.3 above and then disposed of by incineration, deep burial or another method approved by the supervising Quarantine Officer.

A4. Work practices

A4.1 Cleanliness and sanitation

- The Quarantine Facility and holding tanks should be kept clean at all times.
- **Adequate cleaning facilities** (e.g. pressurised water supplies, brooms, shovels) should be provided to enable maintenance of appropriate standards of hygiene.
- No animals other than aquatic animals and live food for aquatic animals should be permitted in the quarantine area.
- All feeds used within the Quarantine Facility should have prior approval of the supervising Quarantine Officer and be of assured sanitary condition.
- Live food should not be used unless no other alternative food is acceptable to the animals under quarantine.

- Live food should be certified to the specifications set by the Competent Authority to ensure it is free of potential disease agents.
- **Equipment used to handle aquatic animals and to clean and maintain tanks should not be shared between tanks.**
- **A separate set of equipment (nets, cleaning equipment, etc.) should be kept for each tank or series of tanks operated on an individual water filtration system.**
- Where several tanks are linked by a shared water recirculation system, a single set of equipment can be used for all tanks within the shared system.
- All nets and other equipment should be regularly disinfected by an approved method of disinfection. Equipment or other material should not be removed from the quarantine area during the period that the shipment is under quarantine conditions.
- In exceptional circumstances, and with the written approval of the supervising Quarantine Officer and his or her verification that proper disinfection has been accomplished, a request to remove specific items of equipment may be granted.
- All footwear and protective clothing used in the quarantine area should be restricted to this site.
- The operator should provide protective clothing for staff and visitors to use in the facility.
- Protective clothing should be kept inside the quarantine area (street footwear should be left outside the quarantine area and within the changing area).
- Cloth protective clothing that should be routinely washed may be removed from the quarantine area after washing for the purpose of drying.
- **A footbath containing hypochlorite, Betadine or another approved disinfectant should be maintained at the entrance of the quarantine area proper. The bath should be routinely replenished for adequate disinfection and a record of bath maintenance maintained.**
- All wastewater disposals should meet any state and local government requirements, be by an approved method, and should not flow directly into natural waterways.
- All filter material should be disinfected by autoclaving on another method approved by the supervising Quarantine Officer before it is removed from the Quarantine Facility and then disposed of by incineration or deep burial.
- Staff and visitors who have had contact with water or aquatic animals should wash their hands and forearms with soap and water before leaving the Quarantine Facility.

A4.2 Handling of aquatic animals

- After a shipment of aquatic animals has arrived at the approved port of entry, the accuracy of details of the shipment has been verified, and customs officers have given it a preliminary inspection and clearance, the supervising Quarantine Officer should reseal the shipment with an approved tamperproof seal and then transfer it to the custody of the operator, who should guarantee the secure transport of the aquatic animals, under quarantine conditions, to the Quarantine Facility.
- When the aquatic animals arrive at the Quarantine Facility, the supervising Quarantine Officer should verify the integrity of the seal. The seal should then be removed and the animals transferred to new water.
- The overseas water should be disinfected using an approved treatment.
- If a shipment of imported aquatic animals is incorrectly represented in any way, the shipment may be destroyed under supervision of the Quarantine Officer.
- A standard Tank Record Sheet should be maintained for each tank.
- Periodically throughout the day, the operator should observe all aquatic animals for signs of illness or abnormal behaviour.
- All dead aquatic animals should be held for inspection by a Quarantine Officer.

- Any equipment that has been in contact with dead aquatic animals should be disinfected before re-use.
- The use of any drug or chemical to treat aquatic animals should have prior approval and be recorded on Tank Record Sheets.
- The operator should ensure that no aquatic animals leave the quarantine area under any circumstances without the approval of the supervising Quarantine Officer.
- Once the Competent Authority has given its approval, the introduced stock (parental), the F1 or subsequent generation aquatic animals may be released from the Quarantine Facility for limited trials in aquaculture facilities or for stocking in enclosed water bodies. The Competent Authority may specify the precise conditions, period and any further risk management measures under which the aquatic animals are to be maintained.
- All original stock and any F1 or subsequent generation aquatic animals not approved for release from quarantine should remain under quarantine conditions.
- When determined by the Competent Authority or at the request of the operator, the operation of the Quarantine Facility may be terminated under the direct supervision of the supervising Quarantine Officer.
- If the operation is terminated, all remaining aquatic animals, including all original parent stock, should be humanely killed by a method approved by the supervising Quarantine Officer, tested for pathogens if required, appropriately sterilised and then disposed of by incineration or deep burial.
- The facility and all tanks and equipment should be thoroughly cleaned and disinfected using approved disinfectants, as should all filters, clothing and other similar materials.

A4.3 Outbreak of a serious exotic disease

If a serious exotic disease is diagnosed, the operator should be immediately notified. In such cases, the supervising Quarantine Officer or other representative of the Competent Authority may direct the management of disease control. Disease control measures may include the extension of quarantine, treatment and/or the destruction of stock.

Measures to be taken are likely to include:

- treating and/or destroying stock from infected tanks or all aquatic animals present in the facility at the time of the outbreak, and providing sanitary treatment to dead stock before removing and incinerating them;
- decontaminating the interior of the facility, all tanks and equipment, and all waters present in the facility at the time of the outbreak; and
- requiring the approval of the Competent Authority before the facility can be re-used.

A5. Record-keeping requirements

A5.1 Summary records

A complete history of the stock of aquatic animals being contained in the Quarantine Facility should be maintained. The operator should, for auditing purposes, maintain all documentation (shipping bills, health certificates, biosecurity clearance, etc.) and records for a minimum period of 36 months after the Quarantine Facility has been closed. During those 36 months, the documentation and records will be readily made available to a Quarantine Officer if requested.

The following summary information about the quarantined stock should be recorded:

- overseas supplier, country of origin and waybill;
- date of arrival of parent stock;
- date/s of release of stock, F1 or subsequent generation from quarantine;
- total number of animals in original shipment/s and total mortalities in each shipment when it arrives in the country of origin;

- original number of animals stocked in each tank;
- details of any clinical signs of disease and number of affected individuals, by tank;
- details of any mortalities, by tank;
- details of any health certificates;
- details of any diagnostic tests and examinations; and
- details of any F1 progeny produced (date and number) and their corresponding transfer tank number.

For parent stock, and for any F1 or subsequent generation aquatic animals that for any reason have not been approved for release from quarantine upon termination of the quarantine licence, the following information is also required: number and size of aquatic animals destroyed; date and method of destruction and disposal; and signature of the supervising Quarantine Officer.

For F1 or subsequent generation aquatic animals, if approved for limited release from quarantine, the following information is also required: number and size of aquatic animals released; date of release; destination; summary of any risk management measures or restrictions to be employed; and signature of the supervising Quarantine Officer.

A5.2 Tank record sheets

A **corresponding approved Tank Record Sheet** should be maintained for each holding tank and must be kept up to date at all times. Tank Record Sheets should be kept for a minimum of 36 months after the portion of the shipment held in the specific tank has been released from quarantine or destroyed.

This sheet should display the following information if possible:

- tank number;
- number of aquatic animals in tank;
- exporter identification details, including country of export;
- importer's name;
- date of arrival;
- shipment or airway bill number;
- number of aquatic animals dead on arrival;
- details of any observed disease conditions and number of sick aquatic animals;
- daily record of number of aquatic animal deaths in tank;
- details of any prophylactic or therapeutic treatments given;
- disposal details;
- disinfection details; and
- details of any F1 progeny produced (date and number) and their corresponding transfer tank number, if any.

A5.3 Operations and entry logbooks

- Details of wastewater treatment (including chlorination records); filter cleaning, replacement or disposal; internal audit; and general maintenance should be recorded in an operations logbook.
- A separate entry logbook should be used to record details of the entry and exit of authorised personnel into the Quarantine Facility.

A6. Auditing

- The operator should undertake systematic internal audits periodically to ensure that the standards for the operation of the Quarantine Facility, as set out in the relevant legislation, are maintained and to identify and correct any deficiencies.
- The operator should record in the logbook any variations from the prescribed criteria identified in the audit and the corrective measures taken.
- The supervising Quarantine Officer or other approved personnel should conduct periodic external audits of the Quarantine Facility to verify that it is secure and functioning properly.

A7. Security

- Control and security of the Quarantine Facility are of the utmost importance and are the responsibility of the operator.
- **The Quarantine Facility and its perimeter fencing should be securely locked when the facility is not in active use or is unattended.**
- Increased security after working hours should be considered to prevent unauthorised entry and theft, particularly where valuable broodstock are being held.
- **Procedures should be adopted to limit access to the premises to authorised people only.**
- The entry of staff into the Quarantine Facility should be restricted to the minimum number required to maintain and observe the quarantined animals as necessary.
- The operator should provide a list of authorised staff to the supervising Quarantine Officer. Except in an emergency, no people other than those on the list should enter the Quarantine Facility.
- A logbook of all entry to and exit from the Quarantine Facility should be maintained. All personnel entering the facility should be required to enter the following information:
  - name of authorised person;
  - date of entry/exit;
  - time of entry; and
  - reason for entry.

On leaving, they should also enter:

- time of exit; and
- signature.

Signature at exit indicates that the staff member who is leaving has confirmed that the Quarantine Facility was in proper order and secure at the time of his or her exit. The operator should ensure that all staff conform to these requirements and should verify the accuracy of record keeping every week. The logbook should be made available for the supervising Quarantine Officer to examine when requested.

A8. Contingency plans

The operator should develop a contingency plan for actions to be taken in an on-site emergency, such as fire, flood, electrical failure or breakdown of essential equipment (aerators pumps, etc.). In such an emergency, the supervising Quarantine Officer should be notified as soon as possible.

B. Other risk management measures to support quarantine

B1. Introduction

Quarantine is one of a wide range of risk management measures that can be applied, either alone or in combination, to reduce the risks of aquatic animal pathogens. Whether or not to require quarantine or other biosecurity measures should be decided on a case-by-case basis with reference to a risk analysis. The following are some other approaches that can be applied to support quarantine in reducing the risks associated with the introduction of an exotic species. These risk reduction measures are subdivided into **pre-border** and **post-border** measures.

B2. Pre-border measures

The success of pre-border measures is often critically dependent on the inspection, certification and compliance regime of the exporting country. Such measures tend to be most effective when the Competent Authorities of the importing and exporting countries undertake them cooperatively.

(a) Certification of production source

A highly effective method of ensuring the introduced species is free of many serious diseases is to inspect and test hatcheries and other aquaculture production facilities and, if the results confirm it, to certify them as free from specific pathogens.

(b) Use of specific pathogen free (SPF) stocks

The pathogen for which freedom is certified varies between SPF production facilities and species. There are also no universally accepted criteria (e.g. type, number and frequency of diagnostic testing that must be performed) that must be met for a production facility to achieve SPF production status.

(c) Zoning

Sourcing stock from production facilities located in disease-free zones is another highly effective method of ensuring that the aquatic animals being moved are free from certain serious pathogens. Such a system is currently in place in the European Union.

(d) Restrictions on life cycle stages

Juvenile stages and especially fertilised eggs generally carry fewer subclinical infections than do adult animals.

Restricting importations to surface-disinfected fertilised eggs is often an effective way to prevent the movement of parasites, most bacteria and some viruses.

(e) Lists of approved species

Restricting importation to certain previously approved 'lower-risk' species is an effective way to reduce the likelihood of introducing pathogens. Such lists should be country-specific as determined by risk analysis, taking into consideration a range of relevant national factors, including possible end uses.

(f) Lists of approved exporting countries

Importing countries may wish to establish lists of exporting countries that have met set risk management conditions and thus can be pre-approved as lower-risk sources for certain types of aquatic animals.

Such conditions might include, for example, that a country has:

- disease surveillance, monitoring and reporting programmes;
- zoning programmes;
- health certification programmes for production facilities;
- standard operating procedures or better management practices for production facilities and exporters; and
- contingency plans for serious disease outbreaks.

(g) On-site inspection of exporting facilities

For movements of 'high-risk' species, the Competent Authority of the importing country may wish to visit proposed hatchery or other production facilities in order to verify the biosecurity measures that are in place to support claims of health status.

(h) Evaluation of Competent Authorities

In cases where, as part of a risk assessment, the Competent Authority of an importing country is uncertain about the adequacy of zoosanitary measures that a potential exporting country is using, an evaluation of the Competent Authority in the potential exporting country may help to relieve any specific concerns.

(i) International and other health certificates

Requiring international health certificates for specific OIE-listed diseases of concern to the importing country can provide a high level of assurance that consignments are free of the specified diseases.

- Importing countries should not require certification for diseases that are not relevant to their own situation and/or the species of aquatic animal being moved.
- Other types of health certificates are of limited value and must be individually evaluated based on the reliability of the diagnostic test(s) performed, the sampling regime, etc.
- Health certificates based on visual inspection for gross signs of pathology/or general 'health' have little value in preventing the international spread of transboundary aquatic animal diseases.

(j) Pre-border quarantine and temporary holding

- Risks to the importing country from 'high-risk' species can be reduced by conducting quarantine and disease testing of the selected aquatic animals either in the exporting country or in a third country that has appropriate quarantine capacity.
- Pre-border quarantine holding of 'lower-risk' aquatic animals in the exporting country can also allow time for any diseases or infections to become evident.
- For 'high-risk' species in quarantine, co-habitation experiments can be performed to investigate the presence of pathogens and the susceptibility of native species to the exotic species. In such experiments, key native species are held in contact with the exotic species or effluent waters from the quarantine holding tank.
- Placing quarantined animals under increased stress may also prompt the overt expression of subclinical infections.

(k) Pre-shipment treatment

In some cases, the use of pre-shipment treatments can reduce the risk of pathogen transfer.

- The surface disinfection of eggs using iodophores is an example of this kind of treatment.
- However, treatment of external parasites and bacterial infections may only reduce infection levels, removing the clinical signs of disease but not eradicating the pathogen(s).

(l) Inspection, certification and compliance audits

Establishing auditing procedures to verify that exporters, importers, Competent Authorities and private contracting agencies are strictly adhering to specified protocols and requirements should be considered.

B3. Post-border measures

Post-border risk management measures that support quarantine include the following.

(a) Restrictions on initial use

Placing restrictions on the initial use of introduced or transferred aquatic animals provides the opportunity to detect any introduced diseases before the animals are released generally into the natural environment and increases the opportunity for control and eradication.

(b) Monitoring programmes

A disease surveillance component in monitoring programmes for introduced or transferred aquatic animal species can be used to confirm that serious diseases have not been spread to new environments. In addition, if serious exotic pathogens do escape detection in quarantine, such surveillance will help minimise their impacts by allowing containment or eradication programmes to be initiated at an early stage.

(c) Contingency planning

All proposals for introductions and transfers should include planning for actions to be taken if animals or pathogens escape from quarantine or a serious pathogen fails to be detected during quarantine and is released into aquaculture facilities or the natural environment.

Annex 2: Live aquatic animal certificate, Ministry of Agriculture and Cooperatives, Department of Fisheries (Thailand)

5. Health Declaration

I,......Ms.Jaree Polchana......, being an official veterinarian of ......Department of Fisheries...... certify that:

5.1 The live fish in this consignment have as their place of harvest a ☐ Country, ☐ Zone, ☐ Aquaculture establishment that is subject to an official Fish health surveillance scheme according to the procedures described in the OIE *Diagnostic Manual for Aquatic Animal Diseases*, and that the Country, Zone, or Aquatic establishment identified in sections 2 and 3 above is/are officially recognised as being free from the diseases identified in the table below.
(Please indicate freedom from disease by ticking appropriate boxes)

	Country		Zone		Aquaculture establishment	
	Yes	No	Yes	No	Yes	No
Epizootic haematopoietic necrosis	/					
Infectious haematopoietic necrosis	/					
Oncorhynchus masou virus disease	/					
Spring viraemia of carp	/					
Viral haemorrhagic septicaemia	/					
Channel Catfish virus disease	/					
Viral encephalopathy and retinopathy					/	
Infectious pancreatic necrosis	/					
Infectious salmon anaemia	/					
Epizootic ulcerative syndrome	/					
Bacterial kidney disease *(Renibacterium salmoniarum)*	/					
Enteric septicaemia of catfish *(Edwardsiella ictalun)*	/					
Piscirickettsiosis *(Piscirickettsia salmonis)*	/					
Gyrodactylosis (*G. salaris*)	/					
Red Sea bream iridoviral disease	/					
White sturgeon iridoviral disease	/					

5.2 Within 30 days prior to export the brood stock population, from which this consignment of fish was produced, was subjected to testing on a representative sample, for each of these diseases and pathogens (to which the species is susceptible), with negative results.

5.3 All tests were conducted according to the OIE *Diagnostic Manual for Aquatic Animal Diseases*.

5.4 All testing was conducted in a government approved testing facility as determined by the Competent Authority of the country of export.

5.5 The hatchery/fish farm of origin maintains a record keeping system that enables traceability of all batches of fish produced for export

5.6 The hatchery/fish farm of origin is approved by, and subject to regular health inspections and testing, by the Competent Authority in the exporting country.

VLOD Schedule 70 Import of Live Tilapia Fish, all countries.
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Page 2 of 6

DEPARTMENT OF FISHERIES

Please see details in Thai Health Certificate No. 2848