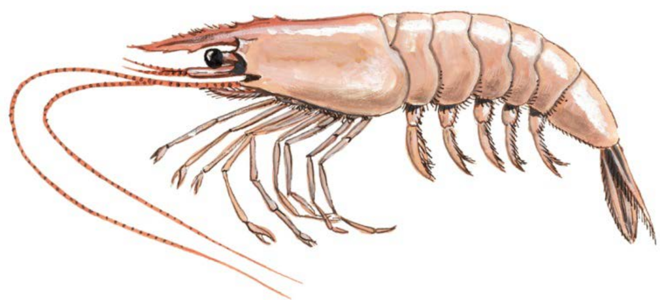
White Shrimp

Litopenaeus vannamei



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Ecuador

Coastal Ponds

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About Seafood Watch®

The Monterey Bay Aquarium Seafood Watch® program evaluates the ecological sustainability of wild-caught and farmed seafood commonly found in the North American marketplace. Seafood Watch defines sustainable seafood as originating from sources, whether wild-caught or farmed, which can maintain or increase production in the long-term without jeopardizing the structure or function of affected ecosystems. The program's mission is to engage and empower consumers and businesses to purchase environmentally responsible seafood fished or farmed in ways that minimize their impact on the environment or are in a credible improvement project with the same goal.

Each sustainability recommendation is supported by a seafood report. Each report synthesizes and analyzes the most current ecological, fisheries and ecosystem science on a species, then evaluates this information against the program's sustainability criteria to arrive at a recommendation of "Best Choice," "Good Alternative," or "Avoid." In producing the seafood reports, Seafood Watch utilizes research published in academic, peer-reviewed journals whenever possible. Other sources of information include government technical publications, fishery management plans and supporting documents, and other scientific reviews of ecological sustainability. Seafood Watch research analysts also communicate with ecologists, fisheries and aquaculture scientists, and members of industry and conservation organizations when evaluating fisheries and aquaculture practices. Capture fisheries and aquaculture practices are highly dynamic; as the scientific information on each species changes, Seafood Watch's sustainability recommendations and the underlying seafood reports will be updated to reflect these changes. Both the detailed evaluation methodology and the scientific reports, are available on seafoodwatch.org.

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Guiding Principles

Seafood Watch™ defines sustainable seafood as originating from sources, whether fished[1] or farmed, that can maintain or increase production in the long-term without jeopardizing the structure or function of affected ecosystems.

The following **guiding principles** illustrate the qualities that aquaculture must possess to be considered sustainable by the Seafood Watch program:

Seafood Watch will:

- Support data transparency and therefore aquaculture producers or industries that make information and data on production practices and their impacts available to relevant stakeholders.
- Promote aquaculture production that minimizes or avoids the discharge of wastes at the farm level in combination with an effective management or regulatory system to control the location, scale and cumulative impacts of the industry's waste discharges beyond the immediate vicinity of the farm.
- Promote aquaculture production at locations, scales and intensities that cumulatively maintain the functionality of ecologically valuable habitats without unreasonably penalizing historic habitat damage.
- Promote aquaculture production that by design, management or regulation avoids the use and discharge of chemicals toxic to aquatic life, and/or effectively controls the frequency, risk of environmental impact and risk to human health of their use.
- Within the typically limited data availability, use understandable quantitative and relative indicators to recognize the global impacts of feed production and the efficiency of conversion of feed ingredients to farmed seafood.
- Promote aquaculture operations that pose no substantial risk of deleterious effects to wild fish or shellfish populations through competition, habitat damage, genetic introgression, hybridization, spawning disruption, changes in trophic structure or other impacts associated with the escape of farmed fish or other unintentionally introduced species.
- Promote aquaculture operations that pose no substantial risk of deleterious effects to wild populations through the amplification and retransmission of pathogens or parasites.
- Promote the use of eggs, larvae, or juvenile fish produced in hatcheries using domesticated broodstocks thereby avoiding the need for wild capture.

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1 "Fish" is used throughout this document to refer to finfish, shellfish and other invertebrates.

- Recognize that energy use varies greatly among different production systems and can be a major impact category for some aquaculture operations, and also recognize that improving practices for some criteria may lead to more energy intensive production systems (e.g., promoting more energy intensive closed recirculation systems).

Once a score and rank has been assigned to each criterion, an overall seafood recommendation is developed on additional evaluation guidelines. Criteria ranks and the overall recommendation are color-coded to correspond to the categories on the Seafood Watch pocket guide:

Best Choices/Green: Are well managed and caught or farmed in environmentally friendly ways.

Good Alternatives/Yellow: Buy, but be aware there are concerns with how they're caught or farmed.

Avoid/Red: Take a pass on these. These items are overfished or caught or farmed in ways that harm other marine life or the environment.

Final Seafood Recommendation

White Shrimp

Litopenaeus vannamei

Ecuador

Coastal Ponds

Criterion	Score (0-10)	Rank	Critical?
C1 Data	4.75	YELLOW	
C2 Effluent	5.00	YELLOW	NO
C3 Habitat	3.77	YELLOW	NO
C4 Chemicals	5.00	YELLOW	NO
C5 Feed	7.70	GREEN	NO
C6 Escapes	4.00	YELLOW	NO
C7 Disease	4.00	YELLOW	NO
C8 Source	10.00	GREEN	
C9X Wildlife mortalities	-4.00	YELLOW	NO
C10X Introduced species escape	0.00	GREEN	
Total	**40.22**		
Final score	**5.03**		

OVERALL RANKING

Final Score	5.03
Initial rank	YELLOW
Red criteria	0
Interim rank	YELLOW
Critical Criteria?	NO

FINAL RANK
YELLOW

Scoring note – scores range from zero to ten where zero indicates very poor performance and ten indicates the aquaculture operations have no significant impact.

Summary

The final numerical score for farmed white shrimp (*L. vannamei*) from Ecuador is 5.03, which is in the yellow range, and with no red criterion, the final ranking is Yellow - Good Alternative.

Executive Summary

Shrimp is the most widely consumed seafood item in the United States; in 2012 Americans ate an estimated 1.7 kilograms (3.7 lbs.) per capita. Approximately 90% of shrimp consumed in the US is imported, and over 81,000 metric tons entered the US from Ecuador in 2012. Farmed shrimp accounted for 95% of this amount. Ecuadorian farmed shrimp therefore plays an important role in the US seafood market.

Virtually all shrimp farmed in Ecuador is the native, white shrimp (*Litopenaeus vannamei*). The industry developed in the 1960s and grew rapidly before repeated viral shrimp diseases resulted in farmers adopting a "live with it" approach and reverting to low production intensities in order to continue producing shrimp. These extensive and semi-intensive pond farms are characterized by low stocking densities, large irregularly shaped coastal ponds, and the use of only supplemental or no added feed. Despite these seemingly low-technology approaches, the Ecuadorian industry has become consolidated, with a number of large vertically integrated companies existing (owning processing plants, feed mills, hatcheries and farms) and resulting in farms that have access to improved resources, such as hatchery-raised seed from broodstock selected to have greater disease resistance. This combination of low-input production systems with improved production technology gives rise to moderate environmental impacts associated with waste, feed, and the use of chemicals. Regulations exist to cover a range of environmental issues but data are limited on the level of compliance resulting from the required annual inspections.

This Seafood Watch assessment involves a number of different criteria and covers impacts associated with effluent, habitats, chemical use, feed production, escapes, introduction of non-native organisms (other than the farmed species), disease, the source stock, wildlife and predator interactions, and general data availability.

Data on Ecuadorian shrimp farming are present for regulations and production data; however, data on environmental impacts are limited. Peer-reviewed literature focuses on "hot-spot" issues to the farming industry, with mangroves, disease and feed receiving the most attention. For some issues, few data were available and conclusions drawn were based on the author's experience and the experience of industry experts as well as the predominant production systems used in the country. The numerical score for Criterion 1 – Data is 4.75 out of 10.

The supplemental use of feed in low intensity shrimp farming results in a relatively low feed conversion ratio (FCR) and therefore relatively low waste production from the shrimp, but fertilizer is also applied to the ponds to stimulate natural feed production. Water exchange is limited—most water loss is due to evaporation as opposed to discharge—and water is often released only during harvest. These factors, result in a waste discharge score of 8 out of 10. Effluent regulations exist, but are not aquaculture specific, farm specific, or based on cumulative factors. No data were apparent to enable scores for the enforcement of regulations. Overall, the country received a score of 5 out of 10 for the Effluent Criterion.

Global shrimp farming has been linked to the historical conversion of ecologically important wetlands, including mangrove forests. The majority of losses occurred before the late 1990s; after which a number of factors, including regulatory protection, the ability to grow shrimp at low salinities, and the knowledge that former mangrove soils negatively affect pond water quality, have greatly reduced mangrove losses due to shrimp farming. Ecuador scores 4 out of 10 for historical (> 10 years ago) conversion of ecologically important habitats, however, current regulations are established to prevent further mangrove and wetland loss during farm construction by way of an environmental impact assessment (EIA). Ongoing environmental monitoring is moderate, but does not address cumulative farm impacts. The final score for Criterion 3 – Habitats is 3.77 out of 10.

Shrimp farming in Ecuador uses low intensity production strategies with little to no daily water exchange. Probiotics are the preferred form of health management, but some use of controlled antibiotics (oxytetracycline or florfenicol) exists. Both oxytetracycline and florfenicol are listed by the World Health Organization (WHO) as “Highly Important” for human health. Overall, the limited data make a robust assessment challenging, but the low production intensity, very limited water exchange, common use of probiotics, and expert opinion on the low use of antibiotics means that despite the potential use of treatments that are highly important to human health, there is a moderate overall concern and a final score of 5 out of 10 for the Chemical Use Criterion.

Fishmeal levels in the diet may be relatively high (~16%), but fish oil inclusion levels are low (2.5%). These are offset by around 60% of fishmeal and 65% of fish oil coming from byproduct sources. Therefore, in addition to the supplemental nature of the feed, FIFO levels are very low (0.34). Data are lacking on the sustainability of direct marine ingredients used in feed, and a mixture of Seafood Watch “yellow” and “red” sources are used for byproduct sources of fishmeal and fish oil. The protein loss from feed is relatively high (~50%) and a total of 5.93 hectares is calculated to be necessary to produce the feed ingredients required for one ton of farmed shrimp. The numerical score for Criterion 5 – Feed is 7.70 out of 10.

Published information on the frequency, magnitude, or impacts of shrimp escapes from shrimp farms in Ecuador was not available, suggesting these issues are poorly reported and/or studied. Shrimp farmed in the country are hatchery-raised from native broodstock that has been selected over several generations for improved farm performance, particularly disease resistance. Pond systems generally use mesh-screens to prevent escapes; though better practices, such as regular inspections and back-up systems are likely to be farm specific and not necessarily industry norms. Should escapes occur, the main potential impact is a reduction in genetic fitness of the wild population as a result of interbreeding with farmed shrimp. Overall, Ecuadorian farmed shrimp are, therefore, considered a moderate risk for impacts associated with escapes and the numerical score for Criterion 6 – Escapes is 4 out of 10.

Disease outbreaks on shrimp farms have the ability to severely impact production, and were the driving force behind Ecuador’s adoption of low intensity farming practices. Shrimp farms are connected to the external environment, primarily by water exchanges, and the transfer of shrimp diseases from them to wild populations and other susceptible species has been demonstrated. However, with exception of one possible event in Mexico, significant impacts on these wild populations have not been reported. Ecuador is, therefore, considered a moderate risk and the numerical score for Criterion 7 – Disease is 4 out of 10.

Based on available data, all Ecuadorian broodstock are hatchery-raised. As such, there is no dependence on wild populations for either breeding stock or postlarvae and, subsequently, no impacts relating to the source of stock. The numerical score for Criterion 8 – Source of Stock is 10 out of 10.

Generally, Ecuadorian shrimp farms apply non-lethal techniques to control predators such as diving birds. While data are limited, available information indicates that wildlife mortalities occur (beyond exceptional cases), but due to high population size and/or high productivity and/or low mortality numbers, they do not significantly impact the affected species' population size. The score for Exceptional Criterion 9X – Wildlife and Predator Mortalities is -4 out of -10.

Farmed shrimp in Ecuador are hatchery-raised from selected, but native, broodstock in the country. International or trans-waterbody live animal shipments are therefore not relevant to this assessment as the hatcheries are in-country and the shrimp are grown in environments that are not ecologically distinct from these hatcheries. Exceptional Criterion 10X is therefore unnecessary to be scored and no adjustment is applied.

The final numerical score for Ecuadorian farmed shrimp is 5.03 out of 10. Overall, farmed shrimp from Ecuador are ranked as a yellow or good alternative.

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Scope of the analysis and ensuing recommendation

Species
White Shrimp (*Litopenaeus vannamei*)

Geographic coverage
Ecuador

Production Methods
Approximately 80% extensive and 20% semi-intensive coastal ponds

Species Overview

Litopenaeus vannamei are native to eastern Pacific waters ranging from Sonora, Mexico to Tumbes in northern Peru (Briggs 2006a), and are therefore native to Ecuador. The life history of white shrimp is similar to other members of the family Penaeidae, in which adults spawn offshore, larvae move toward the coast and develop in estuaries and then move offshore as adults.

Production statistics
Ecuador was the first country in the world to domesticate white shrimp and start farming it (Cordovez (date?) pers. comm.). White shrimp has been introduced to a number of countries around the world, including China, India, Indonesia, and Thailand (Briggs 2006a) and now accounts for approximately three quarters of global farmed shrimp production (Nikolik and Kumar 2013).

In 2011, Ecuador produced 260,000 mt of white shrimp (FishStat Plus 2013) from 202,252 hectares (ha) of shrimp farms (Piedrahita, pers. comm.). The shrimp aquaculture industry in Ecuador is highly consolidated, with a number of large vertically integrated producer groups. The country is currently in a period of transition: for many years after a white spot syndrome virus (WSSV) outbreak in the 1990s, extensive or improved extensive production practices were the preferred option in the country, however, in the last few years there has been an increased adoption of semi-intensive practices by some producers.

Import and export sources and statistics
Shrimp is the most widely consumed seafood item in the United States; in 2012 Americans ate an estimated 1.7 kilograms (kg) (3.7 pounds) per capita (NFI 2013). It has been estimated that 90% of the shrimp consumed in the US are imported (Fluech and Krimsky 2011). In 2012, the US imported over 530,000 metric tons (mt) of shrimp. After Thailand, Ecuador was the second largest shrimp exporter to the US with around 81,000 mt, closely followed by Indonesia and India (NFMS 2013). Approximately 95% of shrimp imported from Ecuador are farmed; only

artisanal shrimp fishing now occurs in the country (Cordovez, pers. comm.). Ecuadorian farmed shrimp therefore plays an important role in the US seafood market.

Common and market names

Scientific Name	*Litopenaeus vannamei*
Common Name	Pacific white shrimp, Pacific whiteleg shrimp, White shrimp
United States	Shrimp, white shrimp
Spanish	Camarón patiblanco
French	Crevette pattes blanches
Japanese	蛯 (ebi)

Product forms
White shrimp from Ecuador are available in a number of product forms including frozen, previously frozen, cooked and raw, head-on, head-off, peeled, and peeled and deveined. They may also be present in value-added goods like breaded shrimp or ready meals.

Production system

Shrimp farming in Ecuador began in the late 1960s in the Province of El Oro; expanding into the Guayas region during the 1970 (Briggs 2006b). In both areas, saltpans were favored for the locations of the shrimp ponds (Briggs 2006b).

During the 90s and early 2000s, a series of disease outbreaks occurred (first Taura syndrome virus (TSV) followed by white spot syndrome virus (WSSV)), resulting in significant production losses (Lighter 2011). Neither disease could be eradicated and so the industry adopted a "live with it" approach, favoring extensive and improved extensive production strategies that reduced the impact of the disease.

Farming systems are generally characterized by relatively low stocking densities of between 8 and 14 post larvae (PLs, or juvenile shrimp) per square meter (m^2) in large, irregularly shaped ponds without the use of aeration. Virtually all farms apply supplemental feed and fertilizer which the shrimp eats in addition to the natural plankton that grows in the ponds (Cordovez, pers. comm.). No official statistics on stocking densities in Ecuadorian shrimp farms are available, however, Sonnenholzner estimates around 80% of the industry stock from 7-12 PL/m^2, with the remaining 20% stocking above 12 and using semi-intensive practices (pers. comm.). These stocking densities are still well below the intensive approaches commonly used for *L. vannamei* in Asia (60 PL/m^2 plus). Most farms apply probiotics to their ponds to promote a good bacterial environment (Cordovez, pers. comm.) and most farms have been in operation for many decades and are still productive (Cordovez, pers. comm.).

The low intensity of farming used in Ecuador can be consistent with the European organic-farming standards (currently no US organic aquaculture standard has been finalized). A number of farms in Ecuador have been certified by the Germany-based Naturland certification scheme, which Seafood Watch considers to be consistent with its "yellow" or "good alternative" ranking. According to Ute Wiedenluebbert of Naturland, only around 2.3 mt of shrimp harvested annually from 1,800 ha of Ecuador's 202,252 ha of shrimp farms are certified (pers. comm.). Approximately 40%–50% of this is sold in the US, and may be differentiated by an environmental claim (Wiedenluebbert pers. comm.)

Figure 1 shows the production cycle of white shrimp. All PLs stocked in Ecuador are hatchery-raised (Sonnenholzner, pers. comm.). Daily water exchange is between 1%–3% or none at all Sonnenholzner et al. 2002).

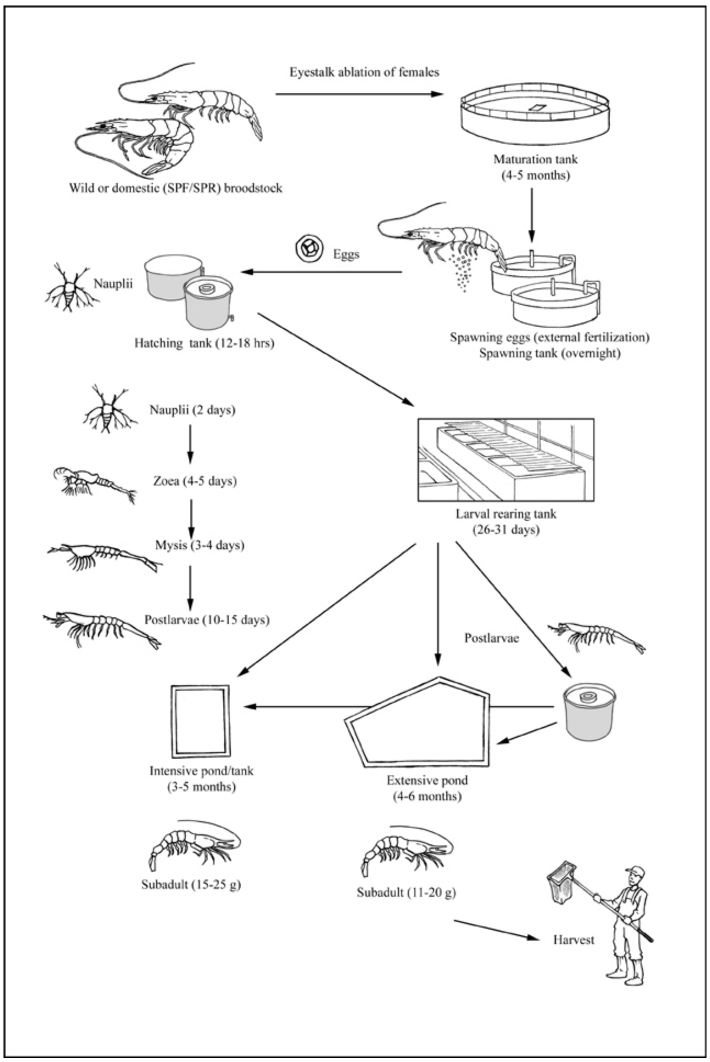

Figure 1. Production cycle for White Shrimp. Copied From Briggs (2006b).

Shrimp in Ecuador is mainly raised in monoculture; however, some farmers favor polyculture with tilapia (*Oreochromis* spp.) (Briggs 2006b) though, in the author's experience in the country, tilapia is considered the primary farmed species, with shrimp a supplementary source of income in these systems.

Analysis

Scoring guide

- With the exception of the exceptional factors (9X and 10X), all scores result in a zero to ten final score for the criterion and the overall final rank. A zero score indicates poor performance, while a score of ten indicates high performance. In contrast, the two exceptional factors result in negative scores from zero to minus ten, and in these cases zero indicates no negative impact.
- The full Seafood Watch Aquaculture Criteria that the following scores relate to are available here http://www.montereybayaquarium.org/cr/cr_seafoodwatch/content/media/MBA_SeafoodWatch_AquacultureCriteraMethodology.pdf
- The full data values and scoring calculations are available in Annex 1.

Criterion 1: Data quality and availability

Impact, unit of sustainability and principle

- *Impact: poor data quality and availability limits the ability to assess and understand the impacts of aquaculture production. It also does not enable informed choices for seafood purchasers, nor enable businesses to be held accountable for their impacts.*
- *Sustainability unit: the ability to make a robust sustainability assessment*
- *Principle: robust and up-to-date information on production practices and their impacts is available to relevant stakeholders.*

Criterion 1 Summary

Data Category	Relevance (Y/N)	Data Quality	Score (0-10)
Industry or production statistics	Yes	7.5	7.5
Effluent	Yes	5	5
Locations/habitats	Yes	5	5
Predators and wildlife	Yes	5	5
Chemical use	Yes	2.5	2.5
Feed	Yes	5	5
Escapes, animal movements	Yes	2.5	2.5
Disease	Yes	5	5
Source of stock	Yes	7.5	7.5
Other – (e.g. GHG	Yes	2.5	2.5

emissions)			
Total			**47.5**

C1 Data Final Score	**4.75**	**YELLOW**

Brief Summary
Data on Ecuadorian shrimp farming are present for regulations and production data; however, data on environmental impacts are limited. Peer-reviewed literature focuses on "hot-spot" issues to the farming industry, with mangroves, disease and feed receiving the most attention. For some issues, few data were available and conclusions drawn were based on the author's and industry expert experience as well as the predominant production systems used in the country.

Justification of Ranking
This Seafood Watch assessment involves a number of different criteria covering impacts associated with effluent, habitats, chemical use, feed production, escapes, introduction of non-native organisms (other than the farmed species), disease, the source stock, wildlife and predator interactions, and general data availability. The Data Criterion rewards those companies or industries that are well researched or that make data on their activities and impacts available. Ecuador is an important shrimp farming nation, and has received some attention in terms of industry overviews. Several government websites exist that detail national regulations, including:

- Ministry of Agriculture, Livestock and Fishery (*www.agricultura.gob.ec/comunicamos/)*
- National Fisheries Institute (INP) (*www.inp.gob.ec/inp/index.html)*
- National Aquaculture Chamber (CAN) (*www.cna-ecuador.com)*

In additional to regulatory data, this assessment has relied on several notable studies, including Tacon and Metian (2008) for feed data, D'Andrea (2005) for legal enforcement, as well as Walker and Mohan (2009) and Lightner (2011) for information on shrimp diseases.

The assessment also relied on the expertise of several industry professionals, including:

- Jessenia Angulo, Sustainability Manager at Natural Habitats Group and an Ecuadorian aquaculture industry expert.
- Ute Wiedenlübbert, Naturland Representative, Ecuador.
- Dr Stanislaus Sonnenholzner, Scientific Coordinator at Centro Nacional de Acuicultura e Investigaciones Marinas (CENAIM)
- Yahira Piedrahita Falquez, Executive Director, National Aquaculture Chamber
- Juan Xavier Cordovez, General Manager of Expalsa

While relative to some aquaculture industries, particularly in the developing world, data on Ecuadorian shrimp farming practices are relatively good, however, information specifically on environmental impacts and regulatory compliance statistics is limited. Overall, data availability for Ecuadorian farmed shrimp are rated as moderate and a score of 5.0 or yellow ranking.

Criterion 2: Effluents

Impact, unit of sustainability and principle

- *Impact: aquaculture species, production systems and management methods vary in the amount of waste produced and discharged per unit of production. The combined discharge of farms, groups of farms or industries contributes to local and regional nutrient loads.*
- *Sustainability unit: the carrying or assimilative capacity of the local and regional receiving waters beyond the farm or its allowable zone of effect.*
- *Principle: aquaculture operations minimize or avoid the production and discharge of wastes at the farm level in combination with an effective management or regulatory system to control the location, scale and cumulative impacts of the industry's waste discharges beyond the immediate vicinity of the farm.*

Criterion 2 Summary

Effluent parameters	Value	Score	
F2.1a Biological waste (nitrogen) production per of fish (kg N ton-1)	33.724		
F2.1b Waste discharged from farm (%)	34		
F2 .1 Waste discharge score (0-10)		8	
F2.2a Content of regulations (0-5)	2		
F2.2b Enforcement of regulations (0-5)	1.75		
F2.2 Regulatory or management effectiveness score (0-10)		1.4	
C2 Effluent Final Score		**5.00**	**YELLOW**
Critical?	NO		

Brief Summary

The supplemental use of feed in low intensity shrimp farming results in a relatively low feed conversion ratio (FCR). Water exchange is also limited—most water loss is due to evaporation as opposed to discharge, with water often released only during harvest. These factors offset the moderate protein content in the feed and the addition of fertilizer to stimulate natural feed production, resulting in a waste discharge score of 8 out of 10. Effluent regulations exist, but are not aquaculture specific, farm specific, or based on cumulative factors. No data were apparent to enable scores for the enforcement of regulations. Overall, the country received a score of 5 out of 10 for the Effluent Criterion.

Justification of Ranking

Factor 2.1 Waste discharge score

No specific references to the environmental impact of pollution from shrimp farms in Ecuador were apparent, which could be a result of the low-intensity nature of the industry as well as the relative lack of scientific inquiry in this regard. As the Criterion 1 – Data score for the Effluent category is 5, there is considered insufficient information to conduct the evidence-based assessment. Instead, the risk-based assessment is utilized, which involves calculating the amount of waste produced by the shrimp and then the amount of that waste that is discharged from the farm. The effectiveness of the regulatory system in managing wastes from multiple farms as well as the entire industry is used to assess the potential cumulative impacts from the industry as a whole.

The shrimp farming industry in Ecuador is defined primarily as "low intensity"; 8-14 PLs are stocked per square meter and there is no supplemental aeration. Supplemental feeding can result in FCRs around 1.2, but ranging from 1 to 1.4 (Tacon and Metian 2008), and only 28.7% of Ecuadorian shrimp feed is crude protein (See Devresse (1995) in Tacon 2002). As noted earlier, daily water exchange is either low (1%–3%) or omitted entirely (Sonnenholzner et al. 2002). These values are still relevant today (Sonnenholzner, pers. comm.).

Approximately 60% of shrimp farms in Ecuador add bokashi (an organic fertilizer made of fermented wheat mixed with molasses) to the ponds, which maintains a beneficial bacterial environment in the ponds and promotes natural plankton blooms used by the shrimp as feed (Sonnenholzner, pers. comm.). Farms may use 10-30 kg/ha of fertilizers, such as urea or commercial fertilizers (e.g., Agripac or Nutrilake) (Sonnenholzner, pers. comm.). Agricultural urea contains between 45%–46% nitrogen (Wiess et al. 2009). Based on annual production in 2011 and the area covered by shrimp farms, shrimp production in Ecuador is estimated to be 1.29 mt/ha. Using an average of 20 kg/ha fertilizer, and assuming 45.5% of the fertilizer is nitrogen, then farms are adding 9.1 kg/ha of nitrogen per cycle, which results in an input of 7.1 kg of nitrogen per metric ton of shrimp produced.

Using the data available, the biological waste (nitrogen) produced by Ecuadorian shrimp farms was calculated to be 33.7 kg/mt of shrimp (see Seafood Watch Aquaculture Criteria document for effluent calculations). Sonnenholzner (2008) reviewed available data on the biological waste (nitrogen) from Ecuadorian and Honduran shrimp farms; his findings ranged from as high as 329 kg/mt for farms in estuarine waters and stocked at 4-8 PL/m^2 to as low as 10 kg/mt for coastal farms stocked at 13-19 PL/m^2. The amount of waste from shrimp farms can, therefore, be highly variable and dependent on a number of farm practices.

As the majority of ponds discharge once per production cycle (i.e., exchange at harvest), the Seafood Watch criteria applies an adjustment of 0.34 to the system discharge score, recognizing that only 34% of the waste produced by the farm is discharged as effluent. The remaining 66% of waste produced remains within the immediate footprint of the farm and is considered in Criterion 3 – Habitat.

11.5 kg of nitrogenous waste is calculated to be discharged per ton of shrimp produced, resulting in Factor 2.1 Waste Discharge score of 8 out of 10.

Factor 2.2 Regulatory or management effectiveness score

The planning, regulation, and monitoring of shrimp farming in Ecuador falls under the jurisdiction of the Vice Ministry of Fisheries and Aquaculture, a sub-component of the Ministry of Agriculture, Livestock and Fishery (*Ministerio de Agricultura, Ganaderia,Acuacultura y Pesca,* MAGAP), and is supported by the Environmental and Labour Ministries (Angulo, pers. comm.). For export, farms must obtain a health or quality certificate from the National Fisheries Institute (INP)—a public corporation which audits farms annually for food safety and quality parameters (Angulo, pers. comm.). This forms part of the National Control Plan (NCP) (*Plan Nacional de Control*) to ensure Ecuadorian farmed shrimp products can be exported to the European Union (EU).

Shrimp farm effluents are regulated according to two laws (Angulo, pers. comm.):

1. Environmental law and regulation—Environmental pollution control and prevention (*Reglamento a la ley de gestion ambiental para la prevencion y control de la contaminacion ambiental*)
2. Environmental quality and effluent discharge standards—water resources from the environmental management laws and regulations. Prevention and control of environmental pollution, Book VI of Environmental Quality TULSMA (Normas de Calidad Ambiental y de Descarga de Efluentes: Recurso Agua, del Reglamento a la Ley de Gestión Ambiental para la Prevención y *Control de la Contaminación Ambiental, Libro VI de Calidad ambiental de TULSMA*)

The first law requires shrimp farms to perform an environmental impact assessment (EIA) and to develop an environmental management plan (EMP) in order to obtain an environmental license to operate. The second law defines the national water quality standards for effluents discharged into different types of water body, including seawater (Angulo, pers. comm.). These values were set by experts in the field and based on the status of receiving water bodies (Angulo, pers. comm.). Conformity to these standards is enforced through annual audits by the INP and internal monitoring by the farms, a requirement on the NCP (Angulo, pers. comm.).

The presence of effluent regulation applicable to aquaculture results in a score of "1" for Question 1 of Factor 2.2a (see Appendix 1 for all scoring values).

Though national discharge standards exist, they are general and not aquaculture specific (D'Andrea 2005). Table 1 shows a selection of the national standards for discharge into seawater (considered relevant for aquaculture by the author) in comparison to effluent water quality limits set for aquaculture specifically, in this example, the initial effluent water quality standards defined in the Global Aquaculture Alliance Best Aquaculture Practices Finfish and Crustacean Standards Rev 4/13 (GAA 2013).

Table 1. Comparison of discharge quality standards relevant to aquaculture between the Ecuadorian national standards and the Global Aquaculture Alliance Finfish and Crustacean Standards Rev 4/13.

Water quality parameter	Environmental Quality and Effluent Discharge Standards: Seawater	Global Aquaculture Alliance Crustacean and Finfish Standards V1.
Biochemical Oxygen Demand (5 days)	250 mg/l	50 mg/l or less
Phosphorus	10 mg/l Total phosphorus	0.5 mg/l Soluble Phosphorus
Nitrogen	40 mg/l Total Kjeldahl Nitrogen	5 or less mg/L Total ammonia nitrogen

Total Suspended Solids	100 mg/l	50 mg/l or less
pH	6-9	6-9.5
Dissolved Oxygen	No Standard	4 mg/l or more

Table 1 shows that while national effluent standards exist in Ecuador, they are not as rigorous as standards defined specifically for aquaculture by international eco-certification organizations. The EIA process does allow for more rigorous site-specific criteria to be included in the farms EMP, but information was not available on how commonly this practice occurs (Angulo, pers. comm.). The national effluent standards are intended to be representative daily average values, as opposed to being assessed at a peak impact time, such as harvesting.

A score of “0.25” is given for questions 2 and 4 of Factor 2.2a, as the national values were generally based on the status of water bodies in Ecuador, but are not highly relevant to aquaculture. A score of “0.5” is given for question 5 of Factor 2.2a as specific sampling is not mandated during peak impact points. A score of “0” is given for question 3 of Factor 2.2a, as no evidence could be found for the control of cumulative farm impacts. Overall, a total score of 2 out of 5 is given for Factor 2.2a.

According to Jessenia Angulo (pers. comm.), enforcement organizations are identifiable, contactable, and willing to share information on control measures in the industry, but it is unclear as to whether they are appropriate to the scale of the industry. This results in a score of “0.75” for question 1 of Factor 2.2b, Enforcement of Effluent Regulations and Management measures. Additionally, Angulo states that “*there are many cases in which penalties go from fines to evictions, or concessions reversals*” for regulatory infringements (pers. comm.). This results in a score of “1” on question 5 of Factor 2.2b. No data were available to show the results of monitoring data, degrees of compliance, or monitoring during periods of peak discharge for effluents, resulting in scores of “0” for questions 2, 3, and4 of Factor 2.2b. Overall, Factor 2.2b received a score of 1.75 out of 5.

Factors 2.2a and 2.2b combine to give a score of 1.4 out of 10 for Factor 2.2.

The low intensity farming techniques, with little to no water exchange applied in Ecuador, result in a relatively low risk of environmental impacts from individual farm effluents and a high score (8 out of 10) for waste discharge. There is some uncertainty regarding the effectiveness of the regulatory system to manage potential cumulative impacts from large or multiple farms, therefore, the final score (from combining Factors 2.1 and 2.2) is 5 out of 10 for Criterion 2 – Effluents.

Criterion 3: Habitat

Impact, unit of sustainability and principle

- *Impact: Aquaculture farms can be located in a wide variety of aquatic and terrestrial habitat types and have greatly varying levels of impact to both pristine and previously modified habitats and to the critical "ecosystem services" they provide.*
- *Sustainability unit: The ability to maintain the critical ecosystem services relevant to the habitat type.*
- *Principle: aquaculture operations are located at sites, scales and intensities that cumulatively maintain the functionality of ecologically valuable habitats.*

Criterion 3 Summary

Habitat parameters	Value	Score	
F3.1 Habitat conversion and function		4.00	
F3.2a Content of habitat regulations	3.00		
F3.2b Enforcement of habitat regulations	2.75		
F3.2 Regulatory or management effectiveness score		3.30	
C3 Habitat Final Score		**3.77**	**YELLOW**
Critical?	NO		

Brief Summary

Global shrimp farming has been linked to the historical conversion of ecologically important wetlands, including mangrove forests. The majority of mangrove losses occurred before the late 90s, after which a number of factors greatly helped to reduce mangrove losses due to shrimp farming, including regulatory protection, the ability to grow shrimp at low salinities, and the knowledge that former mangrove soils negatively affect pond water quality. Ecuador is no exception to this rule and the Habitat Conversion score is 4 out of 10 for the historical (> 10 years ago) conversion of ecologically important habitats.

With respect to the regulatory management of the industry's habitat impacts, illegal habitat conversion has occurred, with some recent national efforts made to partially address these losses. Current regulations are established to prevent further mangrove and wetland loss during farm construction by way of an EIA. Ongoing environmental monitoring is moderate, but does not address cumulative farm impacts. The management effectiveness score is 3.3 out of 10, and overall, the final score for Criterion 3 – Habitats is 3.77 out of 10.

Justification of Ranking

Factor 3.1. Habitat conversion and function

Shrimp farming, in Ecuador, developed primarily on coastal land, with salt pans as the preferred location for the ponds (D'Andrea 2005). Nevertheless, according to the United Nations Food and Agricultural Organization (FAO), shrimp farming was the main cause of ecologically important mangrove and wetland loss since the industry began in the 1960s, with estimated losses of 40,000 ha of mangroves converted to shrimp ponds between 1980 and 1990 (FAO 2007). However, this estimate is at odds with current thought that estimates losses from shrimp aquaculture at 20,000 ha, with a larger portion of loss (35,000 ha) being the result of city growth and other agricultural practices (Piedrahita, pers. comm.).

The prevention of further loss and even some natural recolonization of the converted land is due to a combination of disease outbreaks that constrained industry development, regulatory prohibition of mangrove cutting (introduced in 1994), as well as public pressure.(FAO 2007). In the last few years, the Ecuadorian government has begun an attack on farms illegally sited in mangrove areas (described in further detail below), moving to close them down to allow the area to be recolonized naturally by mangrove plants. (Murias 2010). The shrimp aquaculture industry in Ecuador has restored 2,200 ha of mangroves in the last 10 years (Cordovez, pers. comm.)

Mangroves are considered high-value habitat under the Seafood Watch methodology. While there is clearly a dramatic conversion of this high-value habitat as a result of shrimp aquaculture, this loss is considered historical (> 10 years ago) and is no longer occurring. As such, Factor 3.1 Habitat conversion and function results in a score of 4 out of 10.

Factor 3.2. Habitat and farm siting management effectiveness (appropriate to the scale of the industry)

Historically, regulations regarding the siting of shrimp farms in Ecuador, particularly surrounding mangroves, have lacked clarity. Sonnenholzner et al. (2002) described the laws regarding mangrove protection as "*extremely confusing and amended fast,*" with multiple agencies attempting to control the resource, poor enforcement, and concessions for small-scale conversion, all of which resulted in an apparent, yet incorrect, assumption that these were "*free resources.*" However, at the time of their report, the authors also noted the industry's recognition of the importance of the mangrove resource (Sonnenholzner et al. 2002). This included a collaboration to address mangrove loss and resource protection between a national NGO, Fundación Natura, and the industry association, Camara Nacional de Acuacultura (CNA) (Sonnenholzner et al. 2002).

Recently, the Ecuadorian government has been making efforts to address some illegally sited operations in the country; identifying illegal shrimp farms in Churute Mangrove Swamp Ecological Reserve (4,600 ha), Guayas, Cayapas Mataje (2,900 ha), the Rio Muisne Mangrove Estuary (1,100 ha), Esmeraldas (55 ha), and the Arenillas Ecological Reserve in El Oro (560 ha) (Murias 2010). Some farms in these areas were closed down and removed to allow natural restoration of the mangrove area (Murias 2010). While this is a positive move, the government currently defines 1999 as its cut-off for illegal mangrove conversion (i.e., any farm established after 1999) as opposed to the dates of earlier regulatory protections, which some claim were enacted as early as 1978 (Latore 2012).

An EIA and EMP are required for new shrimp farm developments in Ecuador (Anuglo, pers comm.). These require a certificate from the Directorate General for Merchant Marine and Littoral stating that the proposed area is free of mangroves (D'Angela 2005).

No evidence was found to support the conclusion that the total size of the Ecuadorian shrimp farming industry or its concentration is based on its cumulative impacts and maintenance of the ecosystem.

Overall, a score of 3 out of 5 is given for Factor 3.2a, Regulatory or Management Effectiveness (see Appendix 1 for scores on specific aspects of this Factor).

Enforcement organizations in Ecuador (e.g., INP) are identifiable, contactable, and willing to share information on control measures in the industry (Angulo, pers. comm.), but it is unclear as to whether they are appropriate for the scale of the industry. This results in a score of 0.75 for Question 1 of Factor 3.2b. Current ecosystem conditions and impacts on biotic resources are considered in the EIA process for all new projects (Angulo, pers. comm.), but no clear evidence of an ecosystem-based management strategy could be found. A score of 0.5 is therefore given for Question 2 of Factor 3.2b. All EIAs plans and locations are publically available (Angulo, pers. comm.), resulting in a score of 1 for Question 4 of Factor 3.2b. Recent action to address illegally sited shrimp farms is evidence that some habitat restrictions are being moderately enforced in Ecuador, resulting in a score of 0.5 for Question 5 of Factor 3.2b. When these scores combine, Factor 3.2b Siting regulatory or management enforcement is scored as 2.75 out of 5.

Factors 3.2a and 3.2b combine to give a score of 3.3 for Factor 3.2.

Factors 3.1 and 3.2 combine to give a final numerical score of 3.77 for Criterion 3 – Habitats.

Criterion 4: Evidence or Risk of Chemical Use

Impact, unit of sustainability and principle

- *Impact: Improper use of chemical treatments impacts non-target organisms and leads to production losses and human health concerns due to the development of chemical-resistant organisms.*
- *Sustainability unit: non-target organisms in the local or regional environment, presence of pathogens or parasites resistant to important treatments*
- *Principle: aquaculture operations by design, management or regulation avoid the discharge of chemicals toxic to aquatic life, and/or effectively control the frequency, risk of environmental impact and risk to human health of their use.*

Criterion 4 Summary

Chemical Use parameters	Score	
C4 Chemical Use Score	**5.00**	
C4 Chemical Use Final Score	**5.00**	**YELLOW**
Critical?	NO	

Brief Summary

Shrimp farming in Ecuador uses low intensity production strategies, and probiotics are the preferred form of health management. Any use of antibiotics is recorded by farms, but the data were not available for this assessment. Some potential (but legally controlled) use of oxytetracycline or florfenicol exists, but is likely to be low, and there is little to no daily water exchange with the external environment. No recent evidence supporting impacts on non-target organisms or resistance to key treatments could be found, but oxytetracycline and florfenicol are listed by the World Health Organization (WHO) as highly important treatments for human health. Overall, there is little evidence to support a current concern over antibiotic abuse, though data are generally limited. Ecuadorian shrimp is, therefore, considered a moderate risk, earning a score of 5 and “yellow” ranking for this criterion.

Justification of Ranking

Detailed information on chemical usage in Ecuadorian shrimp farms was not available in either the public domain or the scientific literature.

In 1991, Weber et al. (1994, cited in Serrano 2005) suspected a link between inappropriate use of antibiotics in shrimp farms and a multi-antibiotic resistant strain of cholera, which resulted in an epidemic that first affected shrimp farm workers.

Currently, national controls exist on the use of veterinary drugs in all aquaculture, including shrimp farming, comprising a list of approved products for use (D’Andrea 2005). Chloramphenicol use is banned nationally in aquaculture, a rule enforced through product testing prior to export by the Ecuadorian National Institute of Fisheries (D'Andrea 2005). According to Sonnenholzner, farmers may use oxytetracycline or florfenicol to control bacterial infections, but most farms use probiotics to control bacteria rather than treat with antibiotics (pers. comm.). While both oxytetracycline and florfenicol are approved for various uses in aquaculture by the US Food and Drug Administration (2013),oxytetracycline is listed by the WHO as a highly important antimicrobial for human health due to its use as "*limited therapy for infections due to Chlamydia spp. and Rickettsia spp*" (WHO 2011). Under the Programa Nacional de Control, shrimp farms are required to keep record of any chemical used during the production, which is enforced by National Fisheries Institute (INP) through annual record keeping audits (Sonnenholzner, pers. comm.), however, these data are not publically available. There have been no sanitary alerts for the detection of antibiotic residues since 2006 (Piedrahita, pers. comm.). Broodstock selection practices have resulted in more resistant breeding lines, which, along with full industry uptake of improved PLs, have also decreased antibiotic usage (Cordovez, pers. comm.).

Other chemicals include those to treat pond water prior to stocking, including rotenone (barbasco), chlorine or calcium hydroxide, all of which kill small fish that were drawn into the ponds when the ponds were initially filled (Sonnenholzner, pers. comm.). Since these products are denatured in the ponds before stocking, they are not released into the surrounding environment.

Despite a historic issue in 1991, there is little evidence to suggest a current issue in the modern shrimp farming industry in Ecuador. The low intensity of production favors little or no use of antibiotics, and since farmers generally favor probiotics over the use of antimicrobials, the probable overall usage is low. Water is either not exchanged or done so at very low levels, although pond water is released at harvest, which suggests the release of antimicrobial residues into the surrounding environment would be infrequent. No evidence could be found suggesting an impact to non-target organisms, nor have there been recent references to resistance to key treatments. Overall, the limited data make a robust assessment challenging, but the low production intensity, very limited water exchange, common use of probiotics, and expert opinion on the low use of antibiotics mean that despite the potential use of treatments that are highly important to human health, there is a moderate overall concern and a final score of 5 out of 10 for the Chemical Use Criterion.

Criterion 5: Feed

Impact, unit of sustainability and principle

- *Impact: feed consumption, feed type, ingredients used and the net nutritional gains or losses vary dramatically between farmed species and production systems. Producing feeds and their ingredients has complex global ecological impacts, and their efficiency of conversion can result in net food gains, or dramatic net losses of nutrients. Feed use is considered to be one of the defining factors of aquaculture sustainability.*
- *Sustainability unit: the amount and sustainability of wild fish caught for feeding to farmed fish, the global impacts of harvesting or cultivating feed ingredients, and the net nutritional gains or losses from the farming operation*
- *Principle: aquaculture operations source only sustainable feed ingredients, convert them efficiently and responsibly, and minimize and utilize the non-edible portion of farmed fish.*

Criterion 5 Summary

Feed parameters	Value	Score	
F5.1a Fish In: Fish Out ratio (FIFO)	0.34	9.15	
F5.1b Source fishery sustainability score		-7.00	
F5.1: Wild Fish Use		8.91	
F5.2a Protein IN	26.69		
F5.2b Protein OUT	13.44		
F5.2: Net Protein Gain or Loss (%)	-49.65	5	
F5.3: Feed Footprint (hectares)	5.93	8	
C5 Feed Final Score		**7.70**	**GREEN**
Critical?	NO		

Brief Summary

Shrimp farms in Ecuador generally use low intensity production systems that may only use feed to supplement the natural food that grows in the ponds, resulting in relatively low FCRs. While typical fishmeal levels in the diet are relatively high (~16%), fish oil inclusion levels are low (2.5%),—and are offset by around 60% of fishmeal and 65% of fish oil coming from byproduct sources; FIFO levels are thus very low (0.34). Data are lacking on the sustainability of direct marine ingredients used in feed, and a mixture of Seafood Watch “yellow” and “red” sources are used for byproduct sources of fishmeal and fish oil. The protein loss from feed is relatively high (~50%) and a total of 5.93 hectares is calculated to be necessary to produce the feed ingredients required for one ton of farmed shrimp. The numerical score for Criterion 5 – Feed is 7.7 out of 10.

Justification of Ranking

Factor 5.1a Wild Fish Use

Detailed information on FCRs and feed ingredients are not made public by the industry. Tacon and Metian (2008) reported an average FCR reported by Ecuadorian farmers of 1.2 (values ranged from 1-1.4), using feed with an average fishmeal inclusion rate of 20% (15%–25% range) and fish oil inclusion rate of 3% (2%–5% range). More recent information on marine feed ingredients were provided by a feed expert in the country; fishmeal inclusion ranges from 15%–17%, with around 60% provided by byproducts, while fish oil inclusion ranges from 2%–3%, with 65% sourced from byproducts.

For this report, based on the average values for fishmeal and fish oil usage, and accounting for byproducts, a wild fish inclusion rate of 6.4% fishmeal, 0.875% fish oil, and an FCR of 1.2, was used to calculate FIFO values of 0.34 for fishmeal and 0.21 for fish oil. As Seafood Watch assessments consider the greater of the two FIFO values, in this case FIFO is driven by fishmeal, meaning that it took 0.34 kg of wet fish from wild sources to produce 1 kg of whole, wet shrimp. According to the Seafood Watch methodology, this results in an initial score of 9.15 for Factor 5.1a.

Factor 5.1b Sustainability of the Source of Wild Fish (SSWF).

Seafood Watch applies an adjustment score to the wild fish 'use score' based on the relative sustainability of the wild fish stocks that are utilized for feed ingredients.

The main sources of the marine product are the Pacific chub mackerel (*Scomber japonicus peruanus*), the shortfin scad (*Decapterus macrosoma*), and byproduct from skipjack tuna (*Katsuwonus pelamis*). Information on Pacific chubb mackerel (*Scomber japonicus peruanus*) fisheries is limited; a profile for the species appears on the FishSource website (last updated in 2009) operated by the Sustainable Fisheries Partnership (SFP), but all sustainability scores are labeled as "na" (SFP 2013). According to SFP's review (which focuses on Chile), there is no formal stock assessment for the fishery, but no further access is being granted as it is considered at full exploitation (2013). The full profile can be accessed here: www.fishsource.com/site/goto_profile_by_uuid/23dd651e-7f40-11dd-9e89-daf105bfb8c2**.**

No sustainability data could be found for resources for the shortfin scad (*Decapterus macrosoma*), which is a member of the jack and pompano family and often used as a bait species (FishBase 2013).

The source of fishery byproducts, skipjack tuna (*Katsuwonus pelamis*), has been reviewed by Seafood Watch. These rankings include a "yellow" or "good alternative" for skipjack tuna from the Eastern Pacific Ocean (EPO) caught with troll or pole-and-line gear or unassociated purse seine (i.e., no use of floating aggregating devices (FADs), and a "red" or "avoid" ranking for the same species caught with longline or floating object (FAD) purse seine (Roberts 2010). The full report is available here: www.montereybayaquarium.org/cr/cr_seafoodwatch/content/media/MBA_SeafoodWatch_SkipjackTunaReport.pdf. All of these types of gear are used in the EPO to catch skipjack tuna (IATTC 2009).

Sustainability information is lacking for the two direct sources of fishmeal and fish oil, but sources of byproduct can be from Seafood Watch "yellow" and "red" sources and account for the largest proportion of the marine ingredients used in feed. As such an SSWF value of -7 out of -10 is applied, resulting in an adjustment of -0.24 for the Factor 5.1b Source Fishery Sustainability Score.

When this adjustment is applied to the FIFO score, the score for Factor 5.1 Wild fish use is 8.91 out of 10.

Factor 5.2. Net Protein Gain or Loss

Shrimp are composed of approximately 17.8% protein (Boyd 2007). A general conversion used in the industry for the whole shrimp to edible tail meat is 57%. Devresse (1995, in Tacon 2002) claimed Ecuadorian shrimp feeds contain 28.7% crude protein. According to a feed expert in Ecuador, around 10%–15% of feed protein originates from nonedible sources (e.g., fish processing byproducts) and 30%–40% from terrestrial protein sources such as crops. Average values of 12.5% and 35% respectively were used for the Factor 5.2 calculations. While no specific information is available, it is known that shrimp processing byproducts are often used as an ingredient in other animal feeds, therefore, as the general edible yield (i.e., tail meat) is 57%, the remaining 43% processing byproduct is presumed to be used for other food production and is used for this factor in the protein conversion calculation. These values result in an estimated 49.6% net protein loss during the production cycle of Ecuadorian farmed shrimp. This loss corresponds to a score of 5 out of 10 for Factor 5.2.

Factor 5.3. Feed Footprint

The feed footprint factor takes into account all the feed inputs on the basis of the area of primary productivity required to produce them. Ecuadorian shrimp feeds are considered to contain around 18.5% marine ingredients (combined fishmeal and fish oil) and 35% inclusion level of crop feed ingredients, with an FCR of 1.2. These factors result in an estimated requirement for 5.77 ha of ocean area productivity and 0.16 ha of land area productivity to be appropriated to produce the feed ingredients required for one ton of Ecuadorian farmed shrimp. A total feed footprint of 5.93 hectares corresponds to a score of 8 out of 10 for Factor 5.3.

Factors 5.1, 5.2 and 5.3 combine to give a final numerical score of 7.7 for Criterion 5 – Feed.

Criterion 6: Escapes

Impact, unit of sustainability and principle

- *Impact: competition, genetic loss, predation, habitat damage , spawning disruption, and other impacts on wild fish and ecosystems resulting from the escape of native, non-native and/or genetically distinct fish or other unintended species from aquaculture operations*
- *Sustainability unit: affected ecosystems and/or associated wild populations.*
- *Principle: aquaculture operations pose no substantial risk of deleterious effects to wild populations associated with the escape of farmed fish or other unintentionally introduced species.*

Criterion 6 Summary

Escape parameters	Value	Score	
F6.1 Escape Risk		5.00	
F6.1a Recapture and mortality (%)	0		
F6.1b Invasiveness		4	
C6 Escape Final Score		**4.00**	**YELLOW**
Critical?	NO		

Brief Summary

Published information on the frequency, magnitude, or impacts of shrimp escapes from shrimp farms in Ecuador are not available, suggesting that these issues are poorly studied. Shrimp farmed in the country are hatchery-raised from native broodstock that have been selected over several generations for improved farm performance—particularly disease resistance. Pond systems generally use mesh-screens to prevent escapes, though better practices, such as regular inspections and back-up systems are likely to be farm-specific practices and not necessarily industry norms. The low and infrequent water exchanges also limit the potential for escapes. Should escapes occur, the main potential impact is a reduction in genetic fitness of the wild population as a result of interbreeding with genetically distinct farmed shrimp. Overall, Ecuadorian farmed shrimp are, therefore, considered a moderate risk for impacts associated with escapes and the numerical score for Criterion 6 – Escapes is 4 out of 10.

Justification of Ranking

Factor 6.1a. Escape risk

Data on farmed shrimp escapement in Ecuador are not available. In the author's experience the industry norms are for farms to use mesh-screens on the pond gates to prevent escapes during the production cycle and if water exchange is taking place; however, a final filter or secondary traps on the effluent channel are not common. The INP annual audits cover the required application of escape prevention measures (Angulo, pers. comm.). During harvest, farms often use a primary and secondary net connected to the pond gates to minimize escapes. Flooding and pond wall failure are potential sources of escape risk, but data on the occurrence of this type of event were not available. Data supporting construction standards to 100 or 50 year storm events were also not available.

Water exchange during the production cycle is low (1%–3%) or omitted entirely in Ecuador; prevention of escapes during water exchange is dealt with using simple technologies, such as screens. Better management practices, such as inspection of screens or the use of escape monitoring systems, such as traps in the effluent canal, are likely to be farm specific strategies rather than industry-wide norms.

The guidance given in the Seafood Watch Criteria for scoring suggests that Ecuador is between two scoring brackets, a higher risk (or "4") due to the potential flood risk and uncertain pond construction, and the lower risk (or "6") due to the limited water exchange. For these reasons, a compromised score of "5" or "moderate" risk has been used for this criterion.

If evidence of recapture or mortality of escapees exists, the escape risk score can be adjusted to reflect the mitigation of the impact of these escapes. No specific reference to recapture efforts for escaped shrimp were available; by default, Seafood Watch conservatively gives a 0% recapture/escapee mortality rate in the absence of data. Therefore, the score for Factor 6.1a is 5.

Factor 6.1b. Invasiveness
Specific data were not available on the impact of escaped farmed shrimp on wild populations and regional ecosystems in Ecuador.

L. vannamei are native to Ecuador, but selective breeding of farmed stocks began in 1992 as a way to mitigate the impacts of disease (Moss and Doyle 2005). Selective breeding can result in shrimp that may become genetically similar to one another through inbreeding and genetic drift (a change in frequency of certain genotypes potentially leading to a loss of a particular gene) (de Freitas and Galetti Jnr 2005). Interbreeding of escaped farmed shrimp and the native wild populations may reduce the genetic fitness of the resultant offspring. For Part A of Factor 6.1b, a score of 1 out of 5 is assigned to represent that current farmed stock is native but that "four or more generations of hatchery-raised or clear evidence exists of selected characteristics."

Aside from interbreeding, it is possible that escaped farmed *L. vannamei* could regionally increase the number of shrimp in the local ecosystem. Since *L. vannamei* is a native species to Ecuador, it is unlikely that escaped shrimp would behave differently from wild shrimp and create the novel impacts, such as habitat damage, that a non-native species might. The score for Factor 6.1b is 3 out of 5.

Factors 6.1a and 6.1b combine to give a final numerical score of 4 out of 10 for Criterion 6 – Escapes.

Criterion 7: Disease; pathogen and parasite interactions

Impact, unit of sustainability and principle

- *Impact: amplification of local pathogens and parasites on fish farms and their retransmission to local wild species that share the same water body*
- *Sustainability unit: wild populations susceptible to elevated levels of pathogens and parasites.*
- *Principle: aquaculture operations pose no substantial risk of deleterious effects to wild populations through the amplification and retransmission of pathogens or parasites.*

Criterion 7 Summary

Pathogen and parasite parameters	Score	
C7 Biosecurity	4.00	
C7 Disease; pathogen and parasite Final Score	**4.00**	**YELLOW**
Critical?	**NO**	

Brief Summary

Disease outbreaks on shrimp farms have the ability to severely impact production, and were the driving force behind Ecuador's adoption of low intensity farming practices. Shrimp farms are connected to the environment and the transfer of shrimp diseases from them to wild populations and other susceptible species has been demonstrated. However, with exception of one possible event in Mexico, significant impacts on these wild populations have not been reported. Ecuador is therefore considered a moderate risk and the numerical score for Criterion 7 – Disease is 4 out of 10.

Justification of Ranking

Transmittable diseases that may present serious socio-economic and/or public health threats are tracked globally by the World Organization for Animal Health (OIE) (OIE 2013). OIE listed diseases affecting farmed *L. vannamei* including WSSV, yellow head virus (YHV), TSV, infectious myonecrosis virus (IMNV), necrotising hepatopancreatitis (NHP), and infectious hypoderma and haematopoietic necrosis virus (IHHNV) (OIE 2013). Of these, WSSV, TSV, and YHV are the most problematic globally (Walker and Mohan 2009). In addition to TSV and WSSV, NHP is known to be present, IHHNV is thought to be present, but IMNV and YHV are thought to be absent in the country (Lightner 2011).

Of additional concern to shrimp farming currently is early mortality syndrome (EMS) (the common name for Acute Hepatopancreatic Necrosis Syndrome (AHPNS)) (Nikolik and Kumar 2013). EMS was first detected in China in 2009, and has spread to Vietnam, Malaysia and Thailand (Nikolik and Kumar 2013) and was most recently detected in Mexico (Undercurrent News 2013a). No case of EMS in Ecuador was found at the time of this writing, but the recent detection in Mexico is a concern due to this country's geographic proximity to Ecuador.

Ecuador does not report crustacean diseases to the OIE and so detailed information on the current and historic disease status in the country is limited.

Viral diseases have shaped the modern Ecuadorian shrimp farming industry. Outbreaks of Taura syndrome virus (TSV) in 1991 and white spot syndrome virus in 1999 eventually resulted in shrimp farmers adopting a “live with it approach” and favoring extensive and semi-intensive production practices (Lightner 2011). The industry also increased farm biosecurity practices (Lightner 2011) and used broodstock selection practices to enhance disease resistance in farm stocks (Moss and Doyle 2005).

While the impact of diseases on shrimp farming are well documented, the potential impacts of disease transfer from shrimp farms to wild shrimp populations remain poorly understood (Walker and Mohan 2009). Several farmed shrimp diseases can cross species boundaries, including WSSV, TSV and IMNV (Walker and Mohan 2009). Disease can pass from the farm to wild populations of both shrimp and other susceptible species (Walker and Mohan 2009). For example, WSSV can be carried by a wide range of species and has been found in crabs and wild shrimp populations in regions where infected shrimp have been farmed (Walker and Mohan 2009).

One proposed example of a farmed shrimp disease affecting wild shrimp populations occurred in the 1990s, with an IHHNV outbreak in Mexico that resulted in significant losses in both farms and wild fisheries for the blue shrimp, *Penaeus stylirostris* (Lightner 2011). However, no evidence was detected of a similar impact in Ecuador (Lightner 2011). WSSV effectively wiped out the *P. stylirostris* farming industry in Ecuador; however, despite being detected in wild populations, equivalent losses were not reported (Lightner 2011). TSV has been reported on both wild and farmed populations in Ecuador (Lightner 2011), but again without corresponding losses to the wild stocks.

The available research suggests that farmed shrimp diseases can be very significant on shrimp farms, and can be transferred to wild populations, but that these wild stocks are not generally impacted in a significant way, though further research into these issues is required. Water exchange in the industry is also limited, which suggests a reduced risk of diseases being spread as a result of this action. However, since the farms are still connected to the environment as a results of releasing water at harvest, and disease transfer is known to be possible, the final numerical score is 4 out of 10 for Criterion 7 – Disease; Pathogen and Parasite Interactions.

Criterion 8: Source of Stock – independence from wild fisheries

Impact, unit of sustainability and principle

- *Impact: the removal of fish from wild populations for on-growing to harvest size in farms*
- *Sustainability unit: wild fish populations*
- *Principle: aquaculture operations use eggs, larvae, or juvenile fish produced from farm-raised broodstocks, use minimal numbers, or source them from demonstrably sustainable fisheries.*

Criterion 8 Summary

Source of stock parameters	Score	
100% of production from hatchery-raised broodstock, natural (passive) settlement, or sourced from sustainable fisheries	100	
C8 Source of stock Final Score	**10.00**	**GREEN**

Brief Summary

Based on available data, all Ecuadorian broodstock is hatchery-raised. As such, there is no dependence on wild populations and subsequently no impacts relating to the source of stock. The numerical score for Criterion 8 – Source of Stock is 10 out of 10.

Justification of Ranking

As stated earlier, in response to the TSV and WSSV outbreaks, the industry used broodstock selection practices to enhance disease resistance in farm stocks (Moss and Doyle 2005). All deliberately stocked PLs used in the industry are hatchery-raised (Sonnenholzner, pers. comm.) and all Ecuadorian *L. vannamei* broodstock are farm-raised. As such, there is no dependence on wild populations for the source of stock and the numerical score for Criterion 8 is 10 out of 10.

Criterion 9X: Wildlife and predator mortalities

A measure of the effects of deliberate or accidental mortality on the populations of affected species of predators or other wildlife.

This is an "exceptional" criterion that may not apply in many circumstances. It generates a negative score that is deducted from the overall final score. A score of zero means there is no impact.

Criterion 9X Summary

Wildlife and predator mortality parameters	Score	
C9 Wildlife and predator mortality Final Score	**-4.00**	**YELLOW**
Critical?	NO	

Brief Summary
Generally, Ecuadorian shrimp farms apply non-lethal techniques to control predators such as diving birds. While data are limited, available information indicates that wildlife mortalities occur (beyond exceptional cases), but due to high population size and/or high productivity and/or low mortality numbers, they do not significantly impact the affected species' population size. The score for Exceptional Criterion 9X – Wildlife and Predator Mortalities is -4 out of -10.

Justification of Ranking
Pests and predators can impact the cultured shrimp directly through predation and indirectly through competition for resources, such as food; thus, shrimp farming often requires controls for these problems (FAO 1986). Burrowing crabs can also create an issue by damaging pond walls (FAO 1986). In general, shrimp farm predators that feed directly on shrimp can include amphibians, birds, crustaceans, finfishes, mammals, and snakes (FAO 1986). General predator controls include passive exclusionary systems, such as screens on inlets, netting, or pond linings, and active control systems, such as pesticides.

References to specific predator, predator control, or impacts on predator populations in the Ecuadorian shrimp farming industry were not available in the literature. In the author's experience, the farms generally applied non-lethal, exclusionary, techniques to scare birds away from the ponds during the production cycle, such as fireworks or dogs. Pond water is treated before stocking with rotenone (barbasco), chlorine or calcium hydroxide to kill small fish that are drawn into the ponds when they were initially filled (Sonnenholzner, pers. comm.). Local authorities also monitor farms to ensure the predator control system does not significantly affect wildlife (Angulo, pers. comm.).

While non-lethal methods are preferred, some lethal control is most likely applied at Ecuador shrimp farming operations. However, there is no evidence to suggest those predator mortalities are having population-level impacts on any wildlife in surrounding areas. Without evidence that points to an impact on wild populations, the adjustment score for Exceptional Criterion 9X is -4 out of -10.

Criterion 10X: Escape of unintentionally introduced species

A measure of the escape risk (introduction to the wild) of alien species other than the principle farmed species unintentionally transported during live animal shipments.

This is an "exceptional" criterion that may not apply in many circumstances. It generates a negative score that is deducted from the overall final score.

Criterion 10X Summary

Escape of unintentionally introduced species parameters	Score	
F6.2Xa International or trans-waterbody live animal shipments (%)	10.00	
F6.2Xb Biosecurity of source/destination	0.00	
10X Escape of unintentionally introduced species Final Score	**0.00**	**GREEN**

Brief Summary

Farmed shrimp in Ecuador are hatchery-raised from selected native broodstock in the country. International or trans-waterbody live animal shipments are therefore not relevant to this assessment as the hatcheries are in-country and the shrimp are grown in environments that are not ecologically distinct from these hatcheries. Exceptional Criterion 10X is therefore unnecessary to be scored and no adjustment is applied (i.e., score of 0 out of -10).

Justification of Ranking

Factor 10Xa International or trans-waterbody live animal shipments

See above.

Factor 10Xb Biosecurity of source/destination

Not considered, as Ecuadorian farmed shrimp scores 10 on the above criterion.

Overall Recommendation

The overall recommendation is as follows:

The overall final score is the average of the individual criterion scores (after the two exceptional scores have been deducted from the total). The overall ranking is decided according to the final score, the number of red criteria, and the number of critical scores as follows:

- **Best Choice** = Final score ≥6.6 AND no individual criteria are Red (i.e. <3.3)
- **Good Alternative** = Final score ≥3.3 AND <6.6, OR Final score ≥ 6.6 and there is one individual “Red” criterion.
- **Red** = Final score <3.3, OR there is more than one individual Red criterion, OR there is one or more Critical score.

Criterion	Score (0-10)	Rank	Critical?
C1 Data	4.75	YELLOW	
C2 Effluent	5.00	YELLOW	NO
C3 Habitat	3.77	YELLOW	NO
C4 Chemicals	5.00	YELLOW	NO
C5 Feed	7.70	GREEN	NO
C6 Escapes	4.00	YELLOW	NO
C7 Disease	4.00	YELLOW	NO
C8 Source	10.00	GREEN	
9X Wildlife mortalities	-4.00	YELLOW	NO
10X Introduced species escape	0.00	GREEN	
Total	**40.22**		
Final score	**5.03**		

OVERALL RANKING

Final Score	5.03
Initial rank	YELLOW
Red criteria	0
Interim rank	YELLOW
Critical Criteria?	NO

FINAL RANK
YELLOW

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Data points and all scoring calculations

This is a condensed version of the criteria and scoring sheet to provide access to all data points and calculations. See the Seafood Watch Aquaculture Criteria document for a full explanation of the criteria, calculations and scores. Yellow cells represent data entry points.

Criterion 1: Data quality and availability

Data Category	Relevance (Y/N)	Data Quality	Score (0-10)
Industry or production statistics	*Yes*	7.5	7.5
Effluent	Yes	5	5
Locations/habitats	Yes	5	5
Predators and wildlife	Yes	5	5
Chemical use	Yes	2.5	2.5
Feed	Yes	5	5
Escapes, animal movements	Yes	2.5	2.5
Disease	Yes	5	5
Source of stock	Yes	7.5	7.5
Other – (e.g. GHG emissions)	Yes	2.5	2.5
Total			**47.5**

C1 Data Final Score	4.75	YELLOW

Criterion 2: Effluents

Factor 2.1a - Biological waste production score

Protein content of feed (%)	28.7
eFCR	1.2
Fertilizer N input (kg N/ton fish)	7.1
Protein content of harvested fish (%)	17.8
N content factor (fixed)	*0.16*
N input per ton of fish produced (kg)	62.204
N in each ton of fish harvested (kg)	28.48
Waste N produced per ton of fish (kg)	**33.724**

Factor 2.1b - Production System discharge score

Basic production system score	0.34
Adjustment 1 (if applicable)	0
Adjustment 2 (if applicable)	0
Adjustment 3 (if applicable)	0
Discharge (Factor 2.1b) score	**0.34**

% of the waste produced by the fish is discharged from the farm

2.2 – Management of farm level and cumulative impacts and appropriateness to the scale of the industry

Factor 2.2a - Regulatory or management effectiveness

Question	Scoring	Score
1 - Are effluent regulations or control measures present that are designed for, or are applicable to aquaculture?	Yes	1
2 - Are the control measures applied according to site-specific conditions and/or do they lead to site-specific effluent, biomass or other discharge limits?	Partly	0.25
3 - Do the control measures address or relate to the cumulative impacts of multiple farms?	No	0
4 - Are the limits considered scientifically robust and set according to the ecological status of the receiving water body?	Partly	0.25
5 - Do the control measures cover or prescribe including peak biomass, harvest, sludge disposal, cleaning etc.?	Moderately	0.5
		2

Factor 2.2b - Enforcement level of effluent regulations or management

Question	Scoring	Score
1 - Are the enforcement organizations and/or resources identifiable and contactable, and appropriate to the scale of the industry?	Mostly	0.75
2 - Does monitoring data or other available information demonstrate active enforcement of the control measures?	No	0
3 - Does enforcement cover the entire production cycle (i.e., are peak discharges such as peak biomass, harvest, sludge disposal, cleaning included)?	No	0
4 - Does enforcement demonstrably result in compliance with set limits?	No	0
5 - Is there evidence of robust penalties for infringements?	Yes	1
		1.75

F2.2 Score (2.2a*2.2b/2.5)	**1.4**

C2 Effluent Final Score	5.00	YELLOW
	Critical?	NO

Criterion 3: Habitat

3.1. Habitat conversion and function

F3.1 Score	4

3.2 Habitat and farm siting management effectiveness (appropriate to the scale of the industry)

Factor 3.2a - Regulatory or management effectiveness

Question	Scoring	Score
1 - Is the farm location, siting and/or licensing process based on ecological principles, including an EIAs requirement for new sites?	Yes	1
2 - Is the industry's total size and concentration based on its cumulative impacts and the maintenance of ecosystem function?	No	0
3 – Is the industry's ongoing and future expansion appropriate locations, and thereby preventing the future loss of ecosystem services?	Moderately	0.5
4 - Are high-value habitats being avoided for aquaculture siting? (i.e. avoidance of areas critical to vulnerable wild populations; effective zoning, or compliance with international agreements such as the Ramsar treaty)	Yes	1
5 - Do control measures include requirements for the restoration of important or critical habitats or ecosystem services?	Moderately	0.5
		3

Factor 3.2b - Siting regulatory or management enforcement

Question	Scoring	Score
1 - Are enforcement organizations or individuals identifiable and contactable, and are they appropriate to the scale of the industry?	Mostly	0.75
2 - Does the farm siting or permitting process function according to the zoning or other ecosystem-based management plans articulated in the control measures?	Moderately	0.5
3 - Does the farm siting or permitting process take account of other farms and their cumulative impacts?	No	0
4 - Is the enforcement process transparent - e.g. public availability of farm locations and sizes, EIA reports, zoning plans, etc.?	Yes	1
5 - Is there evidence that the restrictions or limits defined in the control measures are being achieved?	Moderately	0.5
		2.75

F3.2 Score (2.2a*2.2b/2.5)	3.33

C3 Habitat Final Score	3.77	YELLOW

Critical?	NO

Criterion 4: Evidence or Risk of Chemical Use

Chemical Use parameters	Score	
C4 Chemical Use Score	**5.00**	
C4 Chemical Use Final Score	5.00	**YELLOW**
Critical?	NO	

Criterion 5: Feed

5.1. Wild Fish Use

Factor 5.1a - Fish In: Fish Out (FIFO)

Fishmeal inclusion level (%)	16
Fishmeal from byproducts (%)	60
% FM	6.4
Fish oil inclusion level (%)	2.5
Fish oil from byproducts (%)	65
% FO	0.875
Fishmeal yield (%)	22.5
Fish oil yield (%)	5
eFCR	1.2
FIFO fishmeal	0.34
FIFO fish oil	0.21
Greater of the 2 FIFO scores	0.34
FIFO Score	**9.15**

Factor 5.1b - Sustainability of the Source of Wild Fish (SSWF)

SSWF	-7
SSWF Factor	-0.238933333

F5.1 Wild Fish Use Score	**8.91**

5.2. Net protein Gain or Loss

Protein INPUTS	
Protein content of feed	28.7
eFCR	1.2

Feed protein from NON-EDIBLE sources (%)	12.5
Feed protein from EDIBLE CROP sources (%)	35
Protein OUTPUTS	
Protein content of whole harvested fish (%)	17.8
Edible yield of harvested fish (%)	57
Non-edible byproducts from harvested fish used for other food production	43
Protein IN	26.69
Protein OUT	13.4372 2
Net protein gain or loss (%)	- 49.649 9
Critical?	NO
F5.2 Net protein Score	**5.00**

5.3. Feed Footprint

5.3a Ocean area of primary productivity appropriated by feed ingredients per ton of farmed seafood

Inclusion level of aquatic feed ingredients (%)	18.5
eFCR	1.2
Average Primary Productivity (C) required for aquatic feed ingredients (ton C/ton fish)	*69.7*
Average ocean productivity for continental shelf areas (ton C/ha)	*2.68*
Ocean area appropriated (ha/ton fish)	5.77

5.3b Land area appropriated by feed ingredients per ton of production

Inclusion level of crop feed ingredients (%)	35
Inclusion level of land animal products (%)	0
Conversion ratio of crop ingredients to land animal products	*2.88*
eFCR	1.2
Average yield of major feed ingredient crops (t/ha)	*2.64*
Land area appropriated (ha per ton of fish)	0.16

Value (Ocean + Land Area)	**5.93**

F5.3 Feed Footprint Score	**8.00**

C5 Feed Final Score	**7.70**	**GREEN**
	Critical?	**NO**

Criterion 6: Escapes

6.1a. Escape Risk

Escape Risk	**5**

Recapture & Mortality Score (RMS)	
Estimated % recapture rate or direct mortality at the escape site	0
Recapture & Mortality Score	0
Factor 6.1a Escape Risk Score	**5**

6.1b. Invasiveness

Part A – Native species

Score	1

Part B – Non-Native species

Score	**0**

Part C – Native and Non-native species

Question	Score
Do escapees compete with wild native populations for food or habitat?	To some extent
Do escapees act as additional predation pressure on wild native populations?	To some extent
Do escapees compete with wild native populations for breeding partners or disturb breeding behavior of the same or other species?	Yes
Do escapees modify habitats to the detriment of other species (e.g. by feeding, foraging, settlement or other)?	No
Do escapees have some other impact on other native species or habitats?	No
	3

F 6.1b Score	**4**

Final C6 Score	**4.00**	**YELLOW**
	Critical?	**NO**

Criterion 7: Diseases

Pathogen and parasite parameters	Score	
C7 Biosecurity	4.00	
C7 Disease; pathogen and parasite Final Score	**4.00**	**YELLOW**
Critical?	NO	

Criterion 8: Source of Stock

Source of stock parameters	Score	
C8 % of production from hatchery-raised broodstock, natural (passive) settlement, or sourced from sustainable fisheries	100	
C8 Source of stock Final Score	**10**	**GREEN**

Criterion 9X: Wildlife and predator mortalities

Wildlife and predator mortality parameters	Score	
C9X Wildlife and Predator Final Score	**-4.00**	**YELLOW**
Critical?	NO	

Criterion 10X: Escape of unintentionally introduced species

Escape of unintentionally introduced species parameters	Score	
C10Xa International or trans-waterbody live animal shipments (%)	10.00	
C10Xb Biosecurity of source/destination	0.00	
C10X Escape of unintentionally introduced species Final Score	**0.00**	**GREEN**