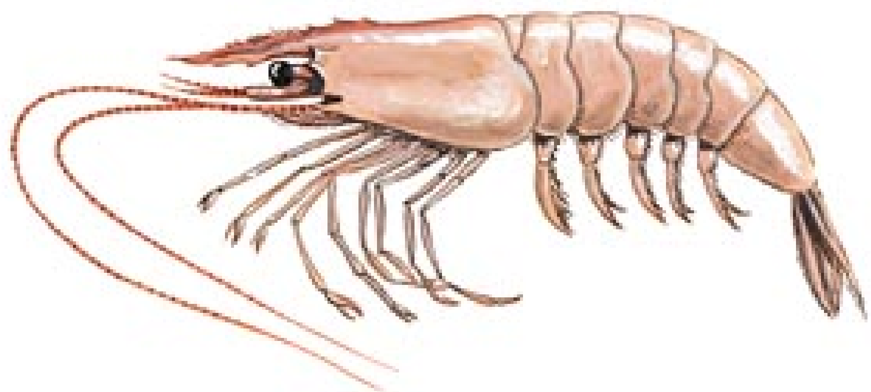
Monterey Bay Aquarium
Seafood Watch®

Farmed Whiteleg Shrimp

Litopenaeus vannamei



Honduras

Ponds

July 21, 2015

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Disclaimer

Seafood Watch® strives to have all Seafood Reports reviewed for accuracy and completeness by external scientists with expertise in ecology, fisheries science and aquaculture. Scientific review, however, does not constitute an endorsement of the Seafood Watch® program or its recommendations on the part of the reviewing scientists. Seafood Watch® is solely responsible for the conclusions reached in this report.

About Seafood Watch®

Monterey Bay Aquarium's Seafood Watch® program evaluates the ecological sustainability of wild-caught and farmed seafood commonly found in the United States 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. Seafood Watch® makes its science-based recommendations available to the public in the form of regional pocket guides that can be downloaded from www.seafoodwatch.org. The program's goals are to raise awareness of important ocean conservation issues and empower seafood consumers and businesses to make choices for healthy oceans.

Each sustainability recommendation on the regional pocket guides 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 conservation ethic to arrive at a recommendation of "Best Choices," "Good Alternatives" or "Avoid." The detailed evaluation methodology is available upon request. In producing the Seafood Reports, Seafood Watch® seeks out 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 regularly 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.

Parties interested in capture fisheries, aquaculture practices and the sustainability of ocean ecosystems are welcome to use Seafood Reports in any way they find useful. For more information about Seafood Watch® and Seafood Reports, please contact the Seafood Watch® program at Monterey Bay Aquarium by calling 1-877-229-9990.

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Seafood Watch® and Seafood Reports are made possible through a grant from the David and Lucile Packard Foundation.

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.
- 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).

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

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

Criterion	Score (0-10)	Rank	Critical?
C1 Data	4.40	YELLOW	
C2 Effluent	4.00	YELLOW	NO
C3 Habitat	4.53	YELLOW	NO
C4 Chemicals	4.00	YELLOW	NO
C5 Feed	8.74	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	**36.72**		
Final score	**4.97**		

OVERALL RANKING

Final Score	4.97
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

Farmed whiteleg shrimp from Honduras has a final numerical score of 4.97 out of 10, and with no red criteria the final ranking is Yellow – Good Alternative.

Executive Summary

Farmed Whiteleg shrimp *(Litopenaeus vannamei)* in Honduras is one of the primary aquaculture outputs for the country. A number of farms, ranging from small artisanal to large commercial operations, are located on the Pacific coast of Honduras along the Gulf of Fonseca. Exports of the white shrimp are to either Europe or the United States. National production is approximately 27,000 metric tons (2013 data).

Data availability is variable with limited volumes of peer-reviewed scientific literature or official regulatory monitoring results, most likely due to the small size of the industry; however, useful information was supplied by the industry itself and also by personal communication with industry experts. Data availability and quality understandably varied considerably across the different criteria topics, and overall the Data Criterion score was a moderate 4.4 out of 10.

Whiteleg shrimp operations in Honduras use semi-intensively managed ponds with moderate daily water exchange rates. A limited number of farms use settling ponds as an outcome of EIA findings. Weekly monitoring of water quality in Honduran shrimp farms is reported to show that the farms are not impacting and not exceeding the carrying capacity of the estuaries that receive them, however, evidence of legal proceedings against farms that exceed regulatory limits raises some concern about excess effluent discharges (although it shows an effective enforcement system may be in place). Overall, the score for Effluent was 4 out of 10, reflecting moderate effluent concerns from the shrimp farm operations.

Historically, the destruction and loss of mangrove ecosystems due to shrimp farming activities has been one of the main habitat concerns associated with shrimp aquaculture production in various regions of the world. The historic loss of mangrove habitats that occurred due to shrimp pond construction in Honduras is considered in this assessment, but many operations are sited on salt flats behind the mangrove fringe and therefore have much less impact. In addition, some operations have created programs to support the maintenance and expansion of mangroves. Regulation and oversight measures to limit habitat-related impacts are in place. For example, a preliminary site license is issued for only one year to ensure that all actions stipulated in the application documents are complied with before the license is extended. However, there is no clear regulatory oversight for farms less than 5 hectares in size and, as many Honduran shrimp farms are smaller than this, there is justifiable concern that cumulative impacts from smaller farms are not taken into account. The final Habitat Criterion score is a moderate 4.5 out of 10.

The use of chemical and antibiotics is reported by both industry and outside experts to be limited, but robust information or data is not available. A publication more than ten years old reported a single use of oxytetracycline, but this was a limited occurrence and was not factored into the scoring. The largest producer, by volume, self-reports zero antibiotic use, but a broader survey to provide up-to date information on antibiotic use may help improve the score for this criterion. Further. The Chemical Criterion scored 4 out of 10

Honduran shrimp farmers utilize a commercial pelleted feed with 7% fishmeal and 2% fish oil inclusion levels. The eFCR was estimated to be 1.4. Half of the fishmeal comes from tilapia processing byproducts, and half of the total protein included in the feed is sourced from nonedible sources. The use of wild fish is therefore low, and there is a net gain in edible protein. With large amounts of crop ingredients in the feed, the feed footprint was relatively small, and the overall feed score was 8.74 out of 10.

The daily exchanging ponds in Honduras have typical escape prevention measures in place, but it is unclear if they are prone to large-scale escapes from flood risks or if secondary measures are in place for key activities such as harvesting. The escape risk is therefore considered moderate. White shrimp are native in Honduras, but have been domesticated and selected over several generations. There is a potential risk of genetic interactions with wild shrimp, although there is little evidence of this occurring. Overall, the Escape Criterion score is a moderate 4 out of 10.

Diseases are problematic for shrimp farming operations in the region and represent a potential environmental concern. The main disease issues reported in Honduras are Taura syndrome virus and white spot syndrome virus and the industry reports that during outbreaks mortalities do not exceed 60%. Low stocking densities are used (and encouraged) in the Honduran shrimp industry and this is believed to help reduce the occurrence and severity of disease outbreaks. It is important to note that through enhanced sanitary precautions and protocols the Honduran shrimp industry has not had any occurrences of early mortality syndrome (EMS), although regional neighbor Mexico has.

The Whiteleg shrimp industry in Honduras utilizes only hatchery-raised shrimp and sourcing of broodstock from the wild is not known to occur for the majority of the industry. The Whiteleg shrimp industry imports about 30% of its post larvae from Nicaraguan hatcheries, but the countries share co-sovereignty in the waterbody (Gulf of Fonseca) where the shipping is conducted. Therefore, both the Source of Stock and the Introduced Species Escape criteria score 10 out of 10 and a deduction of 0 out of 10 respectively.

A study on the impact of shrimp operations on cormorant populations has been conducted to establish baseline data for the populations of these birds. Initial findings indicate that, although lethal controls have been conducted, no population impacts were found. Other wildlife and predator mortalities are not reported in the literature at the time of this assessment. As such, this exceptional criterion receives a moderate precautionary score of–4 out of–10.

Overall, this assessment of Whiteleg shrimp aquaculture in Honduras results in a moderate final numerical score of 4.97 out of 10, and with no red criteria, the final ranking is Yellow – Good Alternative.

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Ponds
(Semi-Intensive with 3%–10% daily water exchange)

Species Overview

The Whiteleg shrimp *(Litopenaeus vannamei)* is a crustacean from the family Penaeidae, which includes several economically important species of marine shrimps/prawns. White shrimp are native to the eastern Pacific Ocean and have a range from Sonora, Mexico to northern Peru (FAO 2006). The range is limited by a requirement for tropical marine habitat where water temperatures remain above 20 °C. The maximum size achieved is 23 cm and females generally grow more quickly than males (FAO 2006).

Commercial culture of the Whiteleg shrimp began in the 1970s in Central and South America (FAO 2006) and production peaks have followed "el niño" years while "la niña" weather patterns have resulted in production dips. In Honduras, the first commercial farm was established in 1973 on a former salt evaporation pond (Rosenberry 2004) and, after 1987, the industry began to grow rapidly in the country (Valderrama & Engle 2000, 2002). The United States (including Hawaii) was the next region to begin production of the Whiteleg shrimp followed by a rapid uptake in Asia, where the species is exotic, at the start of 2000.

Production Statistics:
Global production of *Litopenaeus vannamei* has increased steadily over the period of 2000-2012. Regionally, Asia and the Americas are the two primary producers with Asia dominating production volumes (in 2012: Asia 2,618,981 metric tons compared with the Americas 559,692 metric tons). In the FAO database (FAO 2014), Honduran shrimp production is not reported by species, which leads to some uncertainty in the exact contribution of *L. vannamei* to regional production, but the national industry states that farmed shrimp production in 2012 was 25,800 metric tons and 27,000 metric tons in 2013 (Murias 2013).

In Honduras, shrimp production is predominantly semi-intensive with exchange rates between 3%–10% daily (Green and Ward 2011) with low stocking densities of (average) 10 individuals per square meter (H. Corrales, personal communication, 1 June 2014). Currently, there are 315 active producers (H. Corrales, personal communication, June 1, 2014) and 11 hatcheries operating on approximately 18,200 ha of land (Murias 2013). In total, about 37,000 ha of land are set aside for potential use in shrimp farming concessions, although they are first subject to the regulatory approval process, which includes environmental impact assessments for sites greater than 5 ha (FAO 2009).

Table 1: Figures provided by the Asociación Nacional de Acuicultores de Honduras (ANDAH) (via H. Corrales, personal communication, 1 June 2014) and were accurate as of December 2013.

	#	Total Ha
Number of Producers	315	
Number of Ha in Production	18860	
Number of Ponds in All Farms	1965	
Producers > 1,000 Ha	3	5974 Ha
Producers from 500–999 Ha	6	4335 Ha
Producers from 250–499 Ha	5	1539 Ha
Producers from 100–249 Ha	20	2942 Ha
Producers from 50–99 Ha	25	1678 Ha
Producers from 25–49 Ha	23	762 Ha
Producers from 10–24 Ha	59	881 H
Producers from 1–9 Ha	174	749 Ha
Average Ha/Pond	9.60	

Shrimp farming activity is centered on the Pacific coast of the country in the Valle and Choluteca provinces along the Gulf of Fonseca. The Central American Integration System (Sistema de la Integración Centroamericano, or SICA) is the largest political organization of Central American states: SICA reports commercial and artisanal operations in Honduras (SICA 2014) with sizes ranging between 1.5 – 5700 ha. There are two separate growing seasons in Honduras: one during the wet season and the other during the dry season. The average culture duration was reported as 102 days (Green and Ward 2011) with higher yields generally found in the rainy season. Further, a reliance on fertilizer rather than commercial feed was reported in the dry season (Green and Ward 2011).

The largest operation (5700 ha) is run by the Grupo Granjas Marinas San Bernardo, who produced (live weight) 12,700 metric tons in 2013 (SICA 2014, Grupo Granjas 2013). It is of note that (at the time of writing) one company, Seajoy, had received certification from the Global Aquaculture Alliance as being compliant with their three-star certification criteria. The criteria for “three-star certification” were evaluated as being consistent with a Yellow rating under the Seafood Watch criteria (Seafood Watch 2013).

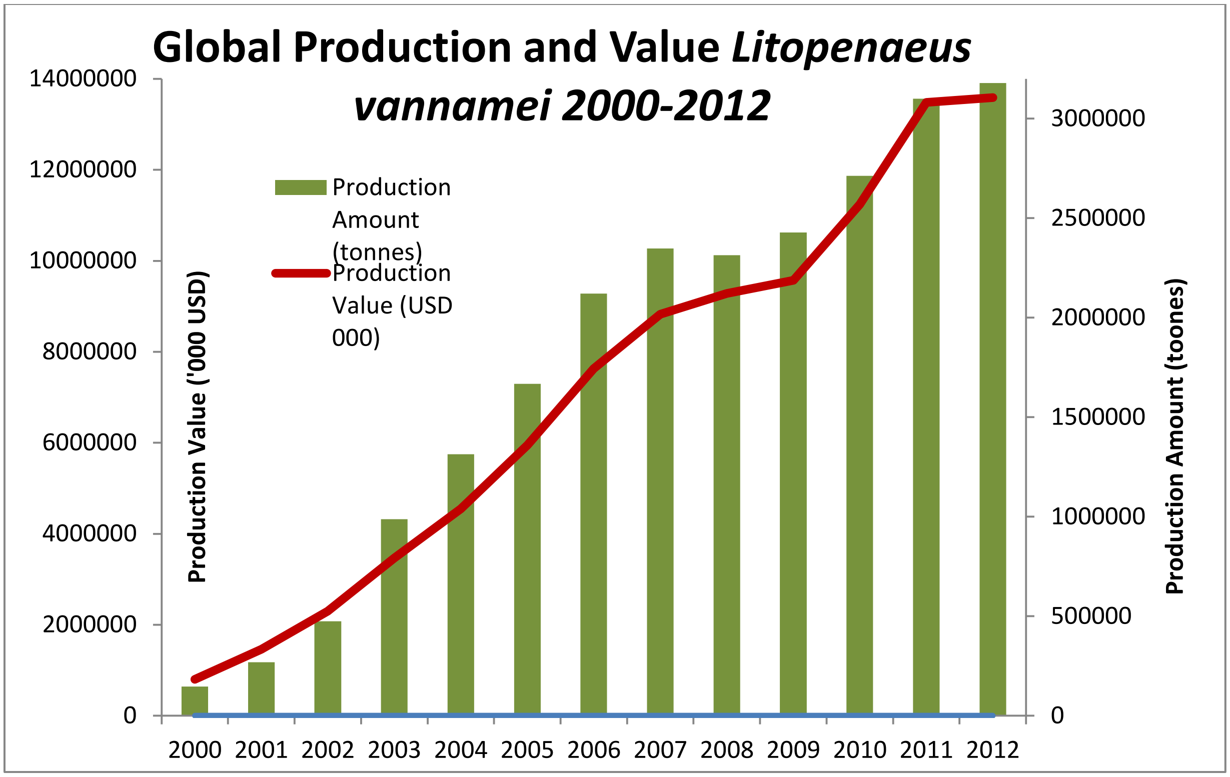

Figure 1. Global production and value as reported by FAO (2014)

Import and Export Sources and Statistics:
Honduras exports Whiteleg shrimp primarily to Europe and the United States (Tveteras 2012). Smaller quantities are also exported to regional neighbors such as Mexico (The Fish Site 2013). The primary country for exports of shrimp from aquaculture production is the United States (Castellón 2005). In the period of 2010-2013, between 8,000 to 10,000 metric tons of shrimp were imported into the United States from Honduras. Between 2008 and 2010 Tveteras (2012) reported exports of shrimp from Honduras to the European Union in the range of 8,000 to 12,000 metric tons. Total export quantities of shrimp were provided by the Honduran shrimp industry–ANDAH (via H. Corrales, personal communication, 1 June 2014) and are shown in the figure below.

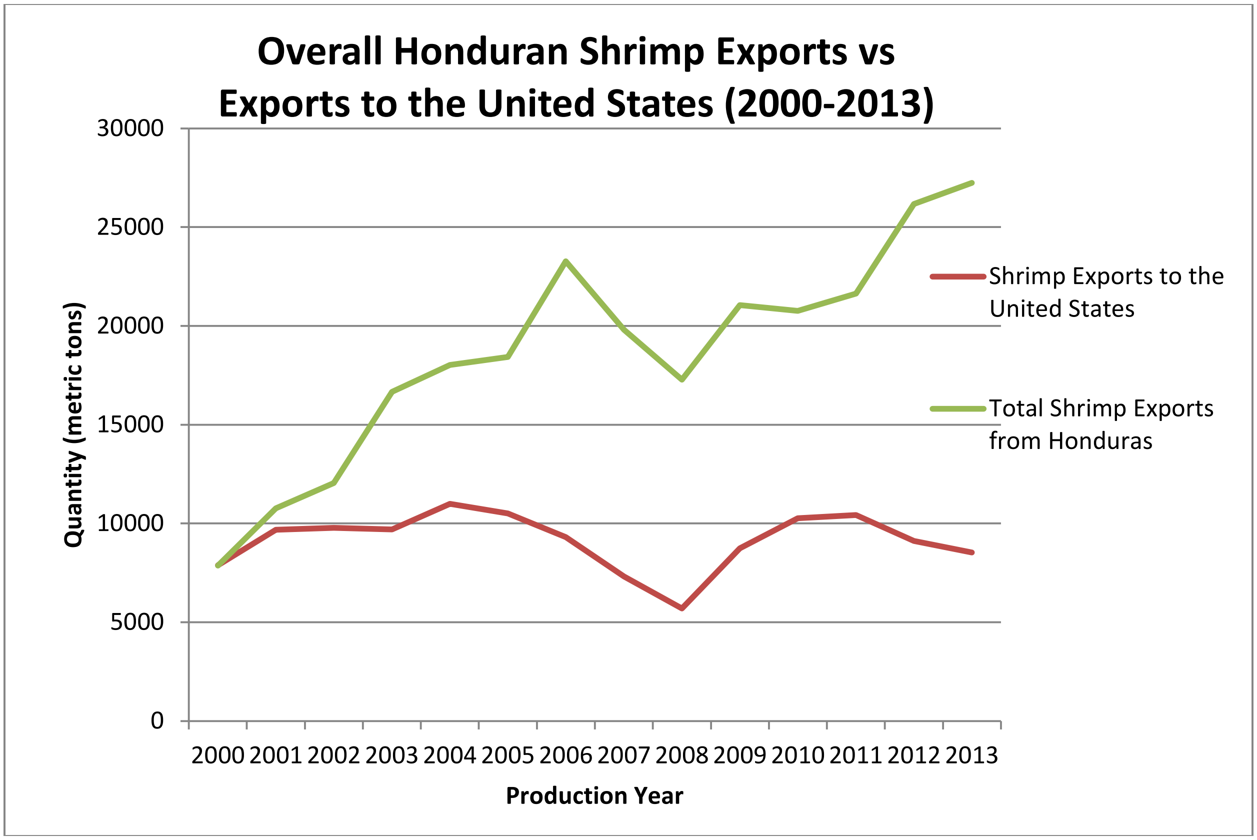

Figure 2. Shrimp Exports from Honduras to Selected Destinations (ANDAH 2014).

Common and Market Names:

Scientific Name	*Litopenaeus vannamei*
Common Name	Whiteleg shrimp, western white shrimp, Pacific whiteleg shrimp
United States	Whiteleg shrimp, Pacific white shrimp
Spanish	Camarón patiblanco
French	Crevette pattes blanches
Former Scientific Name	*Penaeus vannamei*

Product Forms:
Fresh or cooked: head on, shell on, peeled & deveined, peeled & undeveined (Grupo Granjas 2014).

Analysis

Scoring guide

- With the exception of the exceptional factors (3.3x and 6.2X), 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.seafoodwatch.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	5	7.5
Effluent	Yes	7.5	7.5
Locations/habitats	Yes	5	5
Predators and wildlife	Yes	5	7.5
Chemical use	Yes	2.5	5
Feed	Yes	2.5	7.5
Escapes, animal movements	Yes	2.5	7.5
Disease	Yes	2.5	7.5
Source of stock	Yes	7.5	7.5
Other – (e.g. GHG emissions)	No	n/a	n/a
Total			**40**

C1 Data Final Score	**4.4**	**YELLOW**

Brief Summary

Limited volumes of peer-reviewed scientific literature or official regulatory monitoring results were available for any of the assessed criteria, most likely due to the small size of the industry; however, useful information was supplied by the industry itself and also by personal communication with industry experts. Data availability and quality understandably varied considerably across the different criteria topics, and overall, the Data Criterion score was a moderate 4.4 out of 10.

Justification of Ranking

Industry or production statistics scored 5 out of 10 as there was little published information, but relevant information was provided by the Honduran shrimp industry group, ANDAH (Asociación Nacional de Acuicultores de Honduras via H. Corrales, personal communications) and members such as Grupo Granjas (2013 and IFCC 2013), SICA (2014) and in a commodity study conducted by Tveteras (2012). Further production and export statistics were provided in the Honduran country profile of the various 'fact sheets' produced by the Food and Agriculture Organization (Castellón 2005, FAO 2006).

The criterion *Effluents* scored 7.5 out of 10 for data availability. A range of industry, academic, and government publications provided relevant information on pond type and water exchange (Teichert-Coddington, Martinez and Ramírez 2000; Green and Ward 2001 & 2011) and relevant legislation (FAO 2009 & 2013). Since 1993, weekly water quality monitoring has been conducted in the relevant regions and the weight of this data enhances data availability (H. Corrales, personal communication, June 1 2014). The program began as an externally funded operation and then was continued from 1998 onwards through a cooperative agreement between the ANDAH and Ministry of Agriculture in Honduras. Further water quality monitoring results and results of other studies are further disseminated online[2].

Habitat received a moderate score of 5 out of 10, as the information available may not cover all farming operations. The Honduran industry provided information on siting of farms outside of mangrove habitats (Grupo Granjas 2013, IFCC 2013) and this was confirmed in another publication (Corrales et al. 2001) and through personal communication (B. Green, 2 June 2014) with an expert from the United States Department of Agriculture. Data were not available on the early operations that had a small physical footprint that may have been located in former mangrove habitat. This resulted in the lower data score. Relevant legislation and governmental bodies were related from two publications, FAO 2009 & 2013.

Evidence or Risk of Chemical Use also received a low score of 2.5 due to very limited published information. The only available information was provided in personal communications from an industry expert (B. Green, personal communication, 2 June 2014) on the use of chemical therapeutants by the industry, while only one dated academic public was available (Boyd, Haws and Green 2001).

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[2] (http://pdacrsp.oregonstate.edu/pubs/annual_reports/).

The data score for the criterion *Feed* was a low 2.5 out of 10. Recent, country specific data were not available in the literature (Teichert-Coddington, Martinez & Ramírez 2000 was the most recent Honduras-specific publication), but the ANDAH via the primary feed supplier, did supply average values for protein levels, fishmeal content, source of feed fish and use of tilapia byproduct meal (ANDAH via H. Corrales, personal communication, 1 June 2014). Average values for FCR appeared to be representative after a literature survey was used (Boyd, Haws and Green 2001; Tacon et al. 2011; Amaya, Davis & Rouse 2007; Rangen Feeds 2008; Samocha et al. 2004).

The *Escapes* criterion had a low data score of 2.5 out of 10 as the industry (Grupo Granjas 2013) and other publications (Teichert-Coddington, Martinez and Ramírez, 2000; FAO, 2006) provided basic information on escape prevention measures that were corroborated by personal communications with an industry expert (B. Green, personal communication, 2 June 2014), but evidence of genetic differentiation and or potential impacts was limited.

The *Disease* criterion scored a low 2.5 out of 10 for data as while some general information on disease outbreaks on farms was available from the industry (ANDAH via H. Corrales, personal communication, June 1, 2014; FAO 2013), academic (FAO 2006, and Murias 2013), and from an industry expert through personal communication (B. Green, personal communication, 2 June 2014), there is very little information available on potential impacts of pathogen discharge on wild species

The *Source of Stock* criterion scored moderate-high 7.5 out of 10 for data due to the robust nature of the data provided from a few sources (Morales 2011, Valderrama & Engle. 2000, 2002) and confirmed by industry publications (Grupo Granjas 2013; ANDAH via H. Corrales, personal communication, 1 June 2014).

Wildlife and Predator Mortalities—predators and wildlife received a moderate data score of 5 out of 10 as information was available only in the form of personal communication (H. Corrales 2014) and from three reports on a single predator species (cormorants) (Espinal& Manuel Mora 2013; Anonymous 2013; Espinal, Manuel Mora, O'Reilly & Solís 2013). No information was available for other potential predators.

The Whiteleg shrimp industry imports about 30% of its post larvae from Nicaraguan hatcheries, as stated by the ANDAH (via H. Corrales, personal communication, 1 June 2014) and this information availability is reflected in the score for international live animal shipments. The data score for the criterion *Escape of unintentionally introduced species,* was moderate-high (7.5 out of 10) and the references for *Source of Stock* applied for this criterion as well (Morales 2011, Valderrama & Engle. 2000, 2002, Grupo Granjas 2013).

Overall, the final Data Criterion score was a moderate 4.4 out of 10.

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 Evidence-Based Assessment

C2 Effluent Final Score	**4.00**	**YELLOW**

Brief Summary

Shrimp farms routinely exchange water and discharge effluents, but weekly monitoring of water quality in Honduran shrimp farms is reported to show that the farms are not impacting and not exceeding the carrying capacity of the estuaries that receive them. Some evidence of legal proceedings against farms that exceed regulatory limits shows that management and enforcement measure are in place, but raises some concern about excess effluent discharges. Overall, the score for Effluent was 4 out of 10, reflecting moderate effluent concerns from the shrimp farm operations.

Justification of Ranking

The evidence-based assessment was utilized as there was adequate data available to make this assessment.

Nutrient effluents from shrimp ponds result from the incomplete assimilation of nutrients provided in feeds and fertilizer. Feed inputs to semi-intensive ponds are moderate (for example commercial shrimp feeds in Honduras are reported with a range of 20%–25% protein content (Ward and Green 2011) and a relatively low eFCR of 1.4 (Tacon et al. 2011). Fertilizer is used, particularly in the dry season, and the average fertilizer-nitrogen input per ton of shrimp produced is 42.08 kg during that season (Green & Ward 2011). The application is based on specific criteria by pond (e.g., Secchi disk readings) (B. Green, personal communication, 2 June 2014).

Whiteleg shrimp operations in Honduras occur in ponds with reported daily water exchange of, on average, 4.9% per day (Green and Ward 2011). Water exchange events are controlled by the farmers and do not occur at the same time fertilizer is applied as this would mitigate the desired impacts of the fertilizer application (B. Green, personal communication, 2 June 2014). During pond draining the sediment pulse occurs at the end of shrimp pond draining instead of at the beginning as is seen in fish ponds (personal communication, Bartholomew Green, 27 August 2014). Settling ponds or ditches have also been in use in some farms in Honduras since 2000 (personal communication, Bartholomew Green, 2014 and ANDAH via H. Corrales, personal communication, 1 June 2014), and water drained from ponds flows through drainage canals before entering the estuaries and these canals, often hundreds of meters long, also encourage sediments to settle. An example of ponds with drainage canals (indicated in white–below in Figure 3) was provided by an industry expert.

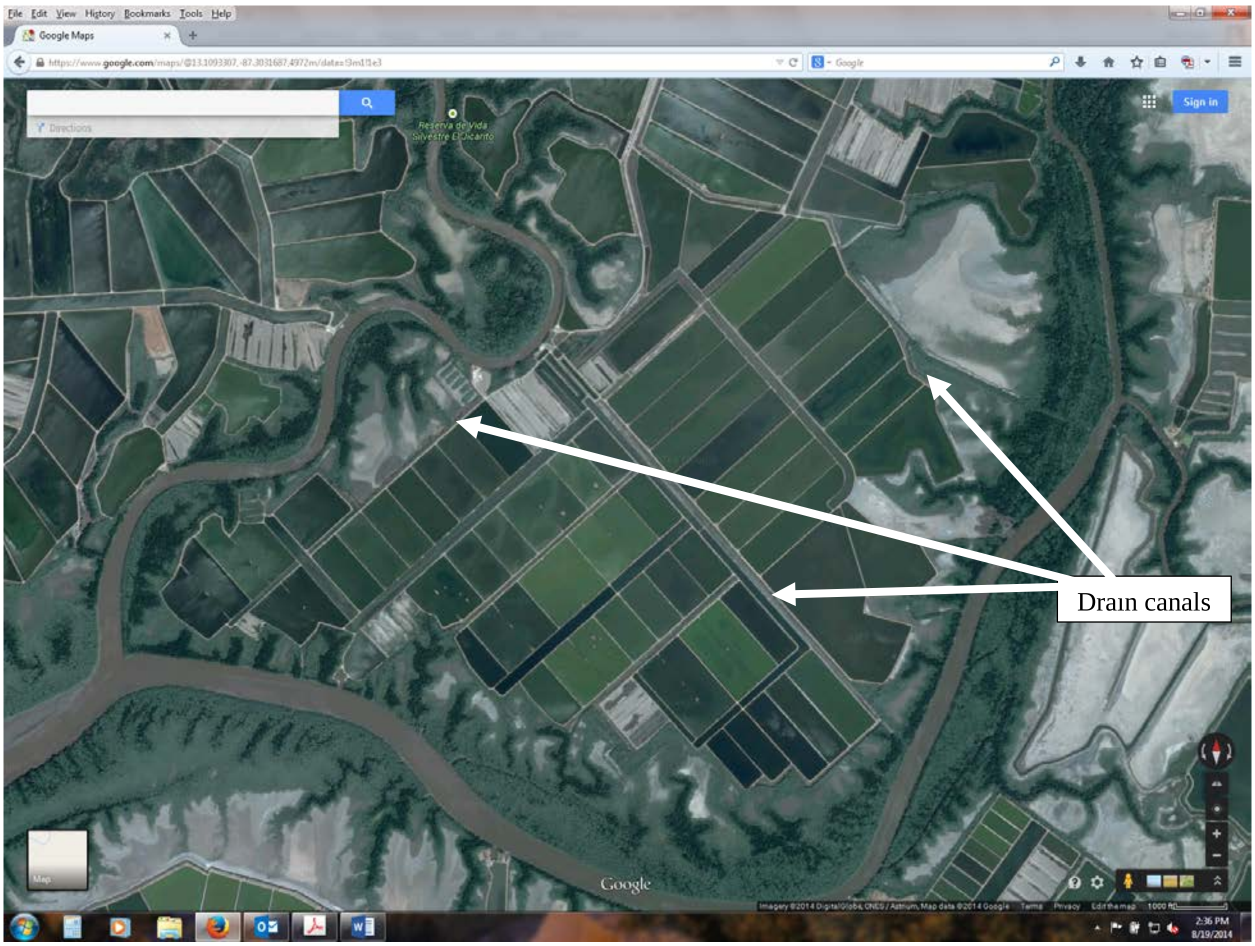

Figure 3. Honduran farm sites accessed on Google Earth, 19 Aug 14, position of drainage canals from shrimp farms. Provided by B. Green (personal communication August 27, 2014)

Since 1993, weekly monitoring of water quality has been conducted in all shrimp farming regions (nitrogen, phosphorus and suspended solids are all tracked). Both incoming water and outputs have been tracked and reported, and while specific data was not available, the results show that farms are 'not impacting' the estuaries (ANDAH via H. Corrales, personal communication, 1 June 2014). Two publications, Ward and Green 2001 and Green and Ward 2011, studied potential impacts on dissolved oxygen levels from shrimp farming operations in Honduras. Both studies found that the effluents released from the operations were not driving the receiving waters beyond carrying capacity. The 2001 publication by Ward and Green incorporated baseline data collected on the receiving waters in the region over an extended period of time (1994-1998). Dissolved oxygen was used to measure water quality while values for salinity, tidal flow, etc. were also collected and compared between farm sites and locations in the receiving waters at established distances from the farms. The dissolved oxygen levels were found to vary seasonally (as expected) and to have become poorer in the San Bernardo estuary system between 1995 and 2000, due to changes in river flow after a major hurricane event. The model developed by the authors suggested that the water quality of the estuary was controlled upstream of the farms by poor dissolved oxygen levels, and outputs from the farms contributed only a small amount of nutrient loading.

The 2011 study by the same authors (Green and Ward) focused more on on-farm conditions for BOD and water quality. They found a clear signal between dry and wet season BOD (dry season was, on average, 26% lower than rainy season) which correlates with the findings in the 2001 study (above). Further data were provided on fertilization (generally from the first week of the production cycle) and formulated feed was used only during the rainy season (with the exception of one farm).

The regulatory framework is outlined in the FAO National Aquaculture Legislation Overview for Honduras (FAO 2013). The 2009 General Water Law (Ley General de Aguas, “Water Law”) and the 2003 Water Framework Law (Ley Marco Del Sector Agua Potable Y Saneamiento, “Water Law Framework”) are set to manage Honduran water resources. One concern noted in a publication (FAO 2009) is that the upper limits for wastewater discharges from any operation set by the Honduran government may be higher than the typically accepted recommendations for maintenance of healthy water systems. All environmental licenses are linked with compliance to environmental measures and each company is required to make an annual report to both local authorities as well as the national government. Audits may also be conducted at any time, by both levels of government. Non-compliance results in fines or a potential forced-closure of the business. Results of reporting or fines are not published, but they are available to any member of the public requesting the information (H. Corrales, personal communication, 1 June 1 2014). It is reported that fines have been levelled, but no licenses revoked and H. Corrales (personal communication, 1 June 2014) stated, “*During 2012, a total of four complaints were presented to the environmental authority. All four had grounds to take them to the next judiciary step and are on trial. During 2013, nine complaints were presented, six had grounds and are following course in the judicial system.”*

Overall, while the farms discharge substantial amounts of nutrients, there is little evidence of shrimp farms exceeding the local environmental carrying capacities. Yet the evidence of legal proceedings against some farms indicates concern and room for improvement in terms of lowering impacts. Therefore, relying on the available literature and expert opinion, the impacts of shrimp farming operations are considered to be moderate and score 4 out of 10.

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	3.50		
F3.2b Enforcement of habitat regulations	4.00		
F3.2 Regulatory or management effectiveness score		5.60	
C3 Habitat Final Score		**4.53**	**YELLOW**
Critical?	NO		

Brief Summary

While there has been some historic habitat damage (i.e., more than 10 years ago) in high-value habitats, the majority of shrimp farms in Honduras are located on salt flats behind the mangrove forest fringe and this has led to substantially less impact on that habitat than on habitats in other parts of the world. In terms of habitat management, the content of the regulatory effectiveness scores well with 4/5 due to requirements for environmental impact assessments and other Honduran habitat oversight regulation. With moderate enforcement, the overall regulatory effectiveness score was moderate. The Habitat Criterion received a final yellow score of 4.53 out of 10.

Justification of Ranking

Factor 3.1. Habitat Conversion and Function

Historically, the destruction and loss of mangrove habitat due to shrimp farming activities has been one of the main environmental concerns with this production system around the world (Ha, van Dijk & Bush 2012 and Valiel, Bowen & York 2001). To the contrary, in Honduras, most shrimp farms are sited on salt flats behind mangrove forests (Grupo Granjas 2013; IFCC 2013; Ward and Green 2001; personal communication, B. Green 2014; Corrales et al. 2011). Some shrimp operations in Honduras have created programs to support the maintenance and expansion of mangroves (IFCC 2013). A limited number of small-scale operations with small physical footprints did impact mangrove habitat (more than 10 years ago) and this resulted in a

Factor 3.1 score of 4 out of 10 (Ward and Green 2001; B. Green, personal communication, 2 June 2014.)

Factor 3.2. Habitat and Farm Siting Management Effectiveness (Appropriate to the Scale of the Industry)

Factor 3.2 is separated into two sub-factors: 3.2a assesses the content of habitat regulations and management processes, and 3.2b assesses the enforcement of the measures identified in 3.2a. These aspects are discussed below. Farm licensing in Honduras is subject to approval through a staged process. A preliminary environmental license is issued for one year to ensure that all actions stipulated in the document for approval are complied with before the license is extended (FAO 2009). Further, the government requires a “collateral deposit” or bond be paid in the case of projects that have high environmental risks. The Fisheries Regulations define “protected areas or nature reserves” as those areas set aside as determined by competent authorities, with intent to guarantee the reproduction, growing and repopulation of hydro-biological resources. (Fisheries Law Article 5) (FAO 2009).

The General Directorate for Fisheries and Aquaculture (DIGEPESCA) requires:

- A bio-economic study is required should the area to be developed be larger than five hectares. This study shall contain:
    - technical and biological indicators
    - biological description of the species to be cultivated
    - selection criteria for the site
    - requirements of and supply programs for the organisms
    - description of the methods to be used in each cultivation stage, through harvest
    - sanitary and technical management
    - infrastructure layout and description
    - investment amount and allotment
    - project financial analysis
    - number of jobs it will generate
- A map of the location to be developed
- Original topographical survey, signed and stamped/sealed. (Fisheries Regulations, Article 53) (FAO 2013)
- The system controlling EIAs in Honduran agriculture, including aquaculture, is the National Environmental Impact Assessment System (Sistema Nacional de Evaluacion de Impacto Ambiental, 1994 “SINEIA” in Spanish). This system establishes specific requirements for obtaining an environmental license.

Full scores were awarded for question 1 of 3.2a and b and question 5 of 3.2b as environmental impact assessments are required and enforcement organizations are identified, contactable and appropriate for the size of the industry (FAO 2009, FAO 2013). Additionally, evidence of the restrictions or control measures in place are required (ANDAH via. H. Corrales, personal communication, 1 June 2014). Similarly, question 4 of 3.2b was scored at 0.75 as the enforcement process is largely (but not entirely) transparent (FAO 2009) and the information is not published but must be requested (H. Corrales, personal communication, 1 June 2014).

Fines for non-compliance with regulations and court case proceedings indicate that active enforcement measures are in place.

There is no clear definition of actions that must be completed for farms under the 5 ha size and, as many of the operations in Honduras are smaller than this, there is concern that impacts from smaller farms are not taken into account. Questions 2 and 3 of section 3.2a scored moderately-poorly (0.75 and 0.25) as regulations do not specify limits on development due to cumulative impacts now, or in the future, but this is somewhat taken into consideration through the process of the mandatory EIA process (FAO 2009; ANDAH via H. Corrales, personal communication, 1 June 2014).

Overall, some questions remain as to whether the industry's ongoing and future expansion is limited to an appropriate scale to prevent future loss of ecosystem services, but Factor 3.2a scores 3.5 out of 5 due to requirements for environmental impact assessments and other Honduran habitat oversight regulations. Factor 3.2b for enforcement scores slightly better with 4 out of 5. The final management score for Factor 3.2 combines the scores for 3.2a and 3.2b and is 5.6 out of 10.

Final Habitat Criterion Final Score
According to the Seafood Watch criteria, the final score for C3 was calculated as ((2xF3.1) + F3.2))/2 = ((2x4) + 5.6))/2 = 4.53 out of 10.

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	**4.00**	
C4 Chemical Use Final Score	**4.00**	**YELLOW**
Critical?	NO	

Brief Summary

The use of chemical and antibiotics is reported by both industry and outside experts to be limited, but robust information or data are not available. A publication more than ten years old reported a single use of oxytetracycline, but this was a limited occurrence and was not factored into the scoring. A more recent survey of antibiotic use may help improve the score for this criterion. Further, the largest producer by volume, self-reports zero antibiotic use. The Chemical Criterion scored 4 out of 10

Justification of Ranking

Very little independent information is available on chemical use in Honduras. A 2001 study (Boyd, Haws and Green) surveyed farms in Honduras and reported a single occurrence of the use of oxytetracycline, a chemical listed as “Highly Important to Human Health” by the World Health Organization. More recently, an expert in the Honduran industry practices advised that antibiotics use is limited and done in accordance with standard aquatic animal health protocol in response to diseases requiring treatment (B. Green, personal communication, 2 June 2014) and this was confirmed in communications with ANDAH (via H. Corrales, personal communication, 25 July 2014). Further, ANDAH reported that the largest producer in Honduras (by volume) declared that they use zero antibiotics. Currently, they are in the process of receiving Global Gap certification and the information from the farm audit document could confirm the zero usage.

Overall, expert opinion states that chemical use is “limited,” but this is difficult to define without robust sources of data. Some use of antibiotics is assumed to take place, but considering the expert opinions, the total amount is likely to be low. While data confirming and defining limited use could improve the score, the final score for the Chemical Criterion is 4 out of 10 on a precautionary basis.

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 nonedible portion of farmed fish.*

Criterion 5 Summary

Feed parameters	Value	Score	
F5.1a Fish In: Fish Out ratio (FIFO)	0. 56	8.60	
F5.1b Source fishery sustainability score		-2.00	
F5.1: Wild Fish Use		8.49	
F5.2a Protein IN	13.44		
F5.2b Protein OUT	16.61		
F5.2: Net Protein Gain or Loss (%)	+23.9	10	
F5.3: Feed Footprint (hectares)	3.52	8	
C5 Feed Final Score		**8.75**	**GREEN**
Critical?	NO		

Brief Summary

Honduran shrimp farmers utilize a commercial pelleted feed with 7% fishmeal and 2% fish oil inclusion levels. The eFCR was estimated to be1.4. Half of the fishmeal comes from tilapia-processing byproducts, and half of the total protein included in the feed is sourced from nonedible sources. The use of wild fish is therefore low, and there is a net gain in edible protein. With large amounts of crop ingredients in the feed, the feed footprint was relatively small, and the overall feed score was 8.75 out of 10.

Justification of Ranking

Factor 5.1. Wild Fish Use

Recent values for FCR of shrimp production in Honduras were not available. As a result, the FCR of 1.4 supplied by Tacon et al. (2011) for shrimp culture was utilized. A fishmeal and fish oil inclusion value of 7% and 2% respectively were supplied (anonymously) by the feed producer, and the industry, through ANDAH, provided a value of 50% use of tilapia byproduct meal (H. Corrales, personal communication, 1 June 2014).

The Fish In: Fish Out (FIFO) value is based on the larger of the two values calculated for fishmeal or fish oil. The calculations are shown below (note that fishmeal and fish oil yield values were not available, so global average data provided in Tacon and Metian (2008) were utilized):

FIFO Fishmeal= ((fishmeal inclusion level) * (economic FCR)) / (fishmeal yield)
FIFO Fishmeal = ((3.5*(1. 4))/ (22.5) = 0.22
FIFO Fish Oil = ((fish oil inclusion level) * (economic FCR)) / (fish oil yield)
FIFO Fish Oil = ((2)*(1. 4))/ (5) = 0.56
Final FIFO Value (larger of the two) = 0.56

The FIFO value for fish oil is larger than the value for fishmeal and as such, fish oil drives the FIFO score. The FIFO value for fish oil of 0.56 corresponds to an initial Factor 5.1 score of 8.60.

This initial Factor 5.1 score is adjusted based on the relative sustainability of the source fisheries. The primary feed supplier reported that feed was comprised of Peruvian anchoveta and tilapia trimmings in variable proportions (ANDAH via H. Corrales, personal communication, August 27 2014). Peruvian anchoveta has Fish Source scores all greater than 6, and one or more score greater than 8 and this corresponds with an assigned score of -2 in this assessment (Fish Source 2014).

When this adjustment score is applied, the final Factor 5.1 score is 8.49 out of 10.

Factor 5.2. Net Protein Gain or Loss
The protein content of feed was reported at 20%–25% for semi-intensive ponds in Green and Ward (2011) while older publications reported a range of 27%–35% (Amaya, Davis & Rouse 2007; Rangen 2008; Teichert-Coddington, Martinez & Ramírez 2000). A 25% protein inclusion value with half of that protein coming from nonedible sources was confirmed in a statement from the feed producer shared by ANDAH (via H. Corrales, personal communication, 25 July 2014). The Seafood Watch criteria assume protein other than that from fishmeal and nonedible sources comes from edible crops, which in this case was calculated to be 40.69% (after deducting the protein originating in whole-fish fishmeal from the remaining 50% of edible protein ingredients).

Regarding the protein content of whole harvested shrimp, a technical reference document (Torry Research Station 1989) was utilized (20.5%) while edible yield of shrimp was set based on expert advice at 62% (B. Green, personal communication, 2 June 2014). Finally, the percentage of nonedible byproducts from harvested, farmed shrimp used for other food production was not available in the literature so the SFW supplied value of 50% was used.

Protein In = [protein content of feed–(protein content of feed*(percentage of feed protein from nonedible sources + (0.286*percentage of feed from edible crop sources)) / 100)] x FCR

Protein In = [25 – (25*(50+ (0.286*40.69)) / 100)] * 1.4 = **13.4**
Protein Out = (protein content of whole harvest farmed fish / 100) * [(edible yield of harvest farmed fish + (percentage of nonedible byproducts from harvest farmed fish used for other food production * (100-edible yield of harvested farmed fish)) / 100]
Protein Out = (20.5/100) * [(62 + (50 * (100-62)) / 100] = **16.6**
Net protein gain or loss = (Protein Out – Protein In) / Protein In
Net protein = (16.6 – 13.4) / 13.4 = **+23.9%**

Due to the relatively low protein content of the feed, and the 50% use of fishmeal made from tilapia byproducts, there is a net gain in edible protein of 23.9%, and score of 10/10 for protein conversion.

Factor 5.3. Feed Footprint
No land animal contribution was certified by the feed provider as shared by ANDAH (via H. Corrales, personal communication, July 25 2014), therefore the 9% of marine ingredients (7% fishmeal and 2% fish oil) are assumed to be complimented by 81% of crop ingredients.

Ocean area appropriated per ton of farmed fish = [(inclusion level of aquatic feed ingredients / 100) * eFCR * average primary productivity (carbon) required for aquatic feed ingredients] / average ocean productivity for continental shelf area
Ocean area appropriated per ton of farmed fish = [(9 / 100) * 1.44 * 69.7] / 2.68 = **2.68** ha ton-1 of farmed fish

Land area appropriated per ton of farmed fish = [inclusion level of crop feed ingredients + (inclusion of land animal products * conversion ratio of crop ingredients to land animal products) * 0.01 * eFCR] / average yield of major feed ingredient crops
The land area appropriated per ton of farmed fish = [91 + (0 * 1. 4) * 0.01 * 1. 4] /2.64 = **0.48** ha ton-1 of farmed fish
Value (ocean + land area) = 3.16 ha ton-1 of farmed fish and this gives a score for Factor 5.3 of 8 out of 10.

Final Feed Criterion Score
The scores for Factors 5.1, 5.2, and 5.3 combine in the calculation F5.1 x 0.5 + F5.2 x 0.25 + F5.3 x 0.25 = 8.49 x 0.5 + 10.00 x 0.25 + 8.00 x 0.25 **= 8.74** out of 10.

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		5.0	
F6.1a Recapture and mortality (%)	0		
F6.1b Invasiveness		3	
C6 Escape Final Score		**4.00**	**YELLOW**
Critical?	NO		

Brief Summary

The daily exchanging ponds in Honduras have typical escape prevention measures in place, but it is unclear if they are prone to large-scale escapes from flood risks or if secondary measures are in place for key activities such as harvesting. The escape risk is therefore considered moderate. White shrimp are native in Honduras, but have been domesticated and selected over several generations. There is a potential risk of genetic interactions with wild shrimp, although there is little evidence of this occurring. Overall, the Escape Criterion score is a moderate 4 out of 10.

Justification of Ranking

Factor 6.1a. Escape Risk

Whiteleg shrimp are cultured in earthen ponds in Honduras, with limited amounts of daily water exchange (3%–10% per day) (Teichert-Coddington, Martinez and Ramírez, 2000; H. Corrales, personal communication, 1 June 2014). Industry experts consulted provided further information that screens are placed on the inlet and outlets of all ponds as was recommended in a production manual in regional circulation since 1991 (B. Green, personal communication, 2 June 2014; Villalon 1991; H. Corrales, personal communication, 1 June 2014). It is not known if secondary escape measures are in place at harvest, or if the ponds are prone to flooding events. Therefore, based on the Seafood Watch Aquaculture Criteria, a score of 5 out of 10 is applied to Factor 6.1a as a moderate escape risk.

Factor 6.1b. Invasiveness

As the Gulf of Fonseca is within the native range of *L. vannamei*, the species is considered native to the region in which it is farmed (FAO 2006). National hatcheries are used as sources for the farming operations (Grupo Granjas 2013; B. Green, personal communication, 2 June 2014; Villalon 1991) with approximately 30% of post larvae coming from neighboring Nicaragua (ANDAH via H. Corrales, personal communication, 1 June 2014). Selective breeding occurs in hatcheries (ANDAH via H. Corrales, personal communication, 25 July 2014) and is considered to have occurred for more than four generations; therefore, the genetic difference from wild populations was scored as 1 out of 5.

As *L. vannamei* are native to the region they are farmed in, both the question "Do escapees compete with wild native populations for food or habitat?" and "Do escapees compete with wild native populations for breeding partners" scored Yes as a logical extension that any escapees would have mating and diets overlapping with their wild equivalents. Members of the *Litopenaeus* family share a common diet described as "opportunistic scavengers" (Hill 2005) and do not pose any particular threat through predation, so this question was scored as No. The species are opportunistic scavengers (Hill 2005) and no behaviors like foraging or settlement are reported in the literature or by experts consulted nor were any other impacts reported. Accordingly, both questions "Do escapees modify habitats to the detriment of other species?" and "Do escapees have some other impact on other native species?" were answered with No.

Ecosystem impacts of escapes were scored as 3 out of a possible 5 due to potential interactions between the wild and farmed species, with concern over impacts of competition for food/habitat or breeding disturbance. Overall, the invasiveness score calculated was 4 out of a possible 10 and the resultant final score for the Escape Criterion (which combines invasiveness with risk of escape) was 4 out of 10.

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 are a dominant characteristic of the industry's development in many shrimp farming countries, of which Honduras is no exception. The frequent water exchange is a direct route for pathogen transfer to wild shrimp populations, but evidence of population-level impacts to wild populations is very limited. Nevertheless the presence of multiple pathogens on farms and the open nature of the production systems dictates a moderate concern and a Disease Criterion score of 4 out of 10.

Justification of Ranking

Shrimp farming globally has been beset by a series of bacterial and viral disease outbreaks, causing serious economic challenges for the industries. The World Organization for Animal Health (OIE) lists several diseases affecting farmed L. vannamei including WSSV, yellow head virus (YHV), TSV, infectious myonecrosis virus (IMNV), necrotizing hepatopancreatitis (NHP), and infectious hypoderma and haematopoietic necrosis virus (IHHNV) (OIE 2015).

The Honduran Aquaculture Association (ANDAH) researches and tests water quality and aquatic pathology (FAO 2013), and two viruses have, historically and still today, been the main cause of mortality in Honduras: Taura syndrome virus and white spot syndrome virus. These diseases were all transferred in live shrimp stocks from country to country and from one continent to another, well before their etiology was understood and diagnostic methods were available (Lightner 2011). During the 1990s, two major disease outbreaks caused reduced production values in Honduras. In 1994-1995, Taura syndrome virus caused increased mortality in Honduras with a survival reduction estimated around 30% (Valderrama & Engle 2004). In 1999, an outbreak of white spot syndrome virus caused another country-wide increase in mortality (*ibid*). Increased mortalities due to disease outbreaks have been reported across the region in

La Niña years where the cooler temperatures reduce the shrimp fitness (FAO 2006). More recent data on the primary diseases impacting shrimp culture (or frequency of occurrence in Honduras) was not available in the literature.

A key current concern to global shrimp farming is early mortality syndrome (EMS, also known as acute hepatopancreatic necrosis syndrome (AHPNS)) (Nikolik and Kumar 2013). EMS is the latest global shrimp disease, and was first detected in China in 2009; since then it has spread to Vietnam, Malaysia and Thailand (Nikolik and Kumar 2013), and it has also been detected in the western hemisphere in Mexico (Murias 2013). It has not been reported in Honduras at the time of this writing.

The impacts and potential impacts of diseases on shrimp production in Honduras are clear, however, the potential impacts of disease transfered from shrimp farms to wild shrimp populations remain poorly understood (Walker and Mohan 2009). The frequent water exchange in Honduran shrimp ponds is an effective transfer route for pathogens. Shrimp diseases such as WSSV, TSV and IMNV may have multiple hosts and therefore can cross species boundaries. For example, WSSV can be carried by a wide range of species and has been found in wild crabs and shrimp in regions where infected shrimp have been farmed (Walker and Mohan 2009). Disease can therefore pass from farms to wild populations of both shrimp and other susceptible species (Walker and Mohan 2009). One example of a farmed shrimp disease affecting wild shrimp populations occurred in Mexico in the 1990s, with an IHHNV outbreak that resulted in significant losses in both farms and wild fisheries for the blue shrimp, *Penaeus stylirostris* (Lightner 2011). There is little concrete evidence of other examples of impacts from farmed shrimp diseases on wild shrimp populations.

The available evidence, therefore, suggests that farmed shrimp diseases can be transferred to wild populations, but that these wild stocks are not generally impacted in a significant way; however, it is clear that further research into these issues is needed. Weighing the material presented above, the score assigned for pathogen and parasite interaction was a moderate concern, or 4 out of 10. The production systems—regulated with biosecurity measures maintaining low stocking densities (H. Corrales, personal communication, 1 June 2014)—and the use of hatchery post larvae stock are important measures to reduce the risk of disease outbreaks. Yet, more detailed reporting on disease occurrence is not available nor are there limits in place for pathogen levels, so a higher score cannot be awarded.

Criterion 8: Source of Stock – Independence from Wild Fisheries

Impact, unit of sustainability and principle

- *Impact: the removal of fish from wild populations for ongrowing to harvest size in farms*
- *Sustainability unit: wild fish populations*
- *Principle: aquaculture operations use eggs, larvae, or juvenile fish produced from farm-raised broodstocks thereby avoiding the need for wild capture*

Criterion 8 Summary

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	**10.00**	**GREEN**

Brief Summary

In Honduras, the Whiteleg shrimp industry utilizes only hatchery-raised shrimp from Honduras or Nicaragua and, accordingly, a score of 10 out of 10 was assigned as no impact on the wild stock from the removal of fish from the populations occurs.

Justification of Ranking

There is a large body of evidence that indicates the Whiteleg shrimp industry utilizes only hatchery-raised shrimp from Honduras (Grupo Granjas 2013, Morales 2011, Valderrama & Engle 2000, 2002) and that there is no collection of wild individuals for use as broodstock. ANDAH (via H. Corrales, personal communication, 1 June 2014) further report that broodstock are selected among strong performing farm stock, not from the wild. As white shrimp farming in Honduras is not dependent on wild fisheries for stock, this criterion receives a score of 10 out of 10 to reflect this independence.

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	
9X Wildlife and predator mortality Final Score	**-4.00**	**YELLOW**
Critical?	NO	

Brief Summary
From the available information, cormorants are the principle predator problem in Honduran shrimp ponds. Lethal control does occur, but the numbers are not considered to lead to population-level declines. The score assigned for this criterion was moderate deduction of–4 out of–10

Justification of Ranking
Information was available in the form of personal communication (H. Corrales 2014) and from three reports on the diet, populations and control plan (including non-lethal deterrents) for cormorant populations (Espinal& Manuel Mora 2013; Anonymous 2013; Espinal, Manuel Mora, O'Reilly & Solís 2013) stating that some mortalities occur, but do not involve endangered or threatened the species. Other species potentially affected are unknown, but wildlife and predator mortalities are not reported in the literature at the time of this assessment. As such, this exceptional criterion receives a moderate score based principally on precaution as lethal control is used, but is unlikely to affect the population size of the affected species.

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	
F10Xa International or trans-waterbody live animal shipments (%)	10.00	
F10Xb Biosecurity of source/destination	10.00	
C6 Escape of unintentionally introduced species Final Score	**0.00**	**GREEN**

Brief Summary

Seventy percent of the stock utilized in Honduras is domestically raised and the remaining 30% is sourced from neighboring Nicaragua through a shared (and co-sovereign) waterbody. Considering these two factors, the shipment from hatcheries in Nicaragua to Honduras is not considered international or trans-waterbody and a full score of 10 was awarded.

Justification of Ranking

The Whiteleg shrimp industry utilizes 70% of domestically raised stock from Honduras (Grupo Granjas 2013, Morales 2011, Valderrama & Engle. 2000, 2002; ANDAH via H. Corrales, personal communication, 25 July 2014) and 30% is sourced from neighboring Nicaragua. However, the shipment occurs in the Gulf of Fonseca, which is managed as a co-sovereign waterbody by Honduras and Nicaragua (and El-Salvador) (United Nations 2006) with 50 km separating the hatchery from the recipient farms (ANDAH via H. Corrales, personal communication, 28 August 2014). Considering these two factors, the shipment from hatcheries in Nicaragua to Honduras is not considered international and a full score of 10 was awarded. The hatchery sources are closed operations and this ensures the source biosecurity at the source while the destination farm scores 4 (ponds with moderate exchange of 3%–10% per day) (Green and Ward 2011). The final score is calculated as [(10-10Xa) x (10-10Xb)]/10 = [(10-10) x (10-10)]/10 = 0.

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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*	5	7.5
Effluent	Yes	7.5	7.5
Locations/habitats	Yes	5	5
Predators and wildlife	Yes	5	7.5
Chemical use	Yes	2.5	5
Feed	Yes	2.5	7.5
Escapes, animal movements	Yes	2.5	7.5
Disease	Yes	2.5	7.5
Source of stock	Yes	7.5	7.5
Other – (e.g., GHG emissions)	No	Not relevant	n/a
Total			**40**

C1 Data Final Score	4.4	YELLOW

Criterion 2: Effluents

Effluent Rapid Assessment

C2 Effluent Final Score	**4.00**	**YELLOW**

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?	Mostly	0.75
3 – Is the industry's ongoing and future expansion appropriate locations, and thereby preventing the future loss of ecosystem services?	Partly	0.25
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)	Mostly	0.75
5–Do control measures include requirements for the restoration of important or critical habitats or ecosystem services?	Mostly	0.75
		3.5

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?	Yes	1
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?	Mostly	0.75
4–Is the enforcement process transparent–e.g. public availability of farm locations and sizes, EIA reports, zoning plans, etc.?	Mostly	0.75
5–Is there evidence that the restrictions or limits defined in the control measures are being achieved?	Yes	1
		4

F3.2 Score (2.2a*2.2b/2.5)	**5.60**

C3 Habitat Final Score	**4.53**	**YELLOW**
	Critical?	NO

Criterion 4: Evidence or Risk of Chemical Use

Chemical Use parameters	Score	
C4 Chemical Use Score	**4.00**	
C4 Chemical Use Final Score	**4.00**	**YELLOW**
Critical?	NO	

Criterion 5: Feed

5.1. Wild Fish Use

Factor 5.1a–Fish In: Fish Out (FIFO)

Fishmeal inclusion level (%)	7
Fishmeal from byproducts (%)	50
% FM	3.5
Fish oil inclusion level (%)	2
Fish oil from byproducts (%)	0
% FO	2
Fishmeal yield (%)	22.5
Fish oil yield (%)	5
eFCR	1.4
FIFO fishmeal	0.22
FIFO fish oil	0.56
Greater of the 2 FIFO scores	0.56
FIFO Score	**8.60**

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

SSWF	-2
SSWF Factor	-0.112

F5.1 Wild Fish Use Score	**8.49**

5.2. Net protein Gain or Loss

Protein INPUTS

Protein content of feed	25
eFCR	1.4
Feed protein from NON-EDIBLE sources (%)	50
Feed protein from EDIBLE CROP sources (%)	40.69
Protein OUTPUTS	
Protein content of whole harvested fish (%)	20.5
Edible yield of harvested fish (%)	62
Non-edible byproducts from harvested fish used for other food production	50
Protein IN	13.4
Protein OUT	16.605
Net protein gain or loss (%)	23.669
Critical?	NO
F5.2 Net protein Score	**10.00**

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 (%)	9
eFCR	1.4
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)	3.28

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

Inclusion level of crop feed ingredients (%)	81
Inclusion level of land animal products (%)	0
Conversion ratio of crop ingredients to land animal products	*2.88*
eFCR	1.4
Average yield of major feed ingredient crops (t/ha)	*2.64*
Land area appropriated (ha per ton of fish)	0.43

Value (Ocean + Land Area)	**3.71**

F5.3 Feed Footprint Score	**8.00**

C5 Feed Final Score	8.74	YELLOW
	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	2

Part C – Native and Non-native species

Question	Score
Do escapees compete with wild native populations for food or habitat?	Yes
Do escapees act as additional predation pressure on wild native populations?	No
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	5

Final C6 Score	5.00	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**

Exceptional Factor 9X: Wildlife and predator mortalities

Wildlife and predator mortality parameters	Score	
F9X Wildlife and Predator Final Score	**-4.00**	**YELLOW**
Critical?	NO	

Exceptional Factor 10X: Escape of unintentionally introduced species

Escape of unintentionally introduced species parameters	Score	
F10Xa International or trans-waterbody live animal shipments (%)	10.00	
F10Xb Biosecurity of source/destination	10.00	
F10X Escape of unintentionally introduced species Final Score	**0.00**	**GREEN**