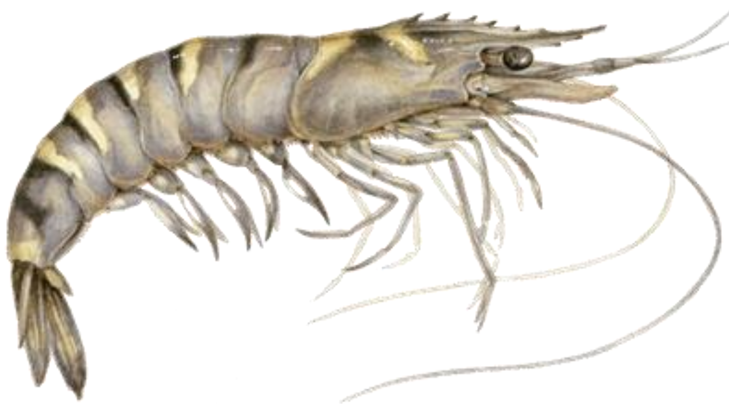
Giant Tiger Prawn and White Shrimp

Penaeus monodon, Litopenaeus vannamei



Malaysia

Ponds

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Final Seafood Recommendation

Giant Tiger Prawn

Penaeus monodon

Malaysia

Ponds

Criterion	Score (0–10)	Rank	Critical?
C1 Data	4.17	YELLOW	
C2 Effluent	4.00	YELLOW	NO
C3 Habitat	1.97	RED	NO
C4 Chemicals	3.00	RED	NO
C5 Feed	5.05	YELLOW	NO
C6 Escapes	4.00	YELLOW	NO
C7 Disease	5.00	YELLOW	NO
C8 Source	10.00	GREEN	
C9X Wildlife mortalities	–5.00	YELLOW	NO
C10X Introduced species escape	–2.00	GREEN	
Total	**30.18**		
Final score	**3.77**		

OVERALL RANKING

Final Score	3.77
Initial rank	YELLOW
Red criteria	2
Interim rank	RED
Critical Criteria?	NO

FINAL RANK
RED

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 score for Malaysian farmed giant tiger prawn *(P. monodon)* is 3.77 out of 10, which is numerically ranked “Yellow,” but with two Red criteria (Habitat and Chemical Use), the final recommendation is “Avoid.”

White shrimp
Litopenaeus vannamei
Malaysia
Ponds

Criterion	Score (0-10)	Rank	Critical?
C1 Data	4.17	YELLOW	
C2 Effluent	4.00	YELLOW	NO
C3 Habitat	1.97	RED	NO
C4 Chemicals	3.00	RED	NO
C5 Feed	5.05	YELLOW	NO
C6 Escapes	4.00	YELLOW	NO
C7 Disease	5.00	YELLOW	NO
C8 Source	10.00	GREEN	
C9X Wildlife mortalities	–5.00	YELLOW	NO
C10X Introduced species escape	–1.00	GREEN	
Total	**31.18**		
Final score	**3.90**		

OVERALL RANKING

Final Score	3.90
Initial rank	YELLOW
Red criteria	2
Interim rank	RED
Critical Criteria?	NO

FINAL RANK
RED

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 score for farmed white shrimp *(L. vannamei)* from Malaysia is 3.90 out of 10, which IS numerically ranked "Yellow," but with two Red criteria (Habitat and Chemical Use), the final recommendation is "Avoid."

Executive Summary

This assessment was originally published in June 2017 and reviewed for any significant changes in June 2021. No changes were made to the body of the report. Please see Appendix 1 for details of review.

Shrimp is the most widely consumed seafood item in the United States; in 2013, Americans ate an estimated 1.6 kilograms (kg) per capita. It has been estimated that 90% of the shrimp consumed in the U.S. are imported. In 2014, Malaysia was the eighth-largest shrimp importer to the United States and accounted for 17,900 metric tons (MT) of the 568,535 MT total U.S. shrimp imports that year. Import data suggest that Malaysia's role in U.S. imports is highly variable, because 2013 imports were half of those in 2014, but in 2011 they were nearly one-third greater. The reason for such variability is unclear.

Two main marine shrimp species are farmed in Malaysia: the native giant tiger prawn *(Penaeus monodon)* and the nonnative white shrimp *(Litopenaeus vannamei).* White shrimp production in Malaysia peaked in 2010 at 69,049 MT, but has since declined to 45,454 MT in 2013. By comparison, giant tiger prawn production has decreased from its peak of 26,352 MT in 2001 to 4,483 MT in 2013. White shrimp farming has therefore virtually replaced giant tiger prawn farming in the country. This change has occurred even though the initial introduction of white shrimp in the country was rejected by the government in 2000 after an extensive Import Risk Assessment (IRA). But illegal farming took place in remote farms in Peninsular Malaysia and Sabah anyway, and the government eventually made white shrimp farming legal because of ongoing disease issues with the giant tiger prawn. Both species are generally farmed in semi-intensive or intensive systems, using compound feeds and harvest or limited water exchange strategies. Most farms are sited in defined Aquaculture Industry Zones (AIZ), which are reportedly pre-defined areas based on Environmental Impact Assessments (EIAs). A national code of practice and certification scheme called MYGAP exists, with 46% of production certified. Although MYGAP contains environmental criteria, it lacks detailed requirements. Current information is limited, but there is sufficient evidence for this report to assume that the production of both species relies on post-larvae from domesticated imported broodstock from broadly disease-free sources (Mozambique and Madagascar for giant tiger prawn; Hawaii for white shrimp). Native wild populations of giant tiger prawn are not used for broodstock because they are carriers of known shrimp pathogens.

There are few relevant and current peer-reviewed studies on the environmental impacts of Malaysian shrimp. Though the relevant government agencies are identifiable and have public websites, they are currently limited to listing registered farms and hatcheries and to publishing production statistics. But a new information system called “e-smpp akua” is forthcoming and is planned to increase public access to regulatory data and reports. Except for a national disease monitoring program, few agencies publish data on the results of farm auditing; however, data were received from the Department of Fisheries Malaysia (DOFM) as part of the review of this report, and further data on aspects of the industry (such as the AIZ) are available by request to the authorities. Overall, data are currently dated with some gaps, which results in precautionary scoring for several criteria in this report. Further transparency could be achieved with the new information system. Data quality is considered the same for both species, with a score 4.17 out of 10 for Criterion 1 – Data quality and availability.

Data on the quality or impact of shrimp farm effluent are not publicly available for the Malaysian shrimp industry, so the Risk-Based Assessment was used. Recent data from Malaysia suggest that both species have the same feed conversion ratio (1.6), but white shrimp requires less protein in its diet than giant tiger prawn, which results in a slightly lower biological waste production (61.12 kg of nitrogen per ton (N/t) compared to 67.68 kg N/t, respectively). Both species are grown in ponds with little water exchange (0%–3% of pond volume daily), and newly introduced regulation requires "treatment" of effluents, but no details on the type of treatment (e.g., settling ponds, proper sludge disposal) or enforcement were stated. Water quality regulations are applied nationwide and assumed to be based on the National Water Quality Standards (NWQS), which are relevant for aquaculture. No data are available on either enforcement or timing of inspections. Overall, the pollution potential from farm effluents is relatively low for both species (due primarily to the infrequent water exchange) and, because the industry's development is controlled by an Aquaculture Industry Zone (AIZ) system, there is potential for some protection from cumulative effluent impacts. But controls for each AIZ are individual and must be requested from the Department of Fisheries Malaysia (DOFM), and the stated goals of AIZ development focus on economic and industry development and sustainability, not mitigation of ecological impact. The new Inland Fisheries Rules provide clearer regulation but are still relatively nonspecific, and there are no enforcement results currently available. Thus, a precautionary score of 4 out of 10 for white shrimp and 4 out of 10 for giant tiger prawn is given for Criterion 2 – Effluent. This score could be improved with the availability of enforcement data from Malaysia.

Globally, shrimp farming has been linked to the historical conversion of ecologically important wetlands, including mangrove forests. Malaysia is no exception, with historical losses for shrimp farming beginning in the 1930s. The industry has been moving away from using these resources, but the current regulatory framework still allows further conversion, and there are examples of such siting less than 10 years ago. To convert wetlands, farmers must go through an EIA-informed decision-making process and undertake a compulsory replanting program. Additionally, farmers are encouraged to site aquaculture within an AIZ. EIAs are generally applied only to large farms (with occasional public consultation) and are required for siting in mangrove forests; farmer awareness of the impacts of farming on mangrove and wetlands appears high. Several issues with the EIA process were identified, including that the majority of farms are too small for the EIA rules to apply and that the quality of predicted impacts is poor. No enforcement data are made publicly available. Overall, the industry is generally developing in a managed zonal process (at least for large farms) with directed regulatory controls, including restoration, so it is limiting the further loss of ecosystem services from high-value habitats such as mangroves. Because of significant historical and recent impacts to high-value habitats, the final score is 1.97 out of 10 for both species for Criterion 3 – Habitat.

Asian shrimp aquaculture is known to use a variety of chemicals over the course of the production cycle, though the environmental impact of these is not always known. Of significant concern is the use of antimicrobials, which proliferate resistant pathogens that affect shrimp health and potentially human health. The focus of Malaysian regulatory control is on food safety, and current regulations only allow the use of drugs if they are permitted by the Director General. Regulatory monitoring data provided by the government for harmful drug residues (e.g., nitrofurans) show a perfect record of compliance from 2008, when the program began, to 2015. Guidance provided to farmers by the government and a document outlining maximum residue limits indicate that Malaysian shrimp farms could potentially use WHO-listed highly and critically important antimicrobials for human health, if approved by regulators. Some antimicrobials, namely oxytetracycline and sulfonamides, were reportedly used on farms according to a dated survey published in 2000. Additionally, two papers found the presence of antimicrobial-resistant pathogens in shrimp farm effluents, but confounding factors such as water supply did not allow either paper to directly link this presence to the farms themselves. Overall, the current environmental impact is unclear, so a precautionary score of 3 out of 10 is given for both species for Criterion 4 – Chemical Use.

In Malaysia, both giant tiger prawn and white shrimp are farmed utilizing the addition of compound feeds; recent government data suggest that the FCR for both species is around 1.6, with white shrimp requiring slightly less protein in feed than giant tiger prawn (35% compared to 38%, respectively). Data specific to Malaysia on sources of fishmeal and fish oil or inclusion rates were not available; thus, the best available (but now dated) global average shrimp feed data were used for both species. These data showed relatively high fishmeal levels (20%) in the diets of both species, but fish oil inclusion levels were low (2%). All fishmeal and fish oil is assumed to be derived from whole fish (i.e., no use of byproducts). FIFO ratios of 1.42 are moderate for both species. In the absence of data on the source of marine ingredients, the default score of –6 out of 10 was used for Factor 5.1b – Source fishery sustainability. The net protein loss from feed is relatively high (> 64%) for both species. The feed footprint for both species is also moderate (9.15 ha of ocean area and 0.47 ha of land area per ton of each species). Ultimately, both species achieve a score of 5.05 out of 10 for Criterion 5 – Feed.

Published information on the frequency, magnitude, or impacts of escapes from shrimp farms in Malaysia was not available, suggesting that these issues are poorly studied. Both white shrimp and giant tiger prawn are farmed in ponds using limited water exchange. But ponds are vulnerable to flooding, and a moderate risk of escape remains without specific regulations for best practices to prevent escapes, such as the use of screens or secondary capture devices (particularly during key activities such as harvest). Although giant tiger prawn is native to Malaysia, the local wild populations, which were initially used for broodstock, were found to be carriers of three major shrimp diseases, including white spot syndrome virus. Subsequently, the industry moved to disease-free imported domesticated (or imported then domesticated) broodstock from Mozambique, then later Madagascar. It is unclear specifically how much of Malaysia's total production comes from each domesticated strain, but it is evident that there has been ongoing access to these resources since 2003; this report therefore makes the assumption that 100% of giant tiger prawn comes from domesticated stocks that have been selected for four or more generations. Therefore, the genotype of giant tiger prawn used in Malaysian shrimp farming is considered to be different from wild populations due to some combination of the East African sources and genetic selection; however, the genetic impact of escaped farm-origin prawns on wild populations in other countries (e.g., Thailand) has been found to be inconclusive. White shrimp is nonnative and raised from imported broodstock, so it potentially has a larger escapement impact if it were to become ecologically established. Although establishment has not been shown in other countries where the species has also been introduced, it remains poorly studied. Overall, white shrimp is considered to have a moderate risk of escapement and a moderate risk for impact, resulting in a score of 4 out of 10 for Criterion 6 – Escapes. Giant tiger prawn has a moderate risk of escapement and impact, also resulting in a score of 4 out of 10.

Disease outbreaks on shrimp farms have the ability to severely affect production and were the driving force behind Malaysia's move from giant tiger prawn farming to white shrimp farming. DOFM performs regular disease surveillance and maintains a reactive national disease response group. Published results indicate a low incidence of disease, but it is unknown how representative they are of the industry at large. 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 in other regions. But significant impacts on these wild populations have not been reported in Malaysia. Because most farms reportedly use harvest exchange practices and new regulation is fairly detailed on biosecurity measures, both shrimp species are considered a moderate risk, scoring 5 out of 10, for Criterion 7 – Disease.

Current and detailed information on the source of stock for both species in Malaysia is unclear. Available evidence suggests that both fully rely on post-larvae from domesticated broodstock. The origin of the broodstock is from imported sources (Mozambique and Madagascar for giant tiger prawn, Hawaii for white shrimp). Therefore, the final score for both species is 10 out of 10 for Criterion 8 – Source of Stock.

Recent data on wildlife and predator mortalities associated with Malaysian shrimp farming are lacking. But general shrimp farming practices include treating ponds during the initial fill to kill resident organisms, and dated literature specified that saponin, hypochlorites, and organophosphates have been used in Malaysia. Passive and non-lethal measures, such as pond linings to deter predatory crabs and fireworks to deter diving birds, are typical in the shrimp farming industry, but use of these practices could not be confirmed. Interactions between wildlife and shrimp ponds that result in mortality do occur during stocking; although these and other mortalities are unlikely to result in population-level impacts, no data or other information are available to determine this. White shrimp and giant tiger prawn each score a deduction of –5 out of –10 for Criterion 9X – Wildlife and predator mortalities.

Between 2003 and 2007, the Malaysian government imported a nonnative strain of giant tiger prawn from Mozambique and began a broodstock selection program with it, achieving disease-free seed for six relevant pathogens. In 2013, it was reported that at least one Malaysian hatchery was importing domesticated, verified SPF broodstock from Madagascar that was free

from five relevant shrimp pathogens. Evidence shows that domesticated and verified specific pathogen free (SPF) (between 9 and 13 pathogens) white shrimp broodstock have been imported from Hawaii since 2013. In the absence of specific and detailed information regarding domestically grown broodstock, this report takes the position that 100% of the industry for both species relies on international live animal shipments.
Malaysia has evident import controls for broodstock, including Fish Health Certificate requirements and quarantine systems. In addition, evidence suggests that the original sources of broodstock for both species were free from a wide range of shrimp pathogens and held under strict biosecurity controls, especially the Hawaiian white shrimp. But it cannot be assured that all broodstock used in Malaysia are sourced from these sources, so a slight reduction in biosecurity of source score was given for both species. Shrimp farms in Malaysia generally operate as harvest exchange systems, but no clear information is available on the application of best management practices (BMP) for biosecurity. As a result of the Hawaiian source of broodstock, giant tiger prawn scores 8 out of 10 and white shrimp scores 9 out of 10 for the biosecurity of source and destination. This difference is also reflected in the final minor deductions of–2 out of –10 for giant tiger prawn and –1 out of –10 for white shrimp for Criterion 10X – Escape of Unintentionally Introduced Species

The final score for Malaysian farmed giant tiger prawn *(P. monodon)* is 3.77 out of 10, which is numerically ranked "Yellow," but with two Red criteria (Habitat and Chemical Use), the final recommendation is "Avoid." The final score for farmed white shrimp *(L. vannamei)* from Malaysia is 3.90 out of 10, which is numerically ranked "Yellow," but with two Red criteria (Habitat and Chemical Use), the final recommendation is "Avoid."

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Giant tiger prawn *(Penaeus monodon)*

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Malaysia

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Species Overview

Two main marine shrimp species are farmed in Malaysia: the native giant tiger prawn *(Penaeus monodon)* and the nonnative white shrimp *(Litopenaeus vannamei).* The introduction of white shrimp to the country was initially rejected by Malaysia in 2000 after an extensive Import Risk Assessment (IRA) (Hashim and Kathamuthu 2005). Based on the IRA, no approvals were given for the importation of broodstock and an official ban was issued in 2003 but, according to Hashim and Kathamuthu (2005), illegal farming of the species occurred in remote farms in Peninsular Malaysia and Sabah. According to Othman (2008), the government eventually made white shrimp farming legal because of ongoing disease issues with the giant tiger prawn, but established biosecurity regulations for importing nonnative broodstock. The farming of another native species, the banana prawn *(Penaeus merguiensis)*, used to occur, but no production has been reported to the Food and Agriculture Organisation (FAO) since 2009. These shrimp species share a similar life history, in which adults spawn offshore, larvae move toward the coast and develop in estuaries, and then move offshore as adults (Briggs 2006) (Kongeo 2005).

Production statistics
Malaysia reported white shrimp production to FAO for the first time in 2009 with a volume of 52,927 metric tons (MT). Production peaked in 2010 at 69,049 MT but declined to 45,454 MT in 2013 (FAO 2015a). By comparison, giant tiger prawn production has decreased from its peak of 26,352 MT in 2001 to 4,483 MT in 2013 (FAO 2015a).

Table 1. Production of white shrimp and giant tiger prawn in metric tons (MT) and area (ha) of brackish water ponds by state in 2013 (Source: DOFM 2015).

	White Shrimp	Giant Tiger Prawn	All Brackishwater aquaculture
State	Production in metric tons (MT)	Production in metric tons (MT)	Pond area in hectares (ha)
Perlis	151	0	62
Kedah	2,509	34	819
Paulau Pinang	11,557	176	395
Perak	4,917	224	1,763
Salangor	1,717	3,484	860

Negeri Sembilan	743	2	202
Melaka	70	8	7
Johor	4,333	207	935
Pahang	3,640	0	460
Terengganu	2,195	7	61
Kelantan	188	0	28
Sarawak	1,757	156	401
Sabah	11,696	187	911
W.P. Labuan	0	0	0
Total	**45,474**	**4,483**	**6,903**

Table 1 shows that the total brackish water pond area in Malaysia in 2013 was 6,903 ha. Department of Fisheries Malaysia (DOFM) does not provide separate pond area information by species, and this figure includes other farmed species including sea bass and tilapia, which had a significant production in 2013 (10,328 MT and 1,124 MT, respectively) as well as a number of minor species. Sarawak is the only state where shrimp is the only species farmed in brackish water ponds (DOFM 2015) and had an average production of 4.8 MT/ha.

Import and export sources and statistics

Shrimp is the most widely consumed seafood item in the United States; in 2013, Americans ate an estimated 1.6 kilograms (kg) per capita (NFI 2015). It has been estimated that 90% of the shrimp consumed in the U.S. are imported (Fluech and Krimsky 2011). In 2014, Malaysia was the eighth-largest shrimp importer to the United States and accounted for 17,900 MT of the total 568,535 MT U.S. shrimp imports that year (ERS 2015). Import data suggest that Malaysia's role in U.S. imports is highly variable; in 2013, imports were half of the 2014 value, but in 2011, they were nearly one-third greater (ERS 2015). The reason for such variability is unclear.

Global markets for shrimp (and specifically shrimp imports to the U.S.) have always been strongly influenced by disease, and are currently affected by an ongoing farmed shrimp bacterial disease, commonly referred to as early mortality syndrome (EMS). EMS was first detected in China in 2009, and has since spread to Vietnam, Malaysia, and Thailand (Nikolik and Kumar 2013) and to Mexico (Undercurrent News 2013a).

Common and market names

According to the U.S. Food and Drug Administration (FDA) Seafood List 2015, most farmed marine shrimp species share the one accepted market name: “shrimp.” Common names for white shrimp include Pacific white shrimp, Pacific whiteleg shrimp, crevette pattes blanches, camarón patiblanco, and Western white shrimp. Common names for giant tiger prawn include tiger shrimp, black tiger shrimp, crevette géante tigrée, and Langostino jumbo.

Product forms

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

Analysis

Scoring guide

- With the exception of the exceptional Criteria (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

Production system

The country of Malaysia is separated into two areas, Peninsular Malaysia, which comprises 13 states and 2 federal territories, and Malaysian Borneo, which comprises 2 states and 1 federal territory (Figure 1).

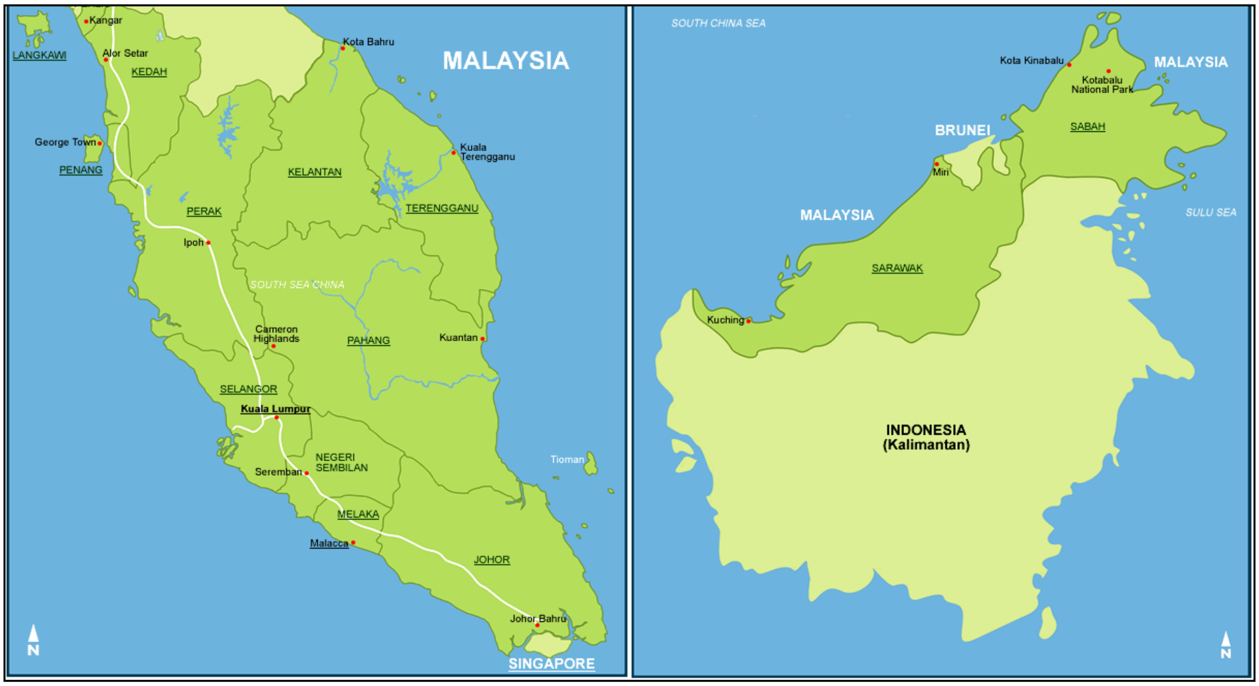

Figure 1. The states and federal territories of Malaysia (Source: DOFM).

The production of shrimp farms in 2013 is shown in Table 1; Pulau Pinang (labeled Penang in Figure 1) and Sabah are the main producing states for white shrimp, while Selangor is the main producing region for giant tiger prawns (DOFM 2015). Labuan is the only state or territory without any reported shrimp aquaculture, while Perilis, Pahang, and Kelantan only practice white shrimp farming (DOFM 2015).

Shrimp farming in Malaysia began in the 1930s with extensive farming systems that were built in mangrove forests, relied on trapping wild post-larvae (PL), and used tidal water exchange (Hashim and Kathamuthu 2005). Hatchery seeds were developed in the 1960s and were able to be produced in sufficient quantity to supply the industry by the 1970s (Hashim and Kathamuthu 2005). After experiencing mass mortality incidents resulting from soil quality issues in the extensive farms, the industry moved to ponds outside mangrove areas and used pumps to exchange water (Hashim and Kathamuthu 2005). The industry moved entirely to using compound feeds in the 1980s (FAO 2008) (Hassan et al. 1988). By the 1990s, Malaysia had switched entirely to semi-intensive and intensive systems (stocking densities of ≥ 25 PL/m^2) (Hashim and Kathamuthu 2005). This intensification was not adequately controlled and led to significant disease outbreaks in that decade. Subsequently, farms adopted closed pond culture systems with little or no water exchange (i.e., only exchanging water at harvest and in the 0%–3% daily water exchange bracket of the Seafood Watch methodology) (FAO 2008) (Othman

2008) (Hashim and Kathamuthu 2005). Ponds were built between 0.5 ha and 1 ha in size and between 1.2 m and 1.5 m in depth, and stocking densities were increased to 30–40 PL/m^2 for giant tiger prawn and as many as 120 PL/m^2 for white shrimp (Othman 2008). Paddle wheels were used to maintain pond water dissolved oxygen levels, and farmers stocked verified disease-free PLs (for monodon baculovirus (MBV), white spot syndrome virus (WSSV), and Taura syndrome virus (TSV)); production cycles take approximately 120 days (Othman 2008). Some farmers also applied probiotics to maintain favorable pond conditions (Othman 2008) (Hashim and Kathamuthu 2005). According to Wah (pers. comm., 2015), an in-country aquaculture specialist, this trend of intensification has continued with giant tiger prawn farming becoming intensive and white shrimp farming becoming super intensive (stocking at 80–160 PL/m^2).

Although giant tiger prawn is native to Malaysia, the local wild populations that were initially used for broodstock were found to be carriers of three major shrimp diseases, including white spot syndrome virus. Current and detailed information on the source of stock for both species in Malaysia is unclear; however, available evidence suggests that both rely fully on post-larvae from domesticated broodstock. The origin of the broodstock is from imported sources (Mozambique and Madagascar for giant tiger prawn, Hawaii for white shrimp), with a significant range of shrimp pathogens that they were verified to be free from.

Sustainable aquaculture became a key priority for Malaysia in its Third National Agriculture Policy (DPN3) covering the period 1998–2010 (Diah et al. 2013), with the end goal of increasing production of all aquacultured species from 200,000 MT at the inception of the policy to 600,000 MT by its end (FAO 2008). A key development of DPN3 was the formation of Aquaculture Industrial Zones (AIZs), which is described in detail in Criterion 2 – Effluent (Diah et al. 2013) (FAO 2008).

Malaysia has developed a national voluntary good aquaculture practice certification standard called MYGAP or MS 1998:2007 (DSM 2007). The standard was developed for the Department of Standards Malaysia (DSM) using a multistakeholder process and has the goal to "promote Good Aquaculture Practice (GAqP) for sustainable fish production that is environmentally sound, socially acceptable and economically viable to ensure quality produce that is safe and suitable for utilisation and/or human consumption" (DSM 2007). At the end of 2016, 34 farms representing 46% of the national production were MYGAP certified; this included 51% of the total production of white shrimp and 5% of giant tiger prawn (pers. comm., DOFM 2017).

This report assesses the ecological sustainability of white shrimp and giant tiger prawns farmed in semi-intensive to intensive brackishwater pond systems and assumed to be discharging water once per production cycle during harvest. Siting is managed through a pre-permitted AIZ system with an average production of 4.8 MT/ha. A portion of the industry remains sited in mangroves.

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

Giant tiger prawn and white shrimp

Data Category	Relevance (Y/N)	Data Quality	Score (0-10)
Industry or production statistics	Yes	7.5	7.5
Effluent	Yes	2.5	2.5
Locations/habitats	Yes	7.5	7.5
Predators and wildlife	Yes	0	0
Chemical use	Yes	5	5
Feed	Yes	2.5	2.5
Escapes, animal movements	Yes	2.5	2.5
Disease	Yes	5	5
Source of stock	Yes	5	5
Other – (e.g. GHG emissions)	No	n/a	n/a
Total			**37.5**

C1 Data Final Score	**4.17**	**YELLOW**

Brief Summary

There are few relevant and current peer-reviewed studies on the environmental impacts of Malaysian shrimp. Although the relevant government agencies are identifiable and have public websites, they are currently limited to listing registered farms and hatcheries and to publishing production statistics. But a new information system called "e-smpp akua" is forthcoming and is planned to increase public access to regulatory data and reports. Except for a national disease monitoring program, few agencies publish data on the results of farm auditing; however, data were received from the DOFM as part of this review of this report, and further data on aspects of the industry, such as the AIZ, are available by request to the authorities. Overall, data are currently dated, with some gaps that result in precautionary scoring for several criteria in this report. Further transparency could be achieved with the new information system. Data quality is considered the same for both species, with a score 4.17 out of 10 for Criterion 1 – Data quality and availability.

Justification of Ranking
There are no significant differences in data between the two species, so they are scored together.

Many of the relevant government agencies that play a role in regulating marine shrimp farming in Malaysia have public websites and appear to have a number of publications and resources available to researchers. But most data are limited to lists of registered farms and hatcheries and production statistics. These agencies and websites include:

- Department of Environment (DOE) www.doe.gov.my
- Department of Fisheries Malaysia (DOFM) www.dof.gov.my
- Environment Protection Department (DPD), Sabah www.sabah.gov.my/jpas
- State Fisheries Department, Sabah www.fishdept.sabah.gov.my
- Ministry of Agriculture www.moa.gov.my

Industry and production statistics can be found on the DOFM website, along with the names of registered farms and hatcheries. The data is up-to-date but does not always separate marine shrimp farming from other aquaculture industries. According to the DOFM (pers. comm., 2017), it has "developed an information system called 'e-smpp akua' to ease the data collection from districts and states and also an EIS (Executive Information System) to generate summary report on aquaculture industry in Malaysia. We plan to make some of the reports available on our website to public." Additionally, interested parties may contact DOFM for additional information on each AIZ (pers. comm., DOFM 2017). Data were available on the number of farms and production certified to MYGAP. This moderate to high data quality results in a score of 7.5 out of 10.

Effluent data are severely limited, with no clear studies and no statistics published on water quality standard compliance monitoring. Details were available on the regulation and protein content of feed. Data were considered of low to moderate quality, scoring 2.5 out of 10.

Current regulatory information was made available by DOFM. The locations of the AIZs are clear and publicly available but additional information must be formally requested from DOFM on a case-by-case basis. But there are no clear statistics on the area of farms sited in critical habitats or on environmental monitoring data. Data were considered reasonably representative for the industry, resulting in a moderate to high score of 7.5 out of 10.

Information on the types of chemicals used in marine shrimp farming and on the presence of antibiotic-resistant bacteria in shrimp pond effluents in Malaysia are available. Data were received from DOFM on the results of residue samples being taken as part of the national surveillance program, but these results focus on food safety matters rather than environmental impacts, and some questions remain about the use of permitted substances on shrimp farms. Data were considered of moderate quality, scoring 5 out of 10.

Information on feed is limited to FCR, protein content, and general ingredient lists. Additional information is available but is severely dated and does not include the sources of marine ingredients or their inclusion rates. Data were considered of low to moderate quality, scoring 2.5 out of 10.

Regulatory information on the prevention of escapes was available but no information on the occurrence or impacts of escapes could be found for Malaysia, resulting in a score of 2.5 out of 10.

The results of a national disease surveillance program are available and relatively up-to-date, but whether these results are representative of the whole industry is unknown, and no specific information was available on disease transmission or impacts to wild populations. Regulatory information on biosecurity was available and relatively detailed. This resulted in a moderate score of 5 out of 10.

Several sources of information were available on the source of seed, but these were generally dated and may not be representative of the whole industry. This resulted in a moderate score of 5 out of 10.

No information on predator controls or their impacts to wild populations in Malaysia could be found, resulting in a score of 0 out of 10.

Overall, regulations are generally publicly available or in response to requests, whereas farm audit data are generally not publicly available but the new information system promised by DOFM may increase transparency in the future. Data on actual impacts are dated, with some significant gaps (e.g., sources of fishmeal), which results in the use of precautionary scoring for several criteria in this report. Data quality is considered the same for both species, with a score of 4.17 out of 10 for Criterion 1 – Data quality and availability.

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

Giant tiger prawn

Effluent Risk-Based Assessment

Effluent parameters	**Value**	**Score**	
F2.1a Biological waste (nitrogen) production per of fish (kg N ton^{-1})	67.68		
F2.1b Waste discharged from farm (%)	34		
F2.1 Waste discharge score (0–10)		7	
F2.2a Content of regulations (0–5)	1.75		
F2.2b Enforcement of regulations (0–5)	2		
F2.2 Regulatory or management effectiveness score (0–10)		1.4	
C2 Effluent Final Score		**4.00**	**YELLOW**
Critical?	NO		

White shrimp

Effluent Risk-Based Assessment

Effluent parameters	**Value**	**Score**	
F2.1a Biological waste (nitrogen) production per of fish (kg N ton^{-1})	61.12		
F2.1b Waste discharged from farm (%)	34		
F2 .1 Waste discharge score (0-10)		7	
F2.2a Content of regulations (0-5)	1.75		
F2.2b Enforcement of regulations (0-5)	2		
F2.2 Regulatory or management effectiveness score (0-10)		1.4	
C2 Effluent Final Score		**4.00**	**YELLOW**
Critical?	NO		

Brief Summary
Data on the quality or impact of shrimp farm effluent are not publicly available for the Malaysian shrimp industry, so the Risk-Based Assessment was used. Recent data from Malaysia suggests that both species have the same feed conversion ratio (1.6), but white shrimp requires less protein in its diet than giant tiger prawn, which results in a slightly lower biological waste production (61.12 kg of nitrogen per ton (N/t) compared to 67.68 kg N/t, respectively). Both species are grown in ponds with little water exchange (0%–3% of pond volume daily), and newly introduced regulation requires "treatment" of effluents, but no details on the type of treatment (e.g., settling ponds, proper sludge disposal) or enforcement were stated. Water quality regulations are applied nationwide and assumed to be based on the National Water Quality Standards (NWQS), which are relevant for aquaculture. No data are available on enforcement or timing of inspections. Overall, the pollution potential from farm effluents is relatively low for both species (due primarily to the infrequent water exchange) and, because the industry development is controlled by an Aquaculture Industry Zone (AIZ) system, there is potential for some protection from cumulative effluent impacts. But controls for each AIZ are individual and must be requested from the Department of Fisheries Malaysia (DOFM), and the stated goals of AIZ development focus on economic and industry development and sustainability, not mitigation of ecological impact. The new Inland Fisheries Rules provide clearer regulation but are still relatively nonspecific, and there are no enforcement results currently available. Thus, a precautionary score of 4 out of 10 for white shrimp and 4 out of 10 for giant tiger prawn is given for Criterion 2 – Effluent. This score could be improved with the availability of enforcement data from Malaysia.

Justification of Ranking
Because the data score for Criterion 1 – Data is 2.5 out of 10 for Effluent, the SFW Aquaculture Criteria require that the Risk-Based Assessment be used for this criterion.

Factor 2.1 – Waste discharged per ton of production

Factor 2.1a – Biological waste production
The Risk-Based Assessment estimates the amount of waste nitrogen produced per ton of shrimp farmed.

Based on the protein information in Table 2, white shrimp feed is assumed to have an average protein content of 35% compared to 38% for giant tiger prawn (noting a relatively high difference between published protein content of shrimp feeds in Malaysian feed companies and the national standard MS 2538:2013). According to Boyd (2007), the protein content of harvested giant tiger prawn is approximately 18.5%, while white shrimp has an approximate protein content of 17.8%. According to a review of the status of aquaculture feed and feed ingredients in Malaysia by Manaf (2015), a reasonable estimated feed conversion ratio (FCR) for marine shrimp was 1.6, so this figure was used for both shrimp species in this report. These figures result in an estimated waste value of 61.12 kg of nitrogen per ton (N/t) of white shrimp production and 67.68 kg N/t of giant tiger prawn production.

Table 2. Protein content of commercial shrimp feeds in Malaysia

Species	Protein content	Source
Black Tiger Prawn	42% starter feed, 40% grow-out feed	Cargill Malaysia (2016)
White shrimp	38%	CP Malaysia (2016)
White shrimp	35%	Cargill Malaysia (2016)
White shrimp	34%	CP Malaysia (2016)
Marine shrimp	38% starter feed, 30% finishing feed	Malaysian Feed Standard MS 2538:2013

<u>Factor 2.1b – Production system discharge</u>

Malaysian shrimp farms generally exchange water only during harvest (Ling et al. 2012) (FAO 2008) (Hashim and Kathamuthu 2005), so a production system discharge basic score of 0.34 was used for both species. There is no historical evidence to support an adjustment for the use of settling ponds or proper sludge disposal in the industry; the new Inland Fisheries Rules introduced in 2017 do require "treatment" of effluents, but there is no detail as to what type of treatment is required. On a precautionary basis, it is therefore determined that 34% of the waste produced by the shrimp is discharged from the farm during harvest.

The waste production and discharge values of Factor 2.1a and Factor 2.1b are multiplied to give an estimated discharge from the farm of 20.78 kg N/t for white shrimp and 23.01 kg N/t for giant tiger prawn. These values equate to scores of 7 out of 10 for both species for Factor 2.1.

Factor 2.2 – Management of farm-level and cumulative impacts

<u>Factor 2.2a – Content of regulatory and management measures</u>

The regulatory background in Malaysia is complex; individual states are responsible for managing their own land and water resources and are able to apply laws in their own way (Philips et al. 2009). Federal laws exist, including the primary law for fisheries, the Fisheries Act No. 317 (1985), but they do not apply to the states of Sabah or Sarawak and often do not provide any substantive detail of any regulatory controls (Philips et al. 2009). Regarding effluents, DOFM (pers. comm., 2017) states that the "Malaysia Inland Water Quality Standard" is applied nationwide; this document could not be found, but it is assumed to be referencing the National Water Quality Standards (NWQS).

Another key element of the industry is the Aquaculture Industry Zone (AIZ) system for farm siting. The goal of an AIZ is to create a large-scale but integrated aquaculture area to minimize its impacts on other industries and vice versa, as well as promoting environmentally friendly practices (Diah et al. 2013). The Department of Fisheries Malaysia (DOFM) is responsible for identifying AIZs, which are then approved by the relevant state government (Diah et al. 2013). According to DOFM (2015a), there are six main objectives for creating AIZs:

1. Creating permanent areas for Aquaculture Industry Zones,
2. Increase the production of fish in line with the goal of the Balance of Trade Plan,
3. Increase the net income of aquaculturists to at least RM 3,000/month,
4. Ensure the production of fish and fish products that are of high quality and safe for consumption,

5. Increase private sector participation through the provision of AIZ areas, infrastructure and Department Delivery System,
6. Create a chain of efficient aquaculture fish production areas.

Information on each AIZ is available by request from the DOFM but it is not published in the public domain (pers. comm., DOFM 2017). An example of the requirements for an AIZ was highlighted by Abdullah et al. (2013), who identified that an Environmental Impact Assessment (EIA) was performed prior to an AIZ designation. Abdullah et al. (2013) used the example of an Integrated Shrimp Aquaculture Park (i-SHARP) in Terengganu that was established under the AIZ system and where 38% of the area was designated for shrimp ponds and the rest, including vegetation and buffer zones, to "ensure the farm is run in ecologically sound practices". Table 3 shows the AIZs currently listed by DOFM (2015a) by state for marine shrimp farming.

Table 3. Aquaculture industry zones (AIZ) in Malaysia by state (From DOFM, 2015a).

State	AIZ Name	Zone area in Hectares (ha)
Kedah	Air Hangat, Langkawi, Kedah	60
Melaka	Taman Akuakultur Sebatu Melaka	100
Sarawak	Taman Akuakultur Lkim Telaga Air, Sarawak	165
Pahang	Kg. Merchong, Pekan, Pahang	404
Terengganu	Kg. Pengkalan Gelap, Setiu, Terengganu	520
Terengganu	Kg. Pasir Puteh, Marang, Terengganu	200
Terengganu	Penarik, Setiu, Terengganu	1,000
Sarawak	Tanjung Manis, Sarawak	430
Perak	Rungkup Hilir, Perak	2,175
Selangor	Sg. Nipah, Sabak Bernam, Selangor	28.0
Pahang	Tanjung Batu, Pekan, Pahang	283
Total		**5,365**

An advantage of the AIZ system, to both potential producers and potentially for the control of environmental impacts, is that the size of the industry is controlled through a pre-permitting system. Figure 2 shows a screenshot of an AIZ from the DOFM website.

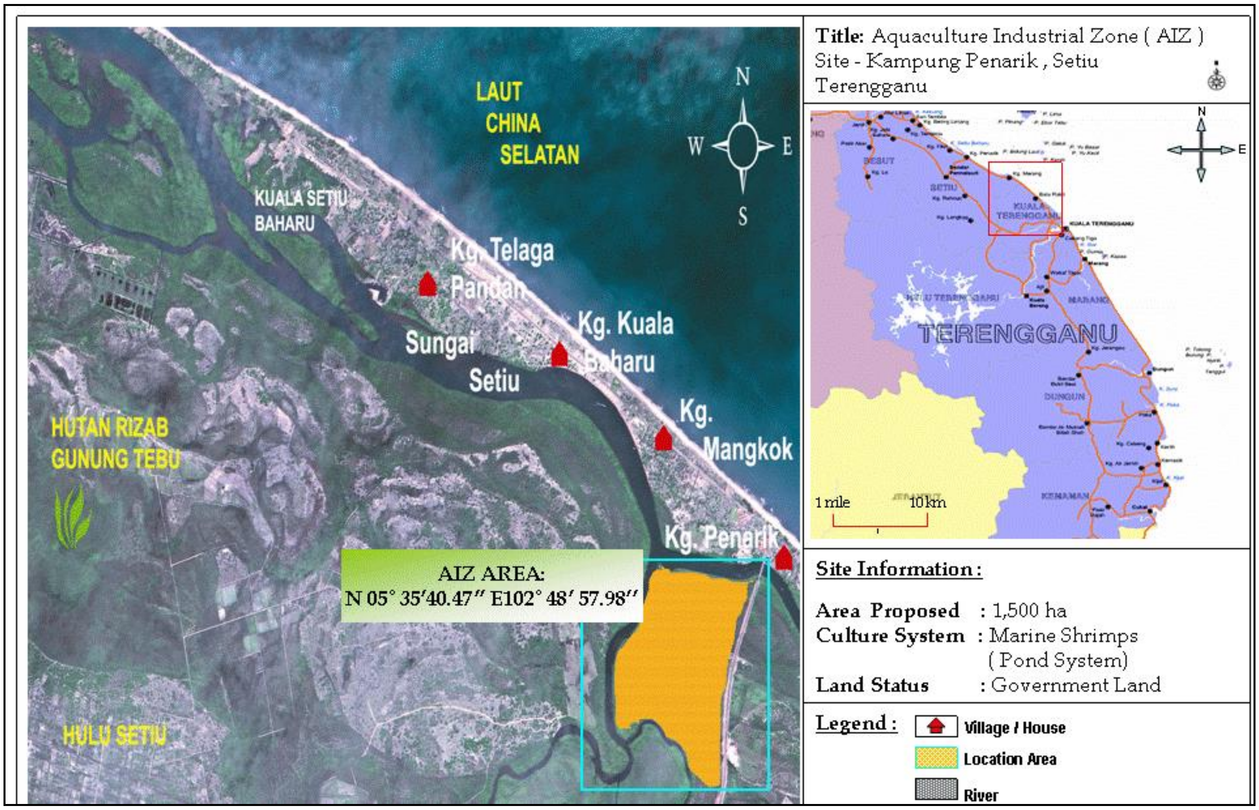

Figure 2. A screenshot of an aquaculture industry zone in Malaysia (from DOFM).

Malaysia also operates a national Code of Practice and certification scheme for a variety of agricultural products, including marine shrimp farming (MOA 2015). According to the Ministry of Agriculture (MOA 2015) "the Malaysian Aquaculture Farm Certification Scheme (SPLAM) is a voluntary Scheme which aims to promote good aquaculture practices and greater accountability at the farm level." The MOA recently grouped all of the individual good agricultural practices into one program called "MYGAP"; MOA (2015) claims that MYGAP's aquaculture standard is based on "MS 1998:2007 Good Aquaculture Practice (GaqP) – Aquaculture Farm – General Guidelines" and has been "benchmarked with international GAP certification scheme such as ASEAN GAP and Global GAP". MYGAP also "reduces environment pollution and assists in developing an environmentally friendly and sustainable national agricultural industry." According to DOFM (pers. comm., 2017), effluent controls form a key part of the MYGAP standard. Several elements of the MYGAP standard are relevant to the effluent criterion, including (DSM 2007):

"4.1.2 It should be suitable for species, culture system and where sources of pollution can be controlled.

4.1.4 The selection of site shall be operated in an environmentally acceptable way and shall take into consideration the preservation of natural habitat.

4.3.4.1 The quality of the water for the culture should be maintained at optimal conditions that ensures good growth and health of the species cultured.

4.3.4.2 The water quality should be monitored throughout the culture period.

4.3.4.3 Effluent from the aquaculture farm shall not be discharged into the public or municipal water body without undergoing proper treatment.
4.3.4.4 The use of approved probiotics may be employed to improve the water quality."

According to DOFM (pers. comm., 2017), "all certified farms must keep the record of waste water treatment for at least 2 years for the inspections and audit by DOFM" and that "annual inspections are carried out to audit the shrimp farms under MYGAP."

At the end of 2016, 34 farms representing 46% of the national production were MYGAP certified; this included 51% of the total production of white shrimp and 5% of giant tiger prawn (pers. comm., DOFM 2017). According to Abdullah et al. (2013), the Code of Practice was a driving force that reduced the total area for shrimp farming from 7,500 ha to 7,300 ha between 2007 and 2009, primarily by encouraging proper site selection away from mangrove areas.

As of March 26th, 2017, only one farm was identified as certified to the Global Aquaculture Alliance (GAA) Best Aquaculture Practices (BAP) standard: Arca Biru Sdn. Bhd. (BAPC 2015). In 2010, the GAA conducted a survey of nine Malaysian shrimp farms to assess compliance to an earlier version of the BAP shrimp standard, finding relatively high compliance with the BAP's critical mangrove conservation standards (79%) but low compliance with the critical effluent management standards (19%) (Petersen 2010).

Table 4 lists the relevant institutions, legislation, and responsibilities by state in Malaysia (as of 2009), and shows that all aquaculture operations must be licensed in Peninsular Malaysia under the Fisheries Act 1985, in Sarawak under Sarawak State Fisheries Ordinance 2003, and in Sabah under the Sabah Inland Fisheries and Aquaculture Enactment 2003 (Philips et al. 2009).

Table 4. Aquaculture regulation and authority by state in Malaysia (Copied from Philips et al. 2009).

State	Institution	Legislation	Provisions / Responsibilities
All States in Peninsular Malaysia	Department of Environment	• Environmental Quality Act 1974 • Environmental Impact Assessment (EIA) Order of 1987 (Prescribed Activities) • Environmental Quality (Sewage and Industrial Effluents) Regulations 1979	• Prescribed activities (EIA) • Monitoring and enforcement in the post-EIA • Prohibition, restriction and control of pollution • Monitoring of river pollution and water quality
	Department of Fisheries Malaysia	• Fisheries Act 1985 • Fisheries (Marine Culture System) Regulations 1990 • Fisheries (Cockles Conservation and Culture) Regulations 2002	• Implementation of aquaculture development zone • Aquaculture licensing • Enforcement and monitoring of aquaculture premise based on conditions imposed in the permit or license • Import and export of fish
Sarawak	Natural Resources and Environment Board, Sarawak	• Natural Resources and Environment Ordinance 1993 • Natural Resources and Environment (Prescribed Activities) Order 1994 • Natural Resources and Environment (Prescribed Activities) (Amendment) Order 1997	• Prescribed activities (EIA) • Monitoring and enforcement in the post-EIA • Prohibition, restriction and control of pollution • Monitoring of river pollution and water quality
	Inland Fisheries Division, Department of Agriculture, Sarawak	• State Fisheries Ordinance 2003	• Aquaculture licensing • Enforcement and monitoring of aquaculture premise based on conditions imposed in the permit or license
	Sarawak River Board	• Sarawak Rivers Ordinance 1993	• Monitoring of river pollution and water quality
Sabah	Environment Protection Department, Sabah	• Environment Protection Enactment 2002 • Environment Protection Enactment (Prescribed Activities) (Environmental Impact Assessment) Order 2005	• Prescribed activities (EIA) • Monitoring and enforcement in the post-EIA • Restrictions on discharge of pollutants into water • Restrictions on activities affecting vegetation • Monitoring of river pollution and water quality
	State Fisheries Department, Sabah	• Sabah Inland Fisheries and Aquaculture Enactment 2003	• Implementation of aquaculture development plan • Aquaculture licensing • Enforcement and monitoring of aquaculture premise based on conditions imposed in the permit or license • Import and export of fish • Transportation of fish from peninsula Malaysia and Sarawak to Sabah, and *vice versa* • Control of fish diseases in aquaculture premise
Local	District Land Office	• National Land Code 1965	• The leasing of state land as the Temporary Occupation Land (TOL) for development purposes including aquaculture development.

Aquaculture effluent regulation is controlled by the Department of Environment to ensure compliance with the NWQS (pers. comm., DOFM 2017). Specific requirements of the NWQS are highlighted in Table 5, noting that the specific water class for aquaculture is not known; the source, Mamun and Zainudin (2013), identifies that most water sources are considered Class II. If this is the case for aquaculture, the values in Table 5 are as strict or stricter than the initial certification requirements on the Best Aquaculture Practices Effluent Water Quality Criteria shown in Table 6. A study of effluent water quality during harvest at one Malaysian giant tiger prawn farm showed that chemical oxygen demand (COD) ranged from 110–114 mg/l, biological oxygen demand (BOD, 5-day) ranged between 5 and 20 mg/l, and total suspended solids (TSS) ranged between 30 and 175 mg/l (Nyanti et al. 2011), which also suggests that the regulatory limits (if appropriately enforced) would moderately limit the waste released from the farms. This results in a score of 0.75 for question 1 of Factor 2.2a – Regulatory or management effectiveness. Because the law sets limits, there are no site-specific effluent controls, resulting in a score of 0 for question 2. Question 3 focuses on the control of cumulative impacts resulting from the effluent of multiple farms; the AIZ could potentially offer some protection or control of these issues, but no details on the management within the AIZ system were apparent, and notably, the stated goals are aimed at economic and industry sustainability, not mitigation of ecological impacts. In the absence of this information and because the general regulatory effluent limits are mostly appropriate for aquaculture, they should partly (a score of 0.25) address the cumulative impacts of multiple farms. The limits in Table 5 are robust but are not set according to the ecological status of the receiving waterbody, resulting in a score of 0.5 on question 4. There is no specific guidance on when effluent sampling occurs, so a precautionary score of 0.25 is given on question 5. These scores are combined to give a total score of 1.75 out of 5 for Factor 2.2a – Regulatory or management effectiveness for both white shrimp and giant tiger prawn.

Table 5. Excerpts from the Malaysian National Water Quality Standard (Copied from Mamum and Zainudin 2013).

Parameter	Unit	Limits for Classes				
		I	II	III	IV	V
Ammoniacal Nitrogen	(mg/l)	< 0.1	0.1 – 0.3	0.3 – 0.9	0.9 – 2.7	> 2.7
BOD	(mg/l)	< 1	1 – 3	3 – 6	6 – 12	> 12
COD	(mg/l)	< 10	10 – 25	25 – 50	50 – 100	> 100
Dissolved Oxygen	(mg/l)	> 7	5 – 7	3 – 5	1 - 3	< 1
pH	-	> 7.0	6.0 – 7.0	5.0 – 6.0	< 5.0	< 5.0
Total Suspended Solids	(mg/l)	< 2.5	25 – 50	50 - 150	50 - 30	> 300

CLASS I: Represent water bodies of excellent quality. Standards are set for the conservation of natural environment in its undisturbed state.

CLASS IIA: Represent water bodies of good quality. Most existing raw water supply sources come under this category. Class IIA standards are set for the protection of human health and sensitive aquatic species.

CLASS IIB: The determination of Class IIB standard is based on criteria for recreational use and protection of sensitive aquatic species.

CLASS III: Is defined with the primary objective of protecting common and moderately tolerant aquatic species of economic value. Water under this classification may be used for water supply with extensive/advanced treatment.

CLASS IV: Defines water quality required for major agricultural irrigation activities which may not cover minor applications to sensitive crops.

CLASS V: Represents other water, which do not meet any of the above uses.

Table 6. BAP Effluent water quality criteria—all pond farms (From BAP 2014).

	Initial Value	**Final (after 5 Years)**	**Collection Frequency**
pH (standard pH units)	6.0–9.5	6.0–9.0	Monthly
Total suspended solids (mg/L)	50 or less	25 or less	Quarterly

Soluble phosphorus (mg/L)	0.5 or less	0.3 or less	Monthly
Total ammonia nitrogen (mg/L)	5 or less	3 or less	Monthly
5-day biochemical oxygen demand (mg/L)	50 or less	30 or less	Quarterly
Dissolved oxygen (mg/L)	4 or more	5 or more	Monthly
Chloride	No discharge above 800 mg/L chloride into freshwater	No discharge above 550 mg/L chloride into freshwater	Monthly

Aquaculture regulation in Malaysia has changed in 2017 with the introduction of the Inland Fisheries Rules (Aquaculture) 2017 (FGG 2017). Relevant content of this new regulation includes a specific section on effluent discharge, which states:

- "A licensee shall not discharge any untreated effluent from an aquaculture premises into riverine waters.
- If a licensee discharges any treated effluent from an aquaculture premises into riverine waters, the licensee shall ensure that the treated effluent discharged complies with good aquaculture practices.
- Any licensee who contravenes subrule (1) commits an offence."

<u>Factor 2.2b – Enforcement of regulatory and management measures</u>

Aquaculture effluent regulation is controlled by the Department of Environment, but effluent data are not published in the public domain (pers. comm., DOFM 2017). No specific information on when regulatory effluent monitoring should occur could be found, except that MYGAP certified farms are audited annually (pers. comm., DOFM 2017). Under the new Inland Fisheries Rules, there will be clear references to causing an "offence" by not treating effluents (FGG 2017). Under the Inland Fisheries Rules, farmers in breach of their permits may have the permit suspended, and if they have not addressed the issue within 3 months, their permit can be cancelled and they would be liable for the costs of closing, removing structures, and rehabilitation of the site (FGG 2017). Although evidence of robust penalties exists, there are no published data on compliance or actual enforcement of the penalties. A relevant example was provided by DOFM (pers. comm., 2017):

"Blue Archipelago Berhad, (BAB), a local Malaysian aquaculture company, was required by DOEM to carry out a Detailed Environmental Impact Assessment (DEIA) which is a much more stringent process than EIA before BAB was allowed to develop one of the biggest shrimp farms in Malaysia. As part of the DEIA approval, BAB is obligated to strictly comply with effluent discharge standards through an elaborate Industrial Effluent Treatment System (IETS) as set by DOEM under its Environmental Quality Act. These effluent and discharge activities by BAB are further monitored by DOEM via monthly reports on waste water quality and quarterly reports on water quality of areas surrounding the farm operated by BAB. DOEM is empowered to initiate legal action against BAB (including to issue a stop-work order) if the effluent from the farm falls below the standards set by the Act. The monthly and quarterly reports submitted by BAB to DOEM are available for public scrutiny."

Historically, Petersen (2010) found low compliance (19% of farms) with the GAA's critical effluent management standards (see Table 6) during a survey of farms and highlighted a lack of effluent monitoring. Abdullah et al. (2013) surveyed 45 shrimp farmers in Malaysia and found that over half of them were aware that shrimp farm pollution was a concern and could affect wild populations of shrimp. But the farmers also felt that, because most farms are built in tidal areas, the waste discharge would be diluted before it could harm the environment (i.e., rather than effluent being released directly into the sea) (Abdullah et al., 2013). This information points to a historic lack of regular and effective monitoring, but the new Inland Fisheries Rules are now in effect. Though general data were available on the regulators and some of the regulation and clear penalties, the overall lack of detailed content results in a score of 2 out of 5 for Factor 2.2b – Enforcement of regulatory and management measures (full details of the scoring questions are in Appendix).

The score for Factor 2.2a is multiplied by Factor 2.2b and then divided by 2.5 to give a total score for Factor 2.2 of 1.4 out of 10 for both species. The low score indicates that there is low confidence that the regulatory system effectively manages the potential cumulative effluent impacts of the shrimp industry in Malaysia, but this may improve with the new regulations in place.

Final Score

The scores for Factors 2.1 and 2.2 are combined using the Risk-Based assessment matrix, resulting in a final score of 4 out of 10 for white shrimp and a score of 4 out of 10 for giant tiger prawn for Criterion 2 – Effluent.

Criterion 3: Habitat

An interim update of this assessment was conducted in Month Year. This criterion was updated with new information. The interim update can be found in Appendix 1 at the end of this document.

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

Giant tiger prawn and White shrimp

Habitat parameters	Value	Score	
F3.1 Habitat conversion and function		1.00	
F3.2a Content of habitat regulations	3		
F3.2b Enforcement of habitat regulations	3.25		
F3.2 Regulatory or management effectiveness score		3.9	
C3 Habitat Final Score		**1.97**	**RED**
Critical?	NO		

Brief Summary

Globally, shrimp farming has been linked to the historical conversion of ecologically important wetlands, including mangrove forests. Malaysia is no exception, with historical losses for shrimp farming beginning in the 1930s. The industry has been moving away from using these resources, but the current regulatory framework still allows further conversion, and there are examples of such siting less than 10 years ago. To convert wetlands, farmers must go through an EIA-informed decision-making process and undertake a compulsory replanting program. Additionally, farmers are encouraged to site aquaculture within an AIZ. EIAs are generally applied only to large farms (with occasional public consultation) and are required for siting in mangrove forests; farmer awareness of the impacts of farming on mangrove and wetlands appears high. Several issues with the EIA process were identified, including that the majority of farms are too small for the EIA rules to apply and that the quality of predicted impacts is poor. No enforcement data are made publicly available. Overall, the industry is generally developing in a managed zonal process (at least for large farms) with directed regulatory controls, including restoration, so it is limiting the further loss of ecosystem services from high-value habitats such as mangroves. Because of significant historical and recent impacts to high-value habitats, the final score is 1.97 out of 10 for both species for Criterion 3 – Habitat.

Justification of Ranking

Factor 3.1. Habitat conversion and function

In 2004, mangrove forests accounted for 2% of the total land area in Malaysia; approximately 622,000 ha total, of which 57% were in Sabah, 26% in Sarawak, and the remaining 17% in Peninsular Malaysia (Shukor 2004). Mangrove forests are important sources of wood and seafood, including shrimp, crabs, and cockles (Shukor 2004). They also serve as spawning and nursery grounds for many native marine species (Shukor 2004). Mangroves and coastal wetlands are therefore high-value habitats, and when mangroves are converted to shrimp ponds, there is a major loss of habitat functionality and of ecosystem services.

Shrimp farming in Malaysia began in the 1930s with extensive farming systems built in mangrove forests. They relied on trapping wild post-larvae (PL) and tidal water exchange (Hashim and Kathamuthu 2005). After experiencing mass mortality incidents resulting from soil quality issues in extensive farms, the industry moved to ponds inland of or entirely outside the mangrove areas and used pumps to exchange water (Hashim and Kathamuthu 2005). Othman (2008) identified abandoned coconut plantations and former paddy fields as the primary areas for pond development. Currently, most farms are built "along coastal mangrove areas" (Adbullah et al. 2013) and use the majority of the brackish water ponds that cover less than 1% of the total mangrove area of Malaysia. This is far less than the 30% coverage used for other human activities including housing and tourist resorts (Shukor 2004). Mangrove protections in Malaysia exist and are outlined in Factor 3.2 below, but at least one example was found that demonstrates that protection of mangroves and other important habitats will not always be prioritized over production. In 2009, World Wildlife Fund Malaysia (WWFM) criticized the development of a farm that would impact 700 ha of the Gelam forest, which they describe as "one of the most severely threatened freshwater ecosystems in Malaysia," and highlight that shrimp farm effluent would affect critically endangered river terrapins. The farm underwent a Detailed Environmental Impact Assessment (described below), which apparently found any impacts to be acceptable; the farm was sited. Figure 3 shows the area in 2010 (undeveloped) and in 2017 (after farm construction had been complete, ca. 2014–2015). Notably, the farm appears to have been sited just outside of the AIZ shown in Figure 2. Figure 4 also demonstrates recent farm siting/expansion in apparently high-value (wetland) habitat.

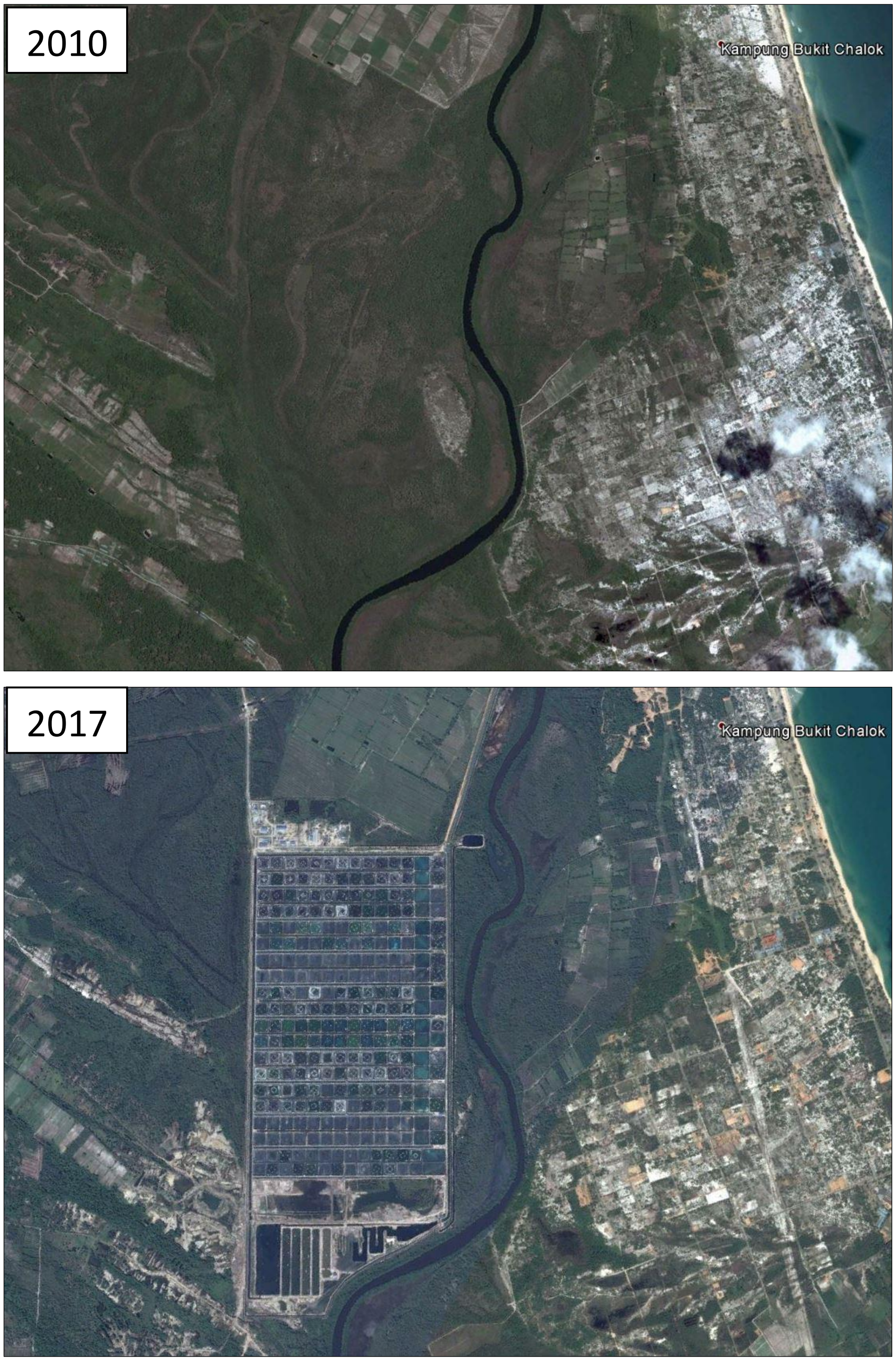

Figure 3: Demonstrated farm siting in high value habitat between 2010 and 2017. Images captured using Google Earth.

Another factor to consider is the MYGAP aquaculture standard, which states (although not specifically referencing mangroves) that “4.1.4 The selection of site shall be operated in an environmentally acceptable way and shall take into consideration the preservation of natural habitat; 4.2.2 The clearing of site shall consider conservation/preservation of natural habitat.”

According to Abdullah et al. (2013), the Code of Practice that MYGAP was based on was a driving force that reduced the total area for shrimp farming from 7,500 ha to 7,300 ha between 2007 and 2009, primarily by encouraging proper site selection away from mangrove areas.

Though widespread mangrove loss is not the most significant factor in Malaysia, it is evident that some farms are sited in former mangrove areas or other high-value habitats. In addition, the current regulatory framework still allows further conversion; to convert wetlands, farmers must go through an EIA-informed decision-making process and undertake a compulsory replanting program. Additionally, farmers are encouraged to site aquaculture within an AIZ. This could give rise to ongoing impacts on high-value habitats, but there is no evidence that the industry-at-large is expanding and siting farms that result in continuous loss of ecosystem functionality. There is evidence that farms have been sited in high-value habitat within the previous 10 years; thus, the score for both white shrimp and giant tiger prawn is 1 out of 10 for Factor 3.1.

Factor 3.2. Habitat and farm siting management effectiveness

Factor 3.2a – Regulatory or management effectiveness

The following information on mangrove forest controls was received from DOFM in a personal communication (2017):

- "Under Malaysia National Physical Plan, natural wetlands and mangroves are categorised in Environmentally Sensitive Areas (ESA) where a 500 m buffer zone is provided for around ESA Rank 1 and 2 areas.
- Malaysia Government does not encourage the conversion of wetland or mangrove into shrimp farms.
- Malaysian Standard (MS 1998:2007) Good Aquaculture Practices (GAqP) [MYGAP]– Aquaculture Farms – General Guidelines (Annex 2), para 4.1.3 Farmers are encouraged to select areas in the Aquaculture Industrial Zone (AIZ).
- A mangrove re-planting program is made compulsory on any party who wishes to develop shrimp farms within mangrove or wetland areas.
- In addition to mangrove re-planting, any party who wishes to develop any aquaculture farm within any mangrove, wetland or sensitive area must conduct an Environment Impact Assessment (EIA) which is to be submitted to and approved by the Department of Environment Malaysia (DOEM)."

Philips et al. (2009) reviewed EIA requirements in Malaysia; three organizations are responsible for enforcing the EIA requirements in Malaysia: the Department of Environment (Peninsular Malaysia), the Environment Protection Department (Sabah), and the Natural Resources and Environment Board (Sarawak) (Philips et al. 2009). EIAs must be conducted by qualified and registered consultants, and there is sufficient capacity in-country (Philips et al. 2009). General considerations for an EIA relevant to aquaculture include buffer zones, water pollution, and preventing damage to unique habitat areas, including mangroves and other wetlands (DoE 2007). An EIA must include a baseline study and a detailed Environmental Management Plan

(EMP) to mitigate certain impacts (DoE 2007). The AIZ locations described in detail in Criterion 2 – Effluent were also developed through the use of informal EIA (Rayner 1988 in Philips et al. 2009). In Peninsular Malaysia and Sabah, an EIA was required for farms greater than 50 ha in size, with reduced requirements for farms between 10 and 50 ha (termed a mitigation measures report); but in Sarawak, an EIA was required for farms greater than 10 ha. Farms smaller than 10 ha were not required to perform impact assessments or reports in any of the three regions of Malaysia (Philips et al. 2009). Philips et al. (2009) also identified several issues with the application of EIAs in Malaysia, including:

- "Mistimed EIAs resulting in siting issues being missed
- No baseline studies for environmental quality data
- Poor estimation of impacts
- Limited public input into the process
- EIA only assessed on a project by project basis; missing cumulative impact factors.
- Many farms are below the regulatory size limit and therefore do not have an EIA"

In addition to regulatory controls, national guidelines for the use of mangrove forests for brackish water aquaculture have been developed by the Working Group to the Malaysian National Mangrove. Shukor (2004) highlighted the following relevant guidelines to aquaculture: "On choice of site, the priority should be:

i. mangrove areas already reclaimed for agricultural purposes, unused or abandoned due to poor soil conditions or production
ii. landward side of mangrove forest where forestry output is poor or where impact on coastal fisheries is the least
iii. State land forests which are outside the forest reserves and are mangrove reserves that are not managed on a sustained yield basis for environmental or economic objectives.

b. On the size and location of site:
i. there should be a 100 m wide buffer zone along the coast between the pond site and the mean high water level of the sea
ii. not more than 20% of existing mangrove land in a given district can be cleared for pond construction
iii. the next project should be constructed at a distance more than 4 times the length of the coastline occupied by the first project.

c. On pond design and culture techniques:
i. the pond should be constructed with minimum excavation to avoid problems associated with acid sulphate soil
ii. the water regimes be managed by pumping rather than be dependent on tidal fluctuations
iii. use of pellet feeds rather than raw trash fish."

Abdullah et al. (2013) conducted a survey of 45 shrimp farmers and found that “the respondents did not believe that shrimp farming would destroy mangrove and its flora and fauna as well as causing depletion of tidal wetlands.” The reason given was that “most of the shrimp farms are built in the approved coastal mangrove area with tides. In fact, the establishment of shrimp farms in mangrove is also monitored by the Department of Environment. Therefore, most of the respondents believed that the mangrove destruction issues due to shrimp farming activities were actually exaggerated” (Adbullah et al. 2013). In addition, the survey found that “with the necessary precautions taken, most of the respondents had denied that their shrimp farms were harmful to mangrove flora and fauna” (Adbullah et al. 2013).

The EIA approach does not mean that mangroves and other important habitats will always be protected. In 2009, World Wildlife Fund Malaysia (WWFM) criticized the development of the aforementioned farm that would impact 700 ha of the Gelam forest, which they describe as “one of the most severely threatened freshwater ecosystems in Malaysia” and highlight that shrimp farm effluent would affect critically endangered river terrapins. But Petersen’s (2010) survey of nine farms found 79% compliance with the GAA’s critical requirements for mangrove conservation and 100% compliance with its scored criteria, which mandated that any mangrove conversion after 1999 had to be legal and required restoration of three times the area of mangrove forest lost or a donation to a restoration fund. Figures 3 and 4 demonstrate that farm siting/expansion has recently occurred in areas outside AIZs or in apparently high-value (e.g., wetland) habitats.

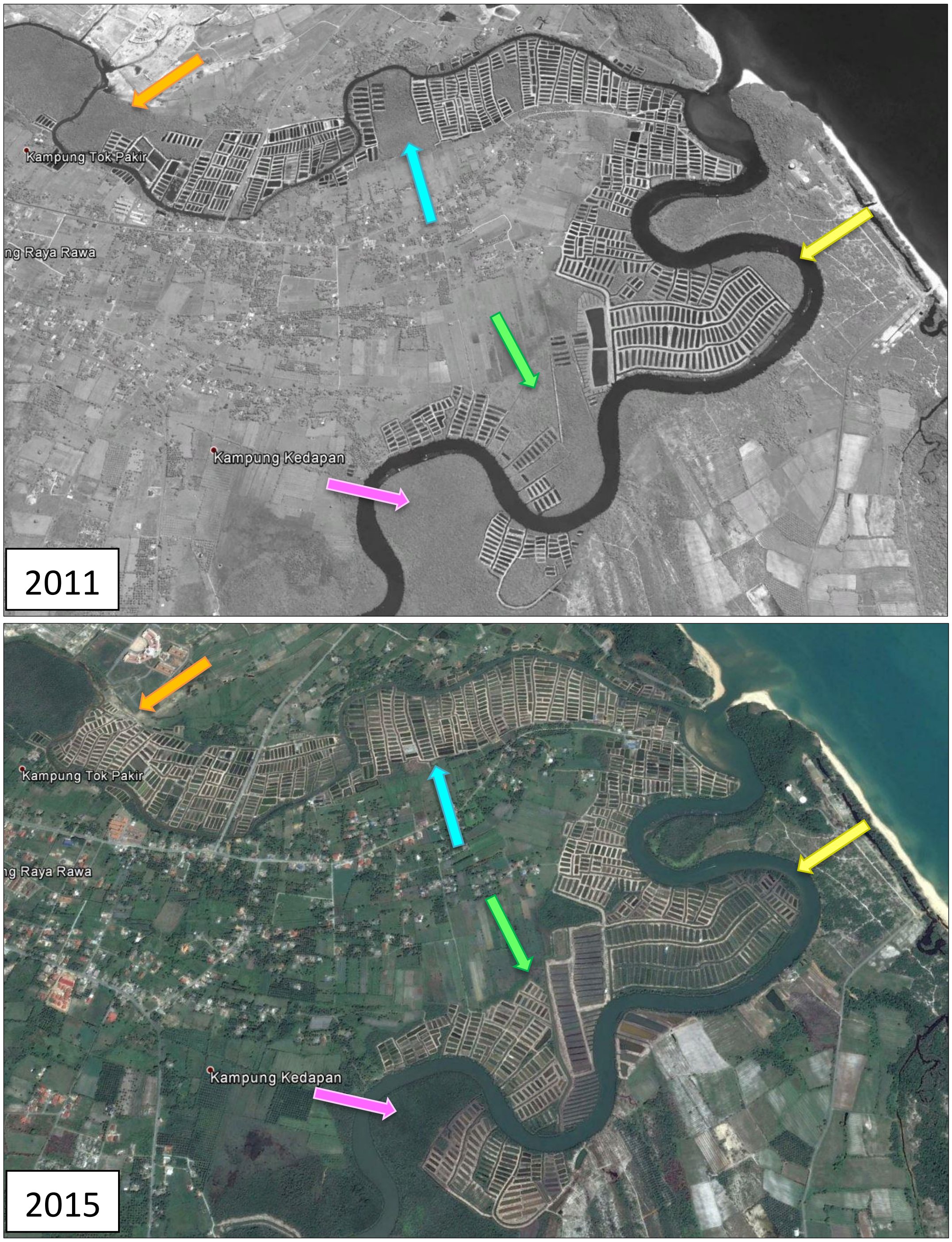

Figure 4: Demonstrated farm siting in apparently high-value wetland habitat between 2011 and 2015. Images captured using Google Earth.

According to the DOFM (pers. comm., 2017) EIAs are required when farms are established in environmentally sensitive areas, such as mangrove forests. The industry is being encouraged to grow in defined areas using the AIZ approach, which may act to control cumulative impacts. The

AIZ approach should also offer a considerable degree of control of the industry's ongoing and future expansion, but it could be limited by the use of preliminary EIAs to define their boundaries. A requirement for mangrove restoration also exists; however, there have been concerns raised about the EIA process in Malaysia and the fact that some mangrove and other high-value habitat conversion is still allowed to occur. The score for Factor 3.2a – Regulatory or management effectiveness is 3 out of 5 (full details of the scoring questions are in Appendix).

Factor 3.2b – Siting regulatory or management enforcement

The enforcement organizations are identifiable for all Malaysian states and there is sufficient technical capacity to support the industry needs for an EIA (Philips et al. 2009). But none of these organizations publishes performance data. The industry seems to be developing mostly, but not entirely, in defined AIZs, so it functions according to a zonal siting process. EIAs are performed on a case-by-case basis and do not inherently consider cumulative impacts, but the industry is being developed in AIZs, which should offer some degree of cumulative impact control. Although public consultation is required on the EIA for some types of projects (termed a Detailed EIA) in Malaysia, aquaculture is not generally listed as one of them (DoE 2007). Yet, the AIZ locations are public and transparent, and in at least one example (the i-SHARP in Terenghanu), the Detailed EIA had been applied (Adbullah et al. 2013) and public consultation was included in the process (pers. comm., DOFM 2017). None of the regulatory agencies publishes an annual summary of its performance, but DOFM (pers. comm., 2017) claims that some data, such as the effluent data in the above example, are publicly available. Generally, there is a lack of data to demonstrate how effective the EIA process is, but one example is that the pond coverage in Tables 1 and 3 appear relatively consistent, which suggests that most of the industry is being contained in the AIZ system. For white shrimp and giant tiger prawn, the score for Factor 3.2b – Siting regulatory or management enforcement is 3.25 out of 5.

The scores from Factor 3.2a and 3.2b are combined to give a score of 3.9 out of 10 for Factor 3.2 Habitat Management.

Final Score

The scores for both Factor 3.1 and Factor 3.2 are combined to give a score of 1.97 out of 10 for Criterion 3 – Habitat for both white shrimp and giant tiger prawn.

Criterion 4: Evidence or Risk of Chemical Use

An interim update of this assessment was conducted in Month Year. This criterion was updated with new information. The interim update can be found in Appendix 1 at the end of this document.

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

Giant tiger prawn and White shrimp

Chemical Use parameters	Score	
C4 Chemical Use Score	**3.00**	
C4 Chemical Use Final Score	**3.00**	**RED**
Critical?	NO	

Brief Summary

Asian shrimp aquaculture is known to use a variety of chemicals over the course of the production cycle, although the environmental impact of these is not always known. Of significant concern is the use of antimicrobials, which proliferate resistant pathogens that affect shrimp health and potentially human health. The focus of Malaysian chemical regulatory control is on food safety, and current regulations only allow the use of drugs if they are permitted by the Director General. Regulatory monitoring data provided by the government for harmful drug residues (e.g., nitrofurans) show a perfect record of compliance from 2008, when the program began, to 2015. Guidance provided to farmers by the government and a document that outlines maximum residue limits indicate that Malaysian shrimp farms could potentially use WHO-listed highly and critically important antimicrobials for human health, if approved by regulators. Some antimicrobials, namely oxytetracycline and sulfonamides, were reportedly used on farms, according to a dated survey published in 2000. Additionally, two papers found the presence of antimicrobial-resistant pathogens in shrimp farm effluents, but confounding factors such as water supply did not allow either paper to directly link this presence back to the farms themselves. Overall, the current environmental impact is unclear, so a precautionary score of 3 out of 10 is given for both species for Criterion 4 – Chemical Use.

Justification of Ranking

In general, Asian aquaculture is known to use a variety of different chemicals to address issues such as water quality or disease, and often the environmental impact of these chemicals is unknown (Rico et al. 2012) (Gräslund and Bengtsson 2001). According to a review of the environmental risks of chemical and biological products in Asian aquaculture (but not Malaysia specifically) by Rico et al. (2012), "chemicals, disinfectants, pesticides and antibiotics have been shown to be the most environmentally hazardous compounds owing to their high toxicity to nontarget organisms and/or potential for bioaccumulation over tropic chains, and can potentially affect the biodiversity and functioning of adjacent aquatic ecosystems." More details from the Rico et al. (2012) review are shown in Table 7.

Table 7. Types of chemicals used in Asian aquaculture and their potential environmental impacts (From Rico et al. 2012 and sources within).

Type of Chemical	Relevant example chemicals	Potential environmental impacts
Water and sediment treatment compounds	Lime to control pH	Short term changes in local water quality (e.g., pH).
Fertilizers	Urea to promote algal growth as an additional food source.	Increased nutrient discharges in effluents; eutrophication.
Pesticides	Saponin (teaseed cake), Rotenone used to kill fish prior to pond stocking.	Can also kill nontarget organisms. Can significantly decrease zooplankton population.
Disinfectants	Chlorine, sodium hypochlorite, Benzaklonium chloride used in hatcheries and ponds to kill fungal and parasitic pathogens before stocking.	Range from moderate to highly toxic impacts on plankton and larger invertebrates but often easily diluted and degraded in the environment.
Antibiotics	Oxytetracycline	Toxic to microorganisms and phytoplankton. Potential long term exposure to invertebrates can disrupt reproduction. Disruption of the basis of the food web, local bacterial communities, and ecosystem functions such as nitrification. Bioaccumulation in top predators.

One of the most concerning issues is the use of antimicrobials, which may also pose a risk to human health (Gräslund and Bengtsson 2001) because significant use of these drugs can further the development of antimicrobial resistant pathogens, including those capable of cross-species and zoonotic transmission (Holmström et al. 2003).

Current data on the types, amounts, or environmental effects of chemicals used on shrimp farms in Malaysia are not publicly available. According to DOFM (pers. comm., 2017), the new Inland Fisheries Rules (Aquaculture) 2017 (FGG 2017) prohibit the use of aquaculture chemicals unless they are approved by the Director General. Guidance is provided to farmers (covering all species: fish and shrimp) in a document called "The usage of veterinary drug, chemical and growth hormone in aquaculture farm" (DOFM 2017b). The document focuses on food safety by outlining permitted drugs, their maximum residue limits for food, and a withdrawal period (the period after treatment when the shrimp should not be harvested until the drug is metabolized) (see Figure 5) and also prohibited drugs (see Figure 6) (DOFM 2017). The guidance also covers how to use antibiotics, such as “Farm operators shall inform the authority on the plan use of any type of antibiotics,” “use only antibiotics approved by the authority,” “keep detailed records of all antibiotics,” and that “the authority will monitor and verify all records on the usage of antibiotics in the farms” (DOFM 2017b).

Substance	Maximum Residue Limits (MRLs) in food (µg/kg)	Withdrawal Period (days)
Amoxicillin	50	30
Ampicillin	50	30
Benzocaine	50	30
Benzylpenicillin	50	30
Chlortetracycline	100	30
Cloxaccillin	300	30
Colistin	150	30
Cypermethrin	50	30
Danofloxacin	100	30
Deltamethrin	10	30
Dicloxaccillin	300	30
Difloxacin	300	30
Diflubenzuron	1000	30
Emamectin	100	30
Enrofloxacin	100	30
Erythromycin	200	30
Florfenicol	1000	30
Flumequie	200	30
Lincomycin	100	30
Neomycin (including framycetin)	500	30
Oxcacillin	300	30
Oxolinic acid	100	30
Oxytetracycline	100	30
Paromomycin	500	30
Sarafloxacin	30	30
Spectinomycin	300	30
Sulfonamides	100	30
Teflubenzuron	500	30
Tetracycline	100	30
Thiamphenicol	50	30
Tilmicosin	50	30
Trimethoprim	50	30
Tylosin	1000	30

Figure 5. Maximum permitted proportion of drug residues in fish and fishery product (Copied from DOFM 2017b).

No	Substance
1	Antithyroid agents
2	Beta-agonists
3	Chloramphenicol
4	Nitrofurans
5	Nitroimidazoles
6	Steroid (Substances having oestragenic, anrogenic and gestagenic action)
7	Stilbenes, stilbene derivatives, and their salts and esters
8	Sum of malachite green and leucomalachite green
9	Crytal violet

Figure 6. Prohibited drugs in fish and fishery product (Copied from DOFM 2017b).

Because the guidance document provided by DOFM (2017b) covers all species, including fish, it is difficult to isolate the use of permitted drugs to just shrimp farms. The most recent review on the use of chemicals in Malaysian aquaculture, including shrimp and other species, was published by Mohamed et al. in 2000 and is therefore markedly dated. Table 8 shows the chemicals identified in Mohamed et al. (2000) as being used in shrimp farming (excluding current information on prohibited chemicals from DOFM (2017b)) and their purpose, as well as additional relevant information. Comparing Tables 7 and 8 shows that some potentially impactful chemicals are used on Malaysian shrimp farms but, except for antibiotics, most would be used to treat pond water prior to stocking and therefore would be most likely degraded before entering the environment.

Table 8. Chemicals that may potentially be used in Malaysian shrimp farming (From (DOFM 2017b), (FDA 2015), (Mohamed et al. 2000), and (WHO 2011)).

Chemical	Purpose	Additional information
Lime	Improving soil and water quality in ponds, piscicide, and disinfectant. Added in powder form to pond water.	-
Saponin (teaseed cake)	Piscicide, used in hatchery to promote molting, used to treat blackspot disease. Added to pond water prior to stocking.	-
Formalin	Used to treat shell and gill diseases in shrimp broodstock. Added to pond water as a general treatment for disease.	U.S. Food and Drug Administration (FDA) approved parasiticide for all finfish and penaeid shrimp.
Benzaklonium chloride (BKC)	Used to treat infections in shrimp ponds. Added to pond water.	-
Acriflavine	Limited use as a prophylactic and as a therapeutant in hatcheries.	-
Hypochlorite	Piscicide and pond water disinfectant. Added to pond water prior to stocking.	Denatures rapidly, so is not an environmental concern.
Polyvinyl pyrrolidone iodide (PVPI)	Used in hatcheries to disinfect eggs.	-
Zeolite	Used to control pond soils, though value is questioned.	-

Copper Sulphate	Pond water disinfectant.	-
Organophosphates	Used to kill crustacean vectors prior to stocking.	-
Sulfonamides	Used in hatcheries to control bacterial infections.	Some types U.S. FDA approved for some finfish not shrimp. Several types listed by the World Health Organization (WHO) as a Highly Important Antimicrobial for Human Medicine
Tetracyclines	While oxytetracycline might be used, it's almost entirely rendered inactive by seawater and the shrimp's digestive tract. In feed application.	Several types, including oxytetracycline, are listed by the WHO as a Highly Important Antimicrobial for Human Medicine. U.S. FDA approved for some finfish but not for shrimp.
Probiotics	10 types available in 2000.	-

In a personal communication, DOFM (2017a) outlined the following information about their inspection program for antibiotic residues:

"Department of Fisheries Malaysia has conducted a monitoring programme for fish/shrimp at the farm level starting year 2008 until now under Aquaculture Residue Monitoring Programme (ARMP) and Sanitary and Phytosanitary (SPS) Aquaculture Programme.

Parameters that are monitored under ARMP Programme are divided into two types of parameter for finfish and shrimp. Parameters for shrimp are as follows:

(1) Chloramphenicol (CAP);
(2) Nitrofurans (NF);
(3) Nitroimidazoles (NI);
(4) Antibacterial Substances;
(5) Anthelmintics;
(6) Organochlorine compounds including PCBs;
(7) Chemical Elements;
(8) Mycotoxins; and
(9) Dyes.

Parameters that are monitored under SPS Aquaculture Programme including shrimp and finfish are as follows:

(1) Heavy Metal;
(2) Microbiology;
(3) Residue Drug Veterinar; and
(4) Chemical Contaminant.

Sample has been taken twice a year. Sampling program was started in 2008 and until 2015, it was found no prohibited antibiotic substances detected under these programmes. Sampling has been carried out on samples of shrimp and fish to monitor the content of the CAP, NF and NI. A total of 2,466 samples have been taken for the period 2008 to 2015 and analyzed in the laboratory of Fisheries Biosecurity has got ISO certification.

Aquaculture Residue Monitoring Programme (ARMP) focused on farms registered with the Department of Fisheries Malaysia, farms that export to EU countries and are required to have a certificate of Fish Quality Certificate (FQC). This programme also conducted on farms that have a commercial-scale export markets abroad and has also been involved with certificate of Malaysia Good Agricultural Practices (myGAP) and National Key Economic Area (NKEA) projects.

Sanitary and Phytosanitary Aquaculture Programme (SPS Akua) is carried out on farms registered with the Department of Fisheries Malaysia, farms certified myGAP, farms that have a market to US and other countries as well as domestic market.
Agri-Food & Veterinary Authority of Singapore (AVA) has informed the shrimp imported from Malaysia has never been detected to contain CAP and NF. This statement was issued by media Malay Mail dated 27 May 2016."

This information is important to highlight because between January and August 2015, Malaysian shrimp accounted for 72% (88 violations) of the U.S. FDA's shrimp import rejections, despite only accounting for 2.5% of total shrimp imports (Ramsingh 2015), which was then followed by a sharp decline in import rejections from Malaysia in the following months (Seafoodnews.com, 2015). But it has been claimed that these issues were due to transshipped shrimp (farmed in other countries then processed in Malaysia for export to the United States). According to DOFM (pers. comm., 2017), as a result of this issue:
"1. Malaysia has strengthen *[sic]* official controls and enhance food safety control program for aquaculture shrimp exported to the United States.
2. The U.S. Immigration and Customs Enforcement has conducted two investigations involving Chinese shrimp producers suspected of shipping their seafood through Malaysia and both investigation are still ongoing.
3. The DOFM is giving good cooperation to the U.S. Immigration and Customs Enforcement during their investigation in Malaysia."

Although transshipped products may explain the recent surge in FDA rejections, it should be noted that both Banerjee et al. (2012) and Wahid et al. (2015) found evidence of pathogenic bacteria resistant to antibiotics (including some listed as important by the WHO) on Malaysian shrimp farms or in their effluents; their attribution solely to antibiotic use by the farms themselves was unclear. Banerjee et al. (2012) studied three intensive white shrimp farms and found bacteria that are pathogenic to humans and animals, including *Salmonella* and *Vibrio* species, in shrimp and in pond water that were resistant to one or more types of antibiotics; however, all three farms reported to the authors that they did not use antibiotics in production. Banerjee et al. (2012) speculated that alternative sources of the resistance could have been the water used to fill the ponds (which was drawn from a river containing effluent from domestic and agricultural sources, both known to be carriers of antibiotic residues), the PLs (as a result of antibiotic use on the hatchery), or from the probiotics used by the farmers. Wahid et al. (2015) studied one farm in the same region but also did not link the resistance to practices on the farm itself.

The information available on chemical use in Malaysian shrimp farms demonstrates that food safety is the primary focus of DOFM's efforts along with primary application of chemicals or the ecological impact of their use, but regulatory monitoring data provided by the agency show a perfect record of compliance with prohibited drugs, such as nitrofurans. The guidance document provided by the agency to farmers and dated information on chemicals used on the farms suggest that drugs listed by the WHO as Highly Important Antimicrobial for Human Medicine, such as oxytetracycline, or Critically Important (for human medicine or veterinary use), such as erythromycin and florfenicol, would be permitted for use if "approved by the Director General." Two recent papers also reported antimicrobial-resistant pathogens in shrimp farm effluents, though confounding factors such as water supply were noted by both authors, and neither paper linked the resistance directly back to the on-farm antibiotic use.

Final Score

Chemical use on Malaysian shrimp farms is largely unknown. Antimicrobials Highly and Critically Important for Human Medicine are permitted (as evidenced by maximum residue limits), but there is no evidence of their actual application. Given that the current situation of environmental impacts resulting from chemical use on the farms is unclear but there is some concern for resistance to treatments, a precautionary score of 3 out of 10 is given for Criterion 4 – Chemical Use for both white shrimp and giant tiger prawn.

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

Giant tiger prawn

Feed parameters	Value	Score	
F5.1a Fish In:Fish Out ratio (FIFO)	1.42	6.44	
F5.1b Source fishery sustainability score		–6.00	
F5.1: Wild Fish Use		5.59	
F5.2a: Protein IN	45.72		
F5.2b: Protein OUT	14.99		
F5.2: Net Protein Gain or Loss (%)	–67.23	3	
F5.3: Feed Footprint (hectares)	9.63	6	
C5 Feed Final Score		**5.05**	**YELLOW**
Critical?	NO		

White shrimp

Feed parameters	Value	Score	
F5.1a Fish In:Fish Out ratio (FIFO)	1.42	6.44	
F5.1b Source fishery sustainability score		–6.00	
F5.1: Wild Fish Use		5.59	
F5.2a: Protein IN	42.11		
F5.2b: Protein OUT	14.86		
F5.2: Net Protein Gain or Loss (%)	–64.71	3	
F5.3: Feed Footprint (hectares)	9.63	6	
C5 Feed Final Score		**5.05**	**YELLOW**
Critical?	NO		

Brief Summary

In Malaysia, both giant tiger prawn and white shrimp are farmed utilizing the addition of compound feeds; recent government data suggest that the FCR for both species is around 1.6, with white shrimp requiring slightly less protein in feed than giant tiger prawn (35% compared to 38%, respectively). Data specific to Malaysia on sources of fishmeal and fish oil or on inclusion rates were not available; thus, the best available (but now dated) global average shrimp feed data were used for both species. These data showed relatively high fishmeal levels (20%) in the diets of both species, but fish oil inclusion levels were low (2%). All fishmeal and fish oil is assumed to be derived from whole fish (i.e., no use of byproducts). FIFO ratios of 1.42 are moderate for both species. In the absence of data on the source of marine ingredients, the default score of –6 out of 10 was used for Factor 5.1b – Source fishery sustainability. The net protein loss from feed is relatively high (> 64%) for both species. The feed footprint for both species is also moderate (9.15 ha of ocean area and 0.47 ha of land area per ton of each species). Ultimately, both species achieve a score of 5.05 out of 10 for Criterion 5 – Feed.

Justification of Ranking

Factor 5.1. Wild Fish Use

All Malaysian shrimp farms use pelleted feed from national and imported sources (pers. comm., Wah 2015).

Both shrimp species uses compound feed with an estimated FCR of 1.6 with feed containing, on average, 35% and 38% protein for white shrimp and giant tiger prawn, respectively (see Criterion 2 for references and justification). According to CPM (2015), their feed contains "fish meal, squid meal, wheat flour, soybean meal, vitamins and minerals"; however, additional details on specific inclusion rates, sources of fishmeal, or the use of byproducts are not published and are considered proprietary. In the absence of country-specific data, the global average inclusion values of 20% fishmeal and 2% fish oil used in shrimp feeds are used for this report. These values are derived from Tacon and Metian's (2008) global survey of shrimp feeds in 19 countries, though it is noted that Malaysia was not surveyed and that the use of byproducts was not estimated or reported. It is also acknowledged that these values are now dated, and would likely improve if more recent data were made available by the industry in Malaysia.

Based on the data cited above, both species have a fish in:fish out (FIFO) ratio of 1.42 for fishmeal (higher than that for fish oil, 0.64), meaning that it takes 1.42 kg of wild fish to produce 1 kg of white shrimp or giant tiger prawn. The FIFO value results a score of 6.44 out of 10 for both species for Factor 5.1a – FIFO.

According to Manaf (2015), in 2014, Malaysia used 261,000 MT of fisheries bycatch landed in the country to produce 65,000 MT of fishmeal. Of this fishmeal, 24,100 MT were exported, while another 5,700 MT were imported from overseas, resulting in 88% of fishmeal used in

Malaysian aquaculture coming from national fish landings. Unfortunately, Manaf (2015) does not provide information on the species composition of the fisheries bycatch, and no recent data could be found. In the absence of data on fishmeal source fisheries or their sustainability status, the default score of –6 out of –10 applies for both species for Factor 5.1b – Source fishery sustainability.

The scores for Factors 5.1a and 5.1b are combined to result in an overall Factor 5.1 score of 5.59 out of 10 for both species.

Factor 5.2. Net Protein Gain or Loss
The specific protein content of the fishmeal used in Malaysian shrimp feeds is not known, so the SFW methodology assumes a default value of 66.5%. Because all fishmeal is assumed to be from forage fisheries and not by-products, and the inclusion of land animal by-products is unknown, it is assumed that all remaining protein in feed is from edible (i.e., suitable for human consumption) crop sources.

Because the global average inclusion rate of fishmeal in shrimp feed is 20%, this provides 13.3% of the total protein in the feed, so the remaining protein (86.7%) is considered to be derived from edible crop sources for both species. According to Boyd (2007), white shrimp is 17.8% protein at harvest and giant tiger prawn is 18.5% protein at harvest. According to Briggs et al. (2004), the processing conversion rates for white shrimp range between 66% and 68% (67% is used for this report) and 62% for giant tiger prawn. In the absence of information, the percentage of nonedible by-products from harvested shrimp used for other food production is assumed to be 50%. These values were used to calculate the shrimp growout cycle protein budget, which resulted in a 64.7% protein loss for white shrimp and a 67.2% protein loss for giant tiger prawn. These values achieve a final score for Factor 5.2 of 3 out of 10 for both species.

Factor 5.3. Feed Footprint
The feed footprint factor takes into account all the feed ingredient inputs on the basis of the area of primary productivity appropriated to produce them. The feeds for both species are considered to contain around 22% marine ingredients (fishmeal and fish oil) and 78% from a range of crop sources (soybean, wheat, etc.). Combined with their FCR, and using primary productivity calculations detailed within the Seafood Watch criteria, these factors result in an estimated requirement for 9.15 ha of ocean area and 0.47 ha of land area per ton of production for each species. This equates to a moderate score of 6 out of 10 for both species for Factor 5.3 – Feed Footprint.

Final Score
The scores for Factors 5.1, 5.2, and 5.3 combine to give a final numerical score for Criterion 5 – Feed of 5.05 out of 10 for both species.

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

Giant tiger prawn

Escape parameters	Value	Score	
F6.1 Escape Risk		4.00	
F6.1a Recapture and mortality (%)	0		
F6.1b Invasiveness		5	
C6 Escape Final Score		**4.00**	**YELLOW**
Critical?	NO		

White shrimp

Escape parameters	Value	Score	
F6.1 Escape Risk		4.00	
F6.1a Recapture and mortality (%)	0		
F6.1b Invasiveness		4.5	
C6 Escape Final Score		**4.00**	**YELLOW**
Critical?	NO		

Brief Summary

Published information on the frequency, magnitude, or impacts of escapes from shrimp farms in Malaysia was not available, suggesting that these issues are poorly studied. Both white shrimp and giant tiger prawn are farmed in ponds using limited water exchange. But ponds are vulnerable to flooding, so a moderate risk of escape remains without specific regulations for best practices to prevent escapes, such as the use of screens or secondary capture devices (particularly during key activities such as harvest). Although giant tiger prawn is native to Malaysia, the local wild populations, which were initially used for broodstock, were found to be carriers of three major shrimp diseases, including white spot syndrome virus. Subsequently, the industry moved to disease-free, imported domesticated (or imported then domesticated) broodstock from Mozambique, then later Madagascar. It is unclear specifically how much of Malaysia's total production comes from each domesticated strain, but it is evident that there has been ongoing access to these resources since 2003. Therefore, this report makes the assumption that 100% of giant tiger prawn come from domesticated stocks that have been selected for four or more generations. Thus, the genotype of giant tiger prawn used in Malaysian shrimp farming is considered to be different from wild populations because of some combination of the East African sources and genetic selection; however, the genetic impact of escaped farm-origin prawns on wild populations in other countries (e.g., Thailand) has been found to be inconclusive. White shrimp is nonnative and raised from imported broodstock, potentially having a larger escapement impact if it were to become ecologically established. Establishment has not been shown in other countries where the species has also been introduced, but it remains poorly studied.

Overall, white shrimp is considered to have a moderate risk of escapement and a moderate risk for impact, resulting in a score of 4 out of 10 for Criterion 6 – Escapes. Giant tiger prawn has a moderate risk of escapement and impact, also resulting in a score of 4 out of 10.

Justification of Ranking

Factor 6.1a. Escape risk

Data on the escapement of shrimp farmed in Malaysia were not available. The MYGAP program includes the requirement, "4.4.2 Efforts shall be undertaken to prevent the harmful effects of introducing alien species including pathogens or genetically modified stocks used for aquaculture, including culture based fisheries into public waters" (DSM 2007) but does not describe any specific best management practices (BMPs) for design, construction, and management of escape prevention. But according to DOFM (pers. comm., 2017), "normally shrimp farms in Malaysia have perimeter bunds (1 m higher than high tide level) to prevent escapees of cultured shrimps to the public waters."

Shrimp are generally farmed in harvest exchange pond culture, with little to no water exchange during the culture period (FAO 2008) (Othman 2008) (Hashim and Kathamuthu 2005), which reduces the risk of chronic, "trickle" escapes, which are generally prevented by the use of mesh screens on the pond gates where the water is drained from. Flooding and pond wall failure, particularly in coastal areas, are both risk factors for larger-scale escape events, but data on the occurrence of this type of event were not available, and the 1 m bund (i.e., pond wall) height above high tide level could not be compared to construction standards for 50- or 100-year storm events, because these data also were not available.

The employment of limited water exchange in pond systems presents a relatively low concern of escape, but water discharge at harvest, the potential flooding risk, and uncertain pond construction result in a moderate concern for white shrimp and giant tiger prawn escapement. For Factor 6.1a, both species achieve a basic Escape Risk score of 4 out of 10.

If evidence of recapture or mortality of escapees exists, the basic Escape Risk score can be adjusted to reflect the mitigation of the impact of these escapes. But no specific references to recapture efforts for escaped shrimp in Malaysia were available. Because no adjustment is applied, the score for Factor 6.1a – Escape Risk is 4 out of 10 for both shrimp species.

Factor 6.1b. Invasiveness

Giant tiger prawn

Giant tiger prawn is native to Malaysia and PLs have been available from hatcheries since the 1980s (FAO 2008). In their 2005 report, Hashim and Kathamuthu (2005) reported that there were 94 hatcheries in Malaysia, all of which were dependent on wild-caught broodstock. But Othman (2009) reported that, between 1999 and 2007, demand for local broodstock plummeted due to the wild populations being carriers of three imported farmed shrimp diseases: white spot syndrome virus (WSSV), monodon baculovirus (MBV), and yellowhead virus (YHV). In 2003, the Malaysian government imported a nonnative strain of giant tiger prawn from Mozambique and began a broodstock selection program with it, achieving slower but more consistent growth and disease-free seed (Othman 2009). According to Othman, by 2009, 90% of giant tiger prawn production had taken advantage of using the Mozambique strain, which had already been selected in Malaysia for seven generations. Othman (2009) described the importation of broodstock as an interim measure and that the future direction for the industry would be the domestication of the local broodstock. More recently, Merican (2013) found that, while reporting on one of the remaining five main giant tiger prawn hatcheries, it was still importing domesticated, verified specific pathogen free (SPF; white spot syndrome virus (WSSV), infectious hypodermal and hematopoietic necrosis virus (IHHNV), Taura syndrome (TSV), yellowhead virus (YHV), and infectious myonecrosis virus (IMNV)) broodstock from Madagascar. Benzie (2002) showed that the Mozambique strain (and presumably the Madagascar strain) originated in the Indo-Pacific and had undergone little genetic differentiation during its time off East Africa, but Le Groumellec et al. (2008) reported that at least one facility in Madagascar had produced domesticated SPF broodstock since 2003. Although it is unclear specifically how much of Malaysia's total production comes from each domesticated strain, it is evident that there has been ongoing access to these resources since 2003. This report therefore makes the assumption that 100% of giant tiger prawn comes from domesticated stocks that have been selected for four or more generations. Considering the impacts, the genetic impact of escaped farm-origin prawns on wild populations in other countries (e.g., Thailand) has been found to be inconclusive (Benzie 2000). Therefore, without evidence of a loss of genetic fitness of wild tiger prawn in Malaysia, the score for Factor 6.1b – Part A is 1 out of 5.

Escaped giant tiger prawn would likely be able to compete to some extent with wild stocks for food, habitat, and mates, but is unlikely to place additional predation pressure on wild stocks, modify habitats to the detriment of other species (because any impact would be the same as the wild stocks), or have additional impacts on habitat or other species. This results in a score of 4 out of 5 on Part C of Factor 1.b.

The scores for Part A and Part C are combined to give a score of 5 out of 10 for Factor 6.1b – Invasiveness for giant tiger prawn.

White shrimp

White shrimp is nonnative to Malaysia; its introduction was initially rejected by the Malaysian government in 2000 after an extensive Import Risk Assessment (IRA) (Hashim and Kathamuthu 2005). Based on the IRA, no approvals were given for broodstock importation, and an official ban was issued in 2003. But the inability to control the illegal farming of white shrimp and ongoing disease concerns with giant tiger prawn led to the eventual approval for white shrimp importation, but no specific date of approval could be found. White shrimp is not currently established in the wild in Malaysia (Briggs et al. 2015); so far, no research has been conducted to evaluate the ecological impact of escaped white shrimp in Malaysia. In Thailand, where white shrimp has been farmed since 1998, some research has indicated that no significant impacts were evident to fishers or the Thai Department of Fisheries (Briggs et al. 2004), but later studies showed that white shrimp, including gravid females, were present in the wild in Thailand (Senanan et al. 2010, referring to 2005 and 2006 sampling data). But the presence of white shrimp was possibly due to repeated escapes, so any conclusions regarding their establishment were not possible. This suggests that the potential impacts of escaped white shrimp on native shrimp stocks in general may be limited, but because similar shrimp species have potentially become established in other countries, a score of 0.5 out of 2.5 is given for Part B of Factor 6.1b.

For Part C of Factor 6.1b, there is no evidence yet that white shrimp has established or is causing ecological problems after many huge escape events in Southeast Asia; white shrimp escapees are not thought to provide additional predation pressure or to modify habitats occupied and used by other species. Therefore, the score is 4 out of 5.

The scores for Part B and Part C are combined to give a score of 4.5 out of 10 for Factor 6.1b – Invasiveness for white shrimp.

Final Score

The scores for Factor 6.1a – Escape Risk and Factor 6.1b – Invasiveness are combined using the SFW scoring matrix and result in a final score for Criterion 6 – Escapes of 4 out of 10 for both shrimp species.

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

Giant tiger prawn and White shrimp

Pathogen and parasite parameters	Score	
C7 Biosecurity	5.00	
C7 Disease; pathogen and parasite Final Score	**5.00**	**YELLOW**
Critical?	**NO**	

Brief Summary

Disease outbreaks on shrimp farms have the ability to severely affect production, and were the driving force behind Malaysia's move from giant tiger prawn farming to white shrimp farming. DOFM performs regular disease surveillance and maintains a reactive national disease response group. Published results indicate a low incidence of disease, but how representative these results are of the industry at large is unknown. 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 in other regions. But significant impacts on these wild populations have not been reported in Malaysia. Because most farms reportedly use harvest exchange practices, and because new regulation is fairly detailed on biosecurity measures, both shrimp species are considered a moderate risk, scoring 5 out of 10 for Criterion 7 – Disease.

Justification of Ranking

Transmittable diseases that may present serious socioeconomic and/or public health threats are tracked globally by the World Organization for Animal Health (OIE) (OIE 2013). OIE-listed diseases affecting farmed marine shrimp include white spot syndrome virus (WSSV), yellowhead virus (YHV), Taura syndrome virus (TSV), infectious myonecrosis virus (IMNV), necrotising hepatopancreatitis (NHP), and infectious hypodermal and haematopoietic necrosis virus (IHHNV) (OIE 2013). Of these, WSSV, TSV, and YHV are the most problematic globally (Walker and Mohan 2009). YHV is thought to have limited impact on white shrimp compared to giant tiger prawn, with the opposite assumed of TSV, IMNV, and IHHNV (Walker and Mohan 2009). 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, has since spread to Vietnam, Malaysia, and

Thailand (Nikolik and Kumar 2013), and was most recently detected in Mexico (Undercurrent News 2013a).

Diseases (most notably Baculovirus penaei (BP), WSSV, and YHV) that are carried by Malaysian giant tiger prawn resulted in the switch to broodstock sources from Mozambique (Othman 2009) and were the primary driver behind the eventual approval to import white shrimp (Othman 2008).

Malaysia is a member of World Organisation for Animal Health (OIE); DOFM produces a quarterly report on aquatic animal health that is sent to the OIE (pers. comm., DOFM 2017a). DOFM operates two programs designed to monitor the occurrence and to limit the impact of aquaculture diseases: the Fish Health Surveillance and Inspection Program (HSIP) and the National Fish Disease Notification Program (NFDNP) (Tan et al. 2014). DOFM conducts disease surveillance audits on a small number of farms twice per year under the HSIP, whereas the NFDMP requires mandatory reporting of diseases by the farms and is a reactive tool for coordinating a national response to prevent the spread of disease when required. The results of the HSIP testing on farmed shrimp are shown in Table 11 (the units are not explained in the original report, but it is assumed they represent the number of surveillance audits with a positive or negative result for the presence of the listed disease) (Tan et al. 2014). No disease was detected between 2011 and 2013, but importantly, EMS does not appear to be included in the samples.

Table 11. Results of Malaysian shrimp disease surveillance program between 2009 and 2013 (Copied from Tan et al. 2014).

Disease	2009 S1		2009 S2		2010 S1		2010 S2		2011 S1		2011 S2		2012 S1		2012 S2		2013 S1	
	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+
WSSV	20	4	11	3	43	0	26	0	11	0	5	0	18	0	18	0	1	0
TSV	24	0	14	0	43	0	26	0	11	0	5	0	18	0	18	0	1	0
YHD	24	0	14	0	43	0	26	0	11	0	5	0	18	0	18	0	1	0
IHHNV	0	0	0	0	40	3	24	2	11	0	5	0	18	0	18	0	1	0
IMNV	0	0	0	0	43	0	26	0	11	0	5	0	18	0	18	0	1	0

- negative result; + positive result

Although the impacts of diseases on shrimp farming can be well documented, the actual 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). For example, WSSV, which was demonstrated by Tan et al. (2014) to have occurred on Malaysian shrimp farms, 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). Lafferty et al. (2015) note: "It might appear that exports of WSSV into the wild would have impacts on wild crustaceans. After all, the virus enters the ocean through the farm effluent and shrimp escapes, and it affects many crustacean species. Interestingly, there are few reports of economic effects caused by viral release from aquaculture. One reason for this might be that the virus kills stressed shrimp in farm conditions, which do not apply to wild shrimp."

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). But no evidence of an impact could be found in Malaysia resulting from detection of the virus there in 2010 (Tan et al. 2014).

The 2017 Inland Fisheries (Aquaculture) regulation has several requirements to address biosecurity (FGG 2017), including the development of a biosecurity plan to reduce the introduction and spread of disease, eradication measures, and informing authorities within 48 hours of a suspected disease. The regulation allows the authorities to quarantine a facility, conduct appropriate laboratory analysis for pathogens, investigate the cause of the disease introduction, fallow and clean the facility, and depopulate the farm using suitable approaches to prevent the spread of disease if necessary (FGG 2017). MYGAP also covers biosecurity, requiring disinfection measures at the entry/exit point of the farm for vehicles, etc., and appropriate disposal of infected animals; however, vector controls are only "encouraged" (DSM 2007) and not mandated. It should be noted that the 2017 rules are too new for enforcement data to be available, but at the end of 2016, 34 farms representing 46% of the national production were MYGAP certified (pers. comm., DOFM 2017).

Conclusions and Final Score

The available research suggests that diseases can be significant on shrimp farms and that transmission to wild populations is possible. Results from a shrimp disease surveillance program indicate that disease incidence is low, but how representative these results are of the industry at large is unknown. Although further research is warranted, there is currently a lack of evidence of farm-origin diseases causing population-level impacts to wild shrimp, particularly in Malaysia. Ponds utilizing little to no water exchange (i.e., 0%–3% daily) have an inherently lower risk of discharging pathogens and parasites into receiving waterbodies than continuous exchange systems do. Regulatory controls for biosecurity are present, but without defined goals, such as the mandatory use of Specific Pathogen Free (SPF) and Specific Pathogen Resistant (SPR) PLs or sterilizing pond water before release or reuse, the concern for on-farm diseases impacting wild populations is moderate. Additionally, there are currently insufficient data to show effective enforcement of new regulations. It is possible that the national surveillance program may be useful in warning farmers about disease outbreaks, limiting the scale of an outbreak and the transfer to wild shrimp populations. The score for Criterion 7 – Disease for both white shrimp and giant tiger prawn is 5 out of 10.

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

Giant tiger prawn and White shrimp

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

Current and detailed information on the source of stock for both species in Malaysia is unclear. But available evidence suggests that both rely fully on post larvae from domesticated broodstock. The origin of the broodstock is from imported sources (Mozambique and Madagascar for giant tiger prawn, Hawaii for white shrimp). Therefore, the final score for both species is 10 out of 10 for Criterion 8 – Source of Stock.

Justification of Ranking

Giant tiger prawn is native to Malaysia, but disease-carrying local wild populations led to the industry adopting imported domesticated (or imported then domesticated) broodstock from Mozambique, and later Madagascar. In 2003, the Malaysian government imported a nonnative strain of giant tiger prawn from Mozambique and began a broodstock selection program, and by 2009, 90% of giant tiger prawn production was supported by the Mozambique strain, and had been selected in Malaysia for seven generations (Othman 2009). More recently, Merican (2013) found that, while reporting on one of the remaining five main giant tiger prawn hatcheries, it was still importing domesticated broodstock from Madagascar. Although the sources may be unclear, the available data indicate that, in contrast to most other giant-tier prawn farming locations, all giant tiger prawn production in Malaysia is supported by domesticated broodstock. The final score for giant tiger prawn is 10 out of 10 for Criterion 8 – Source of Stock.

White shrimp is not native to Malaysia, so the initial broodstock were imported. SPF broodstock imports from Hawaii began in 2013 (pers. comm., Yamasaki 2016), and there is evidence of white shrimp hatchlings and fry production in government and private hatcheries in Malaysia

(DOFM 2013). It remains unclear how much of production is supported by broodstock of each origin, but white shrimp is considered to have been fully domesticated on a global scale, so it is likely that the industry is entirely supported by domesticated broodstock. The final score for white shrimp is 10 out of 10 for Criterion 8 – Source of Stock.

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" factor 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

Giant tiger prawn and White shrimp

Wildlife and predator mortality parameters	Score	
F3.3X Wildlife and predator mortality Final Score	**–5.00**	**YELLOW**
Critical?	NO	

Brief Summary

Recent data on wildlife and predator mortalities associated with Malaysian shrimp farming are lacking. But general shrimp farming practices include treating ponds during the initial fill to kill resident organisms, and dated literature specified that saponin, hypochlorites, and organophosphates have been used in Malaysia. Passive and nonlethal measures, such as pond linings to deter predatory crabs and fireworks to deter diving birds, are typical in the shrimp farming industry, but use of these practices could not be confirmed. Interactions between wildlife and shrimp ponds that result in mortality do occur during stocking; although these and other mortalities are unlikely to result in population-level impacts, no data or other information are available to determine this. White shrimp and giant tiger prawn each score a deduction of –5 out of –10 for Criterion 9X – Wildlife and predator mortalities.

Justification of Ranking

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

References to the specific predator species, the deterrents used to control them, or their impact on predator populations in the Malaysian shrimp farming industry were not available in the literature. A dated account by Mohamed (2000) identified that, prior to stocking PLs, farmers applied saponin (teaseed cake) and hypochlorites to kill fish and applied organophosphates to kill crustaceans that had been introduced during filling of the pond from local waterbodies. No references to impacts on populations of fish or crustaceans as a result of these practices could be found, but no International Union for the Conservation of Nature (IUCN) Red-Listed fish or crustacean species are found in Malaysia (IUCN 2016).

Globally, standard practice for most shrimp farms includes the employment of nonlethal, exclusionary techniques to scare birds away from the pond, such as fireworks or dogs during the production cycle (Gunalan 2015) (Balakrishnan 2011). But Munasinghe et al. (2010) found that only 25% of Sri Lankan shrimp farms employed bird netting, and there is no direct evidence of the employment of these strategies in Malaysia; however, about one-third of the Malaysian industry uses pond linings (pers. comm., DOFM 2017), which may deter some predators.

Conclusions and Final Score

Some lethal control is applied when the ponds are initially filled. Although there is a lack of evidence of population-level impacts to wild species, no data or other information are available to determine the impact to any species that interacts with Malaysian shrimp farms. As a result, impacts are unknown but unlikely to be too severe, so a deductive score of –5 out of –10 is given for Factor 9X – Wildlife and Predator Mortality for both 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

Giant tiger prawn

Escape of unintentionally introduced species parameters	Score	
F10Xa International or trans-waterbody live animal shipments (%)	0.00	
F10Xb Biosecurity of source/destination	8.00	
C6 Escape of unintentionally introduced species Final Score	**–2.00**	**GREEN**

White shrimp

Escape of unintentionally introduced species parameters	Score	
F10Xa International or trans-waterbody live animal shipments (%)	0.00	
F10Xb Biosecurity of source/destination	9.00	
C6 Escape of unintentionally introduced species Final Score	**–1.00**	**GREEN**

Brief Summary

Between 2003 and 2007, the Malaysian government imported a nonnative strain of giant tiger prawn from Mozambique and began a broodstock selection program with it, achieving disease-free seed for six relevant pathogens. In 2013, it was reported that at least one Malaysian hatchery was importing domesticated, verified SPF broodstock from Madagascar that were free from five relevant shrimp pathogens. Evidence shows that domesticated and verified specific pathogen free (SPF) (between 9 and 13 pathogens) white shrimp broodstock have been imported from Hawaii since 2013. In the absence of specific and detailed information regarding domestically grown broodstock, this report takes the position that 100% of the industry for both species relies on international live animal shipments.

Malaysia has evident import controls for broodstock, including Fish Health Certificate requirements and quarantine systems. In addition, evidence suggests that the original sources of broodstock for both species were free from a wide range of shrimp pathogens and held under strict biosecurity controls, especially the Hawaiian white shrimp. But it cannot be assured that all broodstock used in Malaysia are from these sources, so a slight reduction in biosecurity of source score was given for both species. Shrimp farms in Malaysia generally operate as harvest exchange systems, but no clear information is available on the application of best management practices (BMPs) for biosecurity. As a result of the Hawaiian source of broodstock, giant tiger prawn scores 8 out of 10 and white shrimp scores 9 out of 10 for the biosecurity of source and destination. This difference is also reflected in the final minor deductions of –2 out of –10 for giant tiger prawn and –1 out of –10 for white shrimp for Criterion 10X – Escape of Unintentionally Introduced Species.

Justification of Ranking

Factor 10Xa International or trans-waterbody live animal shipments
In 2003, the Malaysian government imported a nonnative strain of giant tiger prawn from Mozambique and began a broodstock selection program with it, achieving disease-free seed (Othman 2009). Subramaniam et al. (2006) showed that some of the imported broodstock from Mozambique were held in various quarantine systems and repeatedly tested for, and free from, WSSV, YHV, gill-associated virus (GAV), MBV, TSV, and HPV. Merican (2013) reported that a Malaysian hatchery was importing domesticated, verified SPF broodstock from Madagascar, which were free from WSSV, IHHNV, TSV, YHV, and IMNV. In the absence of more recent and/or detailed information, this report takes the position that 100% of the industry relies on imported broodstock, resulting in a score of 0 out of 10 for Factor 10Xa.

White shrimp is not native to Malaysia, so the initial broodstock would have been imported. SPF broodstock imports from Hawaii began in 2013 (pers. comm., Yamasaki 2016) and it is likely the industry remains reliant on imported broodstock. DOFM data indicate that white shrimp hatchlings and fry are produced in government and private hatcheries (DOFM 2013), but it is unclear that the broodstock producing these shrimp are not imported. In the absence of more recent and/or detailed information, this report takes the position that 100% of the industry relies on imported broodstock, resulting in a score of 0 out of 10 for Factor 10Xa.

Factor 10Xb Biosecurity of source/destination
As detailed in Criterion 7 – Disease, DOFM operates the Fish Health Surveillance and Inspection Program (HSIP) and the National Fish Disease Notification Program (NFDNP) (Tan et al. 2014). The HSIP conducts disease surveillance audits on farms, and the NFDMP requires disease reporting by farms and is a reactive tool for coordinating a national response when required. But it is unclear how these tools are applied at the hatchery level. DOFM maintains a list of authorized hatcheries on its website and issues annual certifications to them, but the available list has not been updated since 2012 and it included seven shrimp hatcheries (DOFM 2012).

Imports of live shrimp broodstock are controlled by the Department of Malaysian Quarantine and Inspection Services (MAQIS) and require a permit (WTO 2014). Permits are issued with relevant documentation, including a Veterinary Health Certification from the exporting country; however, details of what this certificate covers were not stated (WTO 2014). MAQIS will quarantine shrimp imports in its facilities, which must hold and treat effluents prior to release and appropriately dispose of dead shrimp (MAQIS 2015).

Dr. Yamasaki (pers. comm., 2016) from the state of Hawaii reports that SPF white shrimp broodstock exports to Malaysia began in 2013, but no giant tiger prawn broodstock has been shipped. The requirements for Hawaiian SPF broodstock are quite stringent, including the facility achieving 2 years of disease-free testing for a wide range of pathogens (SOH 2015).

Required tests include IHHNV, WSSV, TSV, YHV, IMNV, BP, monodon baculovirus (MBV), necrotising hepatopancreatitis (NHP), and AHPNS, with potential for testing to include Mourilyan virus (MoV), hepatopancreatic parvovirus (HPV), and enterocytozoon hepatopenaei (EHP) if the receiving company wishes (pers. comm., Yamasaki 2016). These broodstock sources are biosecure, but it cannot be assured that all broodstock are sourced from Hawaii, so the Factor 10Xb score for the source of shrimp movements is 9 out of 10 for white shrimp.

The information available on the disease status of the broodstock imported from Mozambique in 2003 and the potentially ongoing imports of domesticated, verified SPF broodstock from Madagascar in 2013 suggest a high degree of biosecurity from the source locations in order to maintain their SPF status. Subramaniam et al. (2006) showed that some of the imported broodstock from Mozambique were held in various quarantine systems and repeatedly tested for, and free from, WSSV, YHV, gill-associated virus (GAV), MBV, TSV, and HPV. Le Groumellec et al. (2008) highlighted one source of SPF broodstock from Madagascar that used closed production systems and broodstock that were free of WSSV, YHV, TSV, Brazilian IMNV, and NHP from 1999 to the date of their publication in 2008. Because it cannot be assured that all broodstock used in Malaysia are sourced from these sources, and because pathogen testing may not be quite as rigorous as in Hawaii, a precautionary score of 8 out of 10 is given for giant tiger prawn on Factor 10Xb – Source of shrimp movements.

As described elsewhere in this report, shrimp farms in Malaysia generally operate as harvest exchange systems, but no clear information is available on the application of BMPs for biosecurity. Thus, a precautionary score of 5 out of 10 is given for the biosecurity of the destination (i.e., growout farm) of animal movements for both species. This results in a score of 5 out of 10 for Factor 10Xb for white shrimp and giant tiger prawn.

Because the scores for Factor 10Xb for both species are higher for the source than for the destination, the score for the source is used as the final score for Factor 10Xb. For giant tiger prawn, the score for Factor 10Xb is 8 out of 10. For white shrimp, the score for Factor 10Xb is 9 out of 10.

Final Score

The scores for Factors 10Xa and 10Xb are combined to give a total deductive score of –2 out of –10 for giant tiger prawn and –1 out of –10 for white shrimp for Criterion 10X – Escape of unintentionally introduced species.

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.

Giant Tiger Prawn

Penaeus monodon

Malaysia

Ponds

Criterion	Score (0–10)	Rank	Critical?
C1 Data	4.17	YELLOW	
C2 Effluent	4.00	YELLOW	NO
C3 Habitat	1.97	RED	NO
C4 Chemicals	3.00	RED	NO
C5 Feed	5.05	YELLOW	NO
C6 Escapes	4.00	YELLOW	NO
C7 Disease	5.00	YELLOW	NO
C8 Source	10.00	GREEN	
C9X Wildlife mortalities	–5.00	YELLOW	NO
C10X Introduced species escape	–2.00	GREEN	
Total	**29.18**		
Final score	**3.65**		

OVERALL RANKING

Final Score	3.77
Initial rank	YELLOW
Red criteria	2
Interim rank	RED
Critical Criteria?	NO

FINAL RANK

RED

White shrimp

Litopenaeus vannamei

Malaysia

Ponds

Criterion	Score (0–10)	Rank	Critical?
C1 Data	4.17	YELLOW	
C2 Effluent	4.00	YELLOW	NO
C3 Habitat	1.97	RED	NO
C4 Chemicals	3.00	RED	NO
C5 Feed	5.05	YELLOW	NO
C6 Escapes	4.00	YELLOW	NO
C7 Disease	5.00	YELLOW	NO
C8 Source	10.00	GREEN	
C9X Wildlife mortalities	–5.00	YELLOW	NO
C10X Introduced species escape	–1.00	GREEN	
Total	**30.18**		
Final score	**3.77**		

OVERALL RANKING

Final Score	3.90
Initial rank	YELLOW
Red criteria	2
Interim rank	RED
Critical Criteria?	NO

FINAL RANK

RED

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Scientific review does not constitute an endorsement of the Seafood Watch® program, or its seafood recommendations, on the part of the reviewing scientists. Seafood Watch® is solely responsible for the conclusions reached in this report.

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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.

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.

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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.

Data points and all scoring calculations: White Shrimp

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	2.5	2.5
Locations/habitats	Yes	7.5	7.5
Chemical use	Yes	5	5
Feed	Yes	2.5	2.5
Escapes, animal movements	Yes	2.5	2.5
Disease	Yes	5	5
Source of stock	Yes	5	5
Predators and wildlife	Yes	0	0
Other – (e.g., GHG emissions)	No	Not relevant	n/a
Total			**37.5**

C1 Data Final Score	4.17	YELLOW

Criterion 2: Effluents

Factor 2.1a - Biological waste production score

Protein content of feed (%)	35
eFCR	1.6
Fertilizer N input (kg N/ton fish)	0
Protein content of harvested fish (%)	17.8
N content factor (fixed)	*0.16*
N input per ton of fish produced (kg)	89.6
N in each ton of fish harvested (kg)	28.48
Waste N produced per ton of fish (kg)	**61.12**

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**

3
4 % 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?	Mostly	0.75
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?	No	0
3 - Do the control measures address or relate to the cumulative impacts of multiple farms?	Partly	0.25
4 - Are the limits considered scientifically robust and set according to the ecological status of the receiving water body?	Moderately	0.5
5 - Do the control measures cover or prescribe including peak biomass, harvest, sludge disposal, cleaning, etc.?	Partly	0.25
		1.75

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?	Moderately	0.5
2 - Do monitoring data or other available information demonstrate active enforcement of the control measures?	Moderately	0.5
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
		2

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

C2 Effluent Final Score	**4.00**	**YELLOW**
	Critical?	NO

Criterion 3: Habitat

3.1. Habitat conversion and function

F3.1 Score	**1**

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 EIA requirement for new sites?	Moderately	0.5
2 - Is the industry's total size and concentration based on its cumulative impacts and the maintenance of ecosystem function?	Moderately	0.5
3 – Is the industry's ongoing and future expansion in appropriate locations, and thereby preventing the future loss of ecosystem services?	Mostly	0.75
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)	Partly	0.25
5 - Do control measures include requirements for the restoration of important or critical habitats or ecosystem services?	Yes	1
		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?	Mostly	0.75
3 - Does the farm siting or permitting process take account of other farms and their cumulative impacts?	Moderately	0.5
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?	Moderately	0.5
		3.25

F3.2 Score (2.2a*2.2b/2.5)	**3.9**

C3 Habitat Final Score	**1.97**	**RED**
	Critical?	NO

Criterion 4: Evidence or Risk of Chemical Use

Chemical Use parameters	Score	
C4 Chemical Use Score	3.00	
C4 Chemical Use Final Score	**3.00**	**RED**
Critical?	NO	

Criterion 5: Feed

5.1. Wild Fish Use

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

Fishmeal inclusion level (%)	20
Fishmeal from by-products (%)	0
% FM	20
Fish oil inclusion level (%)	2
Fish oil from by-products (%)	0
% FO	2
Fishmeal yield (%)	22.5
Fish oil yield (%)	5
eFCR	1.6
FIFO fishmeal	1.42
FIFO fish oil	0.64
Greater of the 2 FIFO scores	1.42
FIFO Score	**6.44**

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

SSWF	-6
SSWF Factor	-0.853333333

F5.1 Wild Fish Use Score	**5.59**

5.2. Net protein Gain or Loss

Protein INPUTS	
Protein content of feed	35
eFCR	1.6
Feed protein from NON-EDIBLE sources (%)	0
Feed protein from EDIBLE CROP sources (%)	86.7

Protein OUTPUTS		
Protein content of whole harvested fish (%)		17.8
Edible yield of harvested fish (%)		67
Non-edible by-products from harvested fish used for other food production		50
Protein IN		42.11
Protein OUT		14.863
Net protein gain or loss (%)		-64.7078054
	Critical?	NO
F5.2 Net protein Score	**3.00**	

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 (%)	22
eFCR	1.6
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)	9.15

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

Inclusion level of crop feed ingredients (%)	78
Inclusion level of land animal products (%)	0
Conversion ratio of crop ingedients to land animal products	*2.88*
eFCR	1.6
Average yield of major feed ingredient crops (t/ha)	*2.64*
Land area appropriated (ha per ton of fish)	0.47

Value (Ocean + Land Area)	**9.63**

F5.3 Feed Footprint Score	**6.00**

C5 Feed Final Score	**5.05**	**YELLOW**
	Critical?	**NO**

Criterion 6: Escapes

6.1a. Escape Risk

Escape Risk	**4**

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	**4**

6.1b. Invasiveness

Part A – Native species

Score	0

Part B – Non-Native species

Score	**0.5**

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?	No
Do escapees compete with wild native populations for breeding partners or disturb breeding behavior of the same or other species?	To some extent
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
	4

F 6.1b Score	**4.5**

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

Criterion 7: Diseases

Pathogen and parasite parameters	Score
C7 Biosecurity	5.00

C7 Disease; pathogen and parasite Final Score	5.00	YELLOW
Critical?	NO	

Criterion 8: Source of Stock

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

Exceptional Criterion 9X: Wildlife and predator mortalities

Wildlife and predator mortality parameters	Score	
C9X Wildlife and Predator Final Score	**–5.00**	**YELLOW**
Critical?	NO	

Exceptional Criterion 10X: Escape of unintentionally introduced species

Escape of unintentionally introduced species parameters	Score	
F10Xa International or trans-waterbody live animal shipments (%)	0.00	
F10Xb Biosecurity of source/destination	9.00	
C10X Escape of unintentionally introduced species Final Score	**–1.00**	**GREEN**

Data points and all scoring calculations: Giant Tiger Prawn

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	2.5	2.5
Locations/habitats	Yes	7.5	7.5
Chemical use	Yes	5	5
Feed	Yes	2.5	2.5
Escapes, animal movements	Yes	2.5	2.5
Disease	Yes	5	5
Source of stock	Yes	5	5
Predators and wildlife	Yes	0	0
Other – (e.g. GHG emissions)	No	Not relevant	n/a
Total			**37.5**

C1 Data Final Score	4.17	YELLOW

Criterion 2: Effluents

Factor 2.1a - Biological waste production score

Protein content of feed (%)	38
eFCR	1.6
Fertilizer N input (kg N/ton fish)	0
Protein content of harvested fish (%)	18.5
N content factor (fixed)	*0.16*
N input per ton of fish produced (kg)	97.28
N in each ton of fish harvested (kg)	29.6
Waste N produced per ton of fish (kg)	**67.68**

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**

3

4 % 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?	Mostly	0.75
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?	No	0
3 - Do the control measures address or relate to the cumulative impacts of multiple farms?	Partly	0.25
4 - Are the limits considered scientifically robust and set according to the ecological status of the receiving water body?	Moderately	0.5
5 - Do the control measures cover or prescribe including peak biomass, harvest, sludge disposal, cleaning etc?	Partly	0.25
		1.75

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?	Moderately	0.5
2 - Does monitoring data or other available information demonstrate active enforcement of the control measures?	Moderately	0.5
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
		2

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

C2 Effluent Final Score	**4.00**	**YELLOW**
	Critical?	NO

Criterion 3: Habitat

3.1. Habitat conversion and function

F3.1 Score	**1**

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?	Moderately	0.5
2 - Is the industry's total size and concentration based on its cumulative impacts and the maintenance of ecosystem function?	Moderately	0.5
3 – Is the industry's ongoing and future expansion appropriate locations, and thereby preventing the future loss of ecosystem services?	Mostly	0.75
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)	Partly	0.25
5 - Do control measures include requirements for the restoration of important or critical habitats or ecosystem services?	Yes	1
		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?	Mostly	0.75
3 - Does the farm siting or permitting process take account of other farms and their cumulative impacts?	Moderately	0.5
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?	Moderately	0.5
		3.25

F3.2 Score (2.2a*2.2b/2.5)	**3.9**

C3 Habitat Final Score	**1.97**	**RED**
	Critical?	NO

Criterion 4: Evidence or Risk of Chemical Use

Chemical Use parameters	Score	
C4 Chemical Use Score	3.00	
C4 Chemical Use Final Score	3.00	RED
Critical?	NO	

Criterion 5: Feed

5.1. Wild Fish Use

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

Fishmeal inclusion level (%)	20
Fishmeal from by-products (%)	0
% FM	20
Fish oil inclusion level (%)	2
Fish oil from by-products (%)	0
% FO	2
Fishmeal yield (%)	22.5
Fish oil yield (%)	5
eFCR	1.6
FIFO fishmeal	1.42
FIFO fish oil	0.64
Greater of the 2 FIFO scores	1.42
FIFO Score	**6.44**

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

SSWF	-6
SSWF Factor	-0.853333333

F5.1 Wild Fish Use Score	**5.59**

5.2. Net protein Gain or Loss

Protein INPUTS	
Protein content of feed	38
eFCR	1.6
Feed protein from NON-EDIBLE sources (%)	0
Feed protein from EDIBLE CROP soruces (%)	86.7

Protein OUTPUTS		
Protein content of whole harvested fish (%)		18.5
Edible yield of harvested fish (%)		62
Non-edible by-products from harvested fish used for other food production		50
Protein IN		45.72
Protein OUT		14.985
Net protein gain or loss (%)		-67.2272125
	Critical?	NO
F5.2 Net protein Score	**3.00**	

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 (%)	22
eFCR	1.6
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)	9.15

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

Inclusion level of crop feed ingredients (%)	78
Inclusion level of land animal products (%)	0
Conversion ratio of crop ingedients to land animal products	*2.88*
eFCR	1.6
Average yield of major feed ingredient crops (t/ha)	*2.64*
Land area appropriated (ha per ton of fish)	0.47

Value (Ocean + Land Area)	**9.63**

F5.3 Feed Footprint Score	**6.00**

C5 Feed Final Score	**5.05**	**YELLOW**
	Critical?	**NO**

Criterion 6: Escapes

6.1a. Escape Risk

Escape Risk	**4**

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	**4**

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?	No
Do escapees compete with wild native populations for breeding partners or disturb breeding behavior of the same or other species?	To some extent
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
	4

F 6.1b Score	**5**

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

Criterion 7: Diseases

Pathogen and parasite parameters	Score	
C7 Biosecurity	5.00	
C7 Disease; pathogen and parasite Final Score	**5.00**	**YELLOW**
Critical?	NO	

Criterion 8: Source of Stock

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

Exceptional Criterion 9X: Wildlife and predator mortalities

Wildlife and predator mortality parameters	Score	
C9X Wildlife and Predator Final Score	**-6.00**	**YELLOW**
Critical?	NO	

Exceptional Criterion 10X: Escape of unintentionally introduced species

Escape of unintentionally introduced species parameters	Score	
F10Xa International or trans-waterbody live animal shipments (%)	0.00	
F10Xb Biosecurity of source/destination	8.00	
C10X Escape of unintentionally introduced species Final Score	**-2.00**	**GREEN**

Appendix 1 – Interim Update

An Interim Update of this assessment was conducted in June 2021 in the most-up-to-date Seafood Watch Aquaculture Standard Version 4.0. Interim Updates focus on an assessment's limiting (i.e., Critical or Red) criteria (inclusive of a review of the availability and quality of data relevant to those criteria), so this review evaluates the Habitat and Chemical Use criteria. No information was found or received that would suggest the final rating is no longer accurate. No edits were made to the text of the report (except an update note in the Executive Summary). The following text summarizes the findings of the review.

Seafood Watch attempted to contact expert reviewers for this assessment from June 2021 to August 2021 but was unsuccessful. The assessment was also on the public comment webpage in August 2021 and received minimal feedback.

Interim Update Scoring Summary
Results of the interim update support the findings of the previous assessment and the Overall Recommendation for shrimp (*L. vannamei* and *P. monodon*) grown in ponds in Malaysia remains Avoid with a Red rating. The recommendation and rating are driven by two red criterion assessed in the interim update, Criterion 3 – Habitat and Criterion 4 – Chemical Use. According to the Seafood Watch standard, two red criteria automatically result in a Red rating and an Avoid recommendation.

Criterion 1 – Data
Overall, the availability and quality of data for whiteleg shrimp (*L. vannamei)* and giant tiger prawn (*P. monodon)* farmed in Malaysian ponds is low-moderate. Data for Criterion 3 – Habitat were captured from peer reviewed literature, although key insights such as total pond area for whiteleg shrimp and giant tiger prawn through time by state and what habitat was converted by these producers were unclear. Also, literature evaluating farm siting regulation and management was limited. Data for Criterion 4 – Chemical Use was low-moderate since records and documentation of noncompliance were unavailable, and key information such as chemical product use regulation, how chemicals are obtained, and whether or not chemicals are even used on farms was all unclear. As a result, the availability of information for each Criterion (e.g., Habitat and Chemical Use) in this interim update is low-moderate.

Criterion 3 - Habitat

Factor 3.1 Habitat conversion and function

A comprehensive and complete timeline of pond construction in Malaysia was not readily available in the literature, or on the Malaysian Department of Fisheries website. Therefore, a timeline from multiple sources was constructed to estimate total brackish pond area for shrimp farming from 1995 to 2015 (see Table 1). Results show a slight expansion of pond aquaculture development after 1999, but this information appears misleading.

Table 1: Total brackishwater shrimp pond area in Malaysia from 1995 to 2015.[2]

Year	Acreage (ha)
1995	2623
1996	2958
1997	5910
2000	7151
2002	7011
2004	7555
2009	7300
2012	7525
2015	7978

Note: 2012 data is for all brackish water pond production area and 2015 data is for all mariculture earthen pond, net cages, and bottom culture production systems in Malaysia.

To help guide aquaculture siting and development, the Malaysian government created Aquaculture Industrial Zones (AIZ) in 2007 (Abdullah et al. 2013). According to the Department of Fisheries (2014), a total of 5,365 ha of land were allocated for AIZ for shrimp farming activities with the majority shrimp farms zoned in the states of Perak and Terengganu (see Table 2). It is unclear how much shrimp pond development and production are occurring outside the AIZ area currently, and if the initial development of the AIZ included previously sited and operating production or if the AIZ's converted fully functional habitat. But given the difference between total brackishwater shrimp pond area in 2009 (7,300 ha, see Table 1, *Note: 2009 is the last year of total acreage estimates for only shrimp production in brackishwater*) and the sited area for AIZ marine shrimp production in 2014 (5,365 ha, see Table 2), it appears that some shrimp pond production is operating outside AIZ.

[2] Source: Othman, 2008; Abdullah et al. 2013; Yusoff, A., 2015; Omar, A., 2017.

Table 2: Marine Shrimp Aquaculture Industrial Zones in Malaysia by State and Area. Source: DOF, 2015b.

State	Area (ha)
Perak	2,175
Terengganu	1,720
Pahang	687
Sarawak	595
Melaka	100
Kedah	60
Selangor	28
Total	5,365

Although the type of habitat converted for brackishwater shrimp aquaculture is not detailed, there is some, though imprecise, documentation of land use change due to shrimp pond development and/or expansion. Shrimp farming in Malaysia began in the 1930s with extensive farming systems built in mangrove forests. These early extensive production systems relied on trapping wild post-larvae (PL) and tidal water exchange (Hashim and Kathamuthu 2005). However, soil quality issues triggered mass mortality across farms, and by the 1980s the industry moved to ponds inland of or entirely outside the mangrove areas and used pumps to exchange water (Hashim and Kathamuthu 2005). Othman (2008) identified abandoned coconut plantations and former paddy fields as the primary areas for pond development and shrimp farming was identified as contributing to the loss of mangrove habitat by a number of papers (Abdullah et al. 2013; Consumer Association of Penang 2010; Sze et al 2000; Hamdan, 2012; Sarmin et al., 2016; Chong, V.C., 2006; Latiff et al 2013). In 2009, World Wildlife Fund Malaysia (WWFM) criticized the development of a farm that would impact 700 ha of the Gelam forest, which they describe as “one of the most severely threatened freshwater ecosystems in Malaysia,” and highlight that shrimp farm effluent would affect critically endangered river terrapins. Altogether, it appears that three land use categories were converted for brackishwater shrimp aquaculture production through time: mangroves, wetlands, and agricultural land. Further details such as the amount of each land use category (e.g., mangroves, wetland, and agricultural land) converted for brackishwater shrimp production through time was not readily available in peer review literature and attempts to connect with the Malaysian government and other stakeholders were unsuccessful.

General quantified land use change from several land use categories to pond aquaculture, though indiscriminate of species farmed, is available and documented with satellite imagery through time. The Clark Lab from Clark University compiled satellite imagery of landcover and land use change of coastal habitat from 1999 to 2018 in Malaysia and its States (see Table 3). From 1999 to 2018, a total of 10,192.8 hectares of land was converted for pond aquaculture. The majority, 5,447.5 ha or 53%, was mangrove habitat converted to ponds, followed by other land use types to pond, collectively 4,679 ha or 46%, while 26.8 ha of wetlands were converted to pond aquaculture production. States that had the greatest area of land use conversion to ponds were Perak, Sabah, Johor, Sarawak, Terengganu, Selangor, and Pahang (see Table 3). These results from the Clark Lab align with the narratives described in the literature as it appears both mangrove and other land use types (e.g., agricultural land) were the main land use types converted to pond production from 1999-2018.

Table 3: Land use change through time in Malaysia by state and land use type. Source: Clark Lab, 2020.

State	Time Range	All Land Use Categories to Pond (ha)	Mangrove to Pond (ha)	Other to Pond (ha)	Water to Pond (ha)	Wetland to Pond (ha)
Perak	1999 to 2018	2872.8	1738.4	1101.2	33.2	
Sabah	1999 to 2018	2572.8	1248.2	1324.6		
Johor	1999 to 2018	1533.6	600	933.6		
Sarawak	1999 to 2018	891	469.8	421.2		
Terengganu	1999 to 2018	692.7	291.4	374.5		26.8
Selangor	1999 to 2018	661.2	542.4	112.5	6.3	
Pahang	1999 to 2018	530.4	396.1	134.3		
Kedah	1999 to 2018	252.6	95.3	157.3		
Kelantan	1999 to 2018	109.2	12.2	97		
Malacca	1999 to 2018	68.2	52.4	15.8		
Perlis	1999 to 2018	5.1	1.3	3.8		
Penang	1999 to 2018	4.1	0.6	3.5		
Labuan (Federal Territory)	1999 to 2018	3.2	0	3.2		
Negeri Sembilan	1999 to 2018	2.6	1.4	1.1		
Total	1999 to 2018	10199.43	5449.49	4683.62	39.51	26.8

Although the output from the Clark Lab study does not reveal which species are grown in the ponds, shrimp farming production is a likely contributing driver because: a) the majority of land use conversion for pond production is in mangrove habitat which is associated with brackishwater, and, traditionally, the siting of shrimp pond production globally and in Malaysia, b) brackishwater shrimp farming is significant in Malaysia accounting for roughly half of all brackishwater aquaculture production in Malaysia (FAO, 2018), and c) the States with some of the largest expansion of pond aquaculture development (e.g., Perak, Sabah, and Johor) are also leading shrimp producing regions (DOFM, 2015).

In general, it appears mangrove habitat and other land use types (e.g., agricultural land) are the dominant land use types converted to pond aquaculture production with significant land use conversion occurring in Perak, Sabah, Johor, Sarawak, Terengganu, Selangor, and Pahang. Documentation of the impacts of pond aquaculture development in these regions to mangrove forests and agricultural land, specifically, is not well detailed in the literature. However, aquaculture's contribution to the cumulative impacts pressuring mangrove forest ecosystems is nonetheless concerning.

Overall, mangrove habitat across Malaysia is in decline due to a host of drivers, mainly conversion for urbanization and/or other land use types besides aquaculture (Eastman and Toledano, 2020). From 1999-2018, Malaysia has lost approximately 15.2 km^2 of mangroves per year, but the rate of mangrove deforestation has recently increased with an average loss of 31.6 km^2 per year from 2014-2018 (Eastman and Toledano, 2020). Altogether, mangroves in Malaysia accounts for roughly 10% of the coastal zone as of 2018, which accumulates to a loss of -0.48% from 1999 (Eastman and Toledano, 2020). The loss of 0.48% of mangrove forests from 1999 to 2018 is greater than other nearby countries (e.g., Cambodia, Indonesia, Bangladesh, Sri Lanka, Vietnam, India, and Thailand). Therefore, it appears the current management framework does not protect against significant mangrove conversion and may allow for continued loss of mangrove functionality as evidence by its ongoing conversion.

Altogether, 5,500 ha of mangrove and 4,600 ha of other land use types (e.g., agricultural land) were converted for pond aquaculture development from 1999-2018. It is implied that brackishwater shrimp aquaculture is a driver of this conversion but not entirely, as other aquatic species are grown in ponds in Malaysia as well. Documentation of the impacts to the functionality of mangrove forests as a result of recent conversion is lacking. Given the significant area of mangrove conversion in Malaysia from 1999 – 2018, 15.2 km^2 per year, and the recent uptick in conversion from 2014-2018, 31.6 km^2 per year, it seems likely mangrove forests are majorly impacted by development (not limited to shrimp aquaculture). A timeline of brackishwater development, the area converted, and where prior to 1999 is not clear, although development has increased significantly since 1996. As a result, major impacts to high valued habitat (e.g., mangrove forests) from brackish water shrimp ponds appear to have occurred largely after 1999 resulting in a loss of ecosystem functionality. Since data availability about the impacts of brackishwater shrimp production to ecosystem functionality is limited, a precautionary approach of ongoing ecosystem functionality loss is assumed given the known ongoing conversion of high value habitat. Therefore, the score for Factor 3.1 Habitat conversion and function is 0 out of 10.

Factor 3.2 Farm siting regulation and management

Factor 3.2a

There is little information readily available that suggests the site selection, management, and Environmental Impact Assessment process in Malaysia has significantly changed since the completion of the 2017 Malaysia shrimp assessment. One study that was not discussed in the previous assessment outlines the policy and legislation guiding aquaculture in Malaysia, but makes no suggestion that habitat protections or EIA criteria have changed in any substantial way (Witus and Vun, 2016). Therefore, the findings of the previous assessment appear to be consistent with this review: *although EIAs exist, there appears to be limited considerations of cumulative habitat impacts and loss of ecosystem services.* As a result, the score for Factor 3.2a – Regulatory or management effectiveness remains 3 out of 5.

Factor 3.2b

There is little information readily available that suggests the Enforcement of habitat management measures has significantly changed since the completion of the 2017 Malaysia shrimp assessment. Therefore, the findings of the previous assessment appear to be consistent with this review: *enforcement organizations are identifiable and active, cumulative habitat impacts may not be fully addressed, and gaps in transparency or compliance data are apparent.* As a result, the score for Factor 3.2b – Enforcement of habitat management measures remains 3 out of 5.

Criterion 3- Habitat Conclusion

Shrimp aquaculture ponds are sited in high value habitat (e.g., mangrove forests) largely constructed after 1999, yet these is ongoing development resulting in the likely loss of ecosystem functionality, and results in a Factor 3.1 – Habitat conversion and function score of 0 out of 10. There is little information that suggests farm siting and management has changed or its enforcement since the 2017 Malaysia shrimp assessment, and results in a combined Factor 3.2 – Farm siting regulation and management score of 3.6 out of 10. The scores for both Factor 3.1 and Factor 3.2 are combined to give a score of 1.20 out of 10 for Criterion 3 – Habitat for both whiteleg shrimp and giant tiger prawn.

Criterion 4 Chemical Use

Management and enforcement of chemical usage in Malaysian aquaculture appears to be focused on food safety of seafood products and not necessarily the potential impacts to the environment. The Department of Fisheries in Malaysia (DOFM) lists all permitted substances for aquaculture including the maximum residue limits, withdrawal period, and prohibited drugs[3]. All approved drugs are approved by the Director General (see Table 4). Guidance on the usage of chemical substances is provided from the DOFM in a document *The usage of veterinary drug, chemical and growth hormone in aquaculture farm* (DOFM 2017). The guidance covers how to use antibiotics, such as "Farm operators shall inform the authority on the plan use of any type of antibiotics," "use only antibiotics approved by the authority," "keep detailed records of all antibiotics," and that "the authority will monitor and verify all records on the usage of antibiotics in the farms" (DOFM 2017b). However, current data on the types, amounts, or environmental effects of chemicals used on shrimp farms in Malaysia are not publicly available and antimicrobials listed as Highly and Critically Important for Human Medicine by the World Health Organization[4] are permitted (see Table 4). The effectiveness of management measures and their enforcement to limit the usage of approved antimicrobials is unclear. The DOFM conducts monitoring of chemical use of a variety of substances for fish and shrimp aquaculture production at the farm level through the Aquaculture Residue Montioring Programme (ARMP) and the Sanitary and Phytosanitary (SPS) Aquaculture Programme. The results of these farm samples are not made public, but according to the DOFM there have been no prohibited antibiotic substances detected from 2008 to 2015. If prohibited antibiotics are detected, the farm will be sanctioned and cannot export their harvest (The Straits Times, 2020). Results on the documentation and usage of allowed substances and potential exceedances of MRLs was not readily available. The process by which antimicrobials may be legally obtained by farmers is also unclear.

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[3] Prohibited antimicrobials include: *chloramphenicol, nitrofurans nitroimidazoles, malachite green, leucomalachite green, crystal violet, anthyroid agents, and beta agonosis.* Source: DOFM, 2017
See SFW assessment of Malaysian shrimp pond production in 2017 page 38-39 for approved chemical use, maximum residual levels, and withdrawal period. https://www.seafoodwatch.org/recommendation/shrimp/red-shrimp-whiteleg-shrimp-malaysia-ponds?species=156

[4] See World Health Organization's Critically Important Antimicrobials for Human Medicine 6th Revision, 2018: https://www.who.int/foodsafety/areas_work/antimicrobial-resistance/cia/en/

Table 4 Allowed Antimicrobial Agents and Class in Malaysia and WHO Classification. Source: DOFM, 2017b and WHO, 2018.

Allowed Antimicrobials Agents & Class	WHO Classification
Amoxicillin	Critically Important
Ampicillin	Critically Important
Benzylpenicillin	Highly Important
Chlortetracycline	Highly Important
Cloxacillin	Highly Important
Danofloxacin	Critically Important
Dicloxaccillin	Highly Important
Difloxacin	Critically Important
Enrofloxacin	Critically Important
Florfenicol	Highly Important
Lincomycin	Highly Important
Oxacillin	Highly Important
Oxolinic acid	Critically Important
Oxytetracycline	Highly Important
Spectinomycin	Highly Important
Sulfonamides	Highly Important
Tetracycline	Highly Important
Thiamphenicol	Highly Important
Tilmicosin	Critically Important
Trimethoprim	Highly Important
Tylosin	Critically Important

New insights since the last assessment was conducted in 2017 on shrimp farm chemical usage were not readily available in the literature. In the previous assessment, Banerjee et al. (2012) found evidence of pathogenic bacteria resistant to Critically and Highly Important antimicrobials (e.g., ampicillin, tetracycline and trimethoprim) on Malaysian shrimp farms or in their effluents, but the cause of antimicrobial resistance was not identified. Banerjee et al. (2012) speculated that sources of the resistance could have been the water used to fill the ponds (which was drawn from a river containing effluent from domestic and agricultural sources, both known to be carriers of antibiotic residues), and/or the post larvae (as a result of antibiotic use on the hatchery). Other studies, not included in the previous assessment (Hua and Apun 2013**,** Kathleen et al. 2016, and Letchumanan et al. 2019) identified antimicrobial resistance from shrimp pond production in Malaysia, but the cause of antimicrobial resistance is not necessarily attributed to on farm usage of antimicrobials. The Letchumanan et al. (2019) study sampled prawns, crabs, clams and shellfish from markets in Malaysia and found bacterial resistance to multiple antimicrobials (e.g., ampicillin, amikacin, and kanamycin), but the source of bacterial resistance was not identified. The Hua and Apun (2013) study sampled tiger shrimp, water, and sediment from aquaculture ponds in Malaysia between 2006 and 2008 and found bacterial resistance to multiple antimicrobials (e.g., ampicillin, tetracycline and nalidixic acid), although the cause of bacterial resistance is not explicitly stated but could, potentially, be due to antimicrobial usage in shrimp feed. While Kathleen et al. (2016) sampled bacteria from water, sediment and shrimp from a number of farms in Sarawak and found resistance to highly important and critically important antimicrobials (e.g., streptomycin, ampicillin, penicillin, erythromycin and cephalotin) and susceptible to gentamicin, chloramphenicol norfloxacin, and amikacin. The cause of resistance is unclear and may be due to other sources (e.g., water input), and/or residuals from historical usage since farmers denied the usage of any antimicrobials; importantly, 63.1% of the samples scored a MAR <0.2 *meaning the majority of bacterial samples did not exhibit significant resistance to multiple antibiotics and were taken from areas where high antibiotic usage or contamination is unexpected.* However, the remaining 36.9% of samples with MAR >0.2 indicate the opposite, exhibiting high levels of resistance to multiple drugs and expected to be sampled from areas where antibiotic usage or contamination is expected. The study by Kathleen et al. (2016) also identified no resistance to chloramphenicol, which is banned in Malaysia. Altogether, peer reviewed literature and studies detail some concern for the clinical resistance to chemical treatments, but it does not necessarily implicate the usage of critically and highly important antimicrobial usage on farms as the resistant bacteria could result from a multitude of sources.

The Malaysian government also claims shrimp export rejections for banned and illegal chemical use from the US are not due to farm usage, but rather due to transshipment. In 2017, a U.S. Immigration and Customs Enforcement investigation into the 88 Malaysian shrimp import rejections from January and August 2015 was reportedly ongoing and included the investigation of Chinese shrimp producers possibly shipping seafood through Malaysia (personal communication DOFM, 2017). The results of this investigation are unknown. In January of 2020, the USFDA red listed 11 Malaysian exporters due to the detection of chloramphenicol in 18 shipments of shrimp, and red listed another 28 Malaysian shrimp exporters due to the detection of nitrofurans from 56 shipments from 2009 and 2018 (The Straits Times, 2020). According to *The Straits Times* article, Deputy Agriculture and Agro-based Minister Sim Tze Tzin stated that the violations are due to transshipment. As evidence, the Singapore Food Agency (SFA) have not detected chloramphenicol or nitrofuran “in shrimp and prawns imported from Malaysia in 2019”, and the Fisheries Department Biosecurity Division test for antibiotics regularly from farms and "If the samples contain banned antibiotics, the farms will be sanctioned and their harvests will not be allowed to be exported," (quote by Deputy Agriculture and Agro-based Minister Sim Tze Tzin from The Straits Times, 2020). Overall, the USFDA rejected 426 shipments of shrimp from Malaysia from January 2014 to June 2021. There have only been two rejections in the past three years (one in 2018 for veterinary drug residue and one in 2017 for nitrofurans), though import volumes of Malaysian shrimp have declined considerably since 2014, peaking at roughly 17,000 mt in 2014 and never exceeding 1,000 mt since 2015. Thus, there remains concern with illegal veterinary drug contamination of Malaysian shrimp.

Criterion 4- Chemical Use Conclusion

Overall, chemical use on Malaysian shrimp farms is largely unknown. Antimicrobials Highly and Critically Important for Human Medicine are permitted, but there is no evidence of their actual on farm usage, or the lack thereof. There is concern of clinical resistance to chemical treatments as many studies have isolated bacteria taken from farm grown shrimp, pond water and sediment in Malaysia and found antimicrobial resistance to Highly and Critically Important antimicrobials for human medicine, but cause of antimicrobial resistance is not necessarily attributed to on farm usage of antimicrobials and may be explained by outside contamination. Additional concern is due to the red listing of 39 Malaysian shrimp exporters from the U.S. due to chloramphenicol and nitrofuran detection in shrimp samples, although Malaysian authorities blame transshipment of Chinese shrimp as the source.

As little new information is readily available since the 2017 assessment, a precautionary approach is utilized for scoring Criterion 4 – Chemical Use. While there is evidence of clinical resistance to antibiotics on and around shrimp farms, there is little evidence to conclusively determine whether antibiotics are used on farm or not, though some literature indicates they are not (a score of 4 out of 10). However, import rejections due to contamination with illegal antimicrobials such as nitrofurans and chloramphenicol were common when significant volumes of Malaysian shrimp were imported to the US, and continued despite dramatic reductions in import volumes, suggesting usage of illegal antibiotics beyond exceptional cases by farms or other elements of the supply chain (a score of 0 out of 10). As such, an intermediate score is justified, and a final score of 3 out of 10 is given for Criterion 4 – Chemicals for both whiteleg shrimp and giant tiger prawns.

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