



Monterey Bay Aquarium Seafood Watch

Environmental sustainability assessment of farmed Giant tiger prawn (*Penaeus monodon*) from Myanmar farmed using ponds



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Species: Giant tiger prawn (*Penaeus monodon*)
Location: Myanmar
Gear: Ponds
Type: Farmed
Author: Seafood Watch
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Assessed using [Seafood Watch Aquaculture Standard v3.2](#)

Final Seafood Recommendation

Criterion	Score	Rank	Critical?
C1 Data	5.91	YELLOW	
C2 Effluent	10.00	GREEN	NO
C3 Habitat	3.20	RED	NO
C4 Chemicals	10.00	GREEN	NO
C5 Feed	10.00	GREEN	NO
C6 Escapes	10.00	GREEN	NO
C7 Disease	8.00	GREEN	NO
C8X Source	0.00	GREEN	NO
C9X Wildlife mortalities	-3.00	GREEN	NO
C10X Introduced species escape	0.00	GREEN	
Total	54.11		
Final score (0-10)	7.73		

OVERALL RANKING

Final Score	7.73
Initial rank	GREEN
Red criteria	1
Interim rank	YELLOW
Critical Criteria?	NO

FINAL RANK
YELLOW

Scoring note – scores range from 0 to 10, where 0 indicates very poor performance and 10 indicates the aquaculture operations have no significant impact. Criteria 8X, 9X and 10X are exceptional criteria, where 0 indicates no impact and a deduction of -10 reflects a very significant impact. Two or more Red criteria result in a Red final result.

Summary

The final numerical score for *P. monodon* produced in extensive production systems in Myanmar is 7.73 out of 10, which is in the green range, but with one red criterion (Habitat) the final recommendation is a Yellow “Good Alternative”.

Executive Summary

Shrimp is the most popular type of seafood eaten in the United States; per capita consumption in 2015 was 1.8 kilograms (kg). Over 90% of this shrimp was farmed overseas, predominantly in Southeast Asian countries. In 2015, 446 metric tons (MT) of shrimp, with a value of USD 8 million, was imported into the USA from Myanmar; in 2016, Myanmar imports dropped to 174 MT, with a value of USD 2.74 million.

The Republic of the Union of Myanmar, also known as Burma, is the largest country in mainland Southeast Asia, although it is also one of the least densely populated nations in the region with a current population of around 54 million. Myanmar's GDP in 2016 was USD 67.43 billion. It shares its border with Bangladesh, north-eastern India, China, Laos, and Thailand and has a 2,832 kilometers (km) coastline that stretches from the Bay of Bengal in the north to the Andaman Sea in the south. With this extensive coastline, Myanmar has access to diverse marine fishery resources and, with around 8.2 million hectares (ha) of inland water bodies, it also benefits from an abundance of inland fisheries. Shrimp farming in Myanmar takes place in three main regions: Rakhine, Ayeyarwady, and Yangon.

Most of the shrimp cultured in Myanmar are *Penaeus monodon* (giant tiger prawn, also known as black tiger shrimp). FAO data indicate a national production volume of 49,891 MT during 2015, positioning Myanmar as the sixth-highest (7% of total) global aquaculture producer of this species. Production of *P. monodon* in Myanmar relies almost exclusively on extensive production techniques. *Macrobrachium rosenbergii* (giant freshwater prawn) and *Litopenaeus vannamei* (whiteleg shrimp) are also cultured, although to a much lesser extent. The following report shall focus on assessing the production of *P. monodon* in Myanmar only, since the production volumes and target markets of the *M. rosenbergii* and *L. vannamei* sectors bear little relevance to the US marketplace at present.

Fully accurate production figures are not readily available from the Myanmar shrimp farming sector at present; indeed, there is a dearth of publicly accessible information pertaining to this sector in general. This situation, however, is not surprising: Myanmar has only recently emerged from many years of military rule (1962 to 2011), isolation, economic stagnation and civil unrest; in February 2016, a new parliament was formed with an elected, non-military president at its head. In addition to this backdrop of social turmoil, Myanmar regularly suffers from violent tropical cyclones and floods; of particular note in recent years was cyclone Nargis, which hit Myanmar in 2008 killing over 138,000 people.

This Seafood Watch assessment involves a number of different criteria covering impacts associated with: effluent, habitats, wildlife and predator interactions, chemical use, feed production, escapes, introduction of secondary organisms (other than the farmed species), disease, the source of stock, and general data availability. A summary of each assessed aspect is given below.

Data

Although there is not an abundance of literature available on the *P. monodon* farming sector in Myanmar, overall data quality has been assessed as “moderate.” The subject data available were considered adequate to provide a reasonably accurate and contemporary picture of the shrimp farming situation in Myanmar. In areas where specific industry literature was lacking, proxy data from equivalent farming scenarios were utilized, with the confidence that they paralleled the situation in Myanmar reliably. Although data were generally considered to be adequate and accurate for the purpose of preparing this assessment, official production figures were found to be clearly questionable, a fact which was kept in mind while compiling this report. The score for Criterion 1 – Data is 5.9 out of 10.

Effluent

The two main aquaculture inputs that contribute to nutrient loading are feed and fertilizer, and it is well documented that extensive *P. monodon* farmers in Myanmar use virtually none of these. Although specific studies pertaining to shrimp farm effluents in Myanmar have not been identified, ample data on this topic are available from relatively equivalent farming scenarios in neighboring Bangladesh. These data demonstrate that extensive shrimp farms typically act as a nutrient sink, removing nutrients from the environment. Since evidence demonstrates that effluent discharges from extensive shrimp farms do not cause or contribute to cumulative impacts at the regional or waterbody scale, the final score for Criterion 2 – Effluent is 10 out of 10.

Habitat

Primary conversion of mangroves to *P. monodon* farming is not the industry norm in Myanmar, although such land conversion has occurred historically. Shrimp farms have more typically been sited on land that had previously been cleared of mangroves in the process of wood collection and rice production. Although the government of Myanmar has good intentions toward the promotion of environmentally sound practices in shrimp farming, habitat conservation is clearly an area of underachievement for the industry; current legislation and management measures are poorly implemented and enforced and do not encompass habitat connectivity and cumulative ecosystem impacts. The final Criterion 3 – Habitat score for *P. monodon* farms in Myanmar is 3.2 out of 10.

Chemical Use

There is little data that specifically pertains to chemical use in *P. monodon* culture in Myanmar, but this is evidently because extensive production methodologies use zero or minimal inputs, including chemical inputs. This perspective on extensive shrimp culture is borne out by data collected from equivalent farming situations in other Asian nations, which have been studied in more detail. Due to the absence, or limited use, of chemicals in *P. monodon* production in Myanmar, the final score for Criterion 4 – Chemical Use is 10 out of 10.

Feed

The extensive so-called “trap and hold” system of *P. monodon* production employed by shrimp farmers in Myanmar does not utilize any supplementary feeds or fertilizers. Stocking densities

are low enough that the natural carrying capacity of the pond is not exceeded, and shrimp are sustained adequately by the naturally occurring biota of the pond. Since external feeds are typically not used, the final score for Criterion 5 – Feed is 10 out of 10.

Escapes

There are no data available demonstrating escapes from *P. monodon* ponds in Myanmar, but the risk of shrimp escaping from extensive production systems is high because the areas in which ponds are sited frequently experience flooding. Further escape risk arises from the water exchange activities necessary to facilitate natural recruitment of PLs; the retention of shrimp that are already growing in the pond is reliant on the effective installation of a suitable net placed across the sluice gate entrance. However, since shrimp that do escape from culture ponds have mainly been stocked through this method of passive (i.e., tidal) influx, densities are equivalent to those found in the wild, and those PLs that have not been stocked through this technique have either been collected from the wild or are the first-generation progeny from wild broodstock. This means that the likelihood of competitive or genetic disturbance caused by escapees from *P. monodon* farms in Myanmar is very low. The final score for Criterion 6 – Escapes is 10 out of 10.

Disease; Pathogen and Parasite Interactions

Many recently discovered marine shrimp pathogens are now endemic throughout warm-water shrimp-producing regions of the world, including Myanmar. The three main pathogens affecting *P. monodon* in Myanmar are white spot syndrome virus (WSSV), Taura syndrome virus (TSV) and yellow head virus (YHV). It is likely that these viruses entered Myanmar during a brief attempt at intensification of the shrimp farming sector during the early 2000s, although there is also evidence that these pathogens are endemic in wild shrimp populations in the contiguous waterbodies that Myanmar shares with its neighbors, Thailand and Bangladesh. *P. monodon* farms in Myanmar generally use extremely extensive production techniques; since nearly all PLs stocked in ponds are recruited naturally via tidal flow, on-farm diseases are likely introduced from the wild, and stocking densities are similar to those found in nature. The combination of still-present disease occurrence and concern with extensive production characteristics ultimately present a moderate-to-low risk of on-farm pathogen and parasite dynamics impacting wild populations. This results in a final score for Criterion 7 - Disease of 8 out of 10.

Source of Stock

P. monodon production in Myanmar is almost solely dependent upon naturally recruited, wild post larvae (PLs), which passively flow into the culture pond on the influx of a rising tide. Natural disasters, disease and a lack of investment and infrastructure have taken their toll on the hatchery sector, and it would seem that shrimp hatcheries are presently supplying less than 1% of industry requirements. Furthermore, declines in wild *P. monodon* broodstock are evident; in 2012 researchers reported that catch rates were apparently half of what they had been in 2000. A decline in the abundance of wild *P. monodon* post larvae has also been ongoing since at least 2007 and by 2012 wild PL collectors were reportedly catching around just 5 to 10% of what they had been able to collect 10 years earlier. As a result, wild-collection has been curtailed and does not appear to be an active source of fry at present. Since the vast majority of

seed stock used by the *P. monodon* sector in Myanmar arises from the mechanism of passive influx, the final score for Criterion 8X – Source of Stock – is 0 out of –10.

Wildlife and Predator Mortalities

The impact of highly extensive *P. monodon* farming on predators and other wildlife species in Myanmar would appear to be low, and no population-level impacts have been reported. These indicators suggest that such mortalities present a “low” concern; however, poor data availability makes it impossible to confirm that these are limited to exceptional cases. The final score for Criterion 9X – Wildlife and Predator Mortalities is therefore –3 out of –10.

Escape of Secondary Species

All of the PLs stocked by the *P. monodon* sector in Myanmar are of domestic origin; therefore, there is no risk of unintentionally introduced species escaping and impacting wild native populations because of the international and trans-waterbody movement of animals. The score for Criterion 10X – Escape of Unintentionally Introduced Species is therefore 0 out of –10.

Summary

The final numerical score for *P. monodon* produced in extensive production systems in Myanmar is 7.73 out of 10, which is in the green range, but with one red criteria (habitat) the final recommendation is a Yellow “Good Alternative.”

Table of Contents

Final Seafood Recommendation.....	2
Executive Summary.....	3
Introduction	8
Scope of the analysis and ensuing recommendation	8
Analysis	16
Scoring guide.....	16
Criterion 1: Data quality and availability	17
Criterion 2: Effluent	22
Criterion 3: Habitat	25
Criterion 4: Evidence or Risk of Chemical Use.....	37
Criterion 5: Feed	40
Criterion 6: Escapes	43
Criterion 7: Disease; pathogen and parasite interactions.....	47
Criterion 8X: Source of Stock – independence from wild fisheries.....	53
Criterion 9X: Wildlife and predator mortalities.....	57
Criterion 10X: Escape of secondary species	59
Overall Recommendation	61
Acknowledgements.....	62
References	63
About Seafood Watch®	77
Guiding Principles	78
Appendix 1 - Data points and all scoring calculations	80

Introduction

Scope of the analysis and ensuing recommendation

Species

Giant Tiger Prawn (Black Tiger Shrimp), *Penaeus monodon*

Geographic Coverage

Myanmar

Production Method

Ponds

Myanmar Aquaculture Overview

According to recent Department of Fisheries (DoF 2015) figures, aquaculture production in Myanmar covers approximately 184,000 ha (455,513 acres); this area is split fairly evenly between shrimp and fish culture, with shrimp taking up just 1,038 ha more than fish. Shrimp farming occurs in three main regions: Rakhine (68%), Ayeyarwady (25%) and Yangon (4.5%). By comparison, the main fish farming areas are Ayeyarwady (51%), Yangon (26%), and Bago (12%). It should be noted, however, that aquaculture production in Myanmar is dominated by production of freshwater finfish, particularly the carp species rohu (*Labeo rohita*), which is produced in semi-intensive production systems. Belton et al. (2015) note that cultured shrimp comprised just 5.6% of all reported national aquaculture production in 2013, and in 2010, 54% of reported shrimp production was cultured with the balance coming from wild capture.

Statistics from DoF unfortunately do not disaggregate aquaculture production data; however, the total aquaculture production for 2014 to 2015 (April 1 to March 31) was reportedly 999,630 MT (predominantly fish). For the same reporting period, over 17,527 MT of “prawn”¹ was exported; yet, the percentage of farmed product included in this quantity is unclear. USDA figures indicate that the total volume of shrimp imported into the US from Myanmar in 2015 was 446 MT, with a value of USD 8 million; in 2016, imports dropped to 174 MT, with a value of USD 2.74 million.

Most of the shrimp cultured in Myanmar are *Penaeus monodon* (giant tiger prawn aka black tiger shrimp). *Macrobrachium rosenbergii* (freshwater prawn) and *Litopenaeus vannamei* (whiteleg shrimp) are also cultured, although to a much lesser extent. Production of *P. monodon* in Myanmar relies almost exclusively on extensive production techniques, as does *M. rosenbergii* production, which frequently takes place in a polyculture or rice-fish culture environment. At present, there is limited production of *M. rosenbergii*; wild capture is in decline as is the availability of wild PLs and the aquaculture production of this species

¹ Note that the terms “shrimp” and “prawn” are often used interchangeably; herein, the DoF term “prawn” and the USDA term “shrimp” refers to both marine shrimp and freshwater prawn.

amounted to just 2,329 MT in 2015, as per FAO data. By comparison, FAO data indicate a national production volume of 49,891 MT of *P. monodon* for the same year (however, it should be noted that this quantity exceeds other estimates and includes a small, indeterminate amount of *L. vannamei*). The following chart shows the shrimp production volumes that were reported to the FAO between 1996 and 2015; as is evident, the quantity of *M. rosenbergii* produced has historically been extremely low in comparison to that of *P. monodon*.

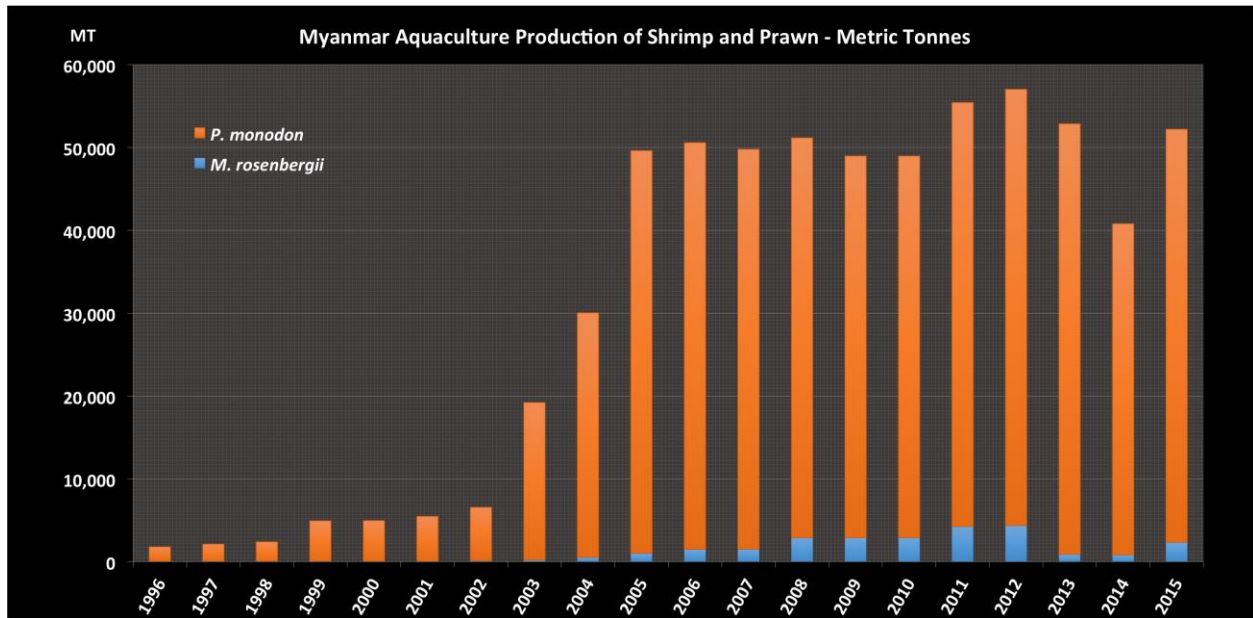


Figure 1: Total aquaculture production of *P. monodon* and *M. rosenbergii* in Myanmar between 1996 and 2015; note that all quantities for 2002 to 2004 are estimates, as are the production volumes for *M. rosenbergii* from 2005 to 2007 (FAO 2017, Fishery and Aquaculture Statistics. Global aquaculture production, Quantity [1950 to 2015], FishstatJ).

Although semi-intensive culture of *L. vannamei* commenced in Myanmar in the early 2000's, a variety of factors have hampered the development of this sector and at the present time only two large companies are culturing this species, with an estimated, combined production volume of 5,500 MT, according to the advice of an in-country expert, who also commented that both companies sell their production to Thailand.

Since the production volumes and target markets of the *M. rosenbergii* and *L. vannamei* sectors bear little relevance to the US marketplace at present, this report only focuses on assessing the production of *P. monodon*.

Brief Overview of *P. monodon*

P. monodon is a tropical marine shrimp, which is indigenous to Myanmar; it is found naturally in the Indian Ocean and the western Pacific (Indo-West Pacific) with a distribution range that includes much of Asia and reaches as far north as Japan and North Korea, and as far south as Australia. The FAO online species profile for *P. monodon* describes their preferred habitat to be brackish, estuarine environments, where they inhabit bottom mud or sand, and states that they

can tolerate a range of salinities from 5 to 45 parts per thousand (ppt) and temperatures between 18 to 35.5 °C. Although they can be cultivated commercially at salinities of 1 to 5 ppt, the optimal range is 15 to 25 ppt. *P. monodon* begins life offshore; this planktonic larval stage lasts 2 to 3 weeks, after which the larvae migrate towards the coast to the protection of mangrove swamps and estuaries where, over the next 6 months, they will complete their benthic post-larval and juvenile phases. They return to deeper water as adolescents and when ready to spawn, their depth range is 0 to 110 meters (m). *P. monodon* can grow to over 33 centimeters (cm), making it the largest shrimp that is commercially available. They get their common names, black tiger shrimp or giant tiger prawn, from the distinctive black and white bands that extend around their carapace and abdomen.

Production System

Production of *P. monodon* in Myanmar is almost exclusively reliant on the so-called “trap and hold” extensive method. Although efforts have been made towards hatchery provision of PLs, farmers mainly rely on naturally recruited, wild juveniles that become “trapped” in the pond after being carried in through sluice gates on a high tide. Gates are typically opened every two weeks, when the new and full moon produce the greatest tidal exchange, and shrimp already in the pond are retained by a net spanning the pond opening when water is discharged during the low/falling tide. This stocking method has been used in Myanmar since the mid-1970s when shrimp farming first commenced on the western coast (BOBLME 2014).

These traditional methods are low-maintenance and typically do not involve any inputs for reasons of pond preparation, chemical therapeutants, predator exclusion, fertilization, or external feeds, with cultivated shrimp deriving their nutrition solely from the naturally occurring phytoplankton and zooplankton in the pond (DoF 2015). The three western regions where most shrimp culture takes place (97.5%) are indicated on the country map in Figure 2.

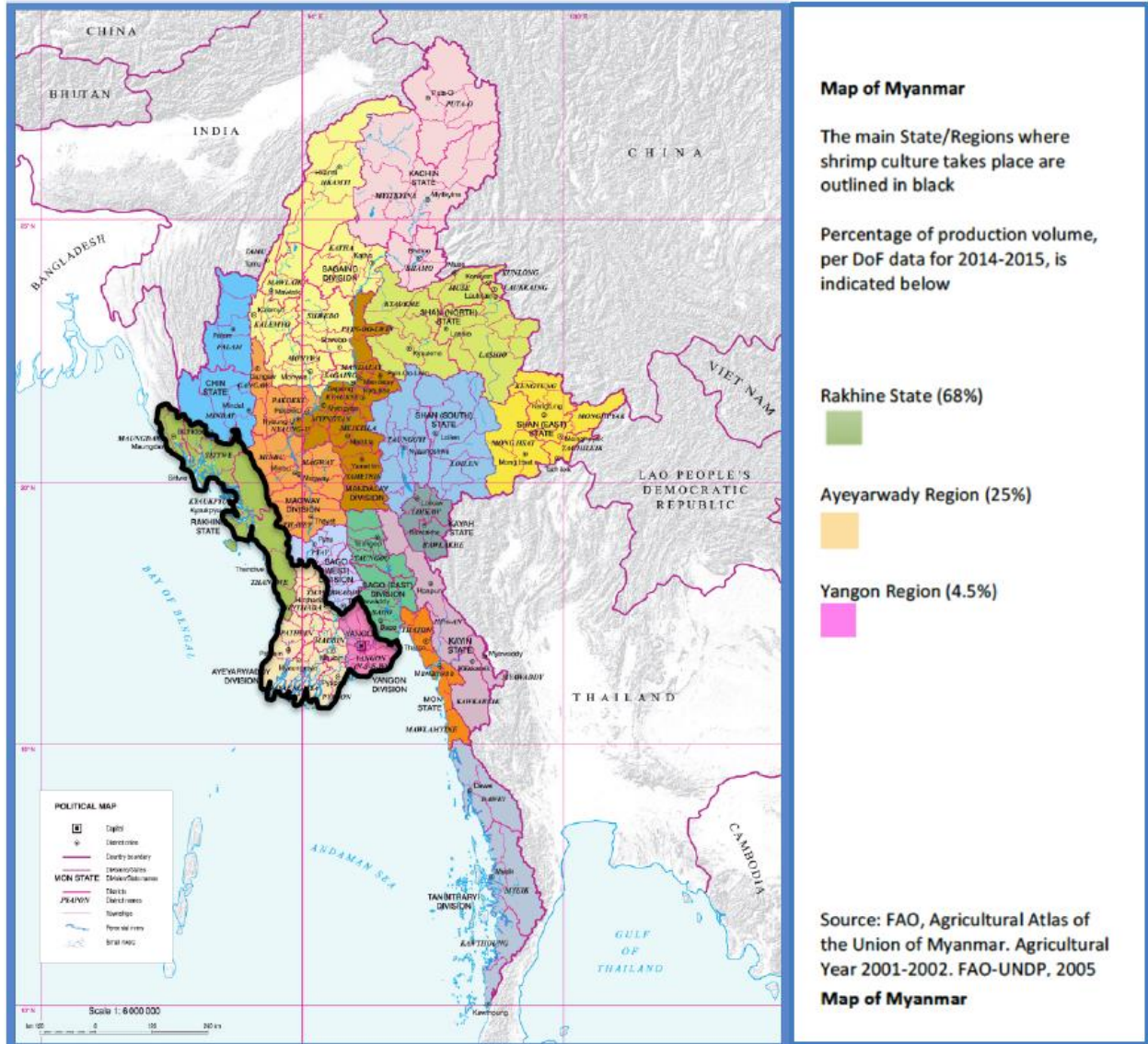


Figure 2: Map of Myanmar showing the three country regions where shrimp culture takes place.

Production Statistics

Using the FAO *P. monodon* production data for 2015 (49,891 MT),² Myanmar ranks globally as the sixth-highest (7% of total) aquaculture producer of *P. monodon*, as is shown in Table 1. However, local in-country experts, suggest that this volume may be over-stated, estimating that 30,000 MT is likely a more accurate statistic (pers. comm. U Soe Tun, May 2017 and STIP 2017); using this figure instead, Myanmar would be the seventh-highest producer, supplying 4.3% of global *P. monodon* production (taking into consideration the almost 20,000 MT drop in production that this adjustment implies).

Table 1: Global top ten producers of farmed *P. monodon* in 2015 (FAO 2017, Fishery and Aquaculture Statistics. Global aquaculture production, Quantity [1950 to 2015], FishstatJ).

Global Top Ten Producers of Farmed <i>P. monodon</i> in 2015			
Rank	Country	MT	% of Total Production
1	Vietnam	223,438	31.3
2	Indonesia	127,626	17.9
3	India	82,043	11.5
4	China	75,682	10.6
5	Bangladesh	75,274	10.6
6	Myanmar	49,891	7.0
7	Philippines	49,527	6.9
8	Thailand	14,465	2.0
9	Sri Lanka	7,090	1.0
10	Malaysia	4,286	0.6
	Others	3,996	0.6
	Global TOTAL	713,318	100.0

² It should be noted that Myanmar currently reports all marine shrimp to FAO together as “giant tiger prawn” and FAO acknowledges that a small quantity of *L. vannamei* is included in this amount (pers. comm. Xiaowei Zhou, FAO Aquaculture Statistician, 19 April 2017).

The reported production volumes of *P. monodon*, farmed in Myanmar between 1996 and 2015, and their respective values are illustrated in Figure 3.

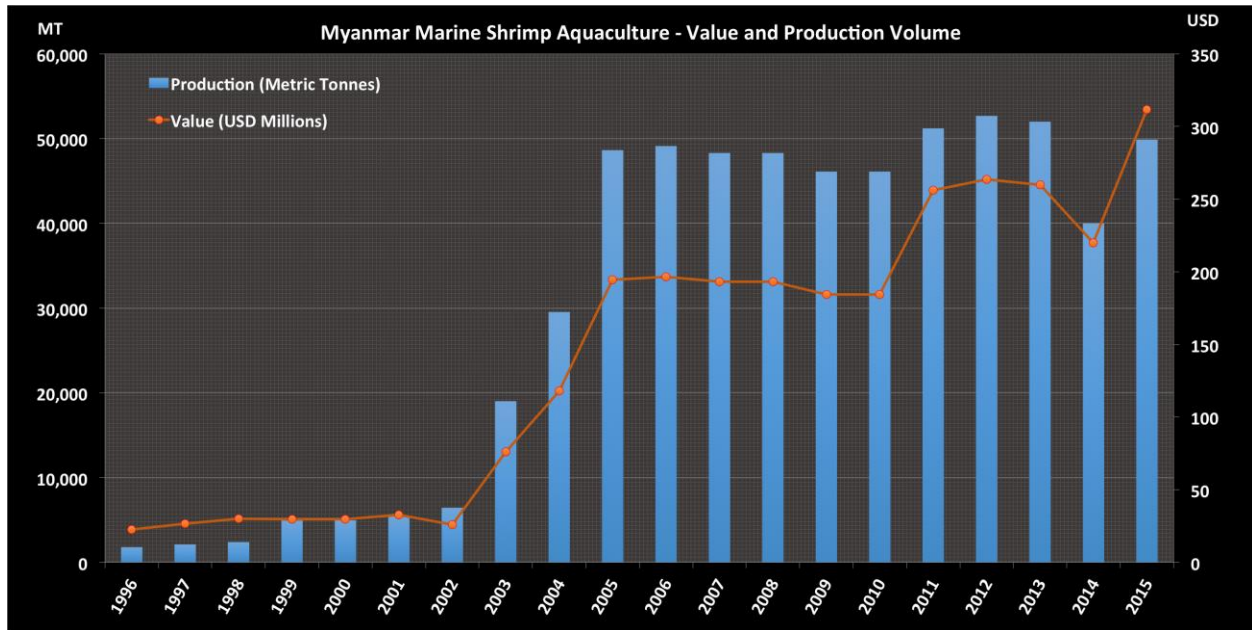


Figure 3: Value and quantity of aquaculture production of *P. monodon* in Myanmar between 1996 and 2015 (FAO 2017, Fishery and Aquaculture Statistics. Global aquaculture production, Value [1984 to 2015] and Quantity [1950 to 2015], FishstatJ).

Import and Export Sources and Statistics

United States Department of Agriculture (USDA) figures indicate that the total volume of shrimp imported into the US in 2016 was 603,360 MT and, of this amount, just 174 MT came from Myanmar. This volume represented just under 0.03% of total US shrimp imports for the year, with a value of USD 2,742,181. As a result of sanctions, there were no imports of shrimp from Myanmar into the US between 2004 and 2012. It should be noted that prior to sanctions, the USDA records show substantially higher import volumes from Myanmar; for example, in 2002, 2,850 MT, with a value of USD 24 million, were imported. The USDA reports that imports in 2014 were 814 MT (USD 13 million) and in 2015, 446 MT (USD 8 million). The DoF record that 500 MT of prawn were exported to the US during the period 2014 to 2015 (1 April to 31 March), with a reported value of just under USD 2 million. It is assumed that the evident disparity between the USDA and DoF values per kg is due to the former expressing retail value and the latter reporting farm-gate value.

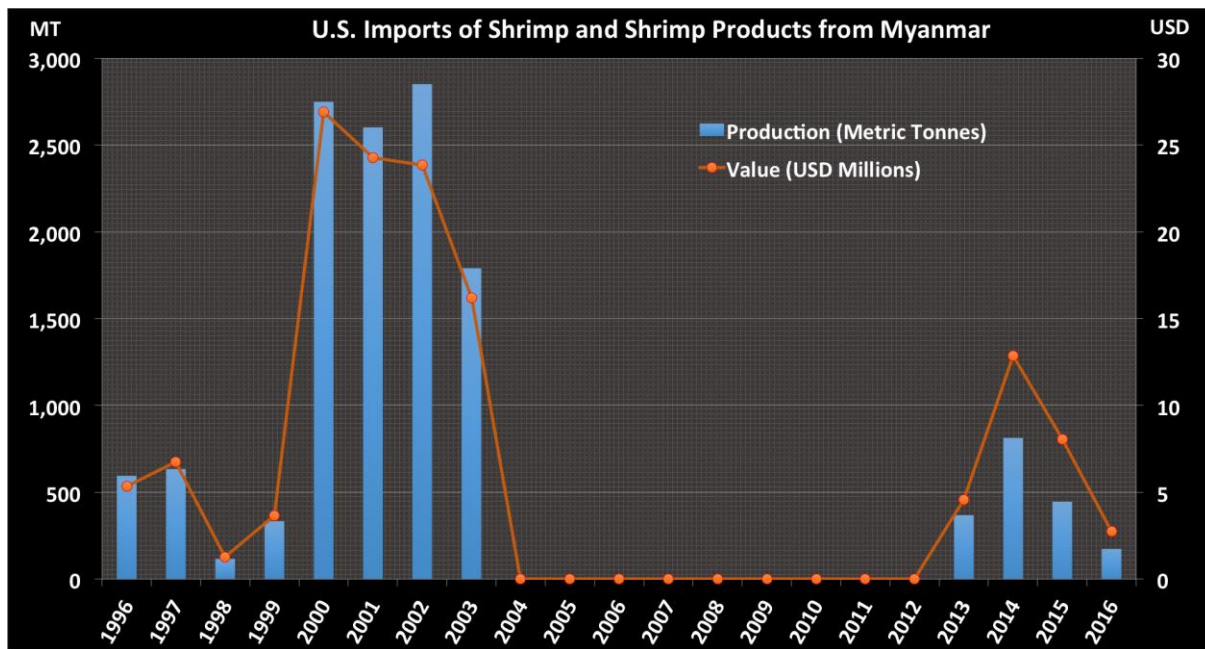


Figure 4: Quantity and value of all shrimp and prawn products (note that the USDA do not differentiate between shrimp and prawn) imported into the U.S. from Myanmar between 1996 and 2016 (USDA Economic Research Service)

A Note on *L. vannamei*'s Effect on US Market Demand for *P. monodon*

Although Myanmar may be ranked as one of the main producers of farmed *P. monodon*, this fact must be considered within the wider context of global shrimp production. FAO data indicate that the total global production of *P. monodon* in 2015 was 713,318 MT; in comparison, the global production of *L. vannamei* was 3,879,786 MT, more than five times as much (Figure 5). In other words, in 2015, Myanmar contributed just over 1% to the combined global production of *P. monodon* and *L. vannamei*. The recent surge in production of *L. vannamei* has resulted in this species becoming highly commoditized in recent years and the subsequent lack of parity in production levels between the two species has had far reaching ramifications for *P. monodon* in the US marketplace. The intensive methods used to farm *L. vannamei* have resulted in greater economies of scale and accelerated production volumes for those farmers who culture this species. Although still occupying the top three spots on the ranking chart above (Table 1), India, Vietnam, and Indonesia are currently producing much less *P. monodon* than they did in the recent past, focusing their efforts instead on the more lucrative returns offered by *L. vannamei* (FAO 2016a). One US importer recently commented that: "... low availability and high prices are causing black tigers to slowly become irrelevant, at least in terms of influencing the market for commodity shrimp" (Undercurrent News – 29 May 2017).

Farming of *L. vannamei*, a non-native species, has occurred in Myanmar since the early 2000's but, unlike *P. monodon* and *M. rosenbergii* culture, modern *L. vannamei* farming relies on semi-intensive and intensive production systems, which require considerable capital investment and infrastructure, neither of which have been forthcoming in the social and economic climate of

Myanmar in recent years. Two particularly destructive cyclones, Nargis and Giri in 2008 and 2010 respectively, had an extremely detrimental effect on the development of all types of shrimp farming in Myanmar, inflicting enormous damage on the land, its people, and the economy. As a result, the shrimp farming sector has many challenges to overcome in order to realize its full potential; however, with the political situation stabilizing, it may be on track to tackle these challenges (STIP 2017). Currently, there are only two companies producing *L. vannamei*, with an output of approximately 5,500 MT per annum, much of which is sold across the border into Thailand (pers. comm., U Soe Tun, May 2017).

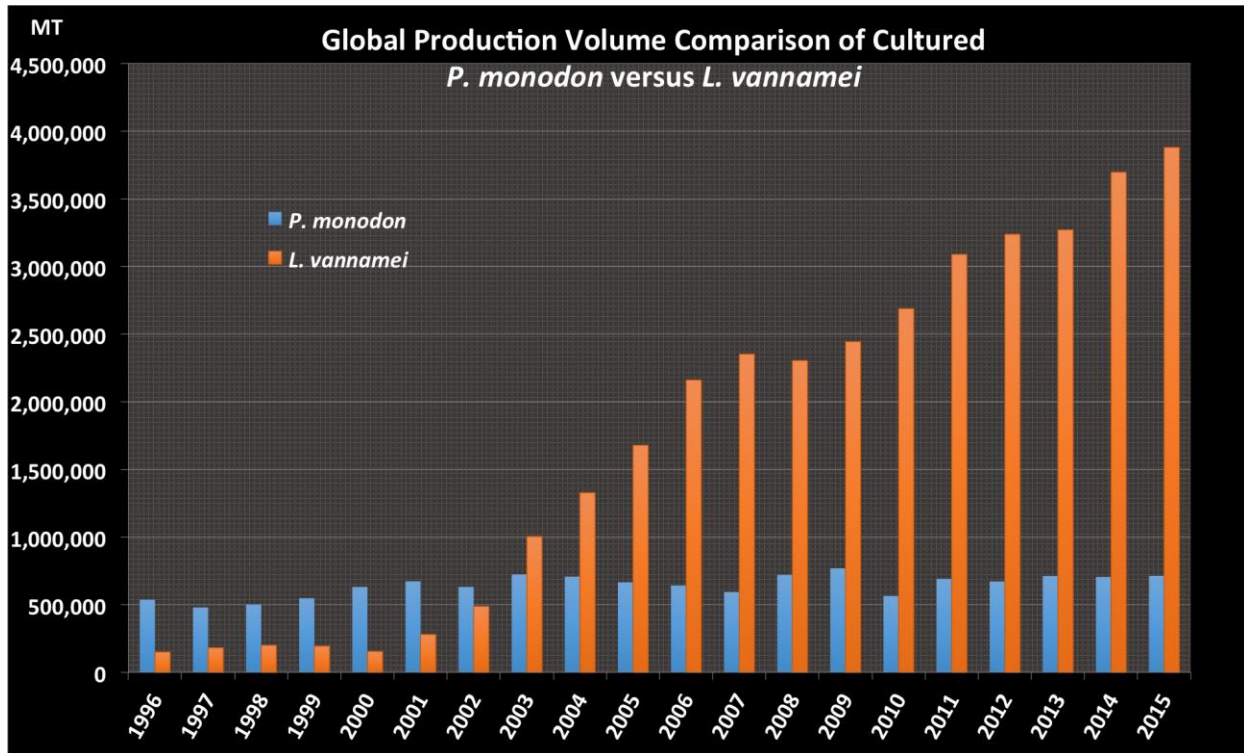


Figure 5: Comparison of total global aquaculture production of *P. monodon* and *L. vannamei* between 1996 and 2015 (FAO 2017, Fishery and Aquaculture Statistics. Global aquaculture production, Quantity [1950 to 2015], FishstatJ).

Common and Market Names

Scientific Name	<i>Penaeus monodon</i>
Common Name	Black tiger shrimp, black tiger prawn, Asian tiger shrimp, tiger shrimp, tiger prawn, giant tiger prawn; known as Kyar-pazun in Myanmar

Product Forms

Frozen: larger sized shrimp are IQF (individually quick frozen), whereas smaller sizes are shipped block frozen.

Analysis

Scoring guide

- With the exception of the exceptional criteria (8X, 9X and 10X), all scores result in a zero to ten final score for the criterion and the overall final rating. A zero score indicates poor performance, while a score of ten indicates high performance. In contrast, the three exceptional criteria result in negative scores from zero to minus ten, and in these cases zero indicates no negative impact.
- The full Seafood Watch Aquaculture Standard that the following scores relate to is available on the Seafood Watch website <http://www.seafoodwatch.org/seafood-recommendations/our-standards>

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: having robust and up-to-date information on production practices and their impacts publicly available.

Criterion 1 Summary

Data Category	Data Quality	Score (0-10)
Industry or production statistics	2.5	2.5
Management	5	5
Effluent	7.5	7.5
Habitat	7.5	7.5
Chemical use	7.5	7.5
Feed	7.5	7.5
Escapes	7.5	7.5
Disease	5	5
Source of stock	5	5
Predators and wildlife	2.5	2.5
Introduced species	7.5	7.5
Other – (e.g. GHG emissions)	Not Applicable	n/a
Total		65

C1 Data Final Score (0-10)	5.9	YELLOW
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Brief Summary

While there is not an abundance of literature available on the *P. monodon* farming sector in Myanmar, overall data quality has been assessed as “moderate” for the purpose of preparing this report. The subject data available were considered adequate to provide a reasonably accurate and contemporary picture of the shrimp farming situation in Myanmar. In areas where specific industry literature was lacking, proxy data from equivalent farming scenarios were utilized, with the confidence that they paralleled the situation in Myanmar reliably. Although data were generally considered to be adequate and accurate for the purpose of preparing this assessment, official production figures were found to be clearly questionable, a fact which was kept in mind while compiling this report. The score for Criterion 1 – Data is 5.9 out of 10.

Justification of Rating

A number of authors have commented on the lack of data available on the aquaculture sector in Myanmar. Portley (2016), for example, in her report on the Asian shrimp sector, notes: *“Myanmar proved a difficult country to gather data for. Published information on particular fisheries and farms is limited, and local experts are also wary of sharing unpublished information with outsiders.”* Similarly, Belton et al. (2015), in their field survey report on the farmed fish value chain in Myanmar, comment: *“Literature on aquaculture in Myanmar is sparse. A review conducted for this study identified a total of 15 English language publications; all of them grey literature, with the exception of a single peer reviewed article.”*

The following discusses the data quality, availability and credibility for each of the topics and environmental criteria covered in the report.

Industry/Production Statistics

Although the volume of literature on Myanmar is not great, it was considered to range between moderate to moderate-high in terms of its quality, availability and credibility for the purposes of this assessment. However, there is one particular aspect of data that needs to be highlighted for its lack of credibility: production volume statistics. This issue is explained well by Svennevig and Lwin (2016) who conducted a study into potential investment opportunities in aquaculture in Myanmar. They noted that the *P. monodon* production volume reported by DoF for 2014 was 40,000 MT (FAO 2017) while the production area for 2013 to 2014 was approximately 92,400 ha (DoF 2015), which equates to an average yield of around 432/kg/ha. However, when they visited Rakhine State, the main *P. monodon* producing region, they were informed that most ponds were not in use due to the impact of white spot disease between 2003 to 2010 and that: *“Those still in use would only be able to produce an average of 5–10 kg per ‘4 month’ crop/acre or 25–70 kg/ha/year with 2 crops due to the monsoon season. Before the white spot disease, the extensive farms produced 30–50 kg/acre (200 kg/ha).”* These production levels are very much on par with the 15–70 kg/ha/year reported by Joffre & Aung (2012) for Rakhine State in 2011. In addition to pointing out that these production figures do not tally with official statistics, Svennevig and Lwin further note that DoF’s annual production statistics have not changed much since 2005, remaining between 40 to 50,000 MT each year, despite the disease and natural disasters that have evidently impacted the sector from time to time.

Data discrepancies in Myanmar’s shrimp production figures have been noted by a number of sources (STIP 2017, Portley 2016, Svennevig and Lwin 2016) and a weakness in the country’s data collection methods has also been identified. The following is an excerpt from FAO’s 2016 *“The State of World Fisheries and Aquaculture 2016,”* which discusses the reliability of wild capture statistics from Myanmar:

Data quality remains a concern for some major producers. Marine catches reported by Indonesia and Myanmar have increased markedly and continuously in the last 20 years. However, the fact that reported capture production did not decline significantly or continued to increase when natural disasters occurred (e.g., the tsunami of December 2004 and Cyclone Nargis in May 2008) made FAO concerned about the reliability of their

official statistics” ... “For Myanmar, recent findings by FAO have shown that official statistics were based on target levels rather than on real data collection. FAO is now in contact with the Myanmar’s Department of Fisheries both to run a pilot project to improve data collection in one region (with a view to extending this to the whole country), and to revise together the official capture production figures for the last 10–15 years (FAO 2016b).

A final low-to-moderate score of 2.5 out of 10 has been assessed for data availability and quality as it pertains to industry and production statistics.

Management and Regulations

Although some informative data is available on the national regulatory requirements and laws that govern Myanmar’s aquaculture industry, key information is missing. Although data on the duties and functions of the Department of Fisheries (DoF) aquaculture division are available, they are very brief and do not go into any detail. Similarly, although the DoF states that since 2011 they have adopted Good Aquaculture Practices (GAP) as a national standard in shrimp and fish farming, this document does not appear to be publicly available. Data on the implementation and enforcement of regulations at the individual farm level are lacking as is data on area-based or cumulative impact measures. A final score of 5 out of 10 has been assessed for data availability and quality as it pertains to management and regulations.

Effluent

The two main aquaculture inputs that contribute to nutrient loading are feed and fertilizer, and it is well documented in literature that extensive *P. monodon* farmers in Myanmar use virtually none of these. This fact has been further verified through farm-level surveys and personal communications with aquaculture experts who have visited domestic shrimp farms. Specific studies pertaining to shrimp farm effluents in Myanmar have not been identified; however, robust data on this topic is available from similar farming scenarios in neighboring Bangladesh. A final score of 7.5 out of 10 has been assessed for data availability and quality for Criterion 2 – Effluent.

Habitat

Myanmar is located in the Indo-Burma Hotspot, an area of exceptional but threatened biodiversity. Due to the significance of the varied habitats present in the country, there is a great deal of literature available on this aspect of Myanmar. In addition to its location in a biodiversity hotspot, Myanmar has also attracted the attention of numerous NGOs in recent years, both due to its ongoing political transformation and also because of aid efforts in the wake of natural calamities. As a result, there is a great deal of information available publicly on the efforts of these NGOs in Myanmar. Several studies were identified which specifically monitored and evaluated the impact of the *P. monodon* farming sector on deforestation, hence, the data available on this subject is considered robust. A final score of 7.5 out of 10 has been assessed for data availability and quality as it pertains to Criterion 3 – Habitat.

Chemical Use

There are few data available that pertain specifically to evidence or risk of chemical use in *P. monodon* farming in Myanmar; however, this is due to an actual lack of chemical usage in the sector rather than a lack of transparency. Literature and farm survey data that do specifically describe the industry mention and show that extensive shrimp culture in Myanmar uses practically zero chemical inputs, and these data sources provide a high degree of confidence that the information they provide is both correct and up-to-date; of particular note is a recent, USAID sponsored report, which is part of the Michigan State University (MSU) International Development Paper series. In addition to these data sources, which specifically refer to chemical use in Myanmar aquaculture, other literature is also available that contains robust data on fairly comparable farming scenarios in neighboring Bangladesh, which further corroborates the fact that chemical use in extensive *P. monodon* farms is very minimal. A final score of 7.5 out of 10 has been assessed for data availability and quality for Criterion 4 – Chemical Use.

Feed

External feeds are typically not used in extensive *P. monodon* culture and there is a great deal of general literature on shrimp aquaculture that supports the fact that extraneous feed is generally not used in this type of production system. Further to this, various data sources (white papers, personal communications) that are specifically focused on *P. monodon* culture in Myanmar note that supplementary feed is generally not used in domestic culture of this species. A final score of 7.5 out of 10 has been assessed for data availability and quality as it pertains to Criterion 5 – Feed.

Escapes

While there are no data or information sources available that specifically quantify escape events from *P. monodon* farms in Myanmar, or that describe the regulatory or producer-level management of escapes, it is apparent from literature on the sector that Myanmar's shrimp culture areas are extremely flood-prone and escapes inevitably occur. Regarding the ecological impact of potential escapees, again there is not a wealth of data available, but the information that is available is considered to be up-to-date, complete, and accurate in relation to this assessment. The data pertaining to this criterion is therefore considered to be of moderate-to-high quality in terms of its availability and content. This results in a data score of 7.5 out of 10 for Criterion 6 – Escapes.

Disease; Pathogen and Parasite Interactions

Not much literature is available specifically dealing with the risk of pathogens and parasites on *P. monodon* farms in Myanmar becoming amplified and re-transmitted to local wild species sharing the same water body. Although there is some good information on diseases that are prevalent in shrimp farming in Myanmar and in the Asia Pacific region in general, this data does not provide a comprehensive overview of the present status of disease within the domestic *P. monodon* sector. Since data availability and quality has been assessed as “moderate,” a final score of 5 out of 10 has been assigned to Criterion 7 – Disease.

Source of Stock

While no data was identified that scientifically assessed the current status of wild *P. monodon* stocks in Myanmar, there was enough general data availability to determine that these stocks have declined markedly over the last 15 years. Particularly helpful in assessing this criterion were a number of FAO documents from various years spanning this timeline, which enabled a comparative analysis of the industry over this period, including information pertaining to the varying sources of PLs used by the industry throughout its history. Also of great help was data contained in a document prepared for LIFT (Livelihoods Food Security Trust Fund), which investigated the value chain of the shrimp industry in Rakhine State, the largest *P. monodon* producing region in Myanmar. Since data availability and quality has been assessed as “moderate,” a final score of 5 out of 10 has been assigned to Criterion 8X – Source of Stock.

Wildlife and Predator Mortalities

There is very little literature or other information that specifically mentions predator and wildlife interactions on *P. monodon* farms in Myanmar—save that production techniques are so extremely extensive that, in the majority of cases, predatory fish are not removed from the culture pond after stocking. It is possible that this lack of data suggests that predator and wildlife interactions on farms are not an issue, hence there has been no need to write about them. Additionally, no population-level impacts or wildlife concerns have been recorded by conservation groups, despite the fact that Myanmar is located in the Indo-Burma Hotspot. However, in light of the scant availability of information pertaining to this topic, data availability and quality for Criterion 9X – Wildlife and Predator Mortalities has been assessed as low-to-moderate and has been assigned a final score of 2.5 out of 10.

Escape of Unintentionally Introduced Species

Several pieces of white paper literature show clearly that PLs stocked in Myanmar are of domestic origin. A final score of 7.5 out of 10 has been assessed for data availability and quality for Criterion 10X – Escape of Unintentionally Introduced Species.

Conclusions and Final Score

As is evident from the above, there is not a great volume of data available that pertain specifically to the *P. monodon* farming sector in Myanmar. However, for the purposes of preparing this report, the data quality has been assessed as “moderate,” since a reasonably clear picture of the current status of the industry has been forthcoming from publicly available resources. One area where data was found to be lacking credibility was the official *P. monodon* production figures reported by DoF, which are in excess of what has been observed in the field. Overall, the final numerical score for Criterion 1 – Data is 5.9 out of 10.

Criterion 2: Effluent

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: not allowing effluent discharges to exceed, or contribute to exceeding, the carrying capacity of receiving waters at the local or regional level.

Criterion 2 Summary

Effluent Evidence-Based Assessment

C2 Effluent Final Score (0-10)	10	GREEN
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Brief Summary

The two main aquaculture inputs that contribute to nutrient loading are feed and fertilizer, and it is well documented that extensive *P. monodon* farmers in Myanmar use none of these. Although specific studies pertaining to shrimp farm effluents in Myanmar have not been identified, ample data on this topic are available from relatively equivalent farming scenarios in neighboring Bangladesh. These data demonstrate that extensive shrimp farms typically act as a nutrient sink, removing nutrients from the environment. Since evidence demonstrates that there are no nutrient inputs into shrimp ponds in Myanmar, and effluent discharges from extensive shrimp farms do not cause or contribute to cumulative impacts at the regional or waterbody scale, the final score for Criterion 2 – Effluent is 10 out of 10.

Justification of Rating

Since effluent data quality and availability is moderately high (i.e., a Criterion 1 score of 7.5 out of 10 for the effluent category), the evidence-based assessment was used (rather than the risk-based assessment).

Farming of *P. monodon* in Myanmar occurs in large, shallow ponds, which are typically between 30 and 90 cm deep (Joffre and Aung 2012). Traditional, extensive production techniques utilize low stocking densities and, as a result, ponds tend to be much larger than those designed for semi-intensive or intensive production (Hanley 2007). Although external (i.e., supplementary) sources of PLs are occasionally (i.e., rarely) available, pond stocking is generally achieved through natural recruitment, with wild juveniles being naturally introduced into the pond on a high tide. *P. monodon* is the target species, due to the higher revenue it generates, but there are also other species passively introduced to ponds, such as *P. indicus*, *P. merguensis*, and *Metapenaeus* spp. Portley (2016) notes that: “approximately 25 species are endemic to the region. Two *Metapenaeus* species, pink shrimp and yellow shrimp, predominate in offshore

trawl catches, while tiger prawn, banana prawn, and redbtail prawn (all *Penaeids*) commonly occur in the coastal, artisanal harvests.” With this heavy reliance on wild recruitment, the subsequent stocking densities in shrimp farms are very low, seldom exceeding 2.5 PL/m² and sometimes as low as 0.5 PL/m² (Joffre and Aung 2012). There are generally no other management inputs in terms of pond drying/preparation, elimination of predatory fish or, of particular importance to the Effluent Criterion, addition of fertilizer or supplementary feed (Joffre and Aung 2012) (DoF 2015) (FAO & NACA 2003) (pers. comm. U. Soe Tun 2017). With little or no nutrient inputs, extensive *P. monodon* farms in Myanmar have a negligible effect on organic loading in the ecosystems that receive discharged pond water. In Table 2, Joffre and Aung (2012) give an overview of the three general types of *P. monodon* pond that can be found in Myanmar.

Table 2: Characteristics of different sized prawn farms (Joffre and Aung 2012, Prawn Value Chain Analysis Rakhine State, Myanmar). Author’s note on average yield: –yield variation is great due to low sample size and differences in 2011 results, between a successful farm stocking PLs at a stocking density above 2.5 PL per m² and an unsuccessful farm with a system based on lower stocking density (<1 PL per m²).

	Small Medium Scale	Large scale landowner	Private Investor
Farm size (ha)	0.5 to 20	20-50	50- 215
Production system	Rice-prawn Prawn monoculture	Prawn monoculture	Prawn monoculture
Water management system	Sluice gate - Tidal	Sluice gate - Tidal	Sluice gate – Tidal
Stocking density (PL/m²)	0 (50% of the farms) <1.5 PL/m ²	0 (40% of the farms) 0.5- 2.5 PL/m ²	0.2 – 3.5 PL/m ²
Origin of the post-larvae	Natural recruitment Wild PLs & Imported	Natural recruitment Wild PLs & Imported	Natural recruitment Wild PLs, Imported & Local Hatchery
Labor force (person/ha)	0.45	0.1	0.1
Average yield (kg/ha) (2011) <i>P. monodon</i>	20-70	15-50	66
Average yield (kg/ha) (2011) <i>Other prawns</i>	20-100	15-70	(not estimated)
Location Specificity	All townships	All townships	Pauktaw; Sittwe

Although no specific studies on Myanmar shrimp farm effluents have been identified, a number of such studies have been conducted in neighboring Bangladesh (Rouf 2012) (Paul and Vogl 2011) (Islam et al. 2004) (Wahab et al. 2003), where the environmental parameters and extensive production methods used are similar to those in Myanmar. These studies all concur that extensive shrimp farms, producing less than 1,000 kg/ha, are typically net removers of nitrogen from the environment, with influent water often exceeding the nitrogen and phosphorous content of effluent water. The production volumes in Myanmar have been estimated to average around 550 kg/ha/year, based on statistics reported to FAO by DoF (BOBLME 2014), although, as has already been noted in the Data Criterion, DoF production statistics apparently overstate actual production levels. In the wake of Cyclone Giri, in 2010, production volumes in Rakhine State were reportedly much lower, between 15 and 70 kg/ha/year in 2011 (Joffre and Aung 2012). In any case, it is apparent that *P. monodon* farms in

Myanmar produce well below 1,000 kg/ha, and as such, have little likelihood of discharging nutrient-rich effluent to receiving waterbodies.

Conclusions and Final Score

The Seafood Watch Aquaculture Standard considers that when the species produced is not provided external feed or nutrient fertilization, the risk of effluent impact is low. The strategy for *P. monodon* production in Myanmar relies on natural pond productivity for shrimp nutrition, and although there may be exceptional cases, no feed or fertilizer inputs are used.

Furthermore, several studies from neighboring Bangladesh, which specifically focused on extensive *P. monodon* farm effluents, found that such farms are net removers of nutrients from the environment. Based on this evidence, the final numerical score for Criterion 2 – Effluent is 10 out of 10.

Criterion 3: Habitat

Impact, unit of sustainability and principle

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

Criterion 3 Summary

Habitat parameters	Value	Score
F3.1 Habitat conversion and function		4
F3.2a Content of habitat regulations	2	
F3.2b Enforcement of habitat regulations	2	
F3.2 Regulatory or management effectiveness score		2
C3 Habitat Final Score (0-10)		3
Critical?	NO	RED

Brief Summary

Primary conversion of mangroves to *P. monodon* farming is not the industry norm in Myanmar, although such land conversion has occurred historically. Shrimp farms have more typically been sited on land that had previously been cleared of mangroves in the process of wood collection and rice production. Although the government of Myanmar has good intentions toward the promotion of environmentally sound practices in shrimp farming, habitat conservation is clearly an area of underachievement for the industry; current legislation and management measures are poorly implemented and enforced and do not encompass habitat connectivity and cumulative ecosystem impacts. The final Criterion 3 – Habitat score for *P. monodon* farms in Myanmar is 3.2 out of 10.

Justification of Rating

Factor 3.1. Habitat conversion and function

Myanmar is located in the Indo-Burma Hotspot, an area that has been identified as one of the world’s “biologically richest and most threatened regions” (CEPF 2011). The intertidal, low-lying, coastal areas where *P. monodon* farming takes place are also the natural habitat of mangrove forests. Over the last several decades, as anthropogenic pressures have intensified, there has been a marked decline in mangrove forests, both in Myanmar and worldwide. Human activities, such as the expansion of agriculture, aquaculture, salt panning, and urban development, plus the over-exploitation of natural resources, have all made significant contributions to the

destruction of mangrove forests. Deforestation is further exacerbated by natural threats, including sedimentation, soil erosion, sea-level rise, plus the impact of natural disasters, such as cyclones, hurricanes, and floods.

The multiple ecosystem services that mangroves provide cannot be overstated: their submerged roots provide a nursery and breeding ground to many marine species; they provide protection against storm surges in the face of floods and cyclones; they stabilize shorelines; they sequester carbon and provide fuel, medicine and construction materials to local communities (Giri et al. 2011). As such, they are a high value habitat. The majority of mangroves are located in Asia (42%), followed by Africa (20%), North and Central America (15%), Oceania (12%) and South America (11%). Three-quarters of the world’s mangroves are found in just fifteen countries, one of which is Myanmar.

Table 3: The fifteen most mangrove-rich countries and their cumulative percentages (Giri et al. 2011).

	Country	Area (ha)	% of global total	Cumulative %	Region
1	Indonesia	3,112,989	22.6	22.6	Asia
2	Australia	977,975	7.1	29.7	Oceania
3	Brazil	962,683	7.0	36.7	South America
4	Mexico	741,917	5.4	42.1	North and Central America
5	Nigeria	653,669	4.7	46.8	Africa
6	Malaysia	505,386	3.7	50.5	Asia
7	Myanmar Burma)	494,584	3.6	54.1	Asia
8	Papua New Guinea	480,121	3.5	57.6	Oceania
9	Bangladesh	436,570	3.2	60.8	Asia
10	Cuba	421,538	3.1	63.9	North and Central America
11	India	368,276	2.7	66.6	Asia
12	Guinea Bissau	338,652	2.5	69.1	Africa
13	Mozambique	318,851	2.3	71.4	Africa
14	Madagascar	278,078	2.0	73.4	Africa
15	Philippines	263,137	1.9	75.3	Asia

Giri et al. (2008) conducted a study into “Mangrove forest distributions and dynamics of the tsunami-affected region of Asia,” which spanned the years 1975 to 2005. Although the authors found that Myanmar had the highest annual rate of deforestation of all countries in the study region (~1%), which peaked at 2.9% between 1990 and 2002, they also discovered that, unlike many Asian nations, conversion to aquaculture was not the main cause of deforestation in Myanmar.

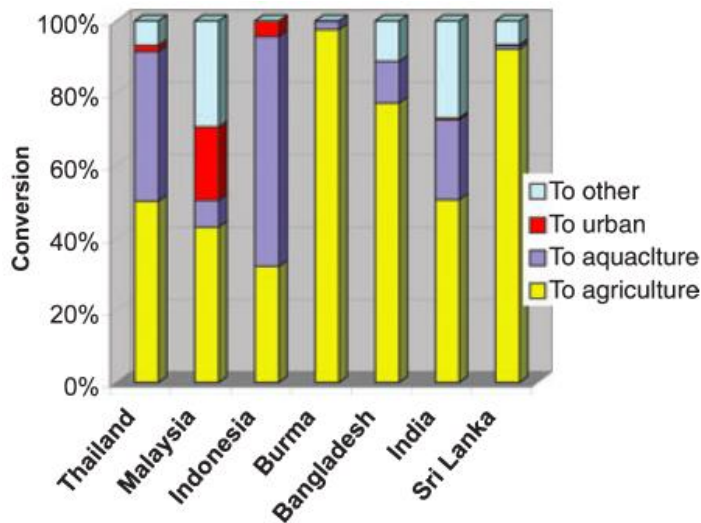


Figure 6: Major causes of mangrove deforestation, in the tsunami-affected region of Asia (1975 to 2005) (Giri et al. 2008).

For the duration of the study period, Giri et al. (2008) concluded that:

The deforestation in Burma is due to the overexploitation of mangrove forests for fuel wood collection, charcoal production and illegal logging, followed by encroachment for paddy cultivation. We estimated that 98% (293,035 ha) of mangrove deforestation in Burma during the period 1975–2005 was due to agricultural expansion. During the same period, approximately 2% (6,870 ha) of forests were converted to aquaculture. In the Ayeyarwady Delta, forests are also being destroyed or degraded by erosion and sedimentation; the delta has the fifth largest sedimentation in the world.

This conclusion is echoed by Richards and Friess (2015), who used geographic information system and remote sensing technologies to study the rates and drivers of Southeast Asian mangrove deforestation between 2000 and 2012:

Aquaculture was a major pressure on mangrove systems during this period, but its dominance was lower than expected, contrary to popular development narratives. Rice agriculture has been a major driver of mangrove loss in Myanmar, and oil palm expansion is a key but under-recognized threat in Malaysia and Indonesia.

As can be seen in the table below, Richards and Friess (2015) found that between 2000 and 2012, the main cause of mangrove deforestation in Myanmar was the expansion of agricultural

land for rice production (87%), whereas aquaculture expansion contributed 1.6% to the total. By comparison, aquaculture was responsible for almost 22% of mangrove deforestation across the whole of Southeast Asia during the study period, and rice production for around 30%. It should be noted that around 95% of reported aquaculture production in Myanmar comes from inland ponds (Belton et al. 2015). While shrimp is the species predominantly cultured in coastal areas, other coastal aquaculture activities include mud crab (*Scylla serrata*) farming and fattening, culture of barramundi or Asian sea bass (*Lates calcarifer*), plus a variety of grouper species and red snapper (van der Pijl 2012) (Win 2011) (FAO and NACA 2003).

Table 4: Percentage of the total deforested mangrove (2000 to 2012) converted to different land uses (Richards and Friess 2015). Notes by authors: Countries are ordered by total mangrove lost. Percentages might not sum to 100 owing to rounding. *The small amount of mangrove deforestation in Timor-Leste is due mainly to shoreline erosion. ** Although most deforested mangrove was replaced with agriculture or aquaculture, a considerable deforested area was classified as mangrove in 2012, particularly in Malaysia and Indonesia. This regrowth may occur after illegal logging of mangrove wood, or after tree removal in sustainably managed mangrove forestry schemes.

Country	Aquaculture	Rice	Oil Palm	Mangrove Forest **	Urban	Other category
Indonesia	48.6	0.1	15.7	22.6	1.9	11.2
Myanmar	1.6	87.6	1.1	0.5	1.6	7.6
Malaysia	14.7	0.1	38.2	17.6	12.8	16.7
Thailand	10.8	5.6	40.0	5.1	14.4	24.1
Philippines	36.7	0.9	11.1	7.3	2.7	41.3
Cambodia	27.7	1.5	8.9	9.8	4.6	47.6
Vietnam	21.0	10.4	0.5	0.6	62.5	4.9
Brunei	29.2	0.0	27.7	12.5	15.9	14.8
Timor-Leste	0.0	26.1	0.0	0.0	0.0	*73.9
Singapore	0.0	0.0	0.0	0.0	0.0	0.0
Total	29.9	21.7	16.3	15.4	4.2	12.3

Agriculture accounts for 50 to 60% of Myanmar’s GDP and supports 70%+ of the nation’s workforce. Historically one of the world’s top rice-producing nations, recent years have seen poor yields, due to a variety of factors including natural disasters and climatic and economic impacts (Torbick et al. 2017). Rice, which is of critical importance to national food security, is predominantly grown in the Ayeyarwady Delta (aka the Irrawaddy Delta); this vast alluvial

floodplain is the “rice bowl” of Myanmar. Myanmar’s 2011 National Biodiversity Strategy and Action Plan said the following, in connection with national mangrove deforestation:

Almost 56% of mangrove area was depleted during the last 6 decades. There are several reasons for the loss of mangrove in Ayeyarwady delta. First and foremost, people from upstream areas migrated to mangrove areas for firewood collection and charcoal making. Once forests were clear-cut, they cultivated the land for growing paddy. When paddy yield declined, land was used for shrimp farming. Then shrimp farming was affected by increased acidification and water pollution, so people encroached into another mangrove area for repeating the process of mangrove exploitation. In this way, the entire mangrove ecosystem was heavily impacted by human activities and mangrove habitats were severely degraded (NBSAP 2011).

Figures 7 and 8, Landsat (satellite) images, show the environmental changes and loss of mangrove forest that have occurred in the Ayeyarwady Delta between 1974 and 2017.

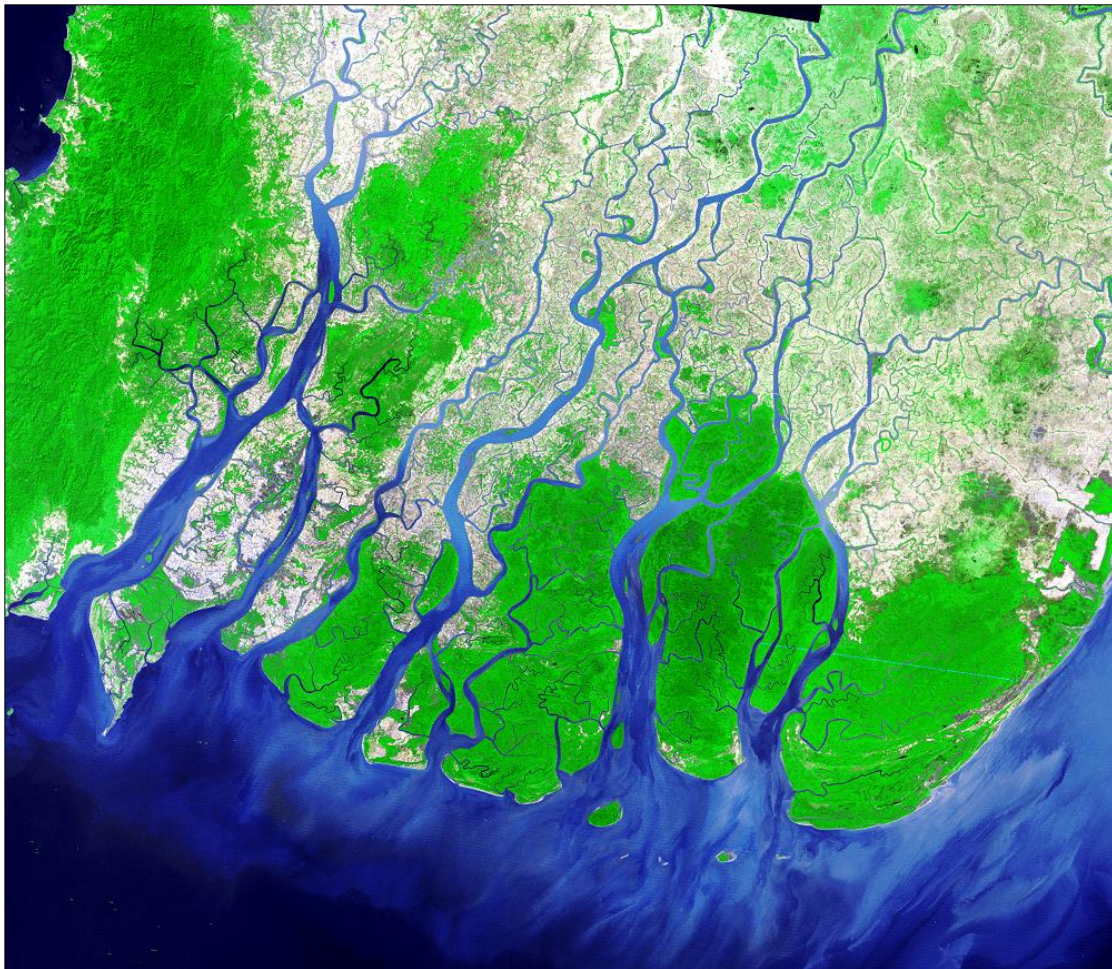


Figure 7: Satellite Image of the Ayeyarwady Delta taken by Landsat 1 in January 1974 showing extensive tracts of mangrove forest. Mangrove forests appear bright green in the Landsat image. Source: USGS 1974. US Geological



Figure 8: Satellite Image of the Ayeyarwady Delta taken by Landsat 8 on February 6, 2017. The relatively rapid loss of mangrove forest in this region is strikingly apparent when this image is compared to historical Landsat images of the same area. Source: USGS 2017. US Geological Survey, Earthshots: Satellite Images of Environmental Change - Ayeyarwady Delta, Myanmar <https://earthshots.usgs.gov/earthshots/node/67#ad-image-14>

It is easy to identify how much the mangrove forests have declined between 1974 and 2017 by comparing the quantity of green present in both images (i.e., Figures 7 and 8). The preservation of Meinmahla Kyun Wildlife Sanctuary (established in 1986) is also easily noted. By zooming in on the original image, it is possible to identify the location of *P. monodon* culture ponds in the southwestern region of the delta, which appear dark blue. The United States Geological Survey (USGS) website states that: “*The Ayeyarwady Delta produces 35% of Myanmar’s rice. Cutting wood for fuel also contributes to mangrove loss, but most of the deforestation in this delta has been for rice fields.*”

Primary conversion of mangrove forests to shrimp farms has occurred historically in Myanmar, mainly in the period prior to 2000 (pers. comm., Dan Friess, 8 November 2017). However,

present-day shrimp farms, located in areas that were previously covered in mangrove forest, are typically not the primary drivers of deforestation—rather, they have been constructed in places where the mangrove had already been collected for charcoal production and cleared for paddy cultivation. Additionally, the challenges which have befallen the shrimp sector in recent years have affected a decline in the industry, hence mangrove clearance for the purpose of shrimp farm development and expansion is unlikely at present. In light of this, the score for Factor 3.1 is 4 out of 10.

Factor 3.2. Habitat management effectiveness

Factor 3.2 assesses the existence and enforcement of regulations or management controls that are in place to oversee the aquaculture industry under consideration and the effectiveness of these measures, with regards to the scale of the industry, and in light of the habitats discussed in Factor 3.1.

Factor 3.2a: Content of habitat management measures

The first specific law pertaining to aquaculture in Myanmar was introduced in 1989 (DoF 2015) (DICA 2014). The Aquaculture Law meant that the industry was now legally acknowledged for the first time and the official registration of aquaculture farms commenced. The new law aimed to assist in the resolution of land-use conflicts between the forestry, agriculture, and aquaculture sectors. The government of the time had a policy of promoting rice culture, prioritizing it over aquaculture as a food security measure (Belton et al. 2015); this meant that numerous coastal shrimp farms were deemed to be illegal and investment in the shrimp farming sector was discouraged as a result (Hishamunda 2009).

In 1997, in compliance with the National Environmental Policy, Myanmar Agenda 21 was established. This initiative, which was a collaborative effort between numerous government agencies, sought to provide a framework to enable sustainable development across all sectors of the country. Its primary driver was to promote environmental management practices and biodiversity conservation. Although sound in principle, this initiative had limited, tangible impact (NBSAP 2011).

By 2000, the Ministry of Livestock and Fisheries actively began to encourage investment in the aquaculture sector and also initiated a mangrove-friendly aquaculture (MFA) shrimp project (Win 2011, 2004). It is interesting to note a comment included in an FAO and NACA report in 2003:

The land use policy in coastal areas is directed towards agriculture development. There appears to be a lack of flexibility in using agriculture land for aquaculture. This may be focusing shrimp farm development towards less suitable mangrove areas, when more suitable sites may be available on sub-optimal agriculture land.

The Department of Fisheries of Myanmar (DoF), which is part of the Ministry of Livestock and Fisheries, is the main governing body responsible for aquaculture oversight. Under the auspices of DoF, the Aquaculture Division is split up into three separate sections, which govern fish and

shrimp culture, water quality management and freshwater fisheries research, and aquatic animal health and disease control. The DoF (2015) states that since 2011 they have adopted Good Aquaculture Practices (GAP) as a national standard in shrimp and fish farming (Myanmar Times 2011) (Win 2011), although this document does not appear to be publicly available. The DoF (2015) further notes that in the financial year 2014 to 2015, seven farms successfully attained GAP certification; these farms covered 1,549 ha, although it was not specified which species these farms were culturing. DoF lists the responsibilities of the Aquaculture Division as follows:

Duties and Functions of the Aquaculture Division

- To ensure the conservation of fisheries and aquatic resources making sure that they are not depleted,
- Monitor, control and provide good management and regulations to the aquaculture industry,
- Strengthen good management for the development of environmentally-friendly aquaculture systems and encouragement of culture-based capture fisheries to increase fish production,
- Issue amendments to aquaculture laws, legislation, and regulations as required in line with modern technologies and with respect to locality and duration,
- Supervise and provide expertise to establish short-term and/or long-term aquaculture development programs,
- Data collection, record keeping, and analysis of fish production plus utilization of fisheries resources and aquatic biodiversity related to aquaculture in national water bodies,
- Application of international, improved aquaculture systems and ASEAN guidelines in compliance with Myanmar weather and environmental conditions,
- Support and conduct training and capacity building to promote aquaculture system skills, technology and techniques,
- Seek to improve technologies and provide extension training for sustainable development and expansion of the aquaculture industry as a whole,
- Implement and manage aquaculture taxation,
- Regularly observe and report on developments in the aquaculture industry to higher authorities, including recording and reporting any extraordinary phenomenon or impacts on the aquaculture industry caused by climate change.

Myanmar has been a member of ASEAN since 1997 and, as indicated above, the Aquaculture Division adheres to the “Guidelines on ASEAN Good Aquaculture Practices” (ASEAN 2015). These guidelines incorporate directives for food safety, animal health and welfare, integrity, and socio-economic aspects. The guidelines concerning environmental integrity are as follows:

Guidelines on ASEAN Good Aquaculture Practices: Environmental Integrity

Principle: Aquaculture should be planned and practiced in an environmentally responsible manner in accordance with applicable national and international rules and regulations. Ensuring

environmental integrity requires that environmental impacts of planning, development, and operational practices for aquaculture are addressed.

- Environmental impact assessments should be conducted if required by national law and according to national legislation, prior to approval of establishment of aquaculture facilities/farms.
- Regular monitoring of farm environmental quality should be carried out, combined with good record-keeping and use of appropriate methodologies.
- Measures should be adopted to promote efficient water management and use, as well as proper management of effluents to reduce impacts on surrounding land and water resources.
- Where possible, hatchery-produced seed should be used for culture. When wild seeds are used, they should be collected using responsible practices or in accordance with national laws and regulations where they exist.
- Exotic species are to be used only when they pose an acceptable level of risk to the natural environment, biodiversity and ecosystem health.
- Where genetic material of an aquatic organism has been altered in a way that does not occur naturally, science-based risk assessment should be used to address possible risks on a case-by-case basis.
- Farm infrastructure construction and waste disposal should be conducted responsibly.
- Feeds, feed additives, chemicals, veterinary drugs, including antimicrobials, manure and fertilizer should be used responsibly to minimize their adverse impacts on the environment.
- Farm workers and managers should be trained in environmental management and mitigation of impact to ensure they are aware of their responsibilities in protecting the environments.

As can be noted in the ASEAN GAP above, the use of an environmental impact assessment (EIA) in the process of siting shrimp farms is encouraged. Although EIAs are not yet implemented in aquaculture siting in Myanmar, their development has been on the government's agenda for some time. In 2011, the government developed the National Biodiversity Strategy and Action Plan (NBSAP 2011), in accordance with Article 6 of the United Nations Convention on Biological Diversity (CBD), which required that each member nation produce its own NBSAP. Included in this document was an acknowledgement that formal guidelines for EIAs needed to be developed, stating that: *"To assure biodiversity and environmental sustainability, the conduct of environmental impact assessment (EIA) should be a compulsory requirement for any type of business, development project and activities before launching operations."* The NBSAP went on to state that:

At present, the institutional capacity is not high, and strenuous effort is needed to invest in building capacity for environmental management. Collaboration with international

organizations is needed to get technical and financial support for building the capacity of managing the environment effectively at the national and local levels. Since capacity is not built over night, it is prudent to start the process of capacity building as soon as possible for environmental security and biodiversity conservation.

In 2012 the Environmental Conservation Law was passed (Environmental Conservation Law 2012), which initiated a legal platform to allow the development of a national environmental impact assessment (EIA) system. The law instructed that a new Environmental Conservation Committee should be formed, under the governance of the Ministry of Environmental Conservation and Forestry, and one of the duties and powers conferred onto this new committee was the ability to “*lay down and carry out a system of environmental impact assessment and social impact assessment as to whether or not a project or activity to be undertaken by any Government department, organization or person may cause a significant impact on the environment.*”

Myanmar’s development of EIAs is a work in progress, which has been contributed to by international partners, most notably the Asian Development Bank. So far, 40 projects, primarily energy, infrastructure, and manufacturing ventures, have reportedly undergone full EIAs. Official EIA procedures were established in 2016, and an unofficial English version of this document, entitled “Myanmar Environmental Impact Assessment Procedure,” is available online (GMS 2017).

Also in progress are efforts towards integrated coastal management (ICM) capacity development in Myanmar. In December 2016, a workshop organized jointly by the Forest Department, Mangrove for the Future (MFF) and International Union for Conservation of Nature (IUCN) was held in Myanmar, with the aim of developing a roadmap for implementation of an ICM strategy. The IUCN notes that:

ICM is an adaptive, multi-sectoral governance approach, which strives to implement balanced development, usage and protection of coastal environments. At present a formal national ICM program does not exist in Myanmar, although the need is clearly articulated. Education and awareness is fundamental for each and every sector, (IUCN 2017).

Another internationally assisted initiative, which strives to promote sustainable management of mangrove forests, is a development cooperation between Denmark and Myanmar called “Climate Adaptation in Coastal Communities of Myanmar through Improved Management of Mangrove Forests.” This is a collaborative project mobilized by the Forest Department, Ministry of Natural Resources and Environmental Conservation (MoNREC), and the Danish International Development Agency (DANIDA) (DMCP 2017).

Although there is significant momentum toward improving the specific content of management measures for *P. monodon* farming in Myanmar, and these measures are based on sound ecological principles, there is presently no evidence that currently implemented management

systems account for habitat connectivity and cumulative impacts on ecosystem services. The score for Factor 3.2a is therefore 2 out of 5.

Factor 3.2b: Enforcement of habitat management measures

The end of military rule in Myanmar brought about the start of a new political era; as a result, numerous institutional reforms are both underway and being planned, including the decentralization of various powers and the establishment of new governing bodies at the regional and state level (Zöckler et al. 2013). When the incoming government took office, they offered assurances that policies for economic and social reform would be developed with sustainable development in mind (NBSAP 2011). This positive intent, however, needs to be grasped in tandem with the fact that a significant portion of Myanmar's population live in poverty, getting by on less than USD 1/day. A recent UNICEF (2012) report states that around a quarter of children are under-weight and a third are stunted; clearly, in pressing social situations such as these, economic necessities easily outcompete environmental goals.

A recent report on "Responsible and inclusive business in Myanmar" (Welford and Zieger 2013) identified a number of "*major challenges*" related to Myanmar's government, politics, laws, and regulations, including an "*insecure regulatory environment, bureaucracy and underdeveloped institutions, conflict and post-conflict situations, bribery and corruption, labour standards*" ... plus "*land rights and land ownership.*" As Belton (2017) notes, "*the resumption of democracy in Myanmar presents a unique opportunity for regeneration*" and it is evident that many changes are afoot in the governance of the country. With the above in mind, it is not surprising that farm siting regulation and management, plus the enforcement of habitat management measures, is in a state of flux and development at the present time. Win (2011) further comments that: "*DoF is mandated to conduct rural development schemes through aquaculture and small-scale fishing but because of the financial problems, the implementation has not been very effective.*"

Johnstone (2016) recently reported that,

In April 2016, at the Pyin Oo Lwin workshop, Myanmar's leading institutions, researchers and practitioners in fisheries and aquaculture came together with international experts to support the new government in finding the path that would best fulfil the potential of the fisheries and aquaculture sectors. The key resulting message from this workshop is that while there is an enormous potential for fisheries and aquaculture to sustainably and significantly increase their contribution to Myanmar's economy and societal well-being, there is an impending need for transformation in the governance and management of these sectors. These changes are needed to bring about positive and profound impacts on the livelihoods and food security of fishing communities and fishworkers and also to contribute to meeting Myanmar's international commitments to achieving the United Nation Sustainable Development Goals (SDGs).

Another recent comment on the status of management measures in the Myanmar aquaculture sector was made by U Hnin Oo, senior vice president of the Myanmar Fisheries Federation

(MFF), who explained that, in order for the industry to realise its full potential, “... we need stronger legislation, international financial and technical assistance for conservation and R&D, [and] a robust aquaculture strategy aligned to Best Aquaculture Practice” (SeafoodSource.com, 18 March 2015).

The government of Myanmar’s updated National Biodiversity Strategy and Action Plan for 2015 to 2020 (NBSAP 2015) states:

Myanmar recently became a member country of Mangroves for the Future (MFF), a project that has been successful in protecting coastal regions, providing alternative livelihoods, and conserving mangroves throughout the region. As this project expands in Myanmar it could be a key tool in protecting the remaining mangroves along Myanmar’s coast, and in helping reduce vulnerability to future natural disasters.

It is clear from the above that, although the government has good intentions, they presently lack the capacity to enforce robust and effective environmental management and, effectively, the deployment and enforcement of proactive management measures are limited. The score for Factor 3.2b is therefore 2 out of 5.

When combined with the Factor 3.2a score of 2 out of 5, the final Factor 3.2 score is 1.6 out of 10.

Conclusions and Final Score

Primary conversion of mangroves to *P. monodon* farming is not the industry norm in Myanmar, although such land conversion has occurred historically. Shrimp farms have more typically been sited on land which had previously been cleared of mangroves in the process of wood collection and rice production. The government has shown strong commitment to prioritizing environmental management systems across all sectors of the country, including the development of national GAP guidelines for aquaculture and EIA requirements for new businesses. However, the content of management measures currently implemented for aquaculture do not account for habitat connectivity and cumulative impacts on ecosystem services and, due to capacity constraints, their enforcement is limited. Factors 3.1 and 3.2 combine to give a final Criterion 3 – Habitat score of 3.2 out of 10.

Criterion 4: Evidence or Risk of Chemical Use

Impact, unit of sustainability and principle

- Impact: Improper use of chemical treatments impacts non-target organisms and leads to production losses and human health concerns due to the development of chemical-resistant organisms.
- Sustainability unit: non-target organisms in the local or regional environment, presence of pathogens or parasites resistant to important treatments
- Principle: limiting the type, frequency of use, total use, or discharge of chemicals to levels representing a low risk of impact to non-target organisms.

Criterion 4 Summary

Chemical Use parameters	Score	
C4 Chemical Use Score (0-10)	10	
Critical?	NO	GREEN

Brief Summary

There are few data that specifically pertain to chemical use in *P. monodon* culture in Myanmar, but this is evidently because extensive production methodologies use zero or minimal inputs, including chemical inputs. The data that do exist, including farm-level surveys, confirm that chemicals are not used in production. This perspective on extensive shrimp culture is additionally borne out by data collected from equivalent farming situations in other Asian nations, which have been studied in more detail. Due to the absence, or limited use, of chemicals in *P. monodon* production in Myanmar, the final score for Criterion 4 – Chemical Use is 10 out of 10.

Justification of Rating

Information regarding chemical use on shrimp farms in Myanmar is sparse (Nhung et al. 2016). However, it is well documented that practically all of *P. monodon* production is extensive, and extensive production techniques typically use little to no inputs, including chemicals. Around 95% of Myanmar’s aquaculture production is comprised of freshwater finfish, relying primarily on semi-intensive culture methods; even in these more intensive production systems, there is limited use of chemicals. Belton et al. (2015) comment that, in Myanmar:

In comparison to other Asian countries, businesses selling antibiotics and other chemical therapeutants to treat fish disease appear to be relatively few in number, despite disease being the most common problem reported by farmers. It is possible that the high average size of ponds makes it difficult to administer chemical treatments effectively. This is positive in as far as antibiotic use appears limited, and drugs do not account for a significant share of production costs (as they often do elsewhere), but means that farmers are unable to manage disease effectively.

A 2017 survey of >100 *P. monodon* farmers in Rakhine State and the Ayeyarwady Delta found that there was no chemical input of any kind (Moore Foundation GA #004694-2.3.AIP-MBayAq). DoF's 2015 Fisheries Statistics document (DoF 2015) reports on the recent inception of a national task force, formulated with the aim of facilitating implementation of Good Aquaculture Practices (GAP), using ASEAN's standard on GAP for shrimp farming, alongside established local practices. Additionally, the document reports that the DoF has also established directives to regulate the use of chemicals in aquaculture.

As a member state of ASEAN, the Competent Authority of Myanmar is a contributor and adherent to ASEAN's "Guidelines for the Use of Chemicals in Aquaculture and Measures to Eliminate the Use of Harmful Chemicals" (ASEAN 2013). Regarding the regulation of chemicals used in aquaculture, including veterinary drugs and pesticides, Myanmar's Competent Authority is the DoF. The aim of ASEAN's guidelines is to help member states develop and implement their own legislative framework and policies for the use of chemicals in aquaculture. The ASEAN guidelines include a list of the chemicals currently used by member states and these are separated into the following eight categories: antibiotics/antimicrobials, disinfectants, chemotherapeutic agents, piscicides (for use in pond preparation of early culture only), hormones, anaesthetics, culture system preparation, and banned chemicals. For example, Table 6 shows the antibiotics/antimicrobials that are reported as being used in all ASEAN aquaculture sectors and the status of their permission for use in Myanmar.

Table 5: List of antibiotic/antimicrobial chemicals used in aquaculture by ASEAN Member States, and the status of permission for their use in Myanmar (ASEAN 2013).

Antibiotics/Antimicrobials	Status in Myanmar
Tetracyclines *	Allowed
Nitrofurans	Prohibited
Chloramphenicol	Prohibited
Oxolinic acid *	Prohibited/ Allowed
Erythromycin *	Allowed
Dimetridazole/Metronidazole	Prohibited
Elbaju/Ebazine	Status Unknown
Sulfonamides *	Allowed
Oxytetracyclines *	Allowed
Chlortetracycline *	Allowed
Sulfamerazine *	Status Unknown
Nifurpirinol	Status Unknown
Amoxicilin	Allowed
Doxycyclin	Status Unknown
Enrofloxacin *	Allowed
Florfenicol	Status Unknown
Norfloxacin	Status Unknown
Rifamicin / or Rifampicin??	Status Unknown
Ciprofloxacin	Status Unknown

Sarafloxacin	Status Unknown
Ormethoprim	Status Unknown
Sulfadimethoxin + Ormethoprim *	Status Unknown
Sulfadimethoxin + trimethoprim *	Status Unknown

*** Residues with Maximum Residual Limit**

A review of data shows that chloramphenicol, a chemical banned in food products by the US, EU, and Canada, was detected in Myanmar shrimp (though the species was not specified) and imported into the EU in 2002 (Johnston and Santillo 2002) (Hagler 2002). Interestingly, a report on Myanmar aquaculture from this same timeframe (FAO and NACA 2003) reported that:

As most shrimp farming is traditional or extensive, shrimp farmers use few chemicals or drugs. Indeed, the shrimp produced from such systems should be very good quality, “organic” type. The team noted however, that some hatcheries and more intensive farms were using a range of chemicals to control shrimp disease. These chemicals were not always in clearly labelled containers (none in Myanmar language), and in one case a banned compound was noted in a hatchery, a chemical that may lead to residue problems for shrimp imported to EU and other countries. The team considers that further attention is needed to restrict use of chemicals, perhaps by developing regulations that control the import and use of chemicals in shrimp aquaculture in Myanmar.

In neighboring Bangladesh, where extensive farming of *P. monodon* also takes place, there have been a number of studies to assess on-farm chemical use and its potential impact on the environment. The conditions in Bangladesh are fairly comparable to those in Myanmar, although 10 to 20% of shrimp farmers use slightly modified, so-called “improved extensive” techniques; therefore, there are slightly more inputs in general, including chemical inputs. Despite this slight intensification of inputs, the risk of environmental impacts resulting from chemical use in *P. monodon* farming in Bangladesh is minimal (Banner-Stevens 2017 and references therein). One comparative study on various farming scenarios around Asia, including Bangladesh, noted that: “earthen ponds act as a sink of chemicals and play a fundamental role in reducing the environmental release of veterinary medicines, in comparison to other aquaculture production systems such as net pens or cages” (Rico and Van den Brink 2014).

Conclusions and Final Score

Since production methods used for farming *P. monodon* in Myanmar are extensive, there are practically no inputs into the pond system, including chemical inputs. The volume of research or monitoring for chemical use in *P. monodon* culture in Myanmar is low, but the data that are available are consistent in demonstrating an absence of chemical use, including a recent survey of >100 farmers in key producing regions. Data pertaining to equivalent farming scenarios elsewhere in Asia support this conclusion. When the data score for chemical use is 7.5 of 10 and data show that chemical treatments have not been used over multiple production cycles, this is considered to be of no concern. Therefore, the final numerical score for Criterion 4 – Chemical Use is 10 out of 10.

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: sourcing sustainable feed ingredients and converting them efficiently with net edible nutrition gains.

Criterion 5 Summary

Feed parameters	Value	Score
F5.1a Fish In: Fish Out ratio (FIFO)	0.00	10.00
F5.1b Source fishery sustainability score	n/a	
F5.1: Wild fish use score		10.00
F5.2a Protein IN (kg/100kg fish harvested)	0.00	
F5.2b Protein OUT (kg/100kg fish harvested)	18.9% ³	
F5.2: Net Protein Gain or Loss (%)	18.9%	10.00
F5.3: Feed Footprint (hectares)	0.00	10.00
C5 Feed Final Score (0-10)		10.00
Critical?	No	GREEN

Brief Summary

The extensive, so-called “trap and hold” system of *P. monodon* production employed by shrimp farmers in Myanmar does not utilize any supplementary feeds or fertilizers. Stocking densities are low enough that the natural carrying capacity of the pond is not exceeded, and shrimp are sustained adequately by the naturally occurring biota of the pond. Since external feeds or fertilizers are not used, the final score for Criterion 5 – Feed is 10 out of 10.

Justification of Rating

In the wild, *P. monodon* are omnivorous, benthic feeders, gaining their nutrition from small crustaceans, molluscs and fish, benthic detritus, vegetable matter, insects, and polychaete worms (FAO 2011) (SEAFDEC 1988). In extensive *P. monodon* culture, supplemental feed is typically not used since the culture pond has its own ecosystem, which provides an adequate

³ The average protein content of harvested *P. monodon* is 18.9% (Boyd et al. 2007).

supply of naturally occurring feed items for the shrimp (Tacon 2002). The extensive production methods that *P. monodon* farmers use in Myanmar is locally called “trap and hold” (Joffre and Aung 2012), which is a concise description of the technique; first, farmers “trap” wild shrimp fry in their ponds when they are introduced upon filling on a high tide; next, they wait for the shrimp to grow, leaving them to feed on the naturally occurring biota of the pond (this is the “hold” phase); finally, the farmer harvests the shrimp. In addition to a reported absence of feed used in *P. monodon* culture in Myanmar, Joffre and Aung’s 2012 analysis of the prawn value chain in Rakhine State also documents zero use of fertilizer on *P. monodon* farms and comments that: “*The production system requires regular exchange of water to trap wild post-larvae in the ponds. Thus, farmers are reluctant to invest in fertilizers or inputs to improve water quality.*” In describing the shrimp farming operations that they visited in Rakhine State, Svennevig and Lwin (2016) commented:

Most of these shrimp ponds were extensive “ponds” or dammed lagoons in tidal flats, where natural shrimp larvae were trapped in the ponds at high tide and then grown based only on the natural biological production inside the pond. This means EXTENSIVE rearing in its purest fashion.

Most recently, none of the >100 farmers surveyed in Rakhine and the Ayeyarwady Delta in 2017 applied feed or fertilizer (Moore Foundation GA #004694-2.3.AIP-MBayAq).

In the early 2000’s, when shrimp farming was expanding in Myanmar and semi-intensive *L. vannamei* production commenced (Win 2011), five aquaculture feed mills were established, using domestically sourced fishmeal (FAO and NACA 2003). Currently, due to disease and natural disasters, *L. vannamei* production has fallen to around only 5,500 MT per annum (pers. comm., U. Soe Tun, May 2017). As demand for commercial diet waned due to the difficulties experienced by semi-intensive farms, this resulted in the closure of feed mills (Win 2011), leaving just one main domestic feed mill providing commercial shrimp diets at present (STIP 2017). Aquaculture development in general has reportedly been hampered due to an inconsistent supply of feed (DoF 2015), and commercial aquaculture diets in Myanmar are reportedly the most expensive in Asia (Belton 2017). Hishamunda et al. (2009) comment that:

the availability and cost of feed can be a constraint critical to aquaculture development. Shortages or irregularity of feed supplies add to risks and may jeopardize operations. This has been a problem in Myanmar where border delays have led to spoilage. To circumvent delays, sea freight is used, but it doubles the cost of delivered feed.

Interestingly, Seafood Trade Intelligence Portal (STIP 2017) states that:

important shrimp feed players, such as Nutreco and CP [Charoen Pokphand Group], are known to be interested in Myanmar. Yet so far, they have not started to invest in the sector. Normally these companies plan to invest first in the production sector, before investing in the establishment of a feed mill itself.

Conclusions and Final Score

As extraneous feeds or fertilizers are typically not used in the culture of *P. monodon* in Myanmar, the final score for Criterion 5 – Feed is 10 out of 10.

Criterion 6: Escapes

Impact, unit of sustainability and principle

- Impact: competition, genetic loss, predation, habitat damage, spawning disruption, and other impacts on wild fish and ecosystems resulting from the escape of native, non-native and/or genetically distinct fish or other unintended species from aquaculture operations
- Sustainability unit: affected ecosystems and/or associated wild populations.
- Principle: preventing population-level impacts to wild species or other ecosystem-level impacts from farm escapes.

Criterion 6 Summary

Escape parameters	Value	Score
F6.1 System escape risk	0	
F6.1 Recapture adjustment	0	
F6.1 Final escape risk score		0
F6.2 Competitive and Genetic Interactions		10
C6 Escape Final Score (0-10)		10
	Critical?	NO
		GREEN

Brief Summary

There are no data available demonstrating escapes from *P. monodon* ponds in Myanmar, but the risk of shrimp escaping from extensive production systems is high because the areas in which ponds are sited frequently experience flooding. Further escape risk arises from the water exchange activities necessary to facilitate natural recruitment of PLs and nutrient provision for pond stock; the retention of shrimp that are already growing in the pond is reliant on the effective installation of a suitable net placed across the sluice gate entrance. However, since shrimp that do escape from culture ponds have mainly been stocked through passive (i.e., tidal) influx, densities are nearly or entirely equivalent to those found in the wild, and those PLs that have not been stocked through this technique have either been collected from the wild or are the first-generation progeny from wild broodstock. This means that the likelihood of competitive or genetic disturbance caused by escapees from *P. monodon* farms in Myanmar is very low. The final score for Criterion 6 – Escapes is 10 out of 10.

Justification of Rating

Factor 6.1. Escape risk

No literature was identified that documented escape events occurring on shrimp farms in Myanmar, and it does not appear that any such industry-reporting requirements are in place. Likewise, escape prevention/mitigation regulations appear to be lacking in governance of this

sector. Joffre and Aung (2012), who investigated and analysed the *P. monodon* value chain in Rakhine State with particular focus on Cyclone Giri-affected areas, noted the following:

Prawn production systems are extensive, located in large scale ponds, owned by one or more households. There is no incentive to improve systems due to climatic hazards and abnormal tides in the rainy season. When these threats materialize, the dikes are too shallow and the prawns can migrate from one pond to another or even escape from the ponds, similar to when strong erosion causes damage to the embankments. Therefore, even large farmers with sufficient investment capacity do not want to invest, as they are afraid of losing their investment due to extreme climatic events such as those in recent years. The DoF estimates that 60% of the ponds have damaged embankments.

Figure 9 demonstrates the catalogue of natural and climate-related disasters the country has experienced since 2005.

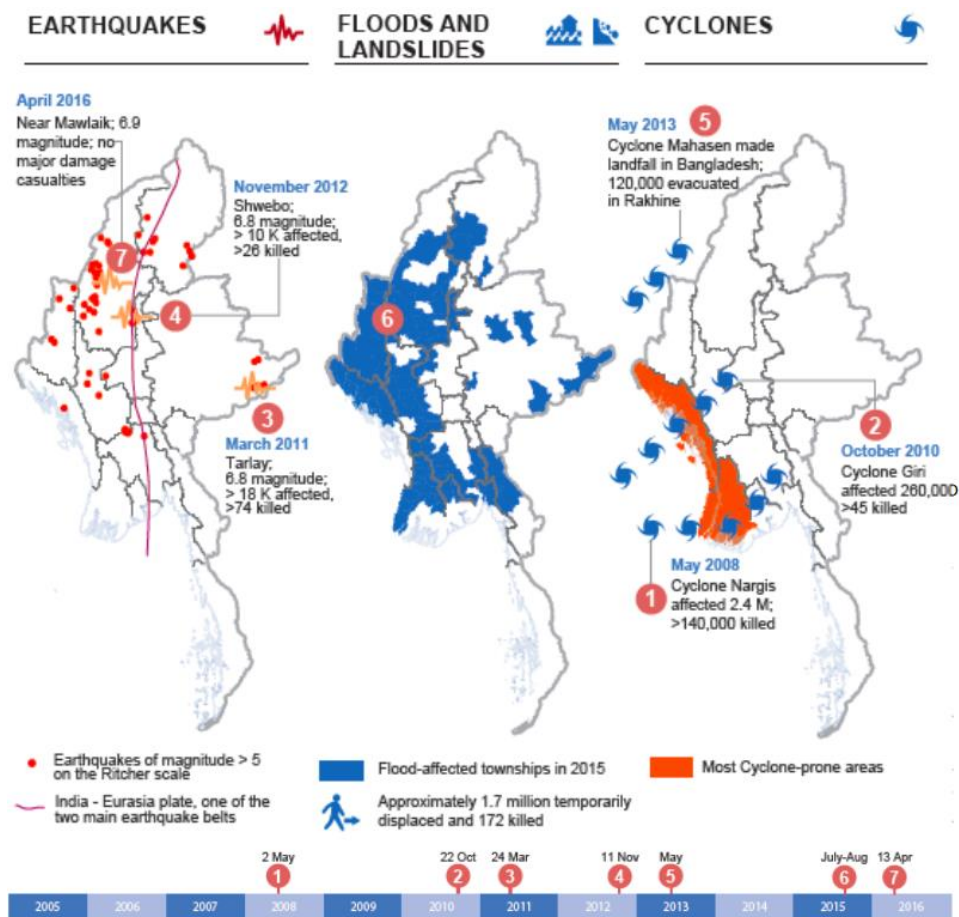


Figure 9: Natural disaster risks and past events (as of 31 May 2016), (OCHA 2016).

The orange area denoted on the Cyclones map in Figure 9, which shows Myanmar’s “most cyclone-prone areas,” defines Rakhine State in the north and the Ayeyarwady Delta further south. Together, these areas are where almost all (~95%) of Myanmar’s *P. monodon* production

takes place; these regions are respectively responsible for 68% and 25% of all domestic marine shrimp culture (see Figure 2). The area indicated on the Floods and Landslides map in Figure 9 includes these shrimp farming areas, in addition to much more of the country situated further inland. In 2015, shrimp ponds in Rakhine experienced severe flooding and stock losses when major flooding occurred nationwide (pers. comm., Ben Belton 30 October 2017).

To add further to the heightened escape risk brought about by severe weather phenomena, another increase in threat arises from the water exchange routines implemented by farmers in order to facilitate natural recruitment of PLs and nutrient provision for farm stock, a process which typically takes place twice a month on both the full and new moon spring tides. PLs are passively collected across a period of 4 to 5 days, which corresponds with the elevated tide; PLs are most abundant during the full moon, with November to December and March to April being the most productive times of year (Joffre and Aung 2012). During periods of water introduction or exchange, the pond's sluice gate is opened and a net is positioned across the opening to prevent those shrimp that are already in the pond from exiting; should the net be misplaced, damaged, or of too large a mesh size, cultured shrimp will have easy access back into the wild.

Since there is little doubt that the risk of *P. monodon* escaping from culture ponds in Myanmar is high, the score for Factor 6.1 is 0 out of 10.

Factor 6.2. Competitive and Genetic Interactions

Although the risk of shrimp escaping from extensive *P. monodon* ponds in Myanmar is high, those that do escape have most likely been passively stocked into the pond during an incoming/high tide from the natural waterbody. Passive influx is the most common way that farmers in Myanmar stock their shrimp ponds (Svennevig and Lwin 2016) (BOBLME 2014) (Joffre and Aung 2012) (Moore Foundation GA #004694-2.3.AIP-MBayAq); those PLs that have not been stocked through this technique of natural recruitment have either been collected from the wild or are the first-generation progeny from wild broodstock (Joffre and Aung 2012). A trade in *P. monodon* PLs from Bangladesh started in 2008–09, but this was banned by the government of Bangladesh in 2011 and Joffre and Aung (2012) reported that they were “*not accessible on the market anymore in 2012.*” More recently, the border crossing between Myanmar and Bangladesh has effectively been closed as a result of conflicts in Rakhine (STIP 2017), so it would seem unlikely that further, illegal, cross-border PL trade occurs to any significant extent. In any case, all *P. monodon* PLs in Bangladesh are the first-generation progeny of wild parents from the Bay of Bengal, a waterbody that Bangladesh shares with Myanmar (Debnath 2015).

Since none of the PLs stocked by farmers in Myanmar are genetically different to native *P. monodon* found locally in the wild, there is no potential for shrimp escapees to impact the genetic integrity of wild populations. In addition, the passive (i.e., tidal) introduction of shrimp into ponds results in farm stocking densities that are similar— if not identical—to those found in the wild; since it is evident that wild populations of juvenile and adult *P. monodon* are in decline in Myanmar (Joffre and Aung 2012) (NBSAP 2015), any escape events that do occur are not believed to impact (still) wild populations, in terms of competition for resources (e.g., food

and habitat). In effect, any shrimp that do escape from farms in Myanmar are returning to the exact environment from which they originally came, therefore the score for Factor 6.2 is 10 out of 10.

Conclusions and Final Score

The risk of *P. monodon* escaping from shrimp farms in Myanmar is high because culture ponds are located in flood-prone areas known to experience severe flooding events. Additionally, there is a high frequency of water exchange with the natural environment during passive influx of PLs and nutrients, and the application of, or requirement for, successful escape mitigation strategies are not apparent. These characteristics result in a score of 0 out of 10 for Factor 6.1 Escape Risk. However, *P. monodon* are native to Myanmar and PLs used in aquaculture production are mainly stocked through passive influx. Shrimp fry that are not recruited into ponds naturally are either the first-generation, hatchery-reared progeny of local, wild broodstock or have been collected from the wild; this means that escaped, cultured shrimp do not represent a genetic threat to their wild counterparts. Furthermore, farmed escapees do not threaten the habitat and food security of wild shrimp since passive influx renders stocking densities almost identical to those in the wild, and it has been demonstrated that wild populations of *P. monodon* are in decline. For these reasons, Factor 6.2 Competitive and Genetic Interactions is scored 10 out of 10. Factors 6.1 and 6.2 combine to give a final numerical score of 10 out of 10 for Criterion 6 – Escapes.

Criterion 7: Disease; pathogen and parasite interactions

Impact, unit of sustainability and principle

- Impact: amplification of local pathogens and parasites on fish farms and their retransmission to local wild species that share the same water body
- Sustainability unit: wild populations susceptible to elevated levels of pathogens and parasites.
- Principle: preventing population-level impacts to wild species through the amplification and retransmission, or increased virulence of pathogens or parasites.

Criterion 7 Summary

Disease Risk-based assessment

Pathogen and parasite parameters	Score	
C7 Disease Score (0-10)	8	
Critical?	NO	GREEN

Brief Summary

Many recently discovered marine shrimp pathogens are now endemic throughout warm-water shrimp producing regions of the world, including Myanmar. The three main pathogens affecting *P. monodon* in Myanmar are white spot syndrome virus (WSSV), Taura syndrome virus (TSV) and yellow head virus (YHV). It is likely that these viruses entered Myanmar during a brief attempt at intensification of the shrimp farming sector during the early 2000s, although there is also evidence that these pathogens are endemic in wild shrimp populations in the contiguous waterbodies that Myanmar shares with its neighbors, Thailand and Bangladesh. *P. monodon* farms in Myanmar generally use extremely extensive production techniques; since nearly all PLs stocked in ponds are recruited naturally via tidal flow, on-farm diseases are likely introduced from the wild and stocking densities are similar to those found in nature. The combination of still-present disease occurrence and concern with extensive production characteristics ultimately present a moderate-to-low risk of on-farm pathogen and parasite dynamics impacting wild populations. This results in a final score for Criterion 7 - Disease of 8 out of 10.

Justification of Rating

As disease data quality and availability is “moderate” (i.e., Criterion 1 scored 5 out of 10 for the disease category), the Seafood Watch Risk-Based Assessment was utilized.

Worldwide expansion of the shrimp farming industry has led to an intensification of production methods and an increase in trans-boundary movements of shrimp broodstock and PLs. A consequence of these developments has been the emergence of previously unknown pathogens and their transmission from one shrimp producing nation to another. This has impacted both the local amplification of pathogens on shrimp farms and their retransmission to wild species on a global level.

White spot syndrome virus (WSSV), which is the causative agent of white spot disease (WSD), was reportedly first detected in Myanmar in 1999–2000, likely introduced into the country via imported PLs from Thailand (Saw 2004). Prompted by the government’s efforts to encourage investment in the sector (Win 2011, 2004), a national expansion and intensification of shrimp farming was taking place at this time, and domestic PL supply could not keep up with demand, which precipitated the need to source PLs from overseas. Soon thereafter, WSSV was identified in farmed *P. monodon* and, subsequently, the disease had evidently spread beyond farm boundaries with FAO and NACA (2003) reporting that: “*The effects on wild populations are unknown, but it appears that shrimp broodstock are already infected with white spot syndrome virus (WSSV) to varying degrees.*” Prior to this, Saw (2004) reported that wild *P. monodon* broodstock had tested negative for WSSV up until the year 2000. Efforts toward the intensification of *P. monodon* production in Myanmar were largely abandoned in the late 2000s, due to the impact that natural disasters and disease had had on the industry; investment in semi-intensive farming, at least in the *P. monodon* sector, waned. During a visit to Rakhine State in 2016, Svennevig and Lwin (2016) noted that many shrimp ponds were not in use due to the crippling impact that WSSV had had on the sector between 2003 and 2010.

WSSV was first detected in cultured kuruma shrimp (*Penaeus japonicas*) in the Fujian Province of China in June 1992, and soon afterwards it was also identified in Taiwan and Japan, subsequently spreading swiftly throughout Asia and the Americas (Walker and Winton 2010). Interestingly, almost simultaneously, Taura syndrome virus (TSV) emerged during June 1992 on the other side of the world; after first being identified in *L. vannamei* farms on the Taura River, near Guayaquil in Ecuador, TSV spread rapidly throughout the region and six years later it had spread to Taiwan, where it was detected in 1998 (Walker and Mohan 2009). A few years later, TSV was also found in Myanmar, and by 2004 it had become endemic in all of the main Southeast Asian shrimp producing nations (Walker and Mohan 2009). TSV primarily affects penaeid shrimp belonging to the subgenus *Litopenaeus*; however *P. monodon* is also susceptible (AGDAFF–NACA 2007).

According to FAO & NACA (2003) and Saw (2004), the government of Myanmar had maintained a ban on importation of the exotic species *L. vannamei*, despite pressure from the private sector to allow importation—although FAO and NACA (2003) also noted that at least one farm had received permission to culture the species experimentally. In 2005, Thame and Aye (2005) reported that: “*At present the import of exotic or alien shrimp species is strictly prohibited in Myanmar for safeguarding the natural ecosystem*”; they also stated that:

In 2001, one private company was permitted to import 500 parent stocks of P. vannamei from Hawaii. Unfortunately or fortunately all the parent-stocks died on the way to the hatchery because of prolonged transport time. At the same time another shrimp farming company was allowed to culture P. vannamei in a far isolated area. That company imported one million post-larvae of P. vannamei. But it harvested only 4 tons and the company never requests the import of vannamei again.

At some time during 2005, the ban was evidently lifted and SPF *L. vannamei* PL importation was permitted (DoF 2015). A number of semi-intensive and intensive *L. vannamei* operations were set up and initially the sector began to develop well; however, during this time, TSV gained a foothold in Myanmar. Walker and Mohan (2009) note that: “By 2004, following the dramatic amplification of *P. vannamei* production, TSV had become endemic in most major shrimp-farming countries in East and South-East Asia, including China, Korea, Thailand, Myanmar, Indonesia and Vietnam.” *P. monodon* is listed in the World Organisation for Animal Health’s “Manual of Diagnostic Tests for Aquatic Animals” as a susceptible host species of TSV (OIE 2017), yet, although it is a potential vector of this virus, it does not appear to succumb to the disease to any significant extent.

It is interesting to consider Walker and Mohan’s (2009) elucidation that:

Shrimp pathogens can be considered to fall into two categories: (i) those for which shrimp are the natural host in which they have existed in for, perhaps, millions of years; and (ii) those that have been introduced to shrimp as a result of a recent cross-species transmission. Of the major viral pathogens of marine shrimp, WSSV, TSV and IMNV have almost certainly emerged through cross species transmission.

In addition to WSSV and TSV, another major disease that impacts *P. monodon* farming in Myanmar is yellow head virus (YHV). This disease, which first arose in Thailand in 1990, is extremely virulent, capable of causing 100% mortality within a few days of onset (Walker and Winton 2010) and has been considered endemic throughout *P. monodon* producing regions in Asia (Subasinghe and Arthur 2004). Wah and Than (2016) reported that acute hepatopancreatic necrosis disease (AHPND) (commonly known as “early mortality syndrome,” EMS) had not been reported in Myanmar, although Table 8, which shows diseases reported by DoF, suggests that this has recently changed. This disease, which affects *P. monodon* and *L. vannamei*, was first reported in 2009 in China and its bacterial etiology was only recently discovered (FAO 2013). Table 8 also indicates the presence of infectious hypodermal and haematopoietic necrosis (IHHN) in Myanmar; this parvovirus is endemic to Asia and *P. monodon* is an asymptomatic, natural host. Infectious myonecrosis virus (IMNV) is also indicated in the chart below, listed as being “present in a very limited zone or zones” in the fourth quarter of 2016; this recently identified shrimp virus was first noted in *L. vannamei* in Brazil in 2002 and it has been demonstrated experimentally that *P. monodon* is susceptible to this virus also (Walker and Mohan 2009).

In 1998 the Asia-Pacific Quarterly Aquatic Animal Disease Reporting System (QAAD) was established by FAO, NACA, and OIE. Essentially, the QAAD system is a disease reporting platform for aquaculture producers, which enables regional communication between participating countries concerning the prevalence of disease in their geophysical vicinity. The intent of the system is to promote surveillance and transparency in order that disease threats and proliferation can be identified and acted upon (Pakingking Jr. and de Jesus-Ayson 2016). Countries that implement routine surveillance and adhere to a national reporting system are

better positioned to rapidly identify disease outbreaks, thus allowing for swifter execution of contingency plans to facilitate disease containment and eradication (FAO/NACA 2000). Four separate species categories are listed in the QAAD Reports: finfish, molluscs, crustaceans, and amphibians. Crustacean diseases reported by the Competent Authority of Myanmar (DoF) are recorded in the Table 8.

Table 6: Data taken from the 2015 and 2016 Organisation for Animal Health (OIE), Quarterly Aquatic Animal Disease (QAAD) Reports for the Asian and Pacific Region, and the OIE Regional Aquatic Animal Disease Yearbook 2014, showing crustacean diseases reported to OIE by DoF Myanmar (OIE 2015 to 2016) (OIE 2014). Note that the list of diseases reported on by the Competent Authority of each participating country is identical, although not all diseases will be relevant to all countries.

Myanmar Quarterly Aquatic Animal Disease Reports	2014				2015				2016			
	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q
OIE-listed diseases (crustaceans)												
TSV, Taura syndrome virus	-	-	-	-	-	-	-	-	-	-	-	-
WSD, White spot disease	-	-	-	-	-	-	-	-	-	-	-	-
YHV, Yellow head virus	-	-	-	-	-	-	-	-	-	-	-	-
IHHN, Infectious hypodermal and haematopoietic necrosis	-	-	-	-	-	*	*	*	*	*	-	-
IMNV, Infectious myonecrosis virus	*	*	*	*	*	*	*	*	*	*	*	+ ()
MrNV, White tail disease	*	*	*	*	*	*	*	*	*	*	-	-
NHP, Necrotising hepatopancreatitis	*	*	*	*	*	*	*	*	*	*	*	*
AHPND, Acute hepatopancreatic necrosis disease ‡						*	*	*	*	*	-	-
Non OIE-listed diseases (crustaceans)												
Monodon slow growth syndrome	*	*	*	*	*	*	*	*	*	*	*	*
HPM-EHP, Hepatopancreatic microsporidiosis caused by <i>E. hepatopenaei</i> ‡‡												*

- Denotes when a disease is not reported during a reporting period. However, the disease is known to be present in the country (date of last outbreak is not always known).

* Denotes no information on a disease in question is available due to reasons such as lack of surveillance systems or expertise.

+ () Denotes a disease is present in a very limited zone or zones as exceptional cases. It may also include the occurrence of a disease in a quarantine area.

‡ Note: AHPND was moved from Non OIE-listed diseases to OIE-listed diseases in 2016.

‡‡ Note: HPM-EHP was not included in QAAD Reports prior to 4Q 2016.

As can be noted above, although TSV, WSSV, YHV, and IHHN are known to be present in background levels in Myanmar, there have been no outbreaks reported during recent years. White tail disease is also mentioned in the QAAD Report above; this disease, first detected in Guadeloupe in 1995, is also referred to as *Macrobrachium rosenbergii* nodavirus (MrNV) since it affects the giant freshwater prawn; although *P. monodon* has displayed some susceptibility to MrNV, it does not develop the disease (Walker and Winton 2010).

It is most likely that the diseases prevalent in Myanmar were introduced during the fleeting period of sector expansion that occurred in the early to mid-2000s, when shrimp farming experienced a brief shift towards intensification, and before natural disasters and disease constraints thwarted development. Although imported PLs were historically the likely source of these pathogens, the precise vectors of disease transmission cannot be stated with any certainty since Myanmar shares contiguous water bodies with Bangladesh to the north and with Thailand to the south. In 1994, the first incident of WSSV was recorded in farmed shrimp in Bangladesh, where there is now a high occurrence in wild populations of shrimp (Debnath et al. 2014). The situation in Thailand is similar: in 2012 and 2013, Hamano et al. (2017) conducted an epizootiological study to determine the incidence and prevalence of WSSV, TSV, YHV, IHNV, and IMNV in wild *P. monodon* and found that viruses were present in 80.9% of wild shrimp, although IMNV was not (and had never been) detected in the country. As a result of their study, Hamano et al. commented: *“This finding suggests that there is a link between the prevalence of pathogenic viruses in wild shrimp and the outbreaks of viral diseases in farmed shrimp.”*

Wah and Than (2016) comment that most shrimp farming currently taking place in Myanmar is extensive, and that disease outbreaks and natural disasters have hampered industry development and intensification. This was echoed in a recent interview with U. Hnin Oo, senior vice president of the Myanmar Fisheries Federation, who commented that: *“Myanmar’s shrimp industry” ... “is currently struggling with disease problems and a lack of investment, technological know-how and trained operators”* (SeafoodSource 2015). This situation has prompted a return to traditional trap and hold methods, which rely on low-density, extensive production systems that have more stable pathogen dynamics in comparison to more intensive farms. Due to the costs of adaptation that affect evolving pathogens, intensive farming techniques are more likely to cause virulent pathogen mutations than extensive production practices, which, by comparison, are more prone to effectuate avirulent or asymptomatic infections (Dieu et al. 2011). Most PLs stocked by farmers in Myanmar are wild-sourced by natural recruitment, being swept into the pond on a high tide, and, following these traditional methods of production, on-farm pathogen levels remain on-par with those levels found in the wild.

Conclusions and Final Score

It is clear that diseases have played a role in the recent history of shrimp farming in Myanmar. A brief move towards intensification elevated disease occurrence and concerns, and pathogens are still reported to occur in low levels across the industry. There has been a shift back towards trap and hold production, which typically does not increase the likelihood of pathogen amplification compared to wild populations, and stocking densities (of wild shrimp) are similar to those found in the natural environment. As a result, there is a moderate-to-low risk of *P. monodon* farms in Myanmar impacting pathogen and parasite load or dynamics of wild populations. The final numerical score for Criterion 7 – Disease is 8 out of 10.

Criterion 8X: 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: using eggs, larvae, or juvenile fish produced from farm-raised broodstocks thereby avoiding the need for wild capture.

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

Criterion 8X Summary

Source of stock parameters	Score	
C8 Independence from unsustainable wild fisheries (0-10)	0	
	Critical?	NO
		GREEN

Brief Summary

P. monodon production in Myanmar is almost solely dependent upon naturally recruited, wild post larvae (PLs), which passively flow into the culture pond on the influx of a rising tide. Natural disasters, disease, and a lack of investment and infrastructure have taken their toll on the hatchery sector, and it would seem that shrimp hatcheries are presently supplying less than 1% of industry requirements. Furthermore, declines in wild *P. monodon* broodstock are evident; in 2012 researchers reported that catch rates were apparently half of what they had been in 2000. A decline in the abundance of wild *P. monodon* post larvae has also been ongoing since at least 2007 and by 2012 wild PL collectors were reportedly catching around just 5 to 10% of what they had been able to collect 10 years earlier. As a result, wild-collection has been curtailed and does not appear to be an active source of fry at present. Since nearly all seed stock used by the *P. monodon* sector in Myanmar arises from the mechanism of passive influx, the final score for Criterion 8X – Source of Stock is 0 out of –10.

Justification of Rating

Extensive *P. monodon* farming was first attempted in Myanmar around the mid-1970s in northern Rakhine State. Local waters contained an abundance of wild shrimp juveniles, which were easily trapped during the ebb and flow of the tide as it rose and fell over the expansive tidal zone. This “trap and hold” technique is still the primary method of shrimp fry recruitment used by Myanmar shrimp farmers today (BOBLME 2014), although the abundance of naturally occurring post larvae has dropped severely since the 1970s. Currently, a lack of PLs is often

noted as one of the biggest constraints to the development of the *P. monodon* sector in Myanmar (STIP 2017) (MYSAP 2015) (van der Pijl 2012) (Hishamunda et al. 2009).

Four Different Sources of PLs: Passive Influx, Wild Collection, Importation and Hatcheries

The earliest identified *P. monodon* aquaculture production record for Myanmar is from 1989, which shows an output of 3 MT for that year and 1 MT per year for the following two years (FAO 2017). With financial assistance from the Asian Development Bank, the country's first two shrimp hatcheries were established in 1984 to 1985 (BOBLME 2014). The shrimp farming sector was very much in its infancy at this time and wild PL abundance was high, so even though the hatcheries were apparently successful, farmers could meet their PL needs through the trap and hold technique.

In the early 2000s, the government actively encouraged development of the shrimp farming sector and, during a particularly dynamic and fast period of expansion, when it became evident that domestic hatcheries could not keep up with demand, the government granted permission to import *P. monodon* PLs (FAO and NACA 2003) from Thailand. Importation of *P. monodon* PLs from Bangladesh also commenced in 2008 to 2009; during 2011, an estimated 100 million fry crossed the border into Myanmar from Bangladesh. By comparison, during the same year, DoF hatcheries produced just 3 million *P. monodon* PLs. By the end of 2011, the government of Bangladesh actively banned fry export, and although some illegal importation was reportedly still occurring in 2012, it was considered “*not accessible on the market*” (Joffre and Aung 2012). More recently, the border between Bangladesh and Myanmar was closed (STIP 2017), so it is unlikely that any significant, illegal cross-border trade of PLs from Bangladesh is on-going.

Joffre and Aung (2012) note that by 2007, the quantity of wild PLs being naturally recruited was dropping, resulting in a corresponding decline in the shrimp yields achieved by farmers. Since local hatcheries were unable to produce enough PLs to bridge the gap, many local fishermen began to collect wild fry along coastlines and up estuaries to sell to shrimp farmers. Before long, however, wild fry catches began to decline – just as passive influx of PLs into ponds had declined markedly a few years prior. The cause of this decline in wild shrimp stocks is undetermined; however, it is likely that a multiplicity of factors have contributed to the situation, including climate change, overfishing, coastal habitat degradation and pollution (pers. comm., Ben Belton, 30 October 2017 and Kevin Fitzsimmons, 8 February 2018).

Joffre and Aung (2012) note that, by 2012, average daily catches for a collector had dropped to around 5 to 10% of what they had been 10 years earlier—clearly an indication of severe *P. monodon* PL depletion in the natural environment. The authors further comment that: “*In Sittwe, ten years ago, PL catchers collected around 100,000 PLs per day, while nowadays the catch is down to 5,000 to 10,000 per day.*” Apparently, wild collection has not been banned in Myanmar (Joffre and Aung 2012), despite intentions toward this goal noted by FAO and NACA in 2003 (FAO and NACA 2003). However, as catches declined, the number of wild collectors subsequently diminished. Recent observations in the field suggest that wild PL collectors seem to have given up the process due to low yield and low offering prices, along with the fact that it is not an approved process (pers. comm., Kevin Fitzsimmons, 8 February 2018).

In 2003, FAO and NACA reported that: “*Shrimp brood stock appear relatively abundant in Myanmar, and indeed the Andaman Sea as a whole is an important source of brood stock for neighbouring countries. Shrimp brood stock can be exported under licence from the Department of Fisheries*” (FAO and NACA 2003). Saw (2004) also commented on *P. monodon* broodstock being traded from Myanmar into Bangladesh. As shrimp farming has evolved, however, it is not only the abundance of wild juvenile *P. monodon* that has been adversely impacted; Joffre and Aung (2012) comment that, although broodstock are still sourced easily enough, catch rates are around half of what they were in 2000.

The Impact of Natural Disasters on *P. monodon* Hatchery Production

Consistent, successful production of PLs has yet to be achieved by Myanmar’s hatchery sector. A major reason for this has been the impact of natural disasters, particularly cyclones Nargis and Giri in 2008 and 2010 respectively. Myanmar was also affected by the December 2004 tsunami and suffers frequently from floods. These events have not only impacted existing hatcheries, but also essential, related infrastructure.

By 2015, only four of the country’s 22 shrimp hatcheries were operational (MYSAP 2015). DoF’s Fishery Statistics for 2015 record a cumulative DoF hatchery production of 3.3 million PLs by three public hatcheries between 2014 and 2015, although it is not specified if these were *P. monodon* or *M. rosenbergii* PLs (DoF 2015). This is a much-reduced production level in comparison to the 45.6 million PLs reportedly produced cumulatively by 8 public hatcheries between 2008 and 2009 (FAO 2010). However, the production levels for both of these years combined are insignificant in comparison to the output reported by FAO and NACA in 2003;

Currently, there are around 31 shrimp (and prawn) hatcheries that have a capacity to produce around 650 million PLs. However, DoF reports that in 2002 demand was not sufficient, and that the[n] only around 300 million PLs were produced. The demand from grow-out shrimp farming is also seasonal. DoF estimate a total demand of 600 million PL/year.

It is evident that shrimp hatcheries in Myanmar face significant challenges and that their present production is negligible. To put this in perspective, if all 3.3 million PLs produced by public hatcheries in 2014 to 2015 were stocked and all survived (note, however, that the industry norm for survival is around 50% [Debnath et al. 2016]) and reached a harvest weight of 35 g each, production yield would be 115.5 MT, which would account for only about 0.25% of the *P. monodon* production reported to FAO for this period.

Conclusions and Final Score

The struggling hatchery sector in Myanmar is presently producing less than 1% of the industry’s juvenile requirements. Additionally, it is evident that all life-stages of wild *P. monodon* are in decline, which in turn has been a disincentive to collectors of wild juveniles. Although some small quantities of PLs may be sourced through illegal wild collection or via cross-border trade from Bangladesh or Thailand, it is apparent that amounts arising from these sources are negligible. It is evident that passive influx is the primary method by which juveniles are

introduced into *P. monodon* farms, a method of recruitment that the Seafood Watch Aquaculture Standard considers to have a negligible impact upon wild stocks; therefore, the final numerical score for Criterion 8X – Source of Stock is 0 out of –10.

Criterion 9X: Wildlife and predator mortalities

Impact, unit of sustainability and principle

- Impact: mortality of predators or other wildlife caused or contributed to by farming operations
- Sustainability unit: wildlife or predator populations
- Principle: aquaculture populations pose no substantial risk of deleterious effects to wildlife or predator populations that may interact with farm sites.

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

Criterion 9X Summary

Wildlife and predator mortality parameters	Score	
C9X Wildlife and predator mortality Final Score (0-10)	-3	
Critical?	NO	GREEN

Brief Summary

The impact of highly extensive *P. monodon* farming on predators and other wildlife species in Myanmar would appear to be low, and no population-level impacts have been reported. These indicators suggest that such mortalities present a “low” concern; however, poor data availability makes it impossible to confirm that these are limited to exceptional cases. The final score for Criterion 9X – Wildlife and Predator Mortalities is therefore –3 out of –10.

Justification of Rating

Globally, the range of anti-predator measures employed by aquaculture farmers can be broadly classified into three different categories of control: exclusory, frightening, and lethal. No data or other information was identified that specifically pertains to the control measures used, or the mortality of predators or other wildlife caused, or contributed to, by shrimp farming operations in Myanmar.

Numerous data sources do mention that *P. monodon* farming in the country has traditionally been absent of inputs and has not involved the eradication of predators post-stocking (Wah and Than 2016) (DoF 2015) (Thame and Aye 2005). Joffre and Aung, writing about their observations in Rakhine State in 2012, commented: “Farmers do not dry the pond or catch predatory fishes in most cases” (Joffre and Aung 2012). No other references pertaining to wildlife or predators (including birds, mammals, reptiles, etc.) on shrimp farms in the country,

including regulations governing wildlife exclusion techniques, lethal control prohibitions or allowances, or mortality reporting requirements, were found.

It is worth noting that Myanmar is located in the Indo-Burma hotspot, an area that is the focus of numerous conservation efforts. There is much data available concerning biodiversity in Myanmar, including the fact that Myanmar has 49 Globally-Threatened mammal species, as well as 16 Near-Threatened and 26 Data-Deficient mammal species (WCS 2017). However, while many anthropogenic and non-anthropogenic population threats are noted (e.g., over- and destructive fishing, general habitat destruction, climate change, etc.), no mention of deliberate or accidental wildlife or predator mortalities within shrimp farms was noted. A likely reason for the apparent lack of predator control measures within the sector is that, in contrast to semi-intensive and intensive operations, where stocking densities are high and farm stock serve as attractants to predatory and other wildlife species, the low stocking densities of extensive *P. monodon* farms in Myanmar do not attract the unwanted attention of predators. It is also relevant to bear in mind that Myanmar is predominantly a Buddhist country, with the majority of the population following a religion which nurtures respect for all living things—a situation that experts communicate likely deters farmers from actively harming wildlife or predators on their farms (pers. comm., with Kevin Fitzsimmons, 8 February 2018).

Conclusions and Final Score

This criterion is a measure of the mortality, whether deliberate or accidental, inflicted upon predator and wildlife populations that interact with aquaculture farms. The risk of such mortalities on extensive *P. monodon* farms in Myanmar appears to be low, and no evidence of lethal control or of population-level impacts has been identified. Should such mortalities occur, they are likely limited to exceptional cases. Based on these factors, it appears that wildlife and predator mortalities are a “low” concern for the shrimp farming sector in Myanmar. However, the availability and quality of data for this criterion was poor (2.5 out of 10), so it is impossible to confirm such mortalities are indeed exceptional occurrences. Therefore, the final numerical score for Criterion 9X – Wildlife Mortalities is –3 out of –10.

Criterion 10X: Escape of secondary species

Impact, unit of sustainability and principle

- Impact: movement of live animals resulting in introduction of unintended species
- Sustainability unit: wild native populations
- Impact: aquaculture operations by design, management or regulation avoid reliance on the movement of live animals, therefore reducing the risk of introduction of unintended species.

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

Criterion 10X Summary

Escape of secondary species parameters	Score	
F10Xa International or trans-waterbody live animal shipments (%)	10	
F10Xb Biosecurity of source/destination	0	
C10X Escape of secondary species Final Score	0.00	GREEN

Brief Summary

All PLs stocked by the *P. monodon* sector in Myanmar are of domestic origin. Therefore, there is no risk of unintentionally introduced species escaping and impacting wild native populations. The score for Criterion 10X – Escape of unintentionally introduced species is therefore 0 out of –10.

Justification of Rating

Factor 10Xa International or trans-waterbody live animal shipments

Farmed *P. monodon* production in Myanmar is almost solely dependent upon naturally recruited wild post larvae, whereby farms are stocked by the mechanism of passive influx, with PLs arriving into the culture pond naturally on an incoming/high tide (Svennevig and Lwin 2016) (BOBLME 2014) (Joffre and Aung 2012). The balance of PLs are either caught locally by wild collectors or are hatchery-raised using locally captured wild broodstock from the Bay of Bengal (Joffre and Aung 2012).

Historically, some *P. monodon* PLs were traded over the border from Bangladesh into Myanmar’s Rakhine State, but this practice was made illegal in 2011 by the government of Bangladesh (Joffre and Aung 2012). Some illegal trade apparently continued thereafter, but a closure of the border in more recent years (STIP 2017) means that further trade in PLs is unlikely. Should any illegal PLs still make their way over the land border from Bangladesh, they

are from the same genetic stock as *P. monodon* in Myanmar, since PLs from Bangladesh are the first-generation progeny of wild parents from the Bay of Bengal (Debnath 2015), which is a contiguous waterbody between the two countries.

Because 0% of production is reliant on international/trans-waterbody animal movements, and 100% of PLs stocked by the sector are of domestic origin, the score for Factor 10Xa is 10 out of 10.

Factor 10Xb Biosecurity of source/destination

Because the Myanmar shrimp industry is not reliant on international or trans-waterbody movements, and the score for Factor 10Xa is 10 out of 10, assessing the biosecurity of the source and destination is not necessary.

Conclusions and Final Score

The risk of unintentionally introduced species escaping because of the international and trans-waterbody movement of animals is not presently a concern in *P. monodon* culture in Myanmar. The final numerical score for Criterion 10X – Escape of Unintentionally Introduced Species is 0 out of –10.

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 rating is decided according to the final score, the number of red criteria, and the number of critical scores as follows:

- **Best Choice** = Final Score ≥ 6.661 **and** ≤ 10 , and no Red Criteria, **and** no Critical scores
- **Good Alternative** = Final score ≥ 3.331 and ≤ 6.66 , **and** no more than one Red Criterion, **and** no Critical scores.
- **Red** = Final Score ≥ 0 and ≤ 3.33 , **or** two or more Red Criteria, **or** one or more Critical scores.

Criterion	Score	Rank	Critical?
C1 Data	5.91	YELLOW	
C2 Effluent	10.00	GREEN	NO
C3 Habitat	3.20	RED	NO
C4 Chemicals	10.00	GREEN	NO
C5 Feed	10.00	GREEN	NO
C6 Escapes	10.00	GREEN	NO
C7 Disease	8.00	GREEN	NO
C8X Source	0.00	GREEN	NO
C9X Wildlife mortalities	-3.00	GREEN	NO
C10X Introduced species escape	0.00	GREEN	
Total	54.11		
Final score (0-10)	7.73		

OVERALL RANKING

Final Score	7.73
Initial rank	GREEN
Red criteria	1
Interim rank	YELLOW
Critical Criteria?	NO

FINAL RANK
YELLOW

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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 fished⁴ or farmed that can maintain or increase production in the long-term without jeopardizing the structure or function of affected ecosystems.

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

Seafood Watch will:

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

⁴ “Fish” is used throughout this document to refer to finfish, shellfish and other invertebrates.

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 rating has been assigned to each criterion, an overall seafood recommendation is developed on additional evaluation guidelines. Criteria ratings 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.

Appendix 1 - Data points and all scoring calculations

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

Criterion 1: Data Quality and Availability

Data Category	Data Quality (0-10)	
Industry or production statistics	2.5	
Management	5	
Effluent	7.5	
Habitats	7.5	
Chemical use	7.5	
Feed	7.5	
Escapes	7.5	
Disease	5	
Source of stock	5	
Predators and wildlife	2.5	
Unintentional introduction	7.5	
Other – (e.g. GHG emissions)	n/a	
Total	67.5	
C1 Data Final Score (0-10)	5.9	YELLOW

Criterion 2: Effluent - Effluent Evidence-Based Assessment

C2 Effluent Final Score (0-10)	10.00	GREEN
Critical?	NO	

Criterion 3: Habitat

Factor 3.1. Habitat conversion and function

F3.1 Score (0-10)	4
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Factor 3.2 – Management of farm-level and cumulative habitat impacts

3.2a Content of habitat management measure	2
3.2b Enforcement of habitat management measures	2
3.2 Habitat management effectiveness	1.6

C3 Habitat Final Score (0-10)	3.20	RED
Critical?	NO	

Criterion 4: Evidence or Risk of Chemical Use

Chemical Use Parameters	Score	
C4 Chemical Use Score (0-10)	10	
C4 Chemical Use Final Score (0-10)	10	GREEN
Critical?	NO	

Criterion 5: Feed

C5 Feed Final Score (0-10)	10.00	GREEN
Critical?	NO	

Criterion 6: Escapes

6.1a System escape Risk (0-10)	0	
6.1a Adjustment for recaptures (0-10)	0	
6.1a Escape Risk Score (0-10)	0	
6.2. Invasiveness Score (0-10)	10	
C6 Escapes Final Score (0-10)	10	GREEN
Critical?	NO	

Criterion 7: Diseases - Risk-based assessment

Disease Evidence-based assessment (0-10)		
Disease Risk-based assessment (0-10)	8	
C7 Disease Final Score (0-10)	8	GREEN
Critical?	NO	

Criterion 8X: Source of Stock

C8X Source of stock score (0-10)	0	
C8 Source of Stock Final Score (0-10)	0	GREEN
Critical?	NO	

Criterion 9X: Wildlife and Predator Mortalities

C9X Wildlife and Predator Score (0-10)	-3	
C9X Wildlife and Predator Final Score (0-10)	-3	GREEN
Critical?	NO	

Criterion 10X: Escape of Unintentionally Introduced Species

F10Xa live animal shipments score (0-10)	10.00	
F10Xb Biosecurity of source/destination score (0-10)	0.00	
C10X Escape of unintentionally introduced species Final Score (0-10)	0.00	GREEN
Critical?	n/a	