Shrimp Aquaculture Landscape

January 25, 2018

CEA | California Environmental Associates

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Prologue

- Introduction
- Executive Summary
- Key takeaways

Introduction

In late October 2017, the Gordon and Betty Moore Foundation's (Moore) Ocean and Seafood Markets Initiative (OSMI) asked CEA to aggregate information on a series of key questions relating to farmed shrimp to inform their Advisory Committee's (AC) December 12th and 13th meetings. As we understand it, our research and insights will inform the AC's future farmed shrimp work planning that will take place in early 2018.

CEA was asked to provide detailed responses to the following topics:

- **Production:** Document global production trends by geography over the past 20 years including countries of origin, intensity of production (land use vs. total production), key markets, key differences in production systems, and their impacts and other issue (e.g. feed, disease, efficiency, mangroves, cumulative impacts).
- **Value Chain:** Lay out/revisit the value chain (as represented in the Shrimp Results Chain) from production to local and global markets. How does shrimp move from the producer in 5 key production geographies to the consumer in 5 key consumption markets?
- **Financing:** What types of finance (investment vs. working capital), in what form (cash or in kind) support production? How do they differ by type of system (e.g. intensive vs. extensive), and why are types of purchases are most common at each transaction (cash/credit, contract/spot, etc.)

CEA conducted 27 interviews and a detailed literature review over the course of six weeks. We are confident that our findings largely reflect the state of farmed shrimp and also recognize that a six-week rapid assessment is by no means sufficient to capture the complexities or nuance of such a complex topic. Given the time constrains, our research was primarily dedicated to assessing the state of the farmed shrimp sector. More research is needed to assess which interventions are most likely to successfully transform the sector. As the AC develops OSMI's farmed shrimp work plan in the future, we hope that CEA can be a resource through this report and through an ongoing thought partnership where we can further draw from and expand this body of research.

Methods

Approach

Desk top research

CEA conducted a review of the available literature and data relevant to the state of farmed shrimp. Sources included a review of relevant Seafood Watch reports, NGO publications (many of which were provided directly by AC members), leading academic publications, FAO and UN production and trade data, and the Seafood Trade Intelligence Portal, among others. We found these resources provided vital context and historic perspective.

Interviews

CEA interviewed 27 experts, including 11 from the NGO community, 5 members of supply chain companies, and 7 finance experts. These interviews were 60 minute, semi-structured conversations that sought to answer OSMI's key questions and provide broader context. Given the dynamic and rapidly evolving nature of the farmed shrimp sector, expert interviews provided critical perspectives into the current state of shrimp farming as well as some insight into where the industry may likely move towards in the future.

Note on social implications of shrimp farming

This research focused on understanding the environmental issues and impacts surround farmed shrimp in keeping with our understanding of OSMI's priorities. There are considerable social and human rights issues that we did not cover but should acknowledge within the sector.

Interviewees

NGO community

- Anton Immink, Dave Martin (SFP)
- Jason Clay, Aaron McNevin , Lucy Holmes (WWF)
- Lisa Trucker, Taylor Voorhees, Tori McConnel, Tyler Issac (MBAq SFW)
- Corey Peet (Postelsia)
- Han Han (China Blue)

Industry

- Ramesh Subbiah (Walmart)
- Nicholas Leonard (Rubicon Group)
- Robert Fields (Formerly Sam's Club)
- Casey Marion (Beaver Street)
- Mark Jefferies (Aqua Star)

Finance

- Rene Benguerel (Blueyou/Meliomar)
- Mike Velings (AquaSpark)
- Gibran Huzaifah (eFishery)
- Rodrigo Laniado-Illingsworth (Sociedad Nacional de Galapagos - SONGA)
- Francisco Velastegui (Velca Farms)
- Alex Markham (Encourage Capital)
- Max Holtzman (Pontos Advisory)

Other

- Urs Baumgartner (Centre for Development and Environment)
- Arlin Wasserman (Changing Tastes)
- Katrina Nakamura via email (Sustainability Incubator)

Executive Summary

Farmed shrimp is among the fastest growing and most traded food commodities in the world; it is intensifying across all major producing countries.

- Global shrimp production has increased from 1M tons in 2000 to almost 5M tons in 2015, making it one of the fastest growing food commodities in the world.
- Intensification of whiteleg shrimp in Asia is responsible for most of this growth, with productivity increasing each year.
- The risks and externalities associated with intensification cannot be fully contained, but the industry is quickly adapting to mitigate disease outbreaks.

US retailers have driven farm level certifications, but have had minimal impact on sector-wide farming practices. However, the high risk of harvest loss drives sustainable intensification in some places.

- 70 percent of imported shrimp into the USA comes from India, Indonesia, Thailand and Vietnam; supply chains in these countries are highly disaggregated and have not significantly influenced farm-level management outside of the farm by farm certifications that comprise a small fraction of total production for any given country.
- The devastating experience of disease outbreaks (particularly EMS in 2013) and the increasing resistance of bacterial strains against antibiotics are slowly driving the industry into responsible intensification, particularly in Thailand.

The business case for responsible intensification is intuitive, but interventions to improve farm management often adds to the operating costs of production

- Automatic feeding, water quality management, and higher quality broodstock and feed are all associated with increases in efficiency and productivity (and therefore revenues) while decreasing farm-level environmental impacts, but currently are seen as added (and therefore unnecessary) costs that cut into farmers' margins. This dynamic is underscored by the nature of shrimp as a commodity where volume matters more than quality.
- Shrimp farms can be highly profitable in as little as a year, driving short-term decision-making that biases making quick profits over long-term value creation.
- Processors and exporters in Ecuador have the strongest incentives to value sustainable production, as consolidation due to previous disease outbreaks and higher labor costs have encouraged processors to seek out higher-value markets that will pay a premium for a higher quality product.

Key Take-aways (1/2)

There are many opportunities to improve farmed shrimp sectors around the world; approach and geography should depend on the OSMI's articulated priority objective(s)

- Key priorities that can guide future strategies and interventions include ecosystem preservation, meeting a growing global demand, and safeguarding livelihoods
- These challenges vary greatly across geographies (i.e., Latin American and Asian producing countries) and species (i.e., extensive black tiger farming and the more intensive whiteleg shrimp farming)
- Depending on OSMI's stated priority objectives, some approaches are more suitable than others

The overall trend of shrimp farming is towards more efficient and cleaner production but significant challenges remain in the dominant, small-scale portion of the sector

- Past disease outbreaks have driven a natural adaptation of precautious and cleaner farming methods and farming practices are evolving more rapidly than the literature is able to capture
- Cleaner and more efficient farming requires capital investments and technical training, which is not broadly accessible
- Most of the smaller, often family-run operations in Asia are continued sources of concern, principally due to wastewater discharge and antibiotics overuse that lead to increased risk of widespread disease outbreaks

The supply chain is highly disaggregated and farmers carry an outweighed share of risk

- Supply chains are highly complex and business relationships up to the processor level are largely informal and opportunistic
- The risk of harvest loss due to disease is almost entirely carried by the farmers
- Processors and retailers are wary about vertical integration as they prefer to outsource the risk to the producers.

Key Take-aways (2/2)

US centered market-mediated interventions are therefore unlikely to be successful at scale to influence farm-level processes without engaging governments to secure policy reforms

- US-based buyers have little purchasing leverage associated with their demand for inexpensive supply due to a lack of product differentiation and low consumer awareness
- This is exacerbated by an increasing competition from Chinese buyers that have low requirements for environmental and social specifications of shrimp farming
- Even if modest price premiums existed, they would be unlikely to lead to systemic change: the lack of vertical integration promotes opportunistic behavior by farms who choose to sell to the highest bidder

Many challenges also impair certifications' effectiveness and impact in Southeast Asia

- Though the continued growth of farm-level certifications is encouraging, experts enumerated a variety of reason for why farm-by-farm certification may be insufficient for improving global shrimp farming
- These included issues around effectively applying standards, the static nature of a certification, the interrelationships among shrimp farms (certified and uncertified), and interactions with other industries that may impact water quality
- Some experts suggested that area based management was critical to sectoral health and long-term stability
- Some experts highlighted that national minimum standards were the best (and possibly only) way to ensure the widespread performance sought by western demand

Shrimp is a profitable industry, but intervening into the supply chain for sustainability poses challenges

- Shrimp is a profitable industry with strong market fundamentals; accordingly, investing in the shrimp supply chain can create significant returns for investors – in spite of high risks
- Like the rest of the seafood industry, transactions throughout the supply chain are opaque
- Sustainability interventions add costs to shrimp production, and are often not perceived as essential to core business
- Processors in Ecuador are one key leverage point for intervention, as they aggregate production and increase the margin through value addition

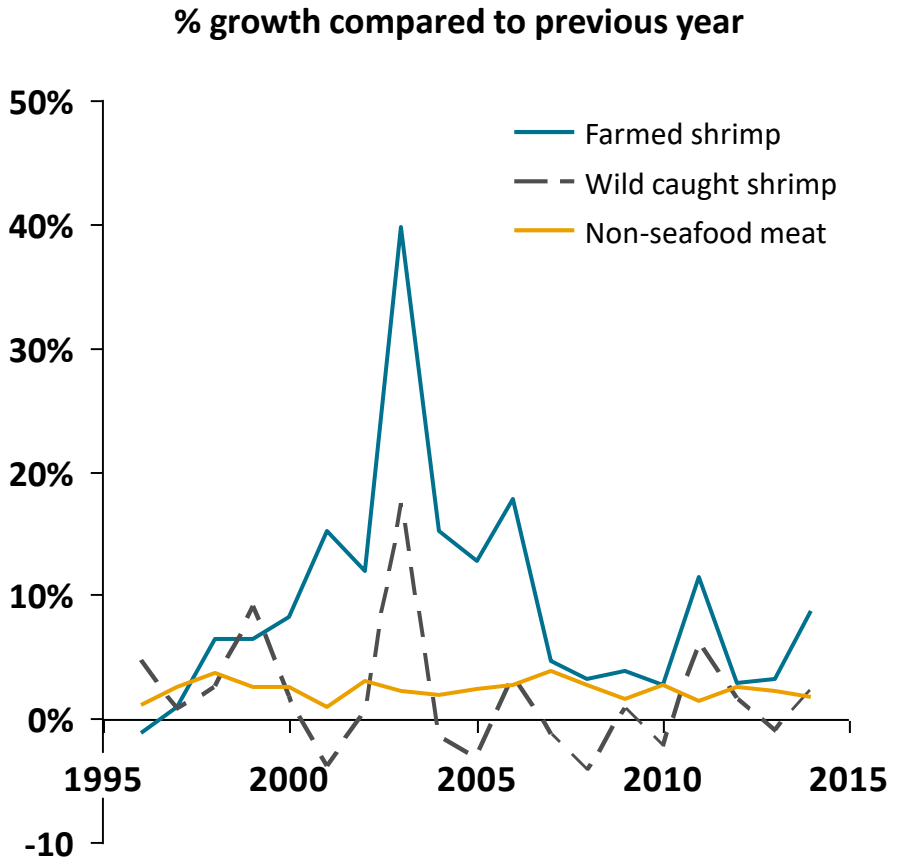
2

Production

- Trends in production and productivity
- Environmental concerns
- Country deep-dives

Global shrimp production has more than quadrupled since the year 2000 and has consistently grown faster than meat production since 1997

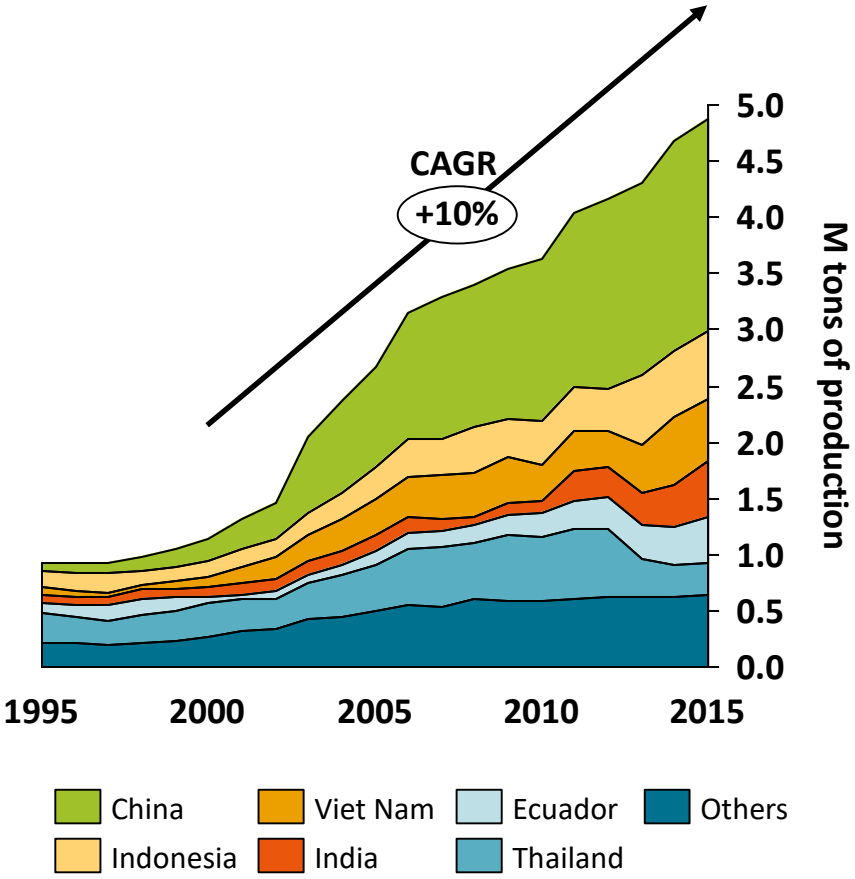
- Global shrimp production has increased by an average of 10% per year since the year 2000 and is not yet flattening out. In comparison, poultry grew roughly 4% annually over that same period.
- Most of the growth has come from China, followed by Indonesia, Vietnam and India.
- Growth has been driven by the rapid increase of intensive whiteleg shrimp (*Litopenaeus vannamei*) production. In 2015, whiteleg production accounted for 80% of farmed shrimp globally.
- Black tiger shrimp (*Panaeus monodon*) production has remained stable over time and its relative share to global production has fallen. In 2014, black tiger shrimp accounted for 14% of farmed shrimp globally.
- Decades of increasing production trends clearly reflect a strong, growing demand for the species.
- Strong growth in the early 2000s came after a few years of high shrimp prices and the encouragement of farm development by governments throughout Asia with land concessions, tax breaks, easy loans and technical assistance.



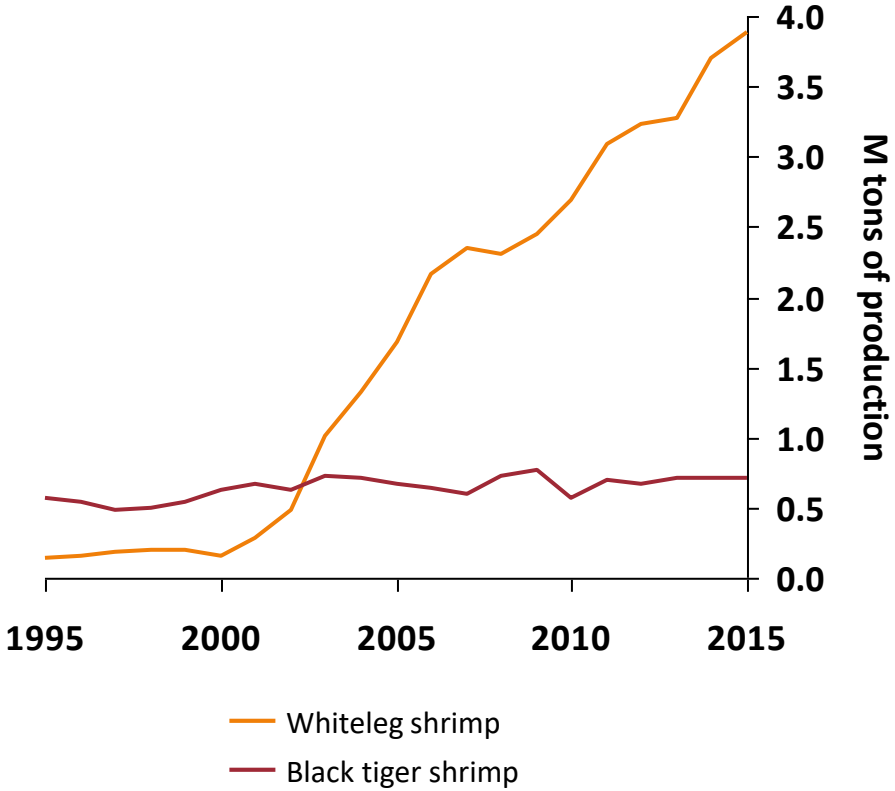
Sources
1 FishststatJ
2 www.shrimpnews.com: World Shrimp Farming 2004

Increased global farmed shrimp supply has been driven by the rapid growth of whiteleg production in China, India, SE Asia, and Ecuador

Global farmed shrimp production (all species) by producing country



Farmed shrimp production by species



Source: FishstatJ

Shifting global production trends to increased intensity has favored whiteleg over black tiger shrimp

"Intensification" refers to increased stocking density

In shrimp farming, the intensity of production relates to the stocking density of ponds with post-larvae (PL) shrimp. At higher densities, yield per hectare of production increase as long as survival rates are constant in the outgrowing period.

Whiteleg is better suited for intensive production

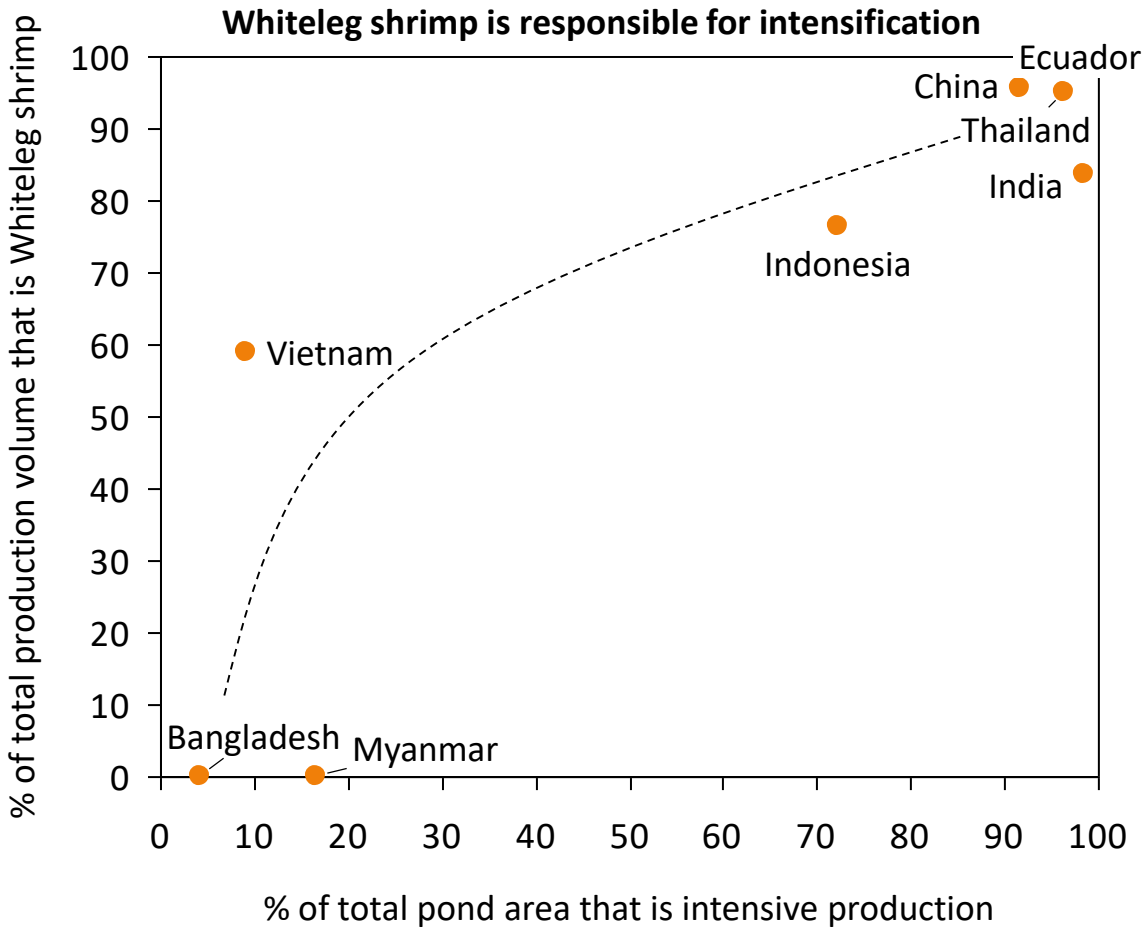
Whiteleg and black tiger are the two most important species in shrimp aquaculture globally, accounting for a combined 94% of farmed production in 2014. Black tiger (native of Southeast Asia) farming requires more extensive production systems, while whiteleg (native of Latin America) can be reared in high densities.

Intensive production requires additional inputs

Global production is increasingly sourced from intensive farms, which require inputs such as feed, broodstock, chemicals, and aeration and other infrastructure along with the electricity to power them. More intensive ponds have greater input requirements but also appreciate efficiency gains from economies of scale.

Production system	Yield ha^{-1} yr^{-1}	Characteristics
Extensive	<1 ton	Low operating costs, relies on the natural productivity of the environment and crop wastes as feed
Semi-intensive	2-20 tons	Uses fertilizers and farm-made feed and may use other chemicals and antibiotics
Intensive	20-200 tons	Relies on inputs made off farms, such as high quality feed, seed, and fertilizers.
Super intensive	>200 tons	Some raceway, recirculating and cage systems can produce extremely high yields.

As countries industrialize and intensify shrimp production, whiteleg shrimp starts to dominate production at the national level



- Current top producing nations have already transitioned to largely intensive shrimp farming dominated by whiteleg shrimp.
- Southeast Asian countries with low degree of technological advancement (Myanmar, Bangladesh) continue to rely on coastal shrimp farming, frequently requiring wild black tiger larvae to stock ponds.
- Vietnam is currently on the path from extensive to intensive, quickly replacing black tiger with whiteleg shrimp.

Source: Boyd C.E. and A.A. McNevin (forthcoming). “Land Use in Shrimp Aquaculture”.

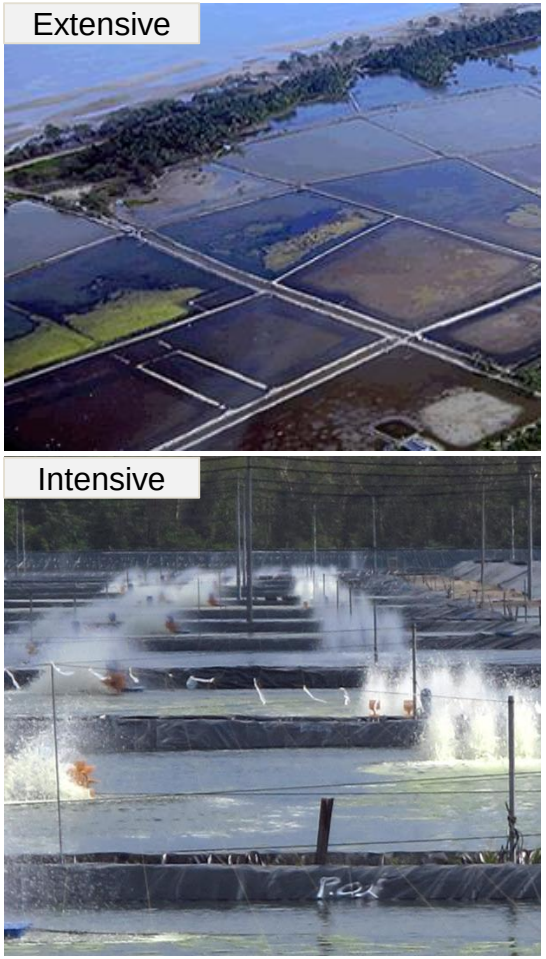
The trend toward intensification is increasing despite the elevated risks of harvest loss from disease outbreaks

- Commercially viable techniques for rearing larvae *in situ* have only recently been established. For decades, shrimp farming had relied on the natural lifecycle of black tiger shrimp in mangroves and estuaries. As a result, most Southeast Asian countries had reared only the native black tiger shrimp.

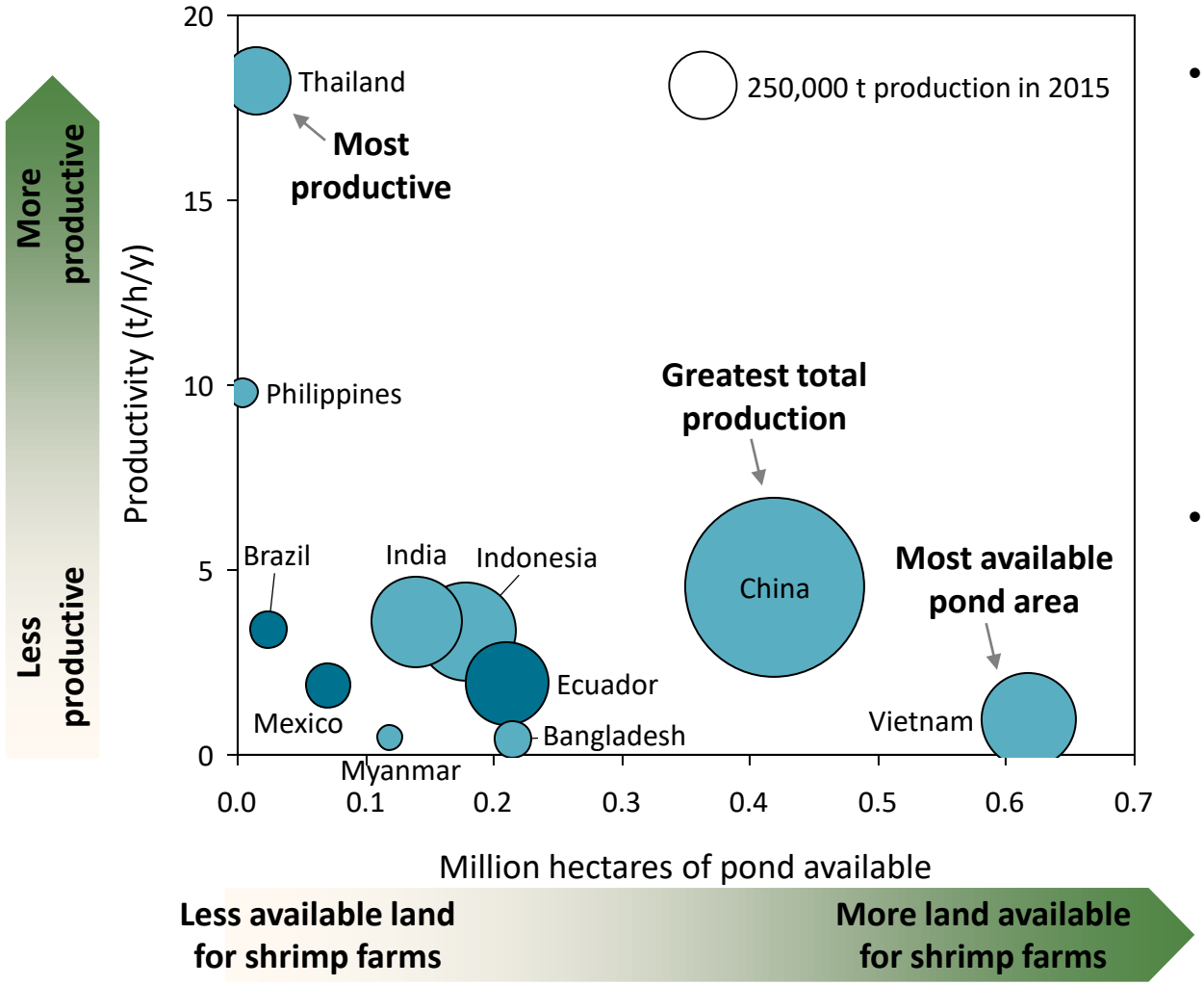
- The legalization and commercial viability of whiteleg shrimp production in Southeast Asia is at the root of the spike of production observed since the late 1990s, as intensification at scale was suddenly possible.

- Although intensification routinely leads to devastating disease outbreaks, it has remained the dominant production form across the globe. Land use restrictions increase that trend, as can be seen in countries like Thailand and the Philippines.

- Intensive farming is also evolving in real time. Thailand's industry has developed an "Intensive 2.0" model, where it allocates 50% or more of total pond area to water treatment, install central drains to clear organic detritus, and utilize PL nurseries. In the future, large-scale, fully self-contained systems may prove viable and will greatly reduce if not eliminate the risk of widespread disease outbreaks.



Availability of land for shrimp farms is not likely to increase, so increased future production will come from productivity gains



- Thailand and Vietnam have similar production volume but are on opposite ends of the productivity spectrum: Thailand is 20 times more productive than Vietnam
- At current land use patterns, Vietnam and China have the highest potential for growth in the next decade if existing ponds can be intensified

Source: Boyd C.E. and A.A. McNevin (forthcoming). "Land Use in Shrimp Aquaculture".

While shrimp farming once was destructive, improvements are being made to reduce the social and environmental externalities

The popular narrative of shrimp aquaculture is bleak: Shrimp farming has been portrayed as having high feed conversion ratios (FCR) that impair wild fish stocks to feed Western demand; mangroves are destroyed to create new ponds; antibiotics threaten human health; wastewater leaves agricultural lands and coastal waters barren; and the boom and bust history of sector has left an image of greed and collapse.

Improvements are underway: While all of the above are founded on legitimate concerns, particularly in regions that have only recently started to intensify production, it would be unfair to consider this the state of all global farmed shrimp production. Overall the industry is changing quickly, adopting more sustainable practices, and aligning with a lower-risk and more profitable business model:

- **Feed**: FCRs are steadily improving and experts report that shrimp do not *require* a fish diet anymore, though growth rates often remain higher when at least some fishmeal is included. Processing byproduct meal is becoming a common replacement in fishmeal, particularly for countries with large seafood processing industries like Thailand.
- **Mangrove deforestation**: The global trend towards the intensification of whiteleg production does not greatly threaten standing mangrove forests, rather relies more frequently on the conversion of existing agriculture land (e.g., rice paddies) or the conversion of existing shrimp ponds. Mangrove deforestation is more associated with black tiger shrimp farming today.
- **Antibiotics:** Though some countries continue to struggle with the overuse of antibiotics (e.g., China, India), these treatments are becoming less effective and are being replaced in many countries by preventive and probiotic solutions.
- **Wastewater discharge:** Circular water treatment and more self-contained systems decrease discharge significantly, reducing risks of disease spread.

Clearly, concerns remain and improvement is crucial particularly in small-scale production that lacks the training and capital to invest into efficiencies such as central drains, water treatment, PL nurseries, and healthy broodstock.

Overview of select environmental concerns to shrimp farming

Environmental concern	Description	Trends	Level of concern by key country
Wastewater	While larger farms treat water in recycling ponds, smaller facilities cannot afford costly installations and release the waste (organic and inorganic pollutants) into local water ways, harming surrounding ecosystems and spreading disease. In addition to groundwater pollution from chemicals, salt can be put into freshwater systems to boost productivity and leaches into the ground and aquifers.	**Increasing.** The increasing intensity of shrimp farming also results in an increase in waste concentration in the water. We expect this problem to increase as many of the small, poorly managed farms are pushing for intensification while simultaneously lack the training or funds to mitigate wastewater.	**High:** • China • India **Medium:** • Indonesia • Thailand • Vietnam **Low:** • Ecuador
Land conversion and degradation	Early shrimp production in tropical countries was accompanied by heavy mangrove destruction and conversion of pristine land to brackish water ponds.	**Decreasing.** Mangrove destruction and virgin habitat conversation for shrimp aquaculture has subsided over time, partly due to the inland movement of shrimp production. In addition, the transition to more intensive whiteleg production has reduced this kind of threat.	**Medium** • India • Indonesia • Vietnam **Low:** • China • Ecuador • Thailand
Antibiotics and chemicals	Antibiotics and chemicals are used to reduce the frequency of disease outbreaks and increase productivity. Apart from the health concern of shrimp containing residue of antibiotics (legal and illegal), multi-resistant bacteria have been found in shrimp ponds.	**Increasing.** Intensification, low quality broodstock, and poor farming practices raise the need for antibiotics. However, strict regulations from the EU are changing practices in producer countries.	**High:** • China • India • Indonesia • Vietnam **Medium**: • Thailand **Low:** • Ecuador

Top countries are continuing to increase output; while only a small portion of shrimp is certified, environmental impacts are being reduced through market fundamentals

Production: Production is on the upward trend for each of the top 6 producing countries, driven in each case by whiteleg shrimp. Black tiger shrimp maintains a strong presence in the estuarine systems of Southeast Asia and India, but production has flattened out over time.

Productivity: Productivity has been steadily increasing due to the conversion from black tiger to whiteleg shrimp, with the help of simple farm techniques such as water treatment ponds, mechanical aeration, central drains, PL nurseries, and raceways. Thailand is at the forefront of intensive production with an average productivity of 18 tons/ha/year, 20 times more productive than Vietnam. Looing forward, it can be expected that most of the sector's growth will come from increased intensification of whiteleg shrimp.

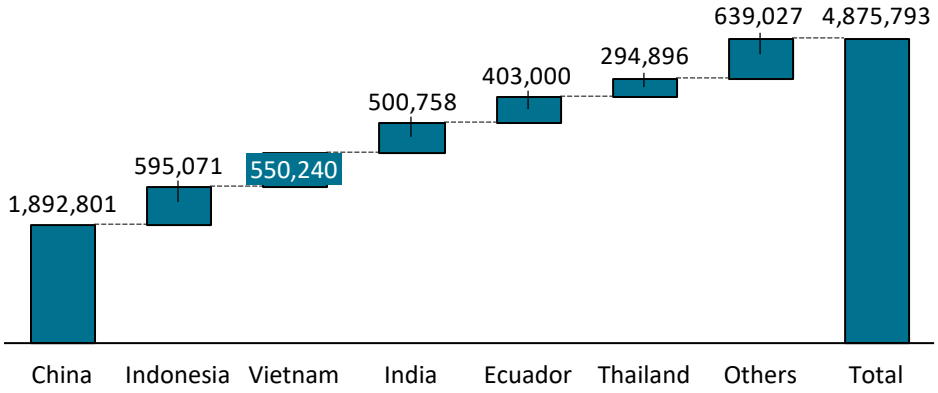
Social and environmental standards: Social and environmental standards for the shrimp sector have evolved for well over a decade, climaxing with the news in the late 2000's that the Thai shrimp sector employed slave labor along the shrimp supply chain. Certifications and rating agencies include Best Practices in Aquaculture (BAP), Global G.A.P., ASC, Naturland, and Seafood Watch. While Seafood Watch rates the overall performance of a country's sector along 10 key environmental criteria, certification agencies usually evaluate farms and entire chains of custody based on their ecological and/or social specifications. To date, certifications only cover a small fraction of production in each of the top producing countries. Maybe most feared by the industry are FDA and EU import restrictions; a credible threat of country-wide bans due to antibiotics overuse currently exists for India and Vietnam that is driving change on the ground.

Environmental performance: Due to multi-resistant bacteria and the primitive immune system of shrimp, intensive farming is increasingly synonymous with environmental precaution. Where capital and technical training is available, farms increasingly manage their farms sustainably (less disease outbreaks), and fishmeal and fish oil are less frequently required for shrimp feed. Water discharge remains a serious problem.

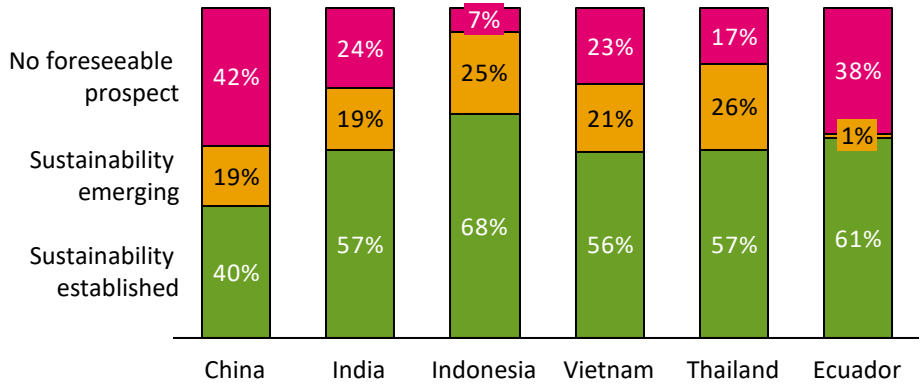
Trade: The US is by far the most important trading country for all major shrimp producers, but demand from China is quickly growing and threatens the potential effectiveness of western demand-driven intervention strategies.

China, the largest producer, continues to have major environmental challenges while Ecuador has largely reduced its environmental impact

Tons of production (2015)



Sustainability awareness of trading partners (SFP categories)



Concerns levels

Country	Wastewater	Land degradation	Chemicals / antibiotics
China	High	Low	High
Indonesia	Medium	Medium	High
Vietnam	Medium	Medium	High
India	High	Medium	High
Ecuador	Low	Low	Low
Thailand	Medium	Low	Medium

China, the largest producer of farmed shrimp, has become a net importer to meet the immense demand of a growing middle class

Production trends

China accounts for about 26% of global shrimp consumption and its domestic demand continues to grow. The country's shrimp production is almost entirely based on semi-intensive, family-run farms that are concentrated in the southern region around Guangdong. Whiteleg shrimp is favored over other species due to its comparative resilience against disease and tolerance for higher freshwater content in ponds. However, production is intensifying, driven by a growing number of more efficient, capital intensive farms in the south and support by the government. This trend has not yet reached the majority of the 14,000 or so family-operated farms that lack the education, training, and capital to invest in better practices or intensification.

Sustainability trends

The rapid growth of domestic whiteleg production in the past decade has come at the expense of land degradation and pollution. Despite the species' tolerance to freshwater, productivity is often boosted by adding salt to ponds, which increases the risk and frequency of groundwater spoilage and depletes the health of adjacent agricultural soil. The main reason for pollution and land degradation is poor farm-level management, a lack of technical knowledge, and the capital-intensive nature of water treatment. Recent policies push for nation-wide improvements, most notably regarding land degradation, signaling a likely increase towards more efficient, intensive farm systems.

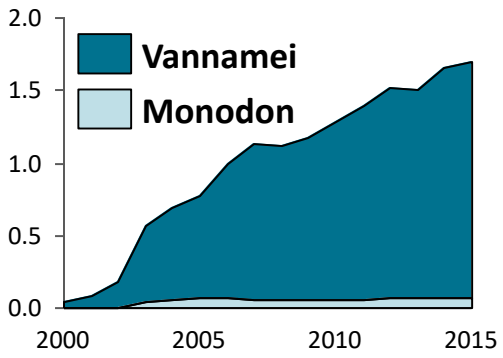
Market and industry trends

China's domestic appetite for shrimp is unparalleled. The consumer preferences of an emerging middle-class has driven much of the global trend in shrimp production; the country has increased imports and decreased exports to meet that demand and to compensate for the decreased production in the north of the country where coal-heated ponds have been discontinued the government regulation. Strikingly, the domestic market prefers unprocessed over processed shrimp, making China a favorite among Southeast Asian producers: Chinese traders arrive with their own trucks, ice and harvesters to even remote farms across the region, pay competitive prices in cash and have minimal requirements regarding social and environmental conditions of production.

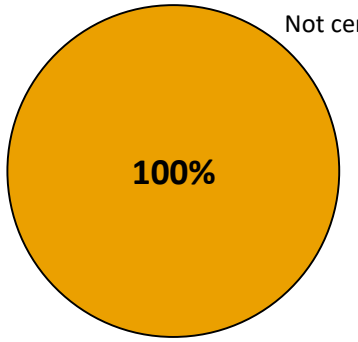
Sources
1 Seafood Watch, 2014
2 X. Biao, Shrimp farming in China […], 2007
3 C. Boyd, A. McNevin, Land use in Shrimp Aquaculture
4 Seafood Source, "China's shrimp industry still leads, but […]

Country dashboard China

Production trends (M tons)[1]



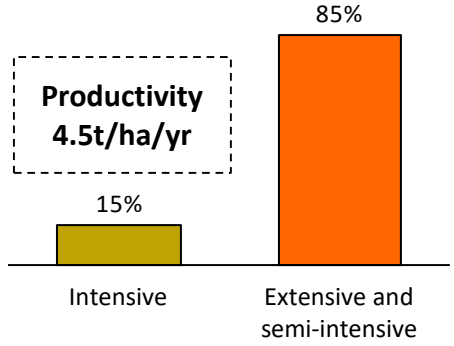
Certification status (by % of volume)[3,*]



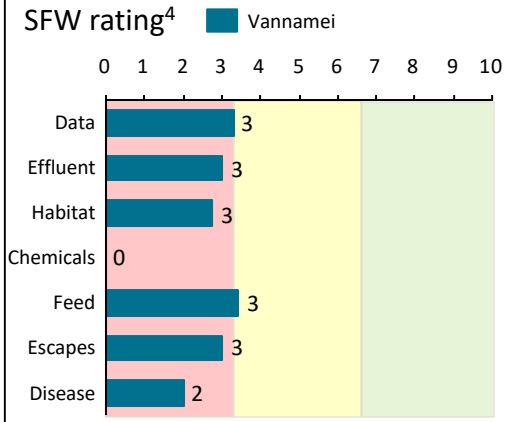
Noteworthy

- Growing domestic demand has made China a net importer of shrimp and the major market force in the region.
- Uncontrolled sectoral growth fostered poor farming practices, the overuse of antibiotics, and poor area management.
- The central government's push for increased intensification will lead to more highly efficient farms in the future.

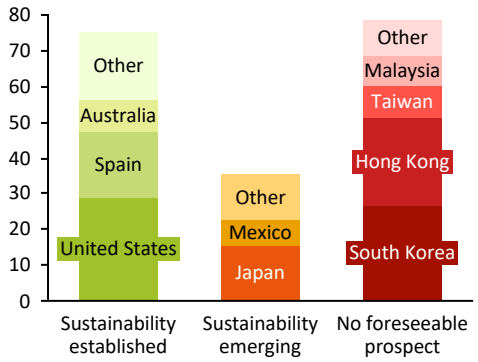
Production systems (% of ha per system)[2]



SFW rating[4]



Export volume[5] (total = 188,218 MT)



1 Source: FishstatJ
2 Source: McNevin et al.

3 Source: Seafood-tip.com
4 Source: Seafood Watch

* Currently unaware of any full certification

5 Source: Trademaps.org, 2015

India's recent, rapid growth in production has made it the world's largest exporter, but it struggles with high antibiotics use

Production trends

Within the last decade, India's shrimp production more than tripled, joining the ranks of the top producers globally. This growth can be almost exclusively attributed to whiteleg production in Andhra Pradesh (region in the Southeast of the country), where a preexisting fisheries industry presence and timely investments into feed mills and processing plants created the enabling environment for the production and marketability of inshore shrimp and allowed the region to respond to increasing global demand.

Sustainability trends

Shrimp production is typically expanded by converting unproductive rice fields or black tiger shrimp farms into intensive whiteleg shrimp farms. The use of antibiotics and chemicals are a major problem, resulting in degraded local water supplies, the creation of multi-resistant bacterial strains, and the rejection of product in international markets. This overuse is exacerbated by a lack of knowledge on the farm level, where "every problem is deemed biotic and every solution antibiotic" as one interviewee put it. Additionally, India's conversion of mangroves has largely subsided due to government regulations.

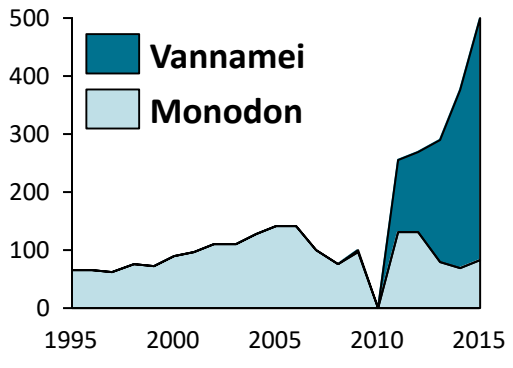
Market and industry trends

In traditional fishing regions of the country (particularly Andhra Pradesh), a supporting industry consisting of feed mills and processors has created the enabling environment for shrimp farms to source inputs and sell production. Although a growing domestic market exists, most of India's production is destined for international trade, making the country the world's leading shrimp exporter (425,000 MT in 2016), and spurring growth of a domestic aquaculture support industry. However, Indian shrimp exports are being rejected by US and EU custom officials due to residues of illegal antibiotics. In 2016 and 2017, the EU increased the frequency of inspections from 10% to 50% and 22 shipments were declined, mainly due to traces of *Nitrofurans*. Based on undercurrentnews.com, Indian exporters fear a ban from the EU and EU importers are "already Shifting Away from Indian Shrimp Prior to [soon expected] EU Inspection Visit".

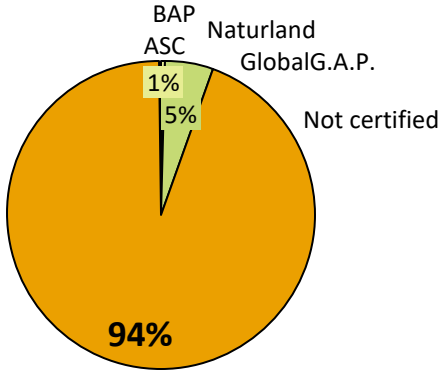
Sources
1 Seafood Watch, 2014
2 Solidaridad, Seafood trade intelligence portal
3 C. Boyd, A. McNevin, Land use in Shrimp Aquaculture
4 J. Jong, Aquaculture in India, 2017

Country dashboard India

Production trends ('000 tons)[1]



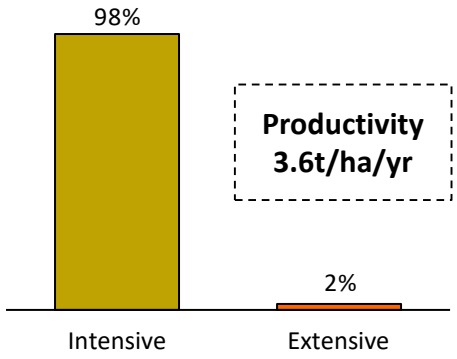
Certification status (by % of volume)[3,*]



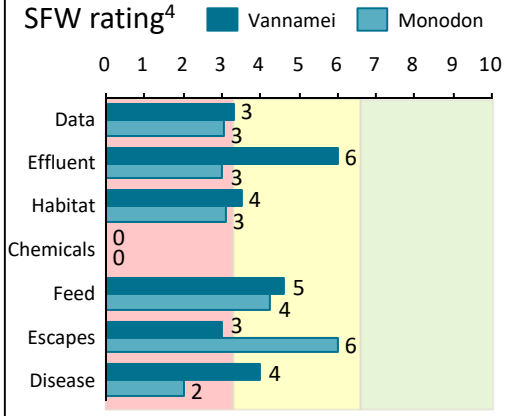
Noteworthy

- Strong increase in vannamei farming, mostly due to intensification
- Development of multi-resistant bacteria
- Threat of EU import ban due to antibiotic residue
- Andhra Pradesh is the major hub of recent production increase due to existing industry but other regions may well see an increase in production soon

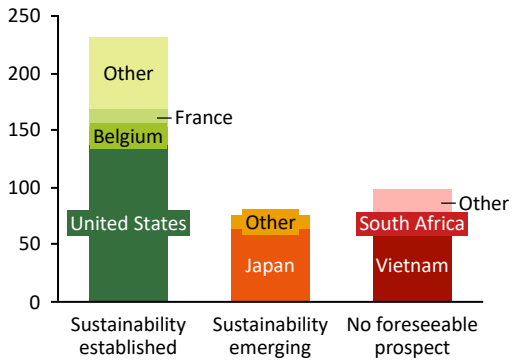
Production systems (% of ha per system)[2]



SFW rating[4]



Export volume[5] (2015: 394,462 MT)



1 Source: FishstatJ
2 Source: McNevin et al.

3 Source: Seafood-tip.com
4 Source: Seafood Watch

5 Source: Trademaps.org, 2015

While shrimp farms in Indonesia range from extensive to super-intensive, disease has curbed expectations of growth

Production trends

Indonesia's farmed shrimp sector consists of almost 100,000 family farms (not necessarily poor farmers), each smaller than a hectare, contribute to the country' approximately half a million hectares of ponds. After the legalization of whiteleg shrimp farming in 2001, extensive black tiger shrimp farming has gradually been displaced by intensive whiteleg shrimp farms. While extensive farms are spread across the country with some concentration in Kalimantan, intensive and super-intensive farms are concentrated in Java and South Sulawesi. The major challenges to increased production and productivity is poor quality broodstock which has contributed to low survival and growth rates recent years, as well as water quality and pollution.

Sustainability trends

A high frequency of disease outbreaks has curbed the expected growth of Indonesian shrimp farming in recent years and can be attributed to poor farm management. A lack of education, training, and capital continues to be a barrier for the adoption of best practices and the excessive use of chemicals and antibiotic are tainting the reputation of Indonesian shrimp. Soil degradation, pollution of nearby water ways and the emergence of multi resistant bacteria are additional concerns.

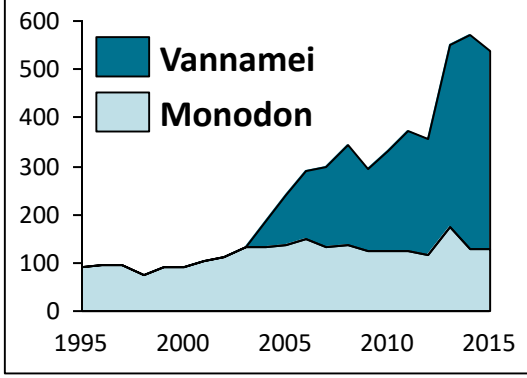
Market and industry trends

65% of farmed shrimp production is exported (compared to international average of 37%). The value of shrimp export (> $US 1.3 Bn in 2015) from Indonesia exceeds the value of all fish exports (wild caught and aquaculture), making it a valuable export commodity on a national scale. The US is the major trading partner for shrimp, followed by Japan. The relatively high awareness of sustainability in these end markets increases the likelihood of market-based sustainability strategies to be successful at scale. This is further helped by the fact that feed companies are highly consolidated and could have some influence on the management of their client farms.

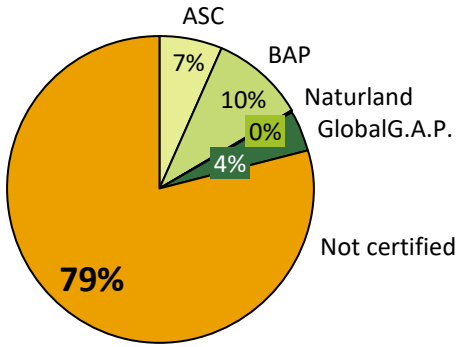
Sources
1 Seafood Watch, 2014
2 Solidaridad, Seafood trade intelligence portal
3 C. Boyd, A. McNevin, Land use in Shrimp Aquaculture

Country dashboard Indonesia

Production trends ('000 tons)[1]



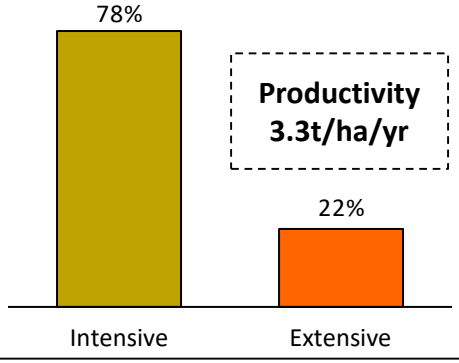
Certification status (by % of volume)[3,*]



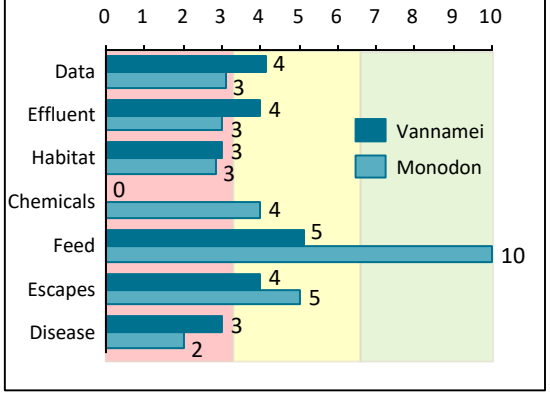
Noteworthy

- Extensive production is distributed, across country but intensive productions and main processing plants are located in East Java
- The value of shrimp export exceeds the value of fish export (capture and farmed)
- The large majority of production ends up in countries with a decent level of sustainability awareness

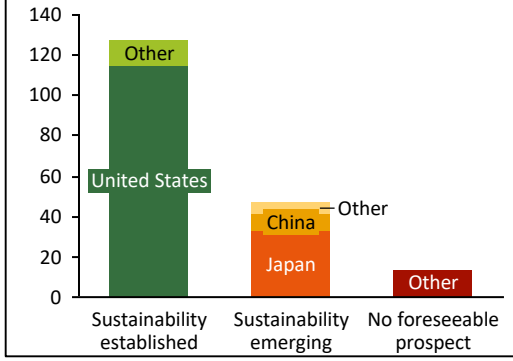
Production systems (% of ha per system)[2]



SFW rating[4]



Export volume[5] (total = 186,193 MT)



1 Source: FishstatJ
2 Source: McNevin et al.

3 Source: Seafood-tip.com
4 Source: Seafood Watch

5 Source: Trademaps.org, 2015

Vietnam's pond area and processing capacity available for shrimp farming are expanding rapidly, but illegal antibiotics limit exports

Production trends

In 2015, Vietnam had 600,000 hectares of land dedicated to shrimp farming. By 2016, it had added another 70,000 hectares, an area equivalent to four times the pond area of Thailand. No country in the world has dedicated nearly as much area to shrimp farming. Most of the production takes place in in the salt water intrusion zone of the Mekong delta (Ca Mau, Bac Lieu, Soc Trang, Ben Tre and Kien Giang). Shrimp production is almost equally split between extensive Black tiger farming and intensive whiteleg, resulting in Vietnam having the lowest overall per hectare production of the major shrimp producing nations (0.89 t/ha).

Sustainability trends

While third party certifications exist and is growing, the residues of illegal antibiotics remain a problem. Between 2014 and July 2016 alone, 101 shipments from Vietnam were rejected by the FDA and 38 by the EU; while FDA and EU do not always specify production systems and species, a large percentage of rejections seem to be based on *oxytetracycline* residues in whiteleg shrimp shipments. Mangrove destruction has been a serious problem in Indonesia, and still remains a relevant concern in some areas (e.g., Kalimantan), but the current focus on intensive whiteleg production systems reduces the overall concern for the future degradation of pristine mangrove systems.

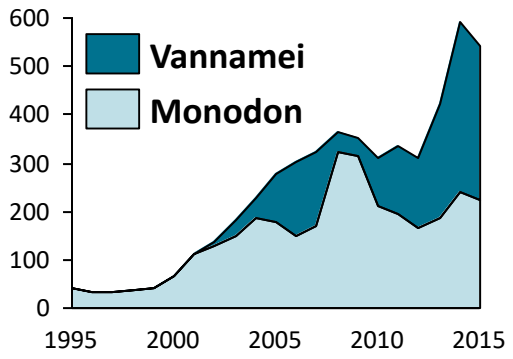
Market and industry trends

While increasing its own production, Vietnam is establishing itself as a major reprocessing hub for shrimp produced in India and Ecuador, importing 65,121 MT (India, 2015) and 103,479 MT (Ecuador, 2015) respectively. The official export volume of 438,500 MT is making Vietnam is the world's second largest exporter of shrimp. Official records do not include illegal shrimp exports to China that were estimated at 270,000 tons in 2016. The annual growth rate of Vietnamese aquaculture production is twice as high as national GDP growth; deemed a successful sector, the government is encouraging the expansion of the nations shrimp aquaculture production and reprocessing.

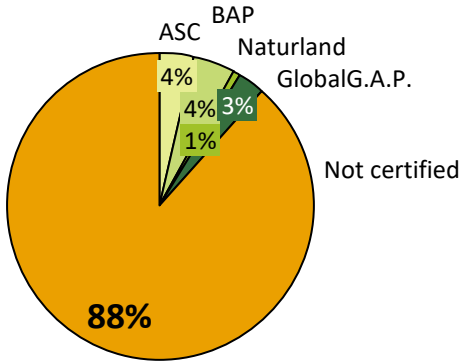
Sources
1 Seafood Watch, 2014
2 Solidaridad, Seafood trade intelligence portal
3 C. Boyd, A. McNevin, Land use in Shrimp Aquaculture
4 Tran Ha, The Changing Roles of the State in Shrimp Farming […]
5 www.undercurrentnews.com

Country dashboard Vietnam

Production trends ('000 tons)[1]



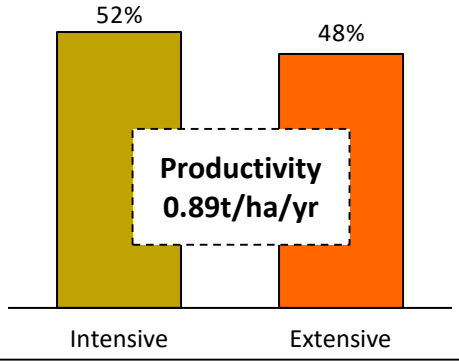
Certification status (by % of volume)[3,*]



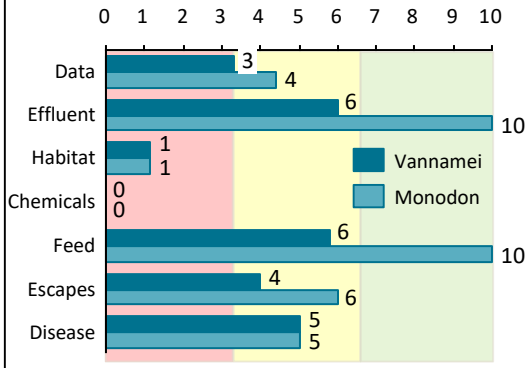
Noteworthy

- More hectares of ponds dedicated to shrimp farming than any other country in the world, mostly in the Mekong river delta
- Strong increase in whiteleg farming, mostly due to intensification
- Major hub for reprocessing
- Evidence of significant volumes of shrimp being smuggled into China

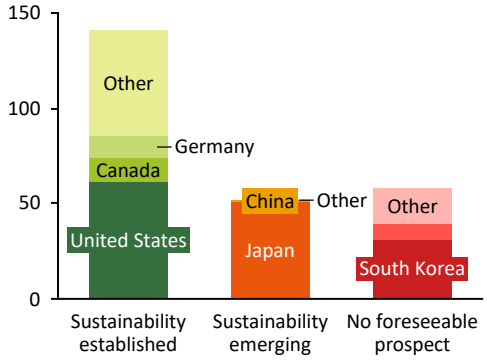
Production systems (% of ha per system)[2]



SFW rating[4]



Export volume[5] (total = 240,733 tons)



1 Source: FishstatJ
2 Source: McNevin et al.

3 Source: Seafood-tip.com
4 Source: Seafood Watch

5 Source: Trademaps.org, 2015

Thailand's next generation of intensive shrimp farming appears to be a model for cleaner, more efficient production systems

Production trends

Thailand now boasts the most productive shrimp farms in the world, averaging 18.2 tons per hectare per year. This is particularly noteworthy since 60%-70% of farms are tiny, family operated "baby-farms." Part of Thailand's success story can be attributed to the industry's quick learning curve that **is made possible through industry-wide platforms and regional farmer cooperatives**. This allowed the industry to quickly transition from extensive monodon production to intensive whiteleg farms (2000-2008) and facilitative the widespread adoption of wastewater treatment practices after the devastating EMS outbreak in 2013.

Sustainability trends

The 2013 EMS outbreak put a pause on the enormous expansion and intensification of shrimp farming that had lasted for decades and was a wake-up call for the industry, underscoring the critical need to minimize the disease risk. Most farms have since repurposed portions of their ponds for water treatment, started to grow post-larvae longer in nurseries before transplant to ponds to strengthen the primitive, non-adaptive immune system, and installed aeration additional devices. While the Thai government has stepped up its environmental regulations, enforcement is weak and these more responsible practices are more about production risk-minimization than regulatory compliance.

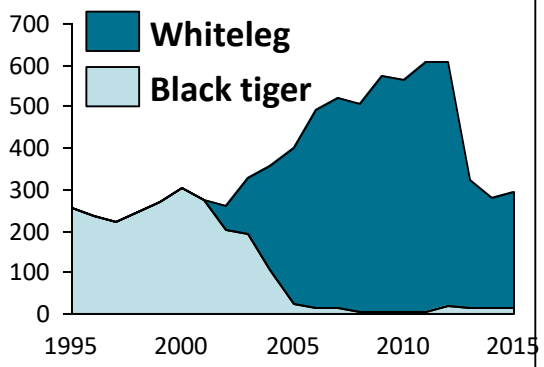
Market and industry trends

The largest export markets are United States (for vannamei) and Japan (for monodon). While small scale farmers mostly produce for domestic markets, larger farms produce shrimp for the export market. Anecdotal evidence suggests that emergency harvests after EMS outbreak created a strong niche market for smaller, salad-sized shrimp. Since the economics of large shrimp are more favorable than small shrimp at the farm level, this trend increases stocking densities in farms, thereby elevating the risk for disease outbreaks.

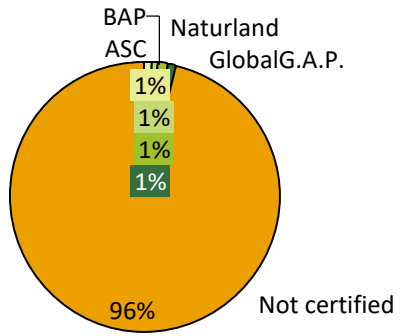
Sources
1 Seafood Watch, 2014
2 Traceability in the Thai Farmed Shrimp Supply Chain, 2016
3 C. Boyd, A. McNevin, Land use in Shrimp Aquaculture

Country dashboard Thailand

Production trends ('000 tons)[1]



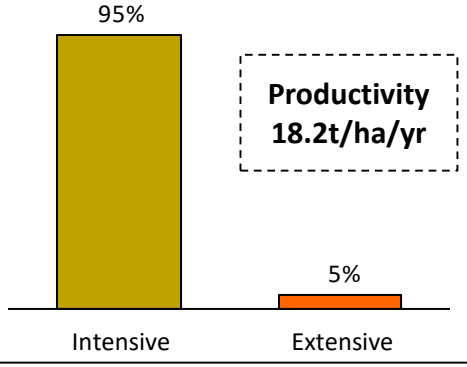
Certification status (by % of volume)[3,*]



Noteworthy

- The 2013 outbreak of EMS sounded the alarm for "intensive 2.0" farming, with increased investments in water treatment and pond cleaning techniques
- 60-70% of farms are family-run "baby farms" that produce 30% of shrimp
- While small farms produce mainly for the domestic market, most of exports originate from larger farms

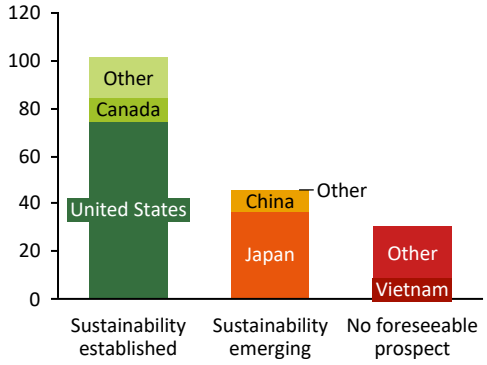
Production systems (% of ha per system)[2]



SFW rating not published; major observations from interviews with Seafood Watch[4]:

- "Intensive 2.0" to expand production in limited space and to reduce disease outbreaks
- Changed water management and farm practices after EMS outbreaks
- Escapes are a low concern as good gates and canals exist before common water bodies are reached
- Feed based on tuna by-products but not efficient at 60% protein in formula

Export volume[5] (total = 176,397 MT)



1 Source: FishstatJ
2 Source: McNevin et al.

3 Source: Seafood-tip.com
4 Source: Seafood Watch, personal communication

5 Source: Trademaps.org, 2015

Ecuador's low stocking densities and quality broodstock result in low impact, high quality organic shrimp that fetches a premium in international markets

Production trends

After disease outbreaks decimated much of the country's production in the late 1990's, Ecuador adopted a model of semi-intensive whiteleg production that earned the country fame for sustainable shrimp farming and continues to yield the highest prices on the market. In the last 15 years, production gradually intensified again, increasing output from 50,000 tons in 2000 to over 400,000 tons in 2015.

Sustainability trends

Virgin land transformation to shrimp farms took place in the 1960s-1990s, with recent production increases stemming from intensification rather than increased land conversion. Vertical integration of farms ensures high quality broodstock/seed, which reduces the occurrence of diseases, resulting in fewer antibiotics being used during the grow-out phase. In addition to the reduced use of antibiotics, ponds are stocked at comparably low densities, further decreasing the environmental impact of shrimp farming. Ecuador receives a premium for EU-certified organic shrimp (Naturland), which is unique for whiteleg and an important incentive to adopt organic farming practices. However, some producers 'cheat' the certification schemes by having a mix of certified and uncertified farms. Ecuador has become the poster child for automatic feeding technologies, as it increased productivity from 3 to 4 cycles per year, nearly quadrupled the growth rate, and reduced environmental impact (almost no pond cleaning required, because dirty ponds usually result from excess feed).

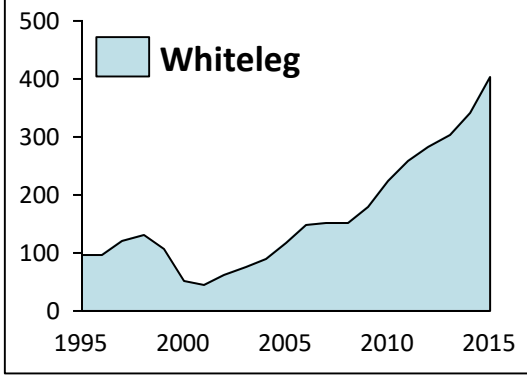
Market and industry trends

The intensive shrimp farming at low stocking densities allows Ecuador to produce high quality shrimp, which generates a strong demand in Asian markets, particularly China, although much of China's import of Ecuadorian shrimp is via grey channels in Vietnam. Compared to Asian supply chains, Ecuador's export market is fairly consolidated, with 71% of all exports attributed to 10 companies. Due to relatively high labor costs, Ecuador's suppliers seek differentiation in the global market through increased product quality while simultaneously competing in the commodity market.

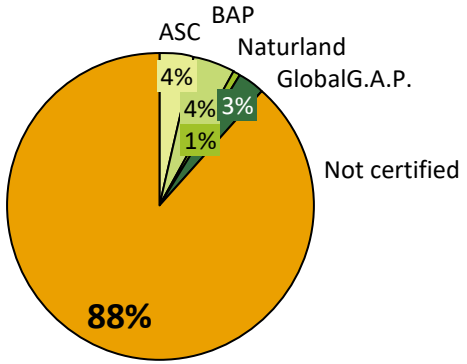
Sources
1 Seafood Watch, 2014
2 Solidaridad, Seafood trade intelligence portal
3 C. Boyd, A. McNevin, Land use in Shrimp Aquaculture

Country dashboard Ecuador

Production trends ('000 tons)[1]



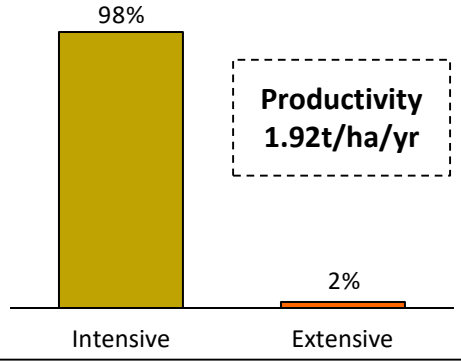
Certification status (by % of volume)[3,*]



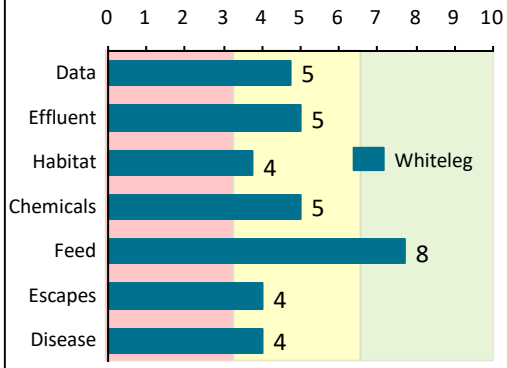
Noteworthy

- Ecuador is the only top-producing country with vertical integration of farms and processing segments
- Intensification is increasing after several years of cautious farming techniques to curb disease
- Ecuadorian shrimp considered high quality and yields premium prices on product market in US and Asia
- Ecuador competing both on product and commodity markets

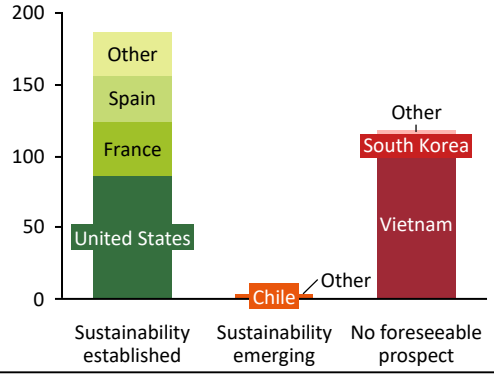
Production systems (% of ha per system)[2]



SFW rating[4]



Export volume[5] (total = 240,733 tons)



1 Source: FishstatJ
2 Source: McNevin et al.

3 Source: Seafood-tip.com
4 Source: Seafood Watch

5 Source: Trademaps.org, 2015

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3

Supply Chain

- Supply chain structures and market-based initiatives
- Deep-dive: Southeast Asian supply chains
- OSMI objective prioritization framework and results chain assessment

Supply chain structures differ greatly across geographies, but US buyers' influence to drive widespread transformation is likely limited

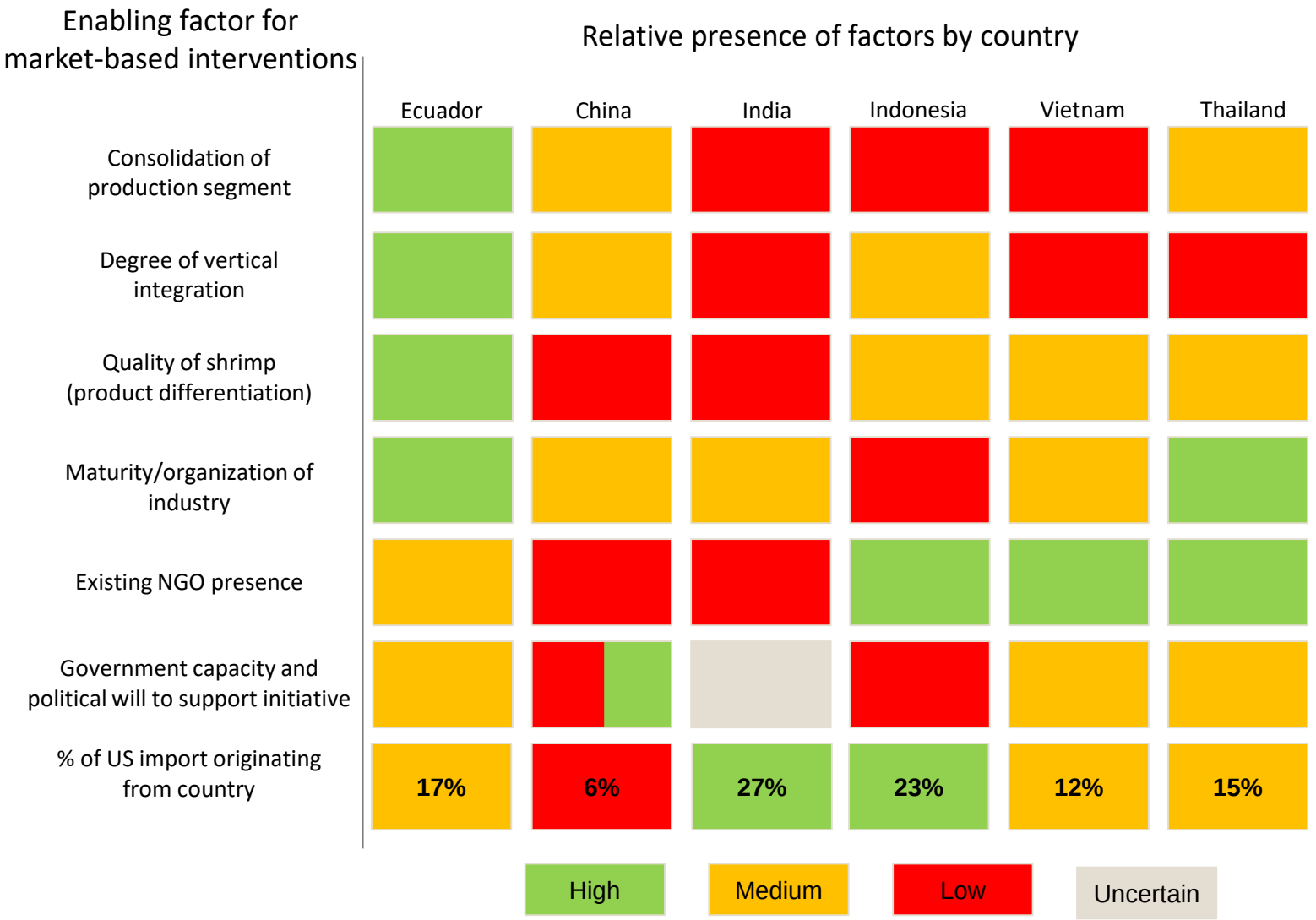
The export-oriented farmed shrimp supply chain always consists of four major segments: inputs (feed and PLs), farm, processor, and importer. The consolidation, vertical integration, and inter-segment interactions differ considerably across regions, but can be broadly grouped by geography into Latin America and Asia.

Latin American farms tend towards vertically integration and produce generally higher quality shrimp: In Ecuador**,** a small number of large, intensified farms directly supply into well-organized, corporate processors that have long-established relationships with international importers. The native whiteleg shrimp is of a distinctly higher quality than its Asian counterpart due to lower stocking densities, high-quality inputs (optimized feed regimens, locally produced broodstock), and well-established farm practices. This allows Ecuador to position its shrimp in higher-priced product markets. However, the recent increase in intensification creates a conflict for producers: increase the differentiated, high-priced product pathway or compete in the international commodity market? Higher salaries in Ecuador make it difficult to compete on the undifferentiated US commodity market (and drives outsourced processing to Vietnam), but a high standing of Ecuadorian shrimp in China will likely absorb increased Ecuadorian volumes.

South and Southeast Asia have a highly disaggregated farming sector and opportunistic farmer-buyer relationships: Well over 80% of shrimp imported by the US is produced in Asia and ends in a poorly differentiated commodity market. The large majority of farms in Southeast Asia, India and China are highly disaggregated, family-operated production units that feed into a large, opportunistic, and informal network of traders and brokers who in turn supply hundreds of processors. Given the high uncertainty of farm yields, purchase agreements between processors and wholesalers/retailers are negotiated on a quarterly. As a result, consistency of supply for US-based buyers is very limited and importers have to diversify their sourcing to mitigate the risk of low supply.

In all geographies, US-centered demand approaches' ability to drive sustainability country-wide is likely low: The lack of price premiums and the opportunistic nature of farm-processor relationships makes it near to impossible for processors or importers to influence widespread farm-level management, beyond farms that chose to pursue certification (which some expert interviewees argue is still insufficient to ensure sustainable production). This is exacerbated by a strong and growing demand for shrimp by China, which pays well and has low environmental and social requirements.

Low hanging fruit for markets-based initiatives include Ecuador (downstream influence on farms) and Thailand (industry readiness)



Shrimp supply chains in Asia are highly disaggregated, with hundreds of thousands of farms supplying into a highly traded commodity

Shrimp is one of the most highly traded commodities of the world, with 37% of production traded internationally. The almost 5 million tons of shrimp entering global trade (including wild caught) are sourced from hundreds of thousands of small scale producers that are distributed across dozens of tropical developing countries.

A critical feature of Southeast Asian shrimp supply chains is the largely informal and disloyal relationship between farmers and the rest of the supply chain. While some contract farming exists, buyers operate on thin margins and have to diversify their sourcing to guarantee consistent supply. This prevents solid pre-purchase agreements and vertical integration from production to retail that would support market demand intervention strategies. Large buyers (Thai Union, CP) are also invested in feed mill and hatchery businesses that can pre-finance farming operations through brokers. However, this doesn't provide them secured access to the farming outputs, and farmers usually sell to the highest bidder.

International wholesale and retail companies interact on the processor level rather than the farm level. While some vertical integration exists, competition among retailers clearly exists. As a result, the main challenge for wholesale and retail is to secure consistent supply of a commodity for which consumer demand drops rapidly as prices go up, giving importers only a small margin in the negotiation of prices with processors.

For the US-based wholesale sector, the large and growing demand for shrimp from China is creating an even more difficult situation: Chinese traders pay good prices in cash and at good prices, prefer unprocessed shrimp, and come with their own trucks and men to harvest the ponds. Furthermore, Chinese buyers have no requirements about farm management and mainly focus on shrimp size and quality.

A typical export-oriented shrimp supply chain

Supply chain segments	Inputs	Farm	Processing & export	Import, wholesale & retail
	 Quality feed and healthy broodstock are key constraints and create highly dynamic markets in itself	 Highly disaggregated, including hundreds of thousands of family-run "baby-farms"	 Processors compete for high quality shrimp. This drives up prices and yields minimum profit margins for processors	 A few importers dominate wholesale and retail; their main challenge is consistency of supply
Inter-dependencies	Feed mills and hatcheries finance working capital at farms			
		Traders play key role connecting farms with processors		
			Vertical integration only through to processing level	
Regulatory constraints	National Legislation			
			Trade restrictions	
Certifications & ratings	Seafood Watch			
	GGN (Global G.A.P.)			
	BAP Four Star			
	Naturland			
	ASC (including chain of custody)			

High quality inputs are needed to increase growth rates and density without losing stock to disease

Profitability at the farm level is mostly a function of volume, which is threatened by disease. In order to reduce losses of shrimp, which have a characteristically primitive immune system, a complex support industry of high quality inputs has developed to give shrimp stocks the best chance of survival in a high-growth, high-density system. These inputs include:

Quality feed: Shrimp health and growth strongly correlate with the quality and management of feed. Most critically, formulated feed must contain around 40% of essential nutrients (including proteins and amino acids). [1] This drives up prices and makes formula food the most expensive input to intensive shrimp farming. Importantly, fishmeal and fish oil are less frequently required for shrimp feed, and high growth rates on entirely vegetarian diet have become a possibility.

Healthy broodstock: Bacterial diseases and viral infections constitute a significant risk to the business. Specific pathogen-resistant (SPR) post larvae reared in remote and disease-free environments like Hawaii have become the broodstock of choice for most operations around the world. While quality broodstock increases the survival in the early stages of a life, it does not prevent later infections.

Chemicals and antibiotics: Chemicals and antibiotics decrease pathogens in ponds and increase survival rates in disease-prone environments. However, multi-resistant bacteria strains have developed as a result, making antibiotics obsolete.

Technology, education, and training: Aeration, sludge management, water treatment, PL nursery use, and feed regimes are examples of best practices that have an outweighed influence on growth and survival rates, but are only slowly adopted by farmers. While investment costs are an apprehensible barrier, knowledge and technical know-how are often mentioned as the major impediment to widespread adoption.

[1] Tacon et al. (2013) “Shrimp feed management: issues and perspectives”. FAO technical paper No. 583

The four key non-labor inputs pose individual challenges, and each is changing over time

Quality Feed

Importance: Primary factor in growth speed and health

Challenge: Represents 50% or more of production costs; depends on some wild fish

Trend: FCR decreasing, Fish in/Fish out decreasing but vegetarian diet still expensive

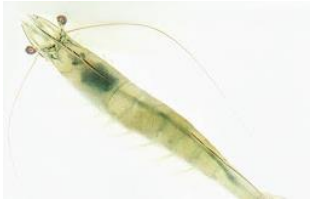
Chemicals & Antibiotics

Importance: Shrimp have no immune system, used to decrease disease.

Challenge: Health and environmental concern; creation of resistant strains

Trend: Avoid disease through pond management

Quality broodstock

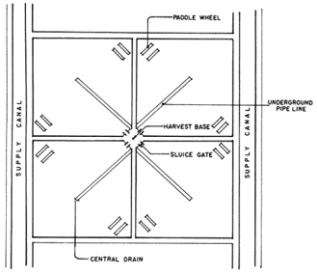


Importance: Disease typically comes in larval stadium; survival rate depends on healthy PL

Challenge: Additional cost for farms

Trend: Strong increase in farms that use SPR broodstock

Technology, education, and training



Importance: Significant improvements possible with simple best practices

Challenge: Capital investments and training are limited

Trend: Best practices slowly replace antibiotics use and allow sustainable intensification.

Shrimp farming is a high-risk, high-return business model that quickly reacts to external signals

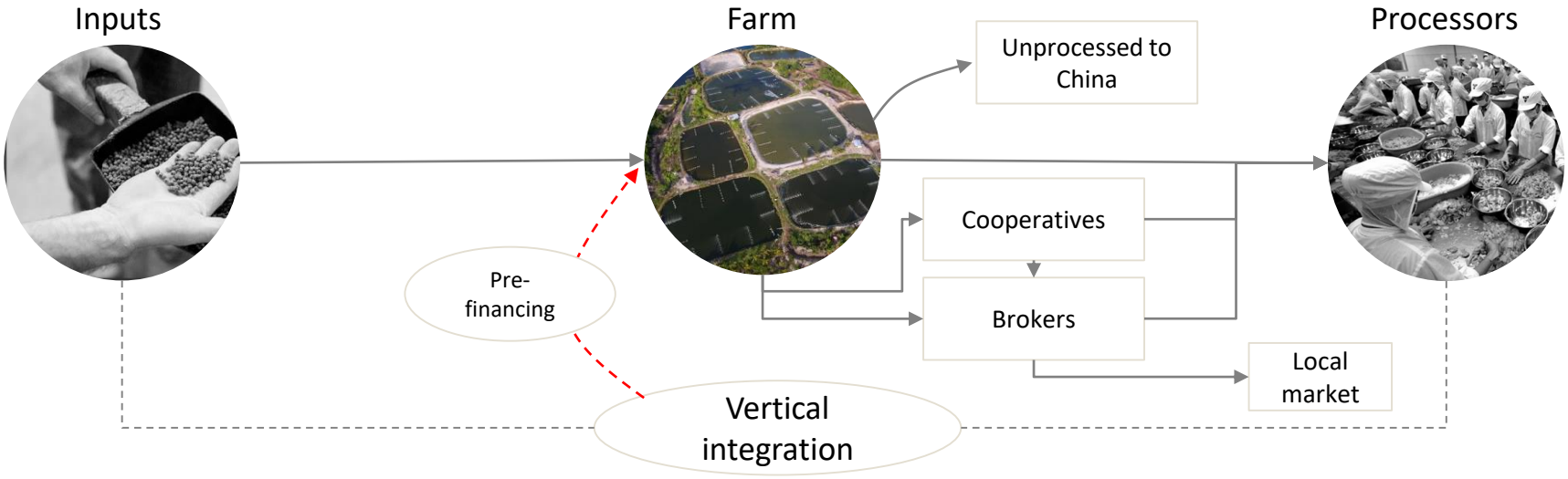
High profit: The rapid expansion of shrimp farming across tropical developing countries is evidence of the high potential profits that can be made at the farm level. Although capital layouts and variable costs are a significant hurdle for most small-scale farmers, fast returns attract risk-takers to bet on high survival rates and strong market demand.

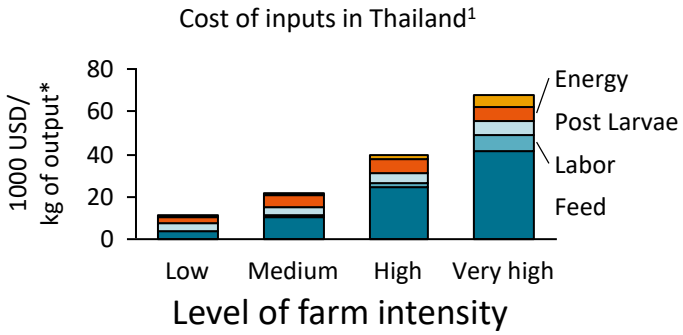
High risk: The steep upward curve of global shrimp production masks hefty boom and bust cycles which have bankrupted thousands of farmers. The primary cause for harvest losses remain bacterial diseases (e.g. Early Mortality Syndrome) and viruses (Whitespot disease), which shrimp are helpless against given their nonexistent immune system.

Intensive 2.0: Disease outbreaks across producing countries have triggered more and more risk-averse practices. This is exemplified in Thailand: production halved after the 2013 EMS outbreak and the 25-30 thousand farms fell to 10-15 thousand. In less than five years, the majority of surviving farms adopted an intensive 2.0 model, in which half of the pond area is repurposed for water treatment bodies, wheel aerators, and microbubblers. These improvements increase dissolved oxygen, drain detritus from pond bottoms, and use probiotics to naturally break down waste such as ammonia and nitrite. In addition, more and more farms use specific pathogen resistant (SPR) broodstock and mature post-larvae longer to increase survival rates.

Disaggregated, dynamic market: 60-70% of farms across Southeast Asia are small, family-run operations; only few thousand farms are medium-to large scale operations. While the latter trade to processors in blind auctions, many small scale farms are represented by regional cooperatives. Given the informality of the supply chain, farmers often sell to the highest bidder. Price premiums for sustainability don't exist to date, which further decreases the influence of downstream supply chain actors on farm level management.

Shrimp farms in Asia are operated by families or small businesses, while input providers and buyers are often vertically integrated





- Shrimp typically auctioned off to highest bidder in blind auctions
- Input providers and processors partially integrated (CP, Thai Union)
- Pre-financing of farm operations through processors/feed suppliers via brokers

[1]Engle C.R. et al. (2017). Economics of Sustainable Intensification of Aquaculture: Evidence from Shrimp Farms in Vietnam and Thailand

Processors connect buyer demand with farm supply, but very low profit margins erode their influence on production systems

Processors are the connective tissue in the international farmed shrimp supply chain. They negotiate volume, size, and price with all major wholesale and retail actors; deploy hundreds of brokers to keep track of farming progress across the country; consolidate and process products from many thousands of farms; and prepare products for shipment.

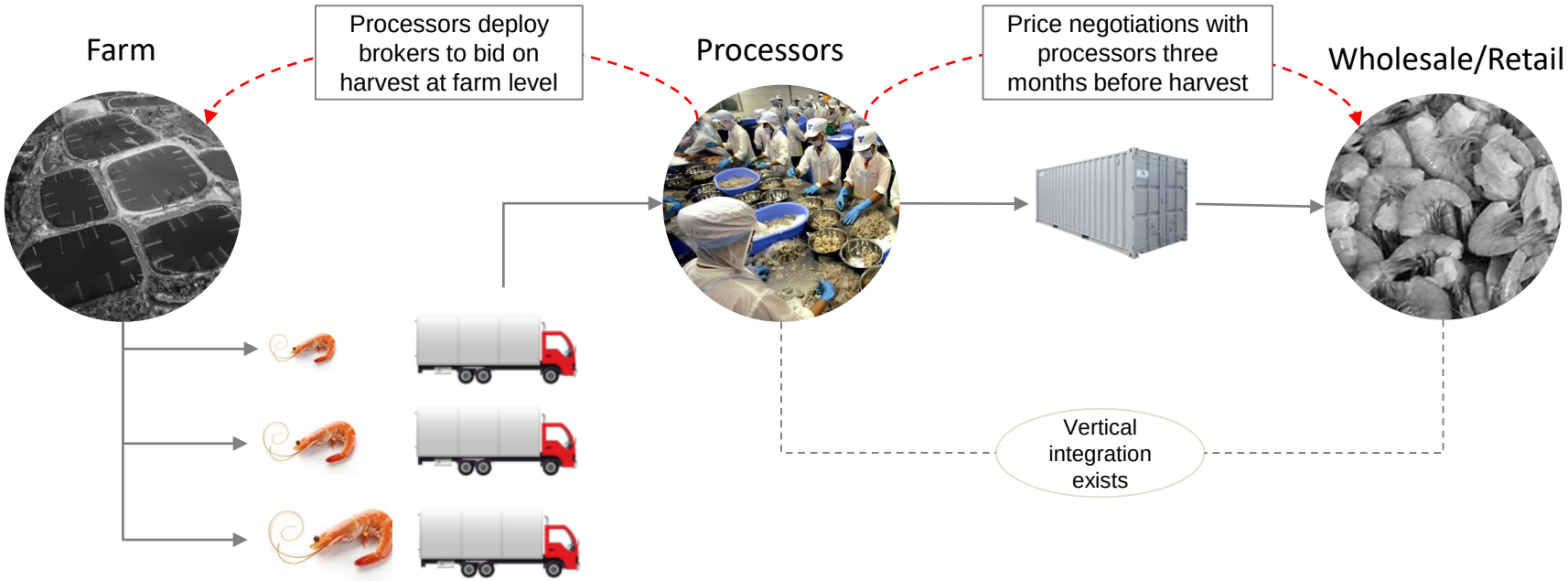
Order negotiation between processors and wholesale agents takes place approximately 3 months before the harvest, at which point almost nothing is known about prospective yield. As processors in each country compete for raw material, prices are driven up in years of low yield or high demand, putting the processing segment at risk of making losses. Even in average years, the majority of processing plants operate at such thin margins that their business model would not work without the additional absorption of water through phosphate-treatment of shrimp meat.

Low profit margins and strong competition make it more difficult for processors to drive sustainability requirements at the farm level. Vertical integration of farms into the processing business would be the only realistic way to demand and control measures of sustainable farm managements. However, processors have maintain flexibility with their sourcing options and are wary to internalize the risk at the farm level.

The favored engagement model for processors is contract farming, in which farmers agree to a set price upon harvest. This model would allow some influence from processors to farmers but has not been very successful yet due to the opportunistic and disloyal business model of shrimp farmers.

Even if contract farming had a realistic chance of becoming a scalable model, it is yet to be seen if this can increase the influence of buyers on production modes, particularly in the absence of any price premiums.

When a processor prepares a container for shipment, it includes shrimp from dozens of farms, making shrimp hard to trace



Shrimp order is by size. Processors and their brokers bid for harvest at hundreds of farms; shrimp from one farm might end up in 3 different trucks

Each container will include shrimp from 5-10 farms with very different management practices. Transparency gets lost.

Wholesale and retail have to balance the business necessity of consistent supply with an increasing demand for sustainability

Diversification to secure consistent supply: The lack of vertical integration from production to retail means that the biggest problem a retailer has is its need to secure consistent supply of shrimp. This becomes more difficult as product specifications (such as quality, environmental and social impact requirements) become more demanding. A common way of managing this risk is to diversify sources across regions and processors.

The challenge of sourcing sustainable shrimp: Retailers in the US are caught in a difficult conundrum. In recent years, major retailers have reacted to a combination of NGO pressure and bad press and committed to "sustainable" or "responsible" sourcing of shrimp. This has turned out to be difficult in two ways. First, consumers know or care little about the shrimp they eat, which is reflected in poor product differentiation and does not allow retailers to pay price premiums for sustainable shrimp. Second, even if a product differentiation existed, retailers do not know what farms their shrimp comes from, and therefore have near to no influence on the way it is managed.

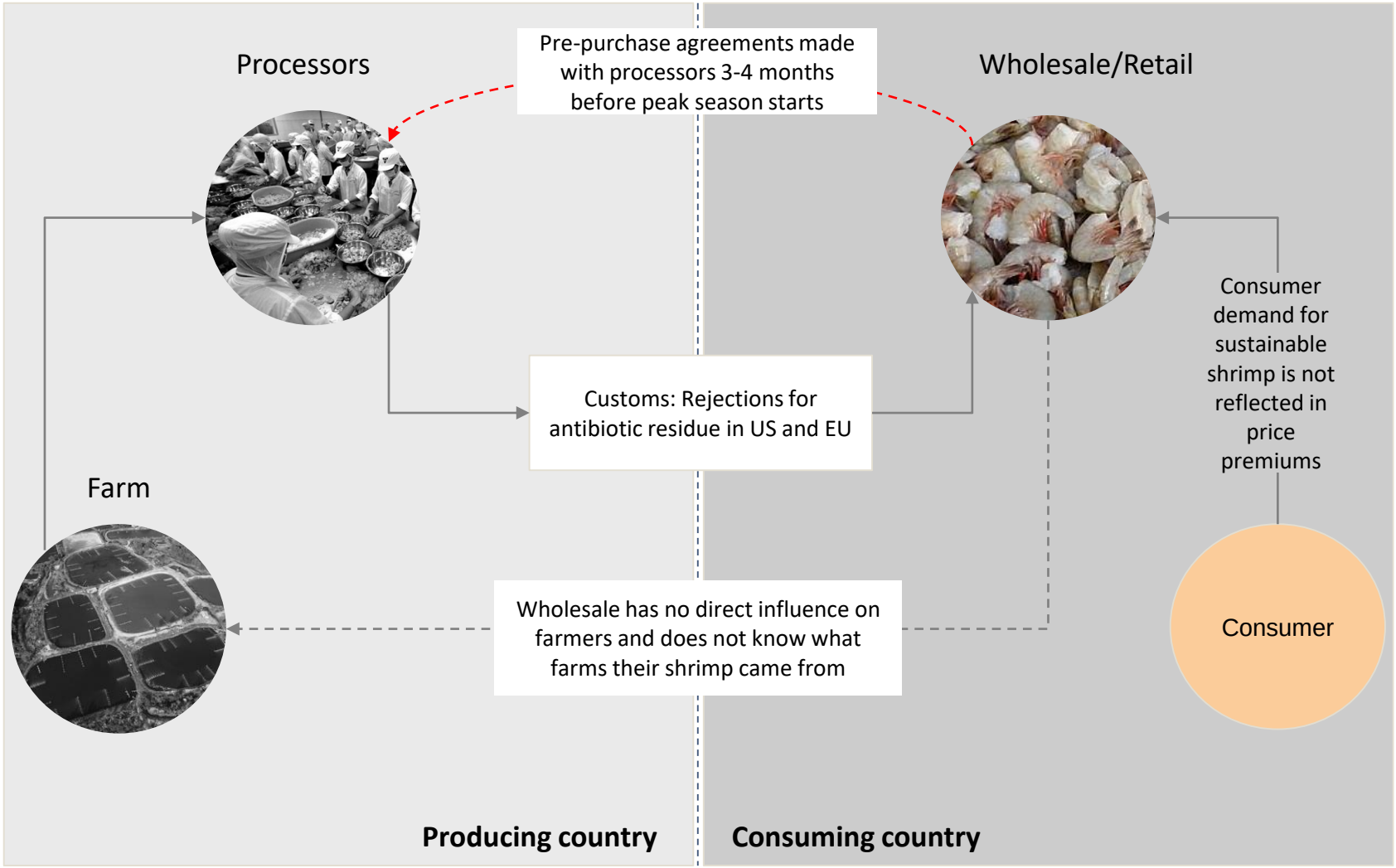
Certifications are welcome, but are insufficient to ensure responsible sourcing: Retailers seek ways to protect their firms from bad press. A welcome solution is offered through certification schemes such as BAP, which have been quickly expanding but still cover only a fraction of production. However, the need for diversification makes it impossible for retailers to source all of their catch from certified shrimp farms, even if they are committed to doing so.

The industry is not suited to drive sustainability themselves: Given a lack of transparency, poor influence on farms, and a lack of price premiums, retailers can not realistically be expected to drive sustainability at scale. Reforms within the industry, coupled with external support, and policy adoption and enforcement would be needed to drive widespread change on the ground.

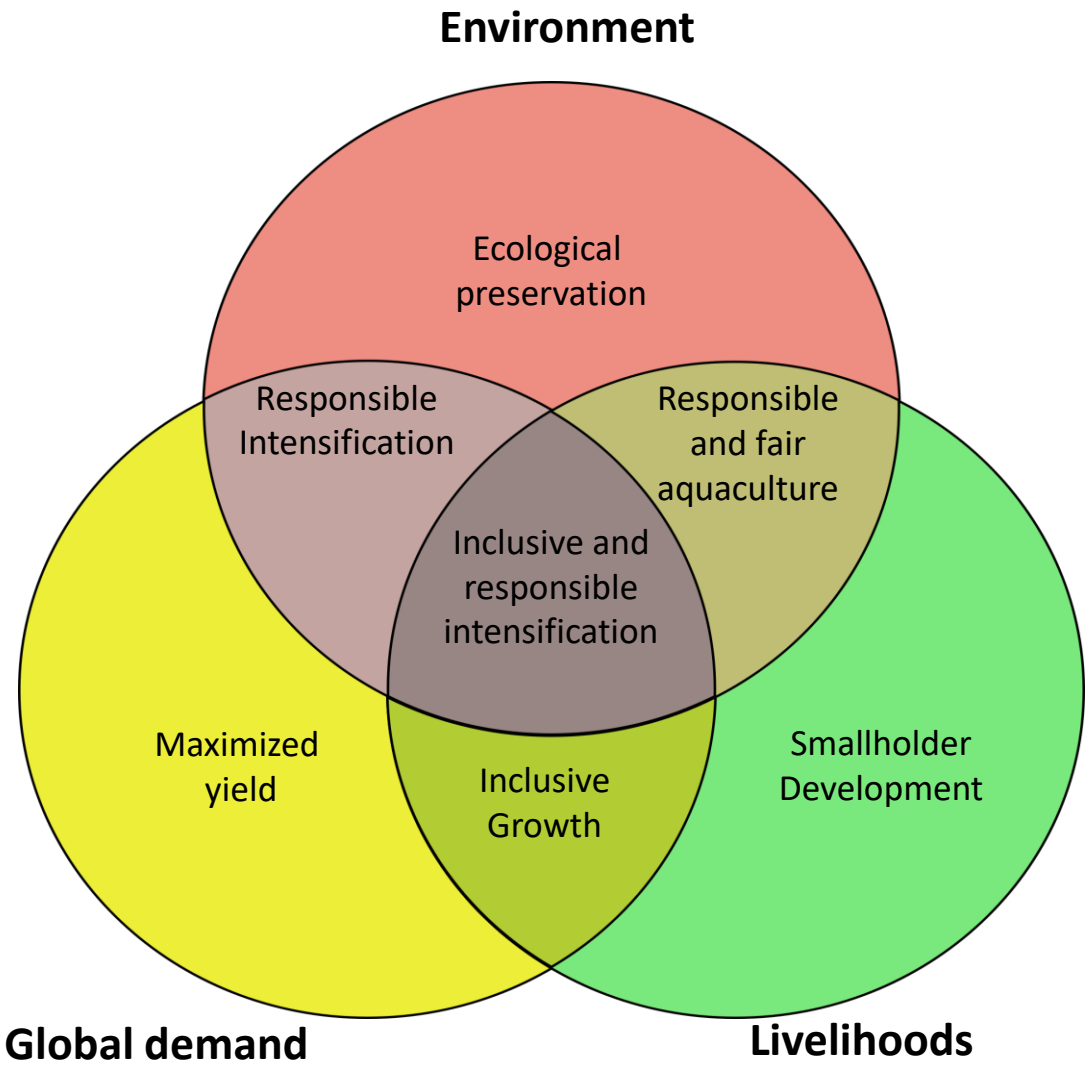
Import restrictions are more and more consequential to trade.[1] Import restrictions in both US and EU are increasingly strict about antibiotic residues. A currently outstanding decision from the European Union to ban shrimp imports from India is closely monitored across the industry. A domino effect is expected, including bans from the FDA and EU for countries across Asia.

1 https://www.undercurrentnews.com/2017/10/27/gulkin-shrimp-industry-fears-domino-effect-from-possible-eu-india-ban/

A large volume wholesaler has poor influence on farm management given a lack of price premiums and low farm-level traceability



Aquaculture reform can be approached in a variety of ways and depending on your priority, different interventions are possible



There is no right or wrong in the choice of interventions, but objective priorities should be a guidance for suitable approaches

Objective	Potential interventions	Priority geographies
Ecological preservation	• Mangrove conservation • Pesticide elimination • Elimination of unmanaged wild capture fish in shrimp feed • Elimination of extensive black tiger farms to restore coastal ecosystems	• Indonesia, Myanmar, Bangladesh • India, Vietnam, China • Global • South and South East Asia
Responsible Intensification	• Producer consolidation • "Intensive 2.0" & self-sustained (recirculation) production systems • Fishmeal free feed • Certifications/Ratings like BAP, ASC, SFW • Zonal management • Responsible expansion	• South and South East Asia • Test in: Thailand, Vietnam, Indonesia • Global • Global • South and South East Asia • Global
Responsible and fair aquaculture	• Small holder extension training programs • Equitable land concessions and permits • Integrated small holder aquaculture	• South and South East Asia • Global • Vietnam, India, Indonesia, Myanmar
Inclusive and responsible intensification	• Support national standards for shrimp farming • Investment into technical extension services • Impact investing with strong social and environmental guidelines • Certifications & collaborations like SeaSAIP, Naturland, Selva Shrimp	• Global • Global • Global • Global
Maximized yield	• Intensification across all production types • Expanded pond network	• Vietnam, China, Indonesia, India • Global
Inclusive Growth	• Environmental deregulation • Microfinance loans • Technical assistance programs	• South and South East Asia • South and South East Asia • South and South East Asia
Smallholder Development	• Subsidies for small holder production • Development of local markets • Crop insurance	• South and South East Asia • South and South East Asia • South and South East Asia

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4

Finance

- Context for investing in shrimp
- Risk, return, and access to finance along the value chain
- Value proposition and impact investment considerations

Fishing and aquaculture are profitable industries, in spite of overfishing, disease, and sustainability concerns

The global seafood industry had a production value of ~$311 billion in 2016 split roughly 50:50 between wild fisheries and aquaculture, and contributed an estimated $871 billion to the global economy[1]

Seafood is the most valuable and widely traded animal commodity, with nearly 37% entering international markets and 12% certified sustainable by the Marine Stewardship Council.[1] Subsidies to the fishing industry of $30-34 billion/year 35-40% of first sale value.[2]

Fishing and aquaculture production and processing are primarily financed through individual fishers and farmers and private firms.

A recent study by the Fish Tracker Initiative concluded that public seafood companies listed on exchanges are responsible for only 8-23% of global production volumes. Individual fishers and farmers as well as private firms make up the remainder of production and processing.[3] Japanese companies comprise the largest segment of publicly traded companies in the seafood industry, followed by Norwegian, Thai, Chilean, and South Korean firms.[3]

Shrimp is an outsized contributor to seafood value creation, and is expected to continue to add value.

Despite making up 5% of global production, shrimp is responsible for 15% of the production value of traded seafood.[4] The shrimp market is expected to grow at a compound annual growth rate of 5.1% between 2017 and 2021, compared to a CAGR of 3% for the global seafood industry across that timeframe.[5,6]

1 CEA 2017 / MSC 2017
2 CEA 2016
3 FishTracker Initiative. 2017

4 CEA Analysis, 2013
5 Shrimp Sector Worldwide Forecast to 2021 ReportLinker. October 2017.
6 Global Seafood Market Research Report - Forecast to 2020. Market Research Future. May 2017.

Shrimp is a profitable industry despite booms and busts, but intervening into the supply chain for sustainability poses challenges

Shrimp is a profitable industry with strong market fundamentals. Accordingly, investing in the shrimp supply chain has the potential to create significant returns for investors – in spite of high risks. Investors in this space are predominantly informal, and operate outside of commercial debt and equity markets. They range from individual entrepreneurs looking to diversify, processors and exporters looking to expand and access higher value markets, domestic commercial banks seeking foreign currency in volatile political environments, and large multinationals seeking to secure greater stability in supply or long-term demand for their products (e.g. feed).

Like the rest of the seafood industry, transactions throughout the supply chain are opaque, with more informality closer to production (cash, in-kind, lines of credit from input suppliers) and more formality (contracts with terms of payment) closer to retail.

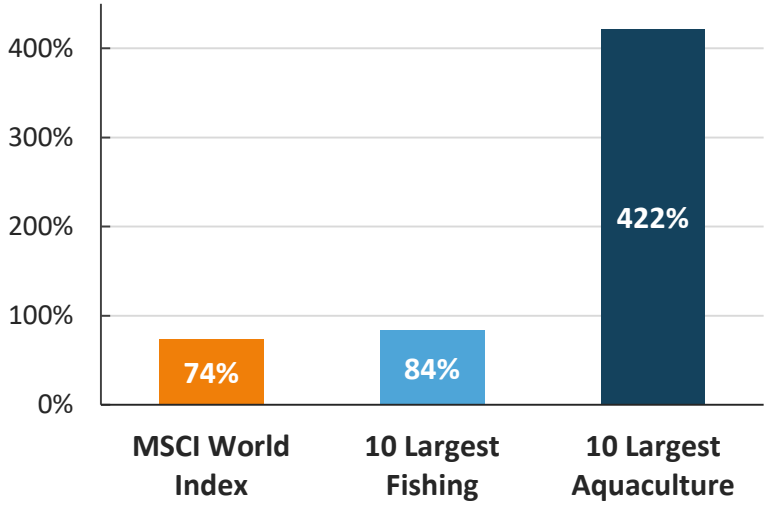
Sustainability interventions add costs to shrimp production, and are not perceived as essential to core business. Quality broodstock, quality feed higher in non-fish ingredients, water quality testing, and automatic feeding technology are all interventions associated with positive environmental outcomes in farms. However, they reflect additional costs to production and are not always perceived as a part of a core business model.

Processors in Ecuador are a key leverage point for intervention, as they aggregate production and increase the margin through value addition. Certification and technology can contribute significantly to that value. This trend was not observed in Asian markets, which dominate production. Ecuador has seen consolidation of its shrimp industry and investment in better management after years of disease. Vertical integration is emerging as a viable business in the face of low-cost production from Asia.

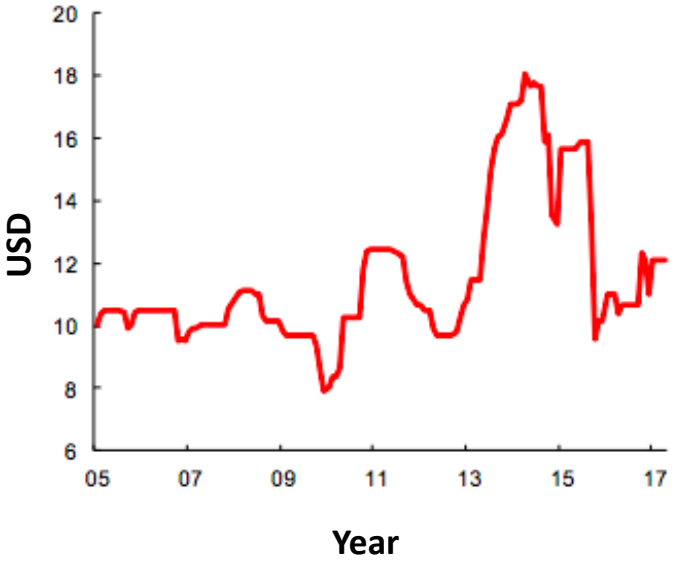
Shrimp is a commodity with potential for high returns accompanied by high risk and uncertainty

Aquaculture is a highly profitable industry. Shrimp is a commodity with volatility roughly similar other agricultural commodities. Prices are highly dynamic – they nearly doubled with the collapse of Thailand's industry in 2013 due to EMS, but rebounded as supply ramped up in other geographies. The result is that shrimp can be high return, but also high risk, attracting investors with a much higher risk tolerance.

Five-year Total Returns for Listed Seafood and Aquaculture Companies (2012-2017)[1]



Shrimp monthly commodity price movements in USD (2005-2017) [2]



1 Empty Nets: How Overfishing Leaves Investors Empty-handed. FishTracker Initiative. 2017

2 Commodity Market Monthly. International Monetary Fund. June 9, 2017.

Risk and return are highest closest to production, which influences the sources of capital and types of transactions through the chain

Despite the highly volatile nature of production, shrimp farms seem to be the profit center of the industry with nominal returns of 30-400% per cycle, driven by high demand and consistent prices. Yet these farms remain predominantly in their mode of operation. Input suppliers, processors/exporters, importers, and retail are able to reduce their risk through diversification and more complex commercial relationships, but face a more competitive global landscape.

		Production Stage			
		 Inputs & Ancillary Services	 Farm	 Processing & export	 Import, wholesale & retail
Risk	Farms bear the greatest proportion of risk due to the potential for complete asset loss. Inputs, processors, and retailers are usually more diversified and therefore insulated due to product range and customers.	**Medium** Customer base usually diversified, across geographies, products, and species	High ← Low	**High** Poor water quality and disease can wipe out value in days, weeks	**Medium** Source from many farms and sell to many buyers, but over-reliance can increase risk	**Medium/Low** Diversified sources of supply, but an unstable global commodity market
Returns	Farms can be profitable in as little as a few production cycles, and high demand and high prices can give them leverage over middlemen and processors. Margins get tighter higher up the chain.	**Medium** Varies depending on business model, but consistent with market returns for debt and equity	High → Low	**High** Profit center. Returns of 30-400% per cycle are not uncommon.	**Medium** Competitive global commodity market. Margins through value addition.	**Medium/Low** Retail mark-up of ~50% over import prices. Certain market segments pay more for quality.
Sources of Capital	Farmers have limited access to traditional sources of capital (market rate debt, equity) and face high interest rates (>15%). Processors/ exporters/ importers/ retail can access commercial debt and equity.	**High** Varies – self-finance, friends and family, commercial debt and equity.	Informal → Institutional	Fixed costs are primarily **self-financed** due to high interest rates. Working capital can be via input suppliers.	Mix of **self-finance, debt financing** (above market rate); limited **equity financing**	**Commercial debt, equity financing.** Mix of public and private ownership.
Transaction Type	Cash, credit or in-kind (with input suppliers) spot, verbal, digital (WhatsApp) prevalent at farms. Processing onward provides more formal contracts with more sophisticated modes of payment.	**Varies** Input suppliers can provide working capital in cash, and in-kind material	Informal → Formal	**Cash or in-kind** for working capital. **Cash** from middlemen or processors in spot transactions.	**Contracts, invoices** outlining terms of payment, payments in **cash.** Transactions in importing currency.	**Contracts, invoices**. Payments made with **credit** and **cash**

Indonesia demonstrates the short-term economic incentive driving growth in whiteleg production

Intensive whiteleg shrimp production in Indonesia requires significant upfront capital investment, but carries the potential for very high returns on a short timeframe due to its high value.

- Constructing a whiteleg shrimp farm reportedly requires ~USD 35k per 3,000m^2 pond, a relatively high capital investment given GNI per capital of USD 3,400 in 2016.[1]
- Shrimp farming is perceived as high risk and without operating experience most new farmers are unable to access commercial debt. Farmers use their own capital to finance capital expenditures (e.g., construction, electricity, paddle wheels). Operating costs (seedlings, feed) may be fronted by feed manufacturers. Intensive shrimp farmers tend to be entrepreneurs with multiple businesses or wealthier individuals seeking to diversify.
- Farmers can be profitable in as little as one production cycle (2.5-4 months), recouping both capital expenditures and operating costs.[2]

High risk accompanies those returns, due to factors inherent to shrimp biology as well as environmental concerns.

Primary risks to production include:

- *Disease*. Shrimp are a primitive species lacking in a complex immune system, making them highly susceptible to disease. When disease hits, all working capital for that cycle is a loss.
- *Water quality*. Shrimp production produces wastewater whose discharge is not regulated. Farmers often dump their wastewater into the same water supply they use for production, creating a negative cycle of disease. Water quality is a key limit on productivity.
- *Seed quality*. Many farmers own their own hatchery facilities, of varying levels of quality. Relatively little research goes into producing higher quality seedlings.

1 World Bank Country Data: Indonesia
2 CEA Analysis

Whiteleg shrimp farming in Indonesia can be highly profitable on a short timeframe, in spite of risks

Intensive shrimp farming can be profitable quickly (<4 months), which drives capital investment from producers and working capital investments from input suppliers, even in the face of high risks.

Prototypical intensive shrimp pond* (Indonesia)

Fixed costs

Item	Cost/unit	# units	Cost
Land	$1/m^2	3,000	$3,000
Pond lining & water pipes	$4,000	1	$4,000
Construction	$5,000	1 week	$5000
Water pump	$200	1 pump	$200
Electricity facility	$15,000	1 facility	$15,00
Paddle wheel	$400/wheel	15 wheels	$6,000
		TOTAL	**$35,000**

Variable costs

Item	% of total	Cost/kg
Feed	50%	$2.00
Electricity	25-30%	$1.00
Antibiotics, chemicals, labor	10-15%	$0.60
Seedlings	10%	$0.40
	TOTAL	**$4.00/kg**

Ideal Production Scenario

Intensity	100 shrimp/m^2
Shrimp size	30 grams
Price/kg	$10-12
Time to maturity	2.5-4 months
Production/cycle/pond	10 tons
# Cycles/year	3
Revenue/cycle	$120,000
Revenue/year	$360,000
Variable Costs/cycle	$40,000
Variable Costs/year	$120,000
Year 1 profit	**$206,000**

Differences for extensive monodon production

- Earthen pond (no lining)
- Land requirements much greater
- No need for paddles because less intensive

- Natural feed for first 3 months; only feed in last month of production

- Much lower density (6-9 shrimp/m2)
- Higher prices in niche markets ($17/kg)

Extensive black tiger production can also be lucrative and can garner a higher price from niche markets ($17/kg from Japan and East Asia), but requires much more land area and faces a longer payback period.

*Refers to one 3,000 m^2 pond. Farmers often have multiple ponds per farm. If costs are shared across ponds, costs listed reflect the cost per 3,000 m^2 pond.

Ecuador demonstrates that even with a fundamentally different cost structure and production model, whiteleg farming is still profitable

A history of disease outbreaks in Ecuador has encouraged investment in better management practices and consolidation into fewer producers, with several large vertically-integrated production companies (hatcheries, farms, and production).

- The average pool size is 40,000m^2 (vs. 3,000 m^2 in Indonesia)
- The top 10 processing companies are responsible for 71% of exports.[1]

Better management (investments in genetic research and selective breeding, technology, water quality testing and treatment) as well as labor contribute to higher costs, but more efficient production when compared to Asia.

- Automatic feeding technology increases the growth rate (from 0.8g/week to 2-4g/week), adding a production cycle each year.
- Labor costs are $1/kg higher in Ecuador than Asia.

Farms are more consistently profitable even in the face of higher costs, and therefore have easier access to credit, albeit at higher rates.

- Farmers can see ~35% net profit on each harvest, less fixed and variable costs; higher quality shrimp can demand higher prices on the global market (0.10-0.20 cents per lb).
- Dealing in USD makes farmers and packers desirable to domestic commercial banks given macroeconomic trends in Ecuador, making access to credit for expansion more widespread, yet still at expensive rates (reported 16% annual interest). The sector is still perceived as high-risk. Said one interviewee, “people would rather buy Venezuelan bonds than invest in shrimp farming.”

The value proposition to farms and packers is in differentiating their product as higher-quality to sell to markets that will pay more (Korea, EU), when compared to Asia – which drives uptake of certifications. That price is driven by quality, not sustainability.

- 90% of certified farms are owned by packers (who are also the exporters). The primary way packers make margins is through value addition: peeling, cooking, de-veining, or skewers.

1 Camara Nacional de Acuacultura. Ecuador. October 2017.

Farms are the locus of profitability in Ecuador, even with a longer timeframe to net profitability

While the timeframe to recoup initial investment is longer when compared to Indonesia (15 months vs. 4 months), intensive farming is still highly profitable, delivering returns of 35-90% per cycle.

Prototypical intensive shrimp pond* (Ecuador)

Fixed costs

Item	Cost/unit	# units	Costs
Land	$1,800/ha/yr	4	$7200
Piping	$3,750	1	$3,750
Pool construction	$2.20/m²	40,000	$88,000
Pumps & engines	$7500	1	$7500
		TOTAL	$106,450

Variable costs

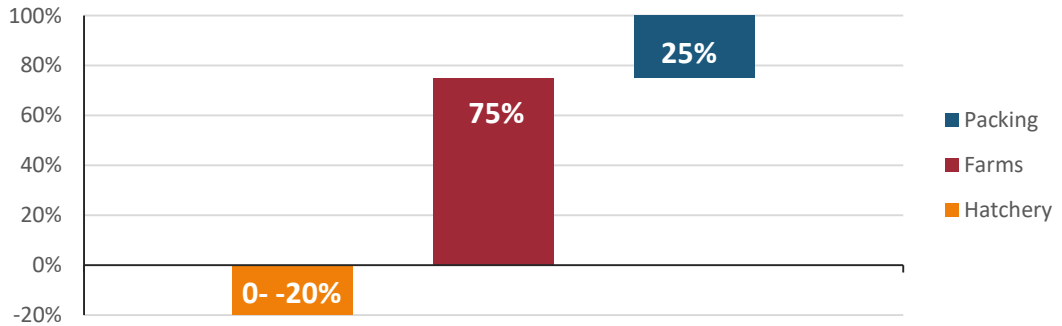
Item	% of total	Cost/kg
Larvae	21%	$0.94
Feed	46%	$2.07
Personnel	27%	$1.22
Diesel	6%	$0.27
	TOTAL	$4.50/kg

Ideal Production Scenario

Intensity	20 shrimp/m²
Shrimp size	18-24 grams
Price/kg	$6.16
Time to maturity	3 months
Production/cycle/pond	11 tons
# Cycles/year	4
Revenue/cycle	$67,760
Revenue/year	$271,040
VC/cycle	$45,000
VC/year	$180,000
Year 1 profit (not incl. FC)	**$91,040**

Unlike the rest of the world where small farms predominate and lack market power, the profit center in Ecuador lies in farming

Share of profitability by asset for a vertically-integrated shrimp company[1]



*Refers to one 40,000 m² pond. There are often multiple ponds per farm. If costs are shared across ponds, costs listed reflect the cost per 40,000 m² pond.

1 CEA Analysis

The 'business case' for sustainable production is not well understood, across all geographies

"Sustainable production" is not understood or valued at the farm level. There is no common definition of sustainable production that is shared across farms within a region, or across geographies. This makes comparing products from different areas difficult, a critical component for market differentiation.

Interventions that would contribute to positive environmental outcomes can increase returns, but cut into profit margins and are therefore not widespread. Automatic feeding technology, better water management systems, higher quality broodstock, and feed lower in fish content can all increase growth and improve shrimp quality (and therefore increase revenues) while improving environmental sustainability (decreasing antibiotic use, decreasing effluent discharge, decreasing residual feed). Furthermore, pursuing eco-certifications could help producers access markets for higher quality shrimp (and slightly higher prices). However, any increase in profits cuts into the already small profit margins, which has limited their ability to scale.

Analysis across a broader spectrum of the shrimp industry is needed to understand the specific conditions – which interventions, which geographies (if any) – under which the additional cost of these interventions creates outsize returns

Opportunities for impact investing in shrimp production remain limited, but may exist in processors or ancillary services

Shrimp farming and the sector more broadly are perceived as highly risky by a broad range of investor types – from individuals and family offices through to commercial banks. "Shrimp is a difficult sector to be in. It's where most of the problems are. We are unlikely to invest in shrimp production in the next three years," said an investor. "Investing in shrimp farming is like going to the casino."

Impact investors in aquaculture have invested in ancillary services (new sources of feed, technology), in vertically integrated companies, companies further upstream in the value chain (processing up through marketing and retail), and in contained aquaculture systems.

- *Aqua-Spark*, an aquaculture-focused impact investment firm, has 10 investments across 9 geographies. One of these is in shrimp (eFishery – an automatic feeder technology company). The remainder are in biotech (2), feed (2), sea cucumber, char, and halibut production (3), and one investment into a hatchery.
- *Rare's Meloy Fund* invested USD $1m in Philippines-based Meliomar in December 2016, a vertically integrated aggregator, processor, exporter, and importer of multiple fish species, including shrimp. This investment has explicit return, conservation, and social impact targets including: $2.5m in additional income to 16,000 local fishers and improved management of 12,000 ha of marine area by 2021.

Interviewees felt that philanthropic support would be best used upstream through improving shrimp genetics (through selective breeding to improve immunity) or in extension services to shrimp farmers.