

## Supplementary Materials for

### Seeing slavery in seafood supply chains

Katrina Nakamura\*, Lori Bishop, Trevor Ward, Ganapathiraju Pramod, Dominic Chakra Thomson,  
Patima Tungpuchayakul, Sompong Srakaew

\*Corresponding author. Email: [katrina@sustainability-incubator.com](mailto:katrina@sustainability-incubator.com)

Published 25 July 2018, *Sci. Adv.* **4**, e1701833 (2018)  
DOI: 10.1126/sciadv.1701833

#### **This PDF file includes:**

Supplementary Methods

Table S1. Summary of country-level labor risks in farmed shrimp.

Table S2. Findings from semistructured interviews with Thai seafood workers ( $n = 197$ ).

Table S3. Disclosure template for seafood suppliers to prepare a human rights statement.

Fig. S1. Pacific yellowfin tuna supply chains for six Asia-Pacific nations supplying the U.S. market.

Fig. S2. Supply chains for shrimp from five major exporting countries and for fishmeal.

## Supplementary Materials for Supplementary Methods

We have copied into the main text the Methods and Materials section.

Supplementary Tables S1 to S3 and Figures S1 and S2

**Table S1. Summary of country-level labor risks in farmed shrimp.**

	Forced or child labor are significant in seafood (DOL)	Fishing ties to forced labor (TIP)	Palermo Protocol ratified (7)	Transparency in the supply chain	Risk level and advice to seafood buyers
India shrimp	No	No	2011	Low to nil oversight in the peeling sector and in local trade due to broker networks and unknown working conditions in feed fisheries	<i>Low to moderate forced labor risk:</i> Maintain a complete list of farms and plant facilities.
Ecuador shrimp	No, but products processed in Vietnam have ties to child labor	Shrimp farming	2002	Low oversight in local trade due to broker networks, exports go to China and Vietnam for processing, work in the domestic processing sector is often temporary/informal	<i>Low to moderate forced labor risk:</i> Maintain a complete list of farms and plant facilities in China and Vietnam.
Indonesia shrimp	Fish not shrimp is produced with forced labor	Seafood processing and fishing for raw material inputs to fish meal	2009	Primary processing includes a high percentage of unregistered facilities, evidence of debt bondage, captive unpaid work on purse seine and trawl vessels in feed production.	<i>Moderate to high forced labor risk:</i> Trace all feed sources and consider screening the feed supplier and fleet workplace, or source IFFO certified feed.
Bangladesh shrimp	Shrimp farming and fry collection utilize child labor	Seafood processing	No	Shrimp and fry reach buyers through trader networks that often include a number of middlemen, with known debt bonding and price fixing. Some fry collectors become indebted to fry traders who advance money in exchange for the harvest.	<i>Moderate to high forced labor risk:</i> Maintain a complete list of farms and fry suppliers and consider screening the farm workplace.

Thai shrimp	Fish and shrimp are produced with forced labor and forced child labor	Fishing for inputs to fish meal, shrimp farms, peeling sheds, seafood processing	2013	High incidence of forced labor in nearshore purse seine and trawl gear fisheries for feed (17%-ILO). Burmese crew and plant workers are indebted to agents and significant reports of unpaid and/or involuntary work.	<i>High risk of forced labor ties:</i> Screen working conditions at all workplaces including vessels, feed and meal mills, farms and plants, or source BAP 4-star shrimp and IFFO certified feed.
-------------	---	--	------	---	---

**Table S2. Findings from semistructured interviews with Thai seafood workers (n = 197).**

Workers in:	Seafood processing, Samut Sakhon (n=84)	Fishing Crew, Mahachai, Samut Sakhon (n=66)	Fishing Crew, Maeklong, Samut Songkram (n=47)
Conditions:			
Payment	8000-9000 baht/month; migrant workers earn pay equal to Thais in large factories but less in family-run smaller plants	Unclear payment terms; the vessel owner pays in lump sum to the labor agent, who has discretion over pay; 26% said they were paid monthly, 18% every 3 months	Unclear payment terms; the vessel owner pays by lump sum to the labor agent, who has discretion over pay
Documentation	50% temporary passport; 48% work permit; 100% hold their own documents	53% temporary passport; 31% work permit; 3% undocumented; 97% hold their own documents	51% temporary passport; 23% work permit; 13% non-Thai ID card; 11% undocumented and held fake Thai seamen's books
Broker fee	Fees of 1000-16,000 baht for travel; 5000 baht for job placement	Travel fee and expenses plus 10,000 baht for toothbrush, toothpaste and boots; 4000-5000 baht/month food charge	45% traveled with brokers to the workplace and paid them 1000-15,000 baht
Debt bondage?	Yes. Migrant workers owe their pay for typically 6 months for the initial fees; workers lacking legal status in Thailand pay significantly more and require forged documents	Yes. 100% of fishers paid brokers around 12,000 baht and worked without pay 5-7 months to clear the debt; crew said the labor agents sustain debt through a system of advances for supplies and food	Yes. 100% of fishers paid brokers around 12,000 baht and worked without pay 5-7 months to clear the debt; crew said the labor agents sustain debt through a system of advances for supplies and food
Origin	82 Burmese, mostly Dawai and Mawlamyine provinces, 2 undeclared	66 Burmese, 2 Thai	41 Burmese, 7 Mon, 2 Thai; 61% cannot communicate in Thai
Contract?	32%	0%	4%
Reports of abuse	No. Some migrant workers reported working at night every day for 3 years and the employer did not allow any change.	8% reported physical abuse in the workplace and 92% said they had never been abused.	No.

Forced labor	No.	2 reported being forced to work on fishing boats by physical assault from the boat captain.	No.
Trafficking victims identified?	No	2 Thai and 3 Burmese said they were sold to boat owners for 25,000-30,000 baht.	No.
Health care	30% of workers said no first aid in the workplace; 46% said the factory has a first aid station; one worker lost her eye on the job and the company refused medical care or compensation	0% had health benefits; 29% said it is the employer responsibility to help if they are injured at work; others were not sure if the employer is responsible	86% had no healthcare insurance; 11% had a healthcare card
Training on safety and labor rights	46% had safety training; 13% had labor rights training	Widespread concern that no training is provided	No training on safety or labor rights
Length of time	Variable	Small boats make 15-20 day trips per month; crew on industrial fishing vessels stayed at sea 1-6 years and were not allowed to go home	Small boats make 15-20 day trips per month; crew on industrial fishing vessels stayed at sea 1-6 years and were not allowed to go home
Want to stay or leave this job?	A majority want to stay: 50% said they moved up to processing work from fishing	94% wanted to continue to work on fishing boats with better conditions; 31% wanted to change employer	A majority want to stay with better conditions

**Table S3. Disclosure template for seafood suppliers to prepare a human rights statement.**

1	Which country has the responsibility for labor regulation for this product?
2	What are the minimum age requirements for fishing employment in the flag state? What are the national minimum age requirements in the countries of farms and processing facilities?
3	Describe any forms of oversight for people working in the supply chain, for example to prevent purchasing products made from bonded labour?
4	Does your supplier produce or purchase its products in a contracted facility? At that facility, what proportion of the labour is subcontracted through agents? If agencies are used, include a list of employment agencies.
5	Describe the proportion of workers who are migrants in each of the facilities you purchase from.
6	Are wages and hours specified clearly in worker contracts?

7	Describe any engagement with fisher, migrant, worker rights, and human rights groups
8	Describe any audits, certifications and labor inspections conducted at the facility level within the last two years? Include proof and any responses to non-compliances.
9	Has your company made a public commitment to protect the people making your products from forced labor or illegal child labor? If yes, please provide the wording and its location.

## Philippines Yellowfin Tuna Supply Chain

Fishing Area	Fishing Countries	Vessels & Gear	Landing & Local Trade	Processing	Export & Retail
<div style="border: 1px solid black; padding: 5px; width: fit-content;">Philippines: PNG waters, Pacific Islands, High seas pockets</div>	<div style="border: 1px solid black; padding: 5px; width: fit-content;">Philippines, Imports from: Taiwan (10%), PNG (8%), Japan (2.5%)</div>	<div style="border: 1px solid black; padding: 5px; width: fit-content;">Purse seiners</div> <div style="border: 1px solid black; padding: 5px; width: fit-content; margin-top: 5px;">Pole-and-line/Handline</div>	<div style="border: 1px solid black; padding: 5px; width: fit-content; margin-bottom: 5px;">Landing in G. Santos, direct to canneries</div> <div style="border: 1px solid black; padding: 5px; width: fit-content; margin-bottom: 5px;">Transshipment to or landing in PNG</div> <div style="border: 1px solid black; padding: 5px; width: fit-content;">Landing in G. Santos</div>	<div style="border: 1px solid black; padding: 5px; width: fit-content; margin-bottom: 5px;">Canning industry: Premium 'white meat' cans</div> <div style="border: 1px solid black; padding: 5px; width: fit-content; margin-bottom: 5px;">Low quality tuna blocks for consumer sushi products</div> <div style="border: 1px solid black; padding: 5px; width: fit-content;">Frozen processing: Sold in loins/bullets/steaks</div>	<div style="border: 1px solid black; padding: 5px; width: fit-content; margin-bottom: 5px;">Thailand, US, EU, Other international markets</div> <div style="border: 1px solid black; padding: 5px; width: fit-content;">US and EU markets</div>
<p>Philippines has bilateral agreements with many Pacific island nations. Looking to expand reach of mainly purse seine fleet including Indonesia.</p> <p>Skipjack and yellowfin are the dominant species caught.</p>	<p>Philippines has 814 vessels registered with WCPFC.</p> <p>33% of the world's yellowfin comes from the Philippines.</p> <p>No foreign flagged vessels allowed to fish in Philippines EEZ.</p>	<p>Philippines: 48% purse seine, 26% ring net, 14% pole-and-line, 12% other gears. Low operating costs of \$400-450/tonne of tuna compared to USA with costs of \$650-700/tonne. Tuna fleets land 1,000 tonnes of tuna a day, 90% into G. Santos</p>	<p>60% of tuna landings into the Philippines are skipjack and 36% are yellowfin. 193,867 tonnes of all tuna landed in G. Santos in 2014, 47% frozen. 70% coming from foreign vessels.</p> <p>Transshipment only permitted at ports.</p> <p>Handline/pole-and-line vessels supply fresh and frozen tuna to G. Santos.</p>	<p>6 out of 8 tuna canneries in Philippines are in G. Santos with 2 others in Zamboanga.</p> <p>There are 17 frozen tuna processors with 70% in G. Santos supporting 3,000 jobs.</p> <p>Skipjack is sold as 'light meat' tuna. Fresh/frozen skipjack is rare as the quality is not as popular as yellowfin or bigeye.</p> <p>Yellowfin is primarily canned and sold as 'light meat' tuna</p>	<p>2<sup>nd</sup> largest canning/processing country after Thailand. 2,098 tonnes of yellowfin exported to the US in 2014. EU cleared yellow card in April 2015. Exports to EU have 0% duty under GSP.</p>
	<p>Filipino crew in tuna fleets experience debt to captains which can turn into forced labor. Some men are subjected to forced labor and debt bondage in fishing according to the U.S. Department of State. Fish goods are made with a significant incidence of child labor (5-14), according to the U.S. Department of Labor.</p>	<p>Handline fleet consists of 2,500 boats and 30,000 crew</p> <p>Philippines ranked at Tier 2 on TIP report. 10 million Filipinos working abroad, many in the fishing industry.</p>	<p>Lower grade yellowfin treated with carbon monoxide and frozen for export.</p>	<p>Tuna processing is a relatively labour intensive process. Loining is difficult to automate, and requires 80% of labour costs in processing due to the size and shape differences of individual fish.</p>	<p>All export tuna from the Philippines is HACCP certified.</p>

## Fiji Yellowfin Tuna Supply Chain

Fishing Area	Fishing Countries	Vessels & Gear	Landing & Local Trade	Processing	Export & Retail
<pre> graph LR     A[Domestic: 66% of tuna comes from High Seas, Fiji EEZ, and PIC EEZs] --&gt; B[Fiji + Foreign charters from China, Taiwan, S Korea]     B --&gt; C[Domestic longline fleet, small pole-and-line fleet]     C --&gt; D1[Landing in Fiji]     C --&gt; D2[Transshipment to China, Taiwan, S Korea via Suva port]     D1 --&gt; E1[Canning industry: Premium 'white meat' cans]     D1 --&gt; E2[Sashimi market: Fresh albacore, yellowfin, sold in loins/bullets/steaks]     D2 --&gt; E2     E1 --&gt; F1[Thailand, American Samoa, Taiwan, Vietnam]     E2 --&gt; F2[Japan, USA, EU]         </pre>					
<p>Fiji has agreements to fish in neighbouring Pacific Island Countries (PIC) EEZs.</p> <p>Albacore is the dominant species landed followed by yellowfin.</p> <p>Fiji's albacore fishery is MSC certified.</p>	<p>Fiji has observers onboard the national fleet.</p> <p>Licenses are also given to foreign charter vessels.</p> <p>Chinese longliners use Suva port as a re-supply port.</p> <p>Chinese vessels are being given licenses to fish in Fiji waters.</p>	<p>Fiji has 105 longliners with 10 of these chartered foreign-flagged vessels. 1,667 crew.</p> <p>On chartered vessels, half of the crew are usually Fijian with a mixture of Indonesian, Filipino, and Chinese.</p>	<p>Total tuna landings in 2014 in Fiji were 13,488 tonnes. Albacore made up 50% followed by Yellowfin with 26%.</p> <p>Chinese caught albacore and bigeye air-freighted to the Japanese and US markets.</p> <p>Tuna are sent to processors and canneries. Several canneries are owned by other Pacific island nations such as Kiribati.</p>	<p>18,652 tonnes of tuna were processed and exported in 2014. Albacore made up 54% of this and Yellowfin = 24%.</p> <p>Fiji has 2 canneries.</p> <p>2,000 people employed in tuna processing.</p> <p>Albacore is sold either fresh/frozen or as valuable canned 'white meat' in premium cans. Fresh albacore is popular in Japan for sashimi.</p> <p>Yellowfin is primarily canned and sold as 'light meat' tuna.</p>	<p>829.5 tonnes of yellowfin exported to the US in 2014, mostly loins.</p> <p>EU lifted yellow card against Fiji in October 2014 and imports and duty free under Interim Economic Partnership Arrangement.</p> <p>EU imports mainly canned tuna and loins.</p>
<p>Catch rates for albacore in Fiji EEZ have dropped from 200/day in 2010 to 15-20/day in 2015.</p>	<p>Evidence of child labor in fishing exists but is limited and the extent of the problem still unknown, according to the U.S. Department of Labor..</p> <p>Forced labor and human trafficking cases on Taiwan and Korea vessels fishing in Fijian waters.</p>	<p>Foreign charter vessels are required to comply with WCPFC regulations and report catches on all trips.</p>	<p>Transshipment is only allowed with government authorization. Fiji has not banned the practice as other PNA countries have already. This list now includes: PNG, Micronesia, Tuvalu, Vanuatu, Nauru, and Samoa.</p>	<p>Tuna processing is a relatively labour intensive process. Loining is difficult to automate, and requires 80% of labour costs in processing due to the size and shape differences of individual fish.</p>	

## Republic of Marshall Islands (RMI) Yellowfin Tuna Supply Chain

Fishing Area	Fishing Countries	Vessels & Gear	Landing & Local Trade	Processing	Export & Retail
<div style="border: 1px solid black; padding: 5px; width: fit-content;">RMI EEZ, PIC EEZs, High Seas pockets</div>	<div style="border: 1px solid black; padding: 5px; width: fit-content;">RMI, China, Micronesia, Japan, Korea</div>	<div style="border: 1px solid black; padding: 5px; width: fit-content;">Purse seiners, longliners</div>	<div style="display: flex; justify-content: space-around; align-items: center;"> <div style="border: 1px solid black; padding: 5px; width: 150px;">Landing into RMI for processing</div> <div style="border: 1px solid black; padding: 5px; width: 150px;">Transshipment in Majuro to other markets</div> </div>	<div style="display: flex; justify-content: space-around; align-items: center;"> <div style="border: 1px solid black; padding: 5px; width: 150px;">Canning industry: Premium 'white meat' cans</div> <div style="border: 1px solid black; padding: 5px; width: 150px;">Processed in other PNA countries, Thailand, Taiwan</div> </div>	<div style="display: flex; justify-content: space-around; align-items: center;"> <div style="border: 1px solid black; padding: 5px; width: 150px;">USA, EU, Thailand</div> <div style="border: 1px solid black; padding: 5px; width: 150px;">International tuna markets in Thailand, Japan, Taiwan</div> </div>
<p>Fishing effort concentrated in Southern half of RMI EEZ and EEZs of PNA countries such as Kiribati, Nauru, and other PIC EEZs.</p> <p>The main species caught by RMI are skipjack followed by yellowfin.</p>	<p>A number of countries are able to receive fishing licenses for RMI waters.</p> <p>Domestically based foreign vessels are managed by the Marshall Islands Fishing Venture Ltd – subsidiary of Luen Thai.</p>	<p>RMI has 10 purse seiners and 4 longliners.</p> <p>There are some pole and line vessels.</p> <p>174 foreign vessels are licensed to fish in RMI waters.</p>	<p>77,634 tonnes of tuna were caught by the purse seine fleet in 2013, 19% from the RMI EEZ. 70,688 tonnes (91%) of this was skipjack followed by yellowfin with 5,431 tonnes (7%).</p> <p>RMI represents a key tuna offloading centre for the PNA countries. Other PNA countries have banned it, including PNG, Micronesia, Tuvalu, Vanuatu, Nauru, and Samoa.</p> <p>Transshipment is allowed only in Majuro lagoon providing considerable source of revenue. 270 transshipments took place in 2013 with total 182,382 tonnes of tuna transhipped.</p>	<p>There are 5 main processors in RMI with Pan Pacific Foods in Majuro being the largest.</p> <p>Skipjack is sold as 'light meat' tuna. Fresh/frozen skipjack is rare as the quality is not as popular as yellowfin or bigeye.</p> <p>Yellowfin is primarily canned and sold as 'light meat' tuna</p>	<p>Exports to EU from PNA countries are duty free under Interim Economic Partnership Arrangement.</p> <p>55 tonnes of yellowfin were exported to the US in 2014.</p>
<p>80-90% of fishing effort by Western Pacific purse seiners takes place in PNA waters.</p>	<p>While Chinese, Taiwanese, Korean boats land in RMI, Japanese boats land their catch in Japan.</p>	<p>Foreign purse seine vessels caught approximately 48% of tuna in RMI EEZ in 2013 with Korea and USA catching the most.</p>	<p>Evidence suggests that crewmembers of foreign fishing vessels account for much of the demand for children in the commercial sex sector, according to the U.S. Department of State. RMI girls are recruited by foreign business owners to engage in prostitution with crew members of foreign fishing and transshipping vessels that dock in Majuro. Foreign women, most of whom are long-term residents, are subjected to forced prostitution in establishments frequented by crew members of Chinese and other foreign fishing vessels;</p>	<p>Tuna processing is a relatively labour intensive process. Loining is difficult to automate, and requires 80% of labour costs in processing due to the size and shape differences of individual fish.</p>	



## Vietnam Yellowfin Tuna Supply Chain

Fishing Area	Fishing Countries	Vessels & Gear	Landing & Local Trade	Processing	Export & Retail
<div style="border: 1px solid black; padding: 5px; width: fit-content;">South China Sea, PIC EEZs,</div>	<div style="border: 1px solid black; padding: 5px; width: fit-content;">Vietnam, Philippines, PNG, PNA vessels</div>	<pre> graph LR     A[Industrial Vessels] --&gt; B[Brokers and intermediaries at port]     C[Small-scale Vessels] --&gt; B     B --&gt; D[Canning industry: Premium 'white meat' cans]     B --&gt; E[Low quality tuna loins/steaks/bullets, blocks. Not suitable for Sashimi]     D --&gt; F[EU: Germany, Spain]     E --&gt; G[US, EU, Japan, ASEAN, Israel, Tunisia]             </pre>	<div style="border: 1px solid black; padding: 5px; width: fit-content;">Brokers and intermediaries at port</div>	<div style="border: 1px solid black; padding: 5px; width: fit-content;">Canning industry: Premium 'white meat' cans</div> <div style="border: 1px solid black; padding: 5px; width: fit-content; margin-top: 10px;">Low quality tuna loins/steaks/bullets, blocks. Not suitable for Sashimi</div>	<div style="border: 1px solid black; padding: 5px; width: fit-content;">EU: Germany, Spain</div> <div style="border: 1px solid black; padding: 5px; width: fit-content; margin-top: 10px;">US, EU, Japan, ASEAN, Israel, Tunisia</div>
<p>Fishing grounds for tuna are around the Paracel Islands, Spratly Islands, and other island chains in the South China Sea.</p> <p>Yellowfin and bigeye tuna are the most commonly caught species by Vietnam</p>	<p>Vietnamese vessels fish in the Vietnam EEZ but there are also distant-water vessels which fish overseas.</p> <p>Foreign vessels and large reefers also import tuna into Vietnam for processing and distribution.</p>	<p>Industrial vessels will fish for several weeks whereas small-scale vessels will have trips lasting 1-2 days.</p> <p>Most vessels are handline vessels, with a small number longline.</p>	<p>Total tuna landings for Vietnam totalled 78,000 tonnes in 2014. In Binh Dinh, Phu Yen, and Khanh Hoa coastal provinces there are 36 merchants and 15 tuna export companies.</p>	<p>Tuna are processed into a variety of different products including loins, bullets, and steaks.</p> <p>Vietnam is attracting canneries to relocate to it due to lower operating costs than its regional competitors.</p>	<p>Canned tuna exports in 2013 totalled \$224 million.</p> <p>In 2014 exports of canned tuna to EU totalled 13,000 tonnes. 60% to Germany.</p> <p>In 2015, Vietnam exported \$190 million worth of tuna to the US. Mainly in the form of frozen loins.</p>
	<p>60% of Vietnamese fishing boats are independently owned.</p>	<p>Independent vessels sell their fish at-sea via transshipment.</p> <p>Fish goods are made with a significant incidence of child labor (5-14), according to the U.S. Department of Labor. Of the child laborers working in fishing, 40% worked in fishing for more than 42 hours a week. 100% were involved in work that could be considered hazardous according to national legislation.</p>	<p>Small-scale fishermen are not currently able to sell directly to processing units and must go through intermediaries.</p> <p>Fishermen who have loans for their boats must sell their tuna to lenders. For boats with no loans, they can sell to the highest bidder.</p> <p>Of the child laborers involved in onshore fish processing, 74% worked for more than 42 hours a week. 84% were involved in work that could be considered hazardous, according to the Government of Vietnam's National Child Labor Survey .</p>	<p>Due to the small-scale nature of many of Vietnam's fishing boats, many tunas are not of suitable quality for sashimi, meaning that Vietnam is losing out on potential revenue. New freezing/preservation tech is needed onboard vessels.</p>	<p>Vietnam has signed a FTA agreement with EU to lower trade tariff to 0% in next 7 years.</p>

## Papua New Guinea Yellowfin Tuna Supply Chain

Fishing Area	Fishing Countries	Vessels & Gear	Landing & Local Trade	Processing	Export & Retail
<div style="border: 1px solid black; padding: 5px; width: fit-content;">PNG EEZ, Solomon Sea, Coral Sea</div>	<div style="border: 1px solid black; padding: 5px; width: fit-content;">FSM agreements with many PNA countries</div>	<div style="border: 1px solid black; padding: 5px; width: fit-content;">PNG and Domestic based foreign longline and purse seine fleets</div> <div style="border: 1px solid black; padding: 5px; width: fit-content; margin-top: 10px;">Foreign distant-water longline and purse seine fleets</div>	<div style="border: 1px solid black; padding: 5px; width: fit-content;">Landing throughout PNG but mainly into Madang province</div> <div style="border: 1px solid black; padding: 5px; width: fit-content; margin-top: 10px;">Transhipment outside PNG</div>	<div style="border: 1px solid black; padding: 5px; width: fit-content;">Canning industry: Premium 'white meat' cans</div> <div style="border: 1px solid black; padding: 5px; width: fit-content; margin-top: 10px;">Low quality tuna loins/steaks/bullets, blocks. Not suitable for Sashimi</div>	<div style="border: 1px solid black; padding: 5px; width: fit-content;">Thailand, Germany, UK, Netherlands, (EU)</div> <div style="border: 1px solid black; padding: 5px; width: fit-content; margin-top: 10px;">EU (Spain, Italy), Taiwan, Japan</div>
<p>Skipjack and yellowfin are the dominant species caught and landed by PNG vessels.</p> <p>PNG waters are home to 18% of the world's tuna stocks and 15% of global tuna trade.</p>	<p>Philippine, Vanuatu, countries all part of the PNA are allowed to fish in PNG waters under FSM agreements.</p> <p>FSMs also signed with Taiwan, China.</p> <p>Locally based foreign vessels are owned or chartered by local companies.</p>	<p>258 vessels fishing in PNG EEZ in 2013 made up of 187 foreign vessels and 71 PNG vessels.</p> <p>Longliners catch the most yellowfin. PNG has 100 longliners which caught 952 tonnes of yellowfin in 2013, 60% of whole longline catch.</p> <p>Most PNG vessels fish in the PNG EEZ.</p> <p>39 foreign vessels based in PNG in 2013 with most of their fishing days in the PNG EEZ.</p>	<p>PNG vessels landed 12,699 tonnes of yellowfin in 2013. Foreign vessels landed 35,364 tonnes.</p> <p>Tuna can also be transhipped by other PNA countries into PNG for processing.</p>	<p>Much of the tuna processing is based in the city of Lae. There are several major seafood companies based here.</p> <p>2 Filipino owned canneries have opened recently with 50,000 tonne/year capacity.</p>	<p>Main tuna exports are frozen skipjack and yellowfin. Mainly to Philippines, Thailand, Taiwan to supplement their canning industries.</p> <p>Most canned products go to the EU with other markets including Solomon Islands, and Vanuatu.</p> <p>Fresh and some frozen products go to Japan for the sashimi market.</p> <p>Exports to EU from PNA countries are duty free under Interim Economic Partnership Arrangement.</p>
<p>From 2016 PNG has declared that fish caught in PNG EEZ must be processed in PNG.</p>	<p>Migrants from Indonesia, Malaysia, Thailand, China and the Philippines are known to be trafficked into the tuna industry by its foreign business interests, according to the U.S. Department of State.. Cases are known on Taiwan and Korea vessels and on a Thai reefer transiting tuna from PNG.</p>	<p>There are approx 250 observers onboard vessels with plans to recruit a further 400 observers.</p>	<p>Transhipment at-sea is banned in PNG waters. PNA countries including PNG, Micronesia, Tuvalu, Vanuatu, Nauru, and Samoa all ban transhipment at-sea.</p>	<p>There are approximately 14,500 people employed in the tuna processing industry.</p>	<p>The EU lifted the yellow card against PNG in October 2015. It was originally issued in June 2014.</p>

### Singapore Yellowfin Tuna Supply Chain

Fishing Countries	Vessels & Gear	Landing & Local Trade	Processing	Export & Retail
<p>PNA Countries, S Korea, Taiwan, Japan</p>	<p>Purse seine, pole-and-line fishing boats, Reefer vessels</p>	<p>Transshipment in PNA countries and transport to Singapore</p> <p>Blast freezing and storage before transport</p> <p>Air freight from Singapore</p>	<p>Fresh/Frozen tuna prepared into steaks/loins</p> <p>Sashimi market: Fresh, yellowfin, sold in loins/bullets</p>	<p>Thailand, International markets, US, EU</p> <p>International markets, EU, Japan, USA</p>
<p>Singapore has a tiny domestic fishing fleet and instead imports tuna to be processed and then distributed domestically and internationally.</p> <p>Bigeye and yellowfin are the main tuna species to pass through Singapore</p>	<p>The largest trans-shipper owns 14 purse seiners and 4 pole and line fishing vessels, and 12 carriers that tranship tuna in PIC EEZs and then transport the tuna to international markets such as Thailand, Singapore, Korea, and Taiwan</p>	<p>One of the largest transshipment firms in the world transports tuna to Singapore to then be loaded onto flights bound for international markets.</p> <p>Singapore has several freezer companies which store tuna in deep freeze conditions until ready for dispatch.</p>	<p>High quality bigeye, albacore tuna set for the sashimi market whereas yellowfin and poorer quality albacore will be processed into steaks.</p> <p>Deep frozen yellowfin + other species not suitable for sashimi</p>	<p>Singapore is a major tuna air freighting centre , with routes to international markets.</p> <p>19.4 tonnes of yellowfin were exported to the US in 2014.</p>
	<p>Singapore is a transit country for Cambodian and Filipino men subjected to forced labor on fishing vessels that stop at ports in Singapore, according to the U.S. Department of State.</p>			

**Fig. S1. Pacific yellowfin tuna supply chains for six Asia-Pacific nations supplying the U.S. market.** Jurisdictional and supply chain points of labor risk are identified in the light green row in each national summary table.

## Thai Shrimp Supply Chain

Hatcheries/ Fry Collection	Farms	Local Trade	Processing	Exporter/Wholesaler	
<pre> graph LR     BH[Backyard Hatcheries] --&gt; BN1[Broker Network]     BN1 --&gt; SF[Shrimp Farms]     FI[Fishmeal Input] --&gt; SF     SF --&gt; BN2[Broker Network]     BN2 --&gt; AM[Auctions/Markets]     BN2 --&gt; DC[Direct Contracts]     AM --&gt; PPS[Primary Processing Peeling Sheds]     DC --&gt; PPS     PPS --&gt; SP[Secondary Processing]     SP --&gt; DM[Domestic Market Retail]     SP --&gt; EX[Export to USA, Europe, Japan, etc]         </pre>					
<p>90% of the country's broodstock comes from over 2,000 backyard hatcheries.</p> <p>These hatcheries use small 10,000 litre tanks so are hard to trace, easy to move. Larvae are sold to hatcheries and nurseries at 5–8,000 baht per thousand.</p> <p>Traceability standard: Best/Good Aquaculture Practices (BAP/GAP)</p>	<p>Broodstock either bought directly or through a broker. Estimated to be 24,000 farms in Thailand with majority of shrimp coming from Surat Thani (64,820 t), Chanthaburi (60,628 t), Songkhla (46,749 t).</p> <p>Fishmeal can be bought directly from factory or through broker.</p> <p>There are 74 fishmeal factories producing 470,000 tonnes/year. 86% of production goes into aquaculture.</p> <p>Traceability standard: BAP/GAP</p>	<p>Harvested shrimp sold through brokers/markets to processors.</p> <p>¾ of Thai shrimp is bought at Samut Sakhon market before processing (900-1050 MT/day).</p> <p>Vertically integrated processors (CPF Foods/Thai Union) will have contracts with farms and buy directly.</p>	<p>No regulations on unregulated peeling sheds. Peeling sheds are highly mobile, making them difficult to track.</p> <p>No reliable figures on number of unregulated/regulated peeling sheds although LPN estimates there to be over 2,000.</p> <p>The TFFA and The Thai Shrimp Association state that there are 163 shrimp freezing plants in Thailand employing 200,000 workers, and 175 shrimp processing plants employing 12,000 workers.</p> <p>Traceability standard (necessary for export): BAP/GAP, Good Labour Practices (GLP), Code of Conduct (CoC).</p>	<p>Factories exporting shrimp to international customers must be a member of the TFFA. Catch certificates from fishmeal processors also needed</p> <p>90% of Thailand's shrimp is exported. 360,700 tonnes of shrimp were exported in 2012, with 49% being exported fresh, chilled, or frozen. The USA is Thailand's biggest market for shrimp, accounting for 35% of shrimp exports by weight followed by Japan (22%), EU (14%), and Canada (6%).</p>	
	<p>Thai shrimp are made with a significant incidence of forced labor and forced child labor according to the U.S. Department of Labor.</p> <p>High incidence of forced labour in nearshore purse seine and trawl gear fisheries for feed (17%-ILO). Burmese and Cambodian crew can be indebted to agents, sometimes in forced labour.</p>		<p>Burmese and Cambodian plant workers can be indebted to agents, sometimes in forced labour.</p>		

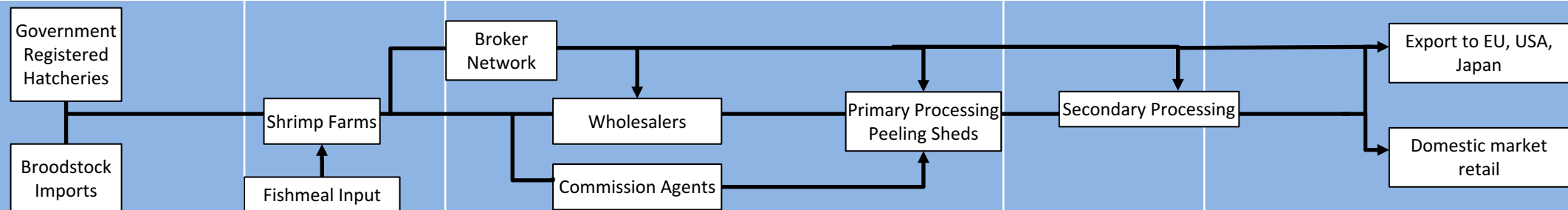
### Ecuador Shrimp Supply Chain

Hatcheries/ Fry Collection	Farms	Local Trade	Processing	Exporter/Wholesaler
<div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 0 auto;">Government Registered Hatcheries</div>	<div style="display: flex; flex-direction: column; align-items: center;"> <div style="border: 1px solid black; padding: 5px; margin-bottom: 5px;">Shrimp Farms</div> <div style="border: 1px solid black; padding: 5px; margin-bottom: 5px;">Fishmeal Input</div> </div>	<div style="display: flex; flex-direction: column; align-items: center;"> <div style="border: 1px solid black; padding: 5px; margin-bottom: 5px;">Broker Network</div> <div style="border: 1px solid black; padding: 5px; margin-bottom: 5px;">Auctions/Markets</div> <div style="border: 1px solid black; padding: 5px; margin-bottom: 5px;">Direct Contracts</div> </div>	<div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 0 auto;">Integrated Processing Facility</div>	<div style="display: flex; flex-direction: column; align-items: center;"> <div style="border: 1px solid black; padding: 5px; margin-bottom: 5px;">Export to Vietnam, China, USA, Europe</div> <div style="border: 1px solid black; padding: 5px; margin-bottom: 5px;">Domestic Market Retail</div> </div>
<p>There are 300 shrimp hatcheries are registered with the CNA producing 410 million shrimp larvae/day. Highly sophisticated process to ensure shrimp are disease free.</p>	<p>There are approx 3,000 shrimp farms, covering 213,000 hectares producing 320,000 tonnes in 2014.</p> <p>Farms utilise low-density stocking with 8-15 larvae/m<sup>2</sup>.</p> <p>There are 14 Shrimp feed factories producing 490,000 tonnes/year, consisting mainly of Peruvian anchovy.</p>	<p>Shrimp can be sold at market or through brokers. CNA estimates there to be 25 intermediary traders who buy product from farms before selling to processors.</p>	<p>Processing in Ecuador is highly integrated. It is concentrated around Guayaquil and Manta. There are 51 processing facilities.</p>	<p>300,000 tonnes were exported in 2014 (worth \$2.6 billion) making it 2<sup>nd</sup> most valuable non-oil export after bananas.</p> <p>75% of Ecuador's shrimp is exported. 33% goes to Europe, 27% goes to Asia, especially Vietnam for further processing and importing into China.</p>
		<p>Low oversight in local trade due to broker networks.</p> <p>Work in the domestic processing sector is often temporary.</p>		<p>Raw material exports go to China and Vietnam for processing.</p>

## India Shrimp Supply Chain

Hatcheries/ Fry Collection	Farms	Local Trade	Processing	Exporter/Wholesaler
<pre> graph LR     subgraph Hatcheries_Fry_Collection         GH[Government Registered Hatcheries]         BI[Broodstock Imports]     end     subgraph Farms         SF[Shrimp Farms]         FI[Fishmeal Input]     end     subgraph Local_Trade         BN[Broker Network]         AM[Auctions/Markets]         M[Middlemen]     end     subgraph Processing         PPS[Primary Processing Peeling Sheds]         SP[Secondary Processing]     end     subgraph Exporter_Wholesaler         DM[Domestic Market Retail]         EJ[Export to EU, USA, Japan]     end     GH --&gt; SF     BI --&gt; SF     FI --&gt; SF     SF --&gt; BN     SF --&gt; AM     SF --&gt; M     BN --&gt; PPS     AM --&gt; PPS     M --&gt; PPS     PPS --&gt; SP     SP --&gt; DM     SP --&gt; EJ                     </pre>				
<p>80% of shrimp broodstock is imported from the USA due to fears about EMS and other diseases.</p> <p>There is a growing domestic hatchery industry with 91 hatcheries (2014). 13 illegal hatcheries were destroyed in 2013.</p>	<p>It is estimated that there are 76,000 workers on pacific white shrimp farms. Farming is concentrated in the East, and mainly in Andhra Pradesh, Tamil Nadu, Orissa, and West Bengal. 70% of farmers are small/marginal with average land holding of only 2-5 hectares. Production is 325,000 tonnes a year from 26,118 farms on 150,000 hectares of land.</p> <p>13 feed companies produce 600,000 tonnes of feed/year. 80% come from 3 companies.</p>	<p>An auction system is operated by broker networks. The total margin added by middlemen can be as high as 75% in local trade, comparing with 20-30% in other countries.</p> <p>In the state of Kerala, legislation and programming to support fishers include social security for unregistered workers and business support to women shrimp catchers and fish vendors.</p> <p>In Tamil Nadu, social security legislation supports seafood workers and fishers.</p>	<p>Primary processing takes place in peeling sheds which are usually informal and only in operation for the harvest season.</p> <p>There are 369 seafood processing facilities registered in India. Charoen Pokphand Foods and Thai Union are also planning to increase their processing capacity in India with Thai Union establishing a joint venture with Avanti Feeds.</p> <p>A study conducted in Kerala found 119 peeling sheds, employing 6,900 workers. Shrimp processing in India is often carried out by women with the MPEDA estimating that 90% of shrimp processing workers are women. In 2008 two acts were passed in India to provide social security to unorganized (unregistered) workers.</p>	<p>90% of Indian shrimp production is exported.</p> <p>Shrimp exports make up 62% of total Indian seafood exports by value. Shrimp exports totalled \$32.2 billion with pacific white shrimp contributing \$2.3 billion.</p> <p>India is the 3<sup>rd</sup> largest supplier of shrimp to the US after Indonesia and Ecuador.</p>
	<p>Unknown working conditions in feed fisheries</p>	<p>Low to nil oversight in the peeling sector and in local trade due to broker networks</p>		

## Bangladesh Shrimp Supply Chain

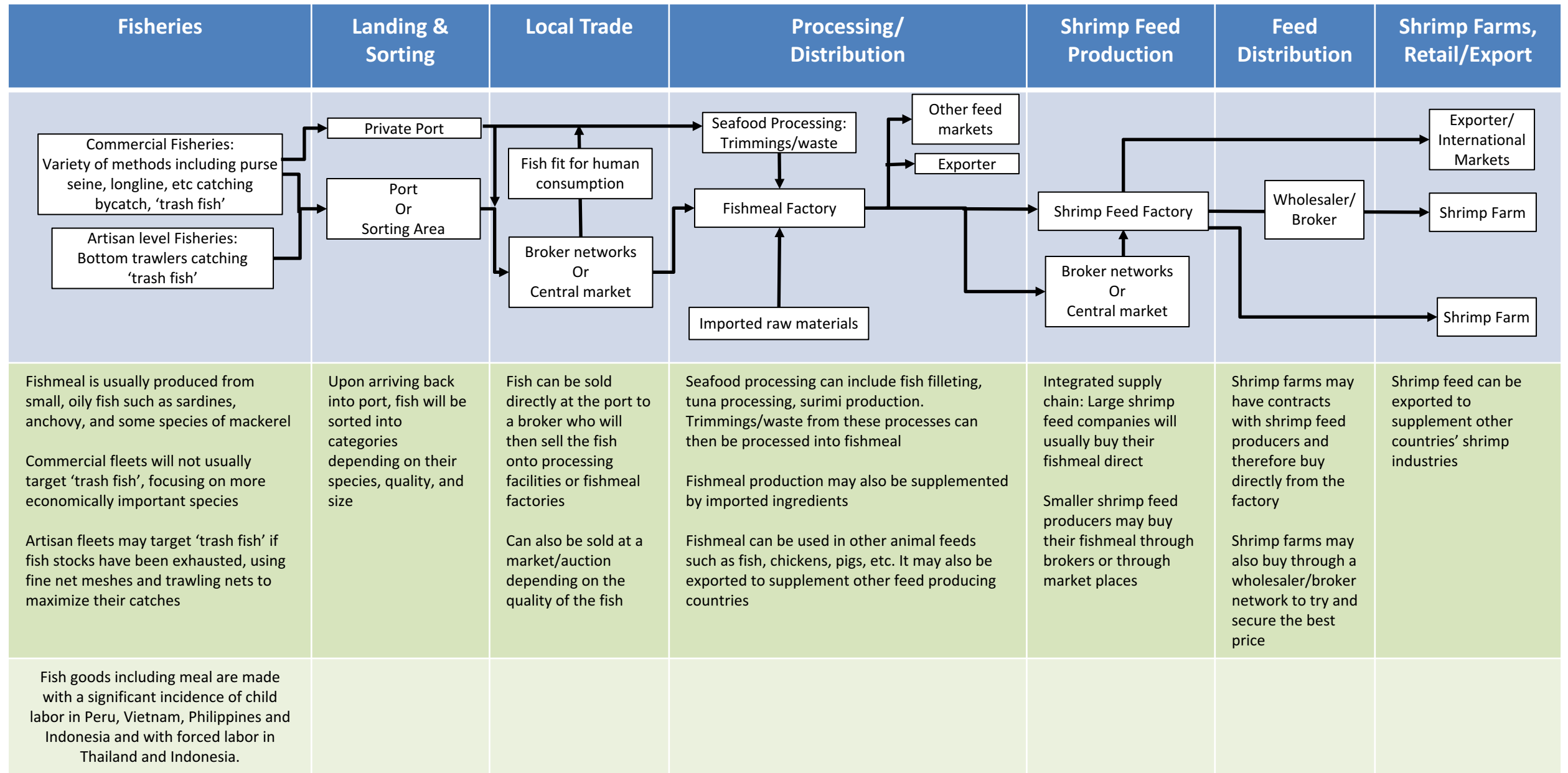
Hatcheries/ Fry Collection	Farms	Local Trade	Processing	Exporter/Wholesaler
	<p>83 hatcheries</p> <p>Wild shrimp fry collection is illegal but still a source of broodstock for the farming industry. This practice employs 400,000 people. Some farms prefer wild broodstock because it has a higher survival rate in cultivation.</p>	<p>Farms operate with semi-intensive production models on 275,274 hectares and concentrated in Bagerhat, Satkhira, Pirojpur, Khulan, Cox's Bazar, and Chittagong.</p> <p>A financial bonding system extorts high profit margins from hatcheries and producers.</p>	<p>Shrimp reaches buyers through trader networks that often include a number of middlemen.</p> <p>Larger regional wholesalers often lock local traders into sales agreements. Processing facilities purchase shrimp from commission agents, who contact the exporters on behalf of local wholesalers for a fee.</p> <p>Each trader along these chains adds substantial margin to the shrimp, despite not adding any value to the product, keeping prices of a number of key input factors at an artificially high level. For example, traders achieve profit by purchasing shrimp from farmers without grading, based on the dry weight of shrimp, then soak and grade the shrimp at a higher weight, reselling it the same day.</p>	<p>There are 135 processing plants in the country, of which 98 are BFFEA members, 78 are licensed; 75 of these have EU approval, and about 42 have a green channel to the U.S., according to the Bangladesh Frozen Foods Exporters Association, and employing 30,000 workers.</p>
<p>Fry reach buyers through trader networks that often include a number of middlemen, with known debt bonding and price fixing. Some fry collectors become indebted to fry traders who advance money in exchange for the harvest.</p>	<p>Bangladesh shrimp are made with a significant incidence of child labor according to the U.S. Department of Labor in farming and fry collection.</p>			<p>Companies that export shrimp to foreign buyers are represented by the Bangladesh Frozen Foods Exporters Association (BFFEA). In 2011, 29 companies sold shrimp to buyers in the U.S., and 24 of those were BFFEA members. Processed shrimp are loaded into refrigerated containers and shipped by barges to the Port of Mongla or Chittagong for loading onto feeder vessels, bound for Europe or the U.S. via Singapore.</p> <p>A large fraction of shrimp exports from Bangladesh (over 99 percent in 2011) are low-margin whole (i.e., largely unprocessed) shrimp sent to the port in freezer trucks for export.</p>

## Indonesia Shrimp Supply Chain

Hatcheries/ Fry Collection	Farms	Local Trade	Processing	Exporter/Wholesaler
<pre> graph TD     subgraph Hatcheries_Fry_Collection         GH[Government Registered Hatcheries] --&gt; I[Inspection]         I --&gt; BI[Broodstock Imports]     end     subgraph Farms         BI --&gt; SF["Shrimp Farms 'Nucleus - plasma' cooperatives"]         FI[Fishmeal Input] --&gt; SF     end     SF --&gt; TN[Tokeh Network]     SF --&gt; AM[Auctions/Markets]     SF --&gt; DC[Direct Contracts]     TN --&gt; PP[Primary Processing Peeling Sheds]     AM --&gt; PP     DC --&gt; PP     PP --&gt; SP[Secondary Processing]     SP --&gt; DM[Domestic Market Retail]     SP --&gt; EU[Export to USA, EU.]     </pre>	<p>Production totalled 592,000 tonnes in 2014, up from 330,000 tonnes in 2007 due to farmers adopting faster growing pacific white shrimp.</p> <p>Total farming area is approx 1.22 million hectares, centralised on the island of Sumatra – 42% of total production.</p> <p>1.3 million tonnes of shrimp feed are consumed by industry, with consumption rising 20% in 2014.</p> <p>Traceability standard: BAP/GAP</p>	<p>Farmers usually sell shrimp to brokers (<i>Tokeh</i>) who then sell onto processing plants or transport the shrimp to auction/market sites.</p> <p>Larger processing may have direct contracts. CP Prima has contracts with around 7,000 farmers and produces 50% of domestic Indonesian shrimp.</p>	<p>Many of the processing plants are situated in East Java, collecting shrimp from across the country. They are concentrated here because Surabaya, the main city in the region is also the key exporting port.</p> <p>Traceability standard (necessary for export): BAP/GAP, Good Labour Practices (GLP), Code of Conduct (CoC).</p> <p>Other standards are HACCP, ISO 9001, ISO 14001.</p>	<p>95% of Indonesian shrimp are exported.</p> <p>Most of the exporters average around 1,000 – 2,000 tonnes/year whilst CP Prima exports over 40,000 tonnes on its own, all of which is GAP certified.</p> <p>Shrimp exports were valued at \$1.55 billion in 2014, making up 45% of Indonesia’s seafood exports by value.</p> <p>Indonesia is the top supplier of shrimp to the USA followed by Ecuador, India, and Thailand.</p>
	<p>Evidence of debt bondage, captive unpaid work in feed production on purse seine and trawl vessels.</p> <p>Indonesia fish goods including some destined for fishmeal are made with a significant incidence of forced labor and child labor according to the U.S. Department of Labor.</p>		<p>Primary processing includes a high percentage of unregistered facilities.</p>	



## Fishmeal Supply Chain



**Fig. S2. Supply chains for shrimp from five major exporting countries and for fishmeal.**