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Trase 'SEI-PCS Ecuador shrimp v1.0.0' supply chain map: Data sources and methods

Trase maps supply chains for agricultural commodities, making it possible to link products and supply chain actors with specific areas of production, and associated sustainability risks and opportunities. It uses an approach called Spatially Explicit Information on Production to Consumption Systems (SEI-PCS) as the basis for this work (see this webpage or our manual for more detail). This document describes the data and methods that Trase used to map the subnational supply chain for Ecuadorian exports of shrimp (see Table 1 for an overview of key statistics), using a model called **'SEI-PCS Ecuador shrimp v1.0.0'**.

For all shrimp exports, this model determined the likely parish in which the shrimp was produced. It used trade and production data, sustainability certification records and information on company-specific assets. The model used a decision tree to allocate exports either directly to shrimp production ponds, or to shrimp processing and packing facilities, by matching company names and asset ownership records. For exports without a direct link to shrimp production ponds, we then used linear programming to link the processing/packing facilities to the parishes where shrimp are farmed. We also used linear programming to allocate the parish of production for exports that we could not match with facilities or ponds.

Table 1. Summary statistics

	2013	2014	2015	2016	2017	2018	2019
Shrimp exports (tonnes*)	251,076	326,555	327,077	405,831	467,549	562,346	702,262
Exporting companies	89	97	102	96	109	103	116
Domestic market (% share of production)**	5	5	5	5	5	5	5
Exports with unknown source of origin (%)	6.9	4.5	3.7	4.3	3.6	3.3	3.0

*= metric tons

**= Based on expert advice we assumed exports to equal 95% of production

Data and sources

Trade data

The model used per-shipment data (such as customs data, bills of lading or cargo manifests) for 2013-2019, covering all exports of the shrimp-based products classified under the 'HS' customs codes listed in Table 2. We used a commodity-equivalence factor of 1 to convert exported weights of each product to a standard commodity equivalent, in this case shrimp. We confirmed the quality of the data by comparing it with other data sources and with data in different aggregated forms (such as COMTRADE, as illustated in Table 3).

Table 2: Shrimp product HS codes, commodity-equivalence factors (to shrimp equivalent) and distribution of total exports among product types

Product	HS code	Commodity-equivalence factor	Distribution of exports among product types (%)							
			2013	2014	2015	2016	2017	2018	2019	Total
Crustaceans: Cold-water shrimps and prawns (*Pandalus* spp., *Crangon crangon*)	030616	1.0	32.5	22.4	16.4	13.6	11.6	8.0	4.6	13.0
Crustaceans: Other shrimps and prawns	030617	1.0	66.9	77.1	82.5	85.9	88.0	91.5	95.1	86.5
Crustaceans: Other shrimps and prawns	030636	1.0	-	-	-	-	<0.0	<0.0	<0.0	<0.1
Crustaceans: Cooked or steamed shrimps and prawns	030695	1.0	-	-	-	-	-	<0.0	<0.0	<0.1
Crustaceans, prepared or preserved: Shrimps and prawns; not in airtight containers	160521	1.0	0.2	0.2	0.4	0.3	0.3	0.4	0.3	0.3
Crustaceans, prepared or preserved: Shrimps and prawns; in airtight containers	160529	1.0	0.4	0.4	0.7	0.1	0.1	0.1	0.1	0.2

Table 3: Comparison of customs data and COMTRADE data (2013-2018)

	Exports (tonnes)	
	Customs	COMTRADE
2013	251,076	223,663
2014	326,555	298,218
2015	327,077	345,161
2016	405,831	372,596
2017	467,549	443,224
2018	562,347	508,848

Domestic demand

This model does not include domestic demand for shrimp. However, the International Trade Office of Ecuador's National Chamber for Aquaculture told us that it estimates domestic demand to be 5% of total production, which industry consultants and in-country experts corroborated.

Production data

We were unable to access data on shrimp production volumes. We therefore calculated shrimp production per pond, using shrimp pond area (see 'Asset data' section, below), export statistics, and assuming uniform pond yields. As 95% of all shrimp production is estimated to be exported (see previous section), we divided annual exports by 0.95 to estimate total production. We then allocated

this total to parishes in proportion to their relative pond area, using the following equation, where $production_{jy}$ is the estimated production for year y in pond j, $export_y$ is the exports in year y, $area_{tot}$ is the pond area summed for Ecuador, and $area_j$ is area of pond j.

$$production_{jy} = \frac{export_y/0.95}{area_{tot}} \times area_j$$

Supply chain data

Asset data

Ponds

A map of shrimp ponds is available as a shapefile from the Aquaculture Sub-secretariat (Ministry of Aquaculture and Fisheries). This provides an up-to-date snapshot of pond locations, ownership and legal status. The annual expansion of shrimp pond area is not available in this format. However, data from Clark Labs show that in recent years there has been relatively little expansion of the total area of shrimp ponds – and particularly little conversion of mangroves to ponds (an interactive map can be found here; note that we also used these maps to calculate mangrove gains/losses).

Processing and packing facilities

The Ministry of Aquaculture and Fisheries keeps a list of companies licensed to export to specific countries (Argentina, Brazil, Guatemala, Nicaragua, South Korea, China, Russia) and the EU. These data include the location of the facility, as well as the company name, allowing us to both filter the companies allowed to export to these particular markets, and to make direct links between traders and facilities that are owned by the same company. The data are in pdf format, so required semi-automated processing to extract them to bring them into our model. We therefore focused only on China and the EU, the only two markets that received a significant share of total exports (Table 4).

Table 4. The proportions of total shrimp exports sent to each of the licensed markets. Asterisks denote markets that import a significant share of Ecuador's total production and which are, therefore, included as a constraint in the model.

Licensed market	Share of total exports 2013-2019
Argentina	0.8%
Brazil	0.0%
China*	19%
EU*	18%
Guatemala	0.1%
Nicaragua	0.0%
Russia	0.7%
South Korea	2.3%

The Ministry of Production, Foreign Trade, Investments and Fisheries also provides a list of all facilities licensed for export, with frequent but irregular updates (for example, here). We followed advice to use the most recent data for v.1.0.0 of this model, as there is relatively little change in facilities between updates other than changes to licensing or ownership.

Transportation data

Road network

We sourced road network data (available here) from the Instituto Geográfico Militar (IGM, 2017).

Company data

Company registration

A registry of all companies in Ecuador — per province — is available from the Ecuadorean Tax Office here [updated 10 January 2020, downloaded 14 Jan 2020]. The data include company name(s), address, owners and RUC codes, which are unique tax registration numbers. We converted RUC codes into 13 digits as necessary (by adding leading zeros). We then matched them to our customs data to verify company names and identify company headquarters for exports with no other matches to assets (ponds, processing facilities).

Sustainability certification records

We used data from sustainability standards to help identify company ownership of ponds. We used the following records:

- Locational records and descriptions from the Best Aquaculture Practices (BAP) certification website (here [accessed April 2020])
- Database and certification documents from the Aquaculture Stewardship Council (ASC) website (here [accessed April 2020])

Company connections

In addition, we drew on expert knowledge and research to identify links to pond ownership records for three companies: EXPALSA; EDPACIF S.A; and ROJAS & CEVALLOS EXPORTADORA CEVAROEX S.A.

Boundaries

The model's administrative boundaries are based on data from the Instituto Nacional Estadísticas y Censos (INEC), available here. As some land-cover changes (from Clark Labs data) happen outside of formal administrative boundaries, such as along coastlines and estuarine edges, we buffered coastal parishes to associate these changes with the appropriate parish. We used the Euclidean allocation function provided by ArcGIS Pro to do this.

SEI-PCS implementation

We used a logic-based decision tree (see illustration in Annex 1) to identify direct links between shrimp exports and company assets such as ponds or processing facilities. The decision tree had the following five branches, which we ran sequentially, starting with those exports with the strongest link to ponds and working down to those whose source location was less certain.

Branch 1: Links exporters to ponds via sustainability certification data (including pond identifier / location).

Branch 2: Links exporters to ponds using names on pond-ownership records.

Branch 3: Links exporters to ponds via processing facilities that are licensed to export to each licensed market, by linking exporter names and the name or ownership of the licensed facilities, and assuming that facilities process shrimp produced in their own parish.

Branch 4: Links exporters to ponds via other licensed export facilities, by linking exporter names and the name or ownership of the licensed facilities, and assuming that facilities process shrimp produced in their own parish.

Branch 5: Links exporters to ponds in their (assumed) parish of headquarters, as deduced from RUC tax registration codes.

At each branch, the total production is depleted, with subsequent branches sourcing shrimp from the remaining (as yet unallocated) production.

For branches 1 and 2, we allocated shrimp production to exports in the following way. First, we aggregate demand per exporter and match these flows to ponds, split proportionally to pond production. We then calculated how much each pond can supply to each flow and labelled any remaining demand as ‘unsolved’ to be sent to subsequent branches. We set the parish of processing to the same as the parish of production for these unsolved flows.

For branches 3-5, we allocated shrimp production to exports in the following way. First, we aggregate demand per exporter (and, for branch 3, import country) and split these flows between parishes, proportionally to parish production. However, if parishes cannot supply the demand (depleted production) we allocate the flows based on split on number of parish matches (e.g. this happens when there is demand in a parish without shrimp ponds). We then calculated how much each parish can supply to each flow and split any remaining demand into unsolved flows. We use matches to processing and packing facilities, or to company HQs to set the parish of processing for unsolved flows that are sent to the linear program.

Once we made these links, we marked as ‘solved’ the trade volumes that could be sourced and we sent the remainder to a linear program (see below). However, if we could not identify a trader in the customs data, we did not send that flow to the linear program and instead we labelled the exports as having an 'unknown source of origin'.

We used the linear program to link the remaining exports and parishes of production. The linear program minimised the overall distance shrimp could have travelled from supply nodes (parishes of production) to demand nodes (processing facilities). It used a distance matrix, based on the road network data, to calculate distances between the geometric centres of parishes.

How to cite this document

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Annex 1: Decision tree for the 'SEI-PCS Ecuador shrimp v1.0.0' supply chain model

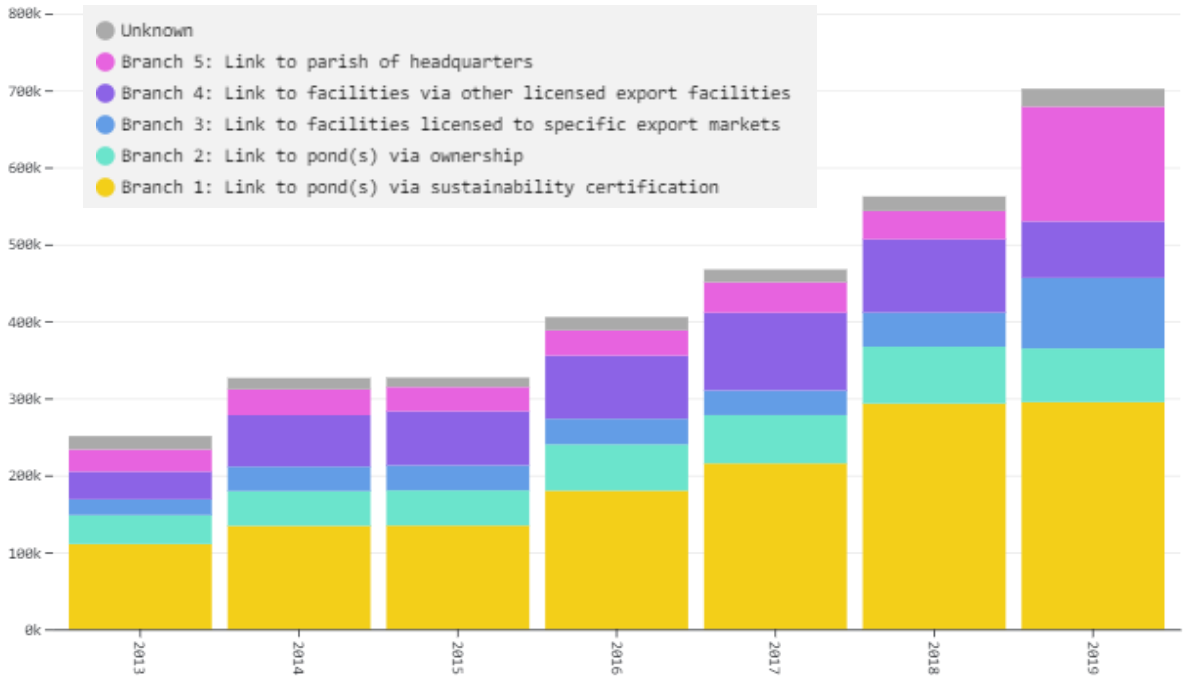

Figure 1. Visualisation of the decision tree and relative proportions of flows under each branch for each year.