Contributions of marine capture fisheries to the domestic livelihoods and seafood consumption of Chile

Draft Chile

Camila Vargas e Ignacia Rivera

Scope 1: Top domestic marine, capture fisheries based on landings and value

Fishing is a major industry in Chile with a total catch of wild fish that went up to more than 7 million of tones in the 90' and has dropped to about 2.1 millions recently (2015) (Ritchie and Roser (2017)). This position it as among the top fishing countries in the world.

Fishing activity occurs along the entire coastline of the country which is divided in 16 administrative regions (one without coastline).

Here we assess the main wild capture marine species in terms of landed volume and economic value using information from the National service of fisheries and Aquaculture (SERNAPESCA).

Methods

We used landing records from SERNAPESCA (available online) to evaluate the main species in terms of landed volume over the last five years (2013-2017). To estimate most important fisheries in terms of economic value, we used data on first-transaction prices per species per month and location (requested to SERNAPESCA) and computed the national average price per year. We used two different approaches, one considers the total revenue generated by different fisheries while the other considers how valuable they are based on their price. To estimate total revenue we multiplied price by the landed tons per year. We converted Chilean pesos to 2018 dollars. Data on price at first transaction at the level of species was only available for the artisanal sector since data on industrial transactions is not recorded officially.

Results

Most important species regarding landed volume are the Peruvian anchovy (*Engraulis ringens*), the Araucanian herring (*Strangomera bentincki*) and the Giant grey weed (*Lessonia nigrensis*) over the last five years. More detail on their anal variability and other important species can be found in **Table 1**.

Table 1: Landings (in tons) between 2013 and 2017 for most common species landed in Chile

Species	2013	2014	2015	2016	2017	Mean	SD
Engraulis ringens	803,404	817,900	732,659	337,436	625,697	21,540	56,989
Strangomera bentincki	236,968	543,278	793,337	280,421	344,262	14,274	50,767
Lessonia nigrescens	313,341	219,998	230,622	155,740	211,257	13,464	30,374
Trachurus murphyi	225,443	267,590	264,475	317,241	341,555	9,197	39,930
Dosidicus gigas	106,249	176,602	247,917	180,914	152,537	5,612	15,163
Lessonia trabeculata	38,724	60,531	144,142	49,802	71,771	4,345	8,224
Gracilaria spp.	46,053	32,336	90,614	26,413	47,584	2,893	8,510
Sarcothalia crispata	34,153	34,693	82,154	30,694	21,267	2,416	7,131
Scomber japonicus	31,226	24,127	69,373	57,769	64,915	1,607	4,683
Normanichthys crockeri	55,045	50,543	52,224	20,169	61,192	1,553	6,582

Most important fisheries in terms of revenue for the artisanal sector are presented in **Table 2**. The three species that bring more revenues are the Southern king crab (*Lithodes santolla*), the Chilean sea urchin (*Loxechinus albus*) and the Southern rays bream or Corina (*Brama australis*).

Further anlayses and data gaps

Landings are generally well documented in Chile and we are confident the data-set we are using for the estimates are the best we could find. However, SERNAPESCA's records of landings come mostly from

Table 2: Species that generated the most revenue for the artisanal sector over the past five years based on records on landings and prices by SERNAPESCA.

Species	Total Revenues (from 2013 to 2017
Centolla	16,469,470.4
Erizo	8,203,587.3
Reineta	5,542,599.2
Bacalao de profundidad	3,177,619.0
Navajuela	2,303,414.0
Congrio dorado	2,075,529.7
Albacora o pez espada	1,603,796.6
Corvina	1,504,457.1
Besugo	1,201,681.2
Merluza del sur	954,194.3

Table 3: Most expensive species in Chile based on the mean price over the past five years based on records on prices by SERNAPESCA.

Species	Price (average from 2013 to 2017
Bacalao de profundidad	13,349
Puye	12,124
Acha o Hacha	10,335
Acha	5,906
Loco	5,645
Lenguado	5,342
Pez Sol	5,168
Lenguado de ojos chicos	4,934
Centolla	4,498
Congrio colorado	4,447

self-reported landings for each vessel which means it does not account for Illegal, unreported and unregulated fishing (IUU). This means that we are likely underestimating catch, in general. We do not expect IUU to be occurring at the same rate for all species, this could be a factor that can make the relative importance of species vary. We will try to incorporate estimates of species-specific (or group of species) IUU fishing in a future analysis if we find estimates in the literature.

A better proxy for economic value would be profits rather than revenues. This would require accounting for species-specific differences in fishing costs. For this reason, we will explore the possibility of including costs in this analysis in the future. In addition, our current approach only accounts for the value generated by the first transaction. We are not including any value generated at further stages in the supply chain. We would like to investigate value at other stages of the supply change for different species.

Current data availability allow us to identify the most landed species at the regional level and for each sub-sector artisanal and industrial as well as the most valuable in the artisanal sector per regions (not reported here). Nonetheless, a major data gap to address this scope is the lack of data on the value of catch for the industrial sector. We will reach to companies and look into papers and grey literature to search for information on estimates for it.

Scope 2: Top domestic marine, capture fisheries based on employment and income

The fishing activity is considered to be the economic sector providing less direct employment in the country relative to other sectors (SENSE (2015)).There are two marine extraction sectors in Chile, the artisanal and the industrial.

The artisanal sector correspond to fishing activities performed by vessels equal or smaller than 18 meters in length and by harvesters in the inter-tidal zone (SUBPESCA (2018a)). Artisanal fishers and their vessels must be registered in the National Records of Artisanal Fishers (RPA, acronym in Spanish) in order to be allow to operate. The RPA register all artisanal fishers and lists the kind of species each one is allowed to extract in a given region. The number of unregistered fishers is low since being registered gives fishers access to potential benefits like subsidies or territorial users' rights for fishing. Based on the current RPA, there are around 89,000 artisanal fishers along with 12,700 vessels in Chile. Artisanal fishers are concentrated in the central south in the region of Los Lagos, which has the major number of registered fishers, followed by Bio Bio and Los Rios (Maturana et al. (2017)).

The industrial sector involves all the fishing activities performed by vessels larger than 18 meters. SERNAPESCA keeps a record on each industrial vessels and its owner in the Industrial Fishing Record (RPI, acronym in Spanish). Currently, there are 475 industrial vessels and 164 vessel owners according to the RPI. SERNAPESCA estimates a total of 3,500 jobs generated directly by the industrial sector, through vessels operations (SUBPESCA (2018b)).

Fisheries also support employment in the production facilities in which marine resources are processed to elaborate products for direct or indirect human use. There were around 740 facilities operating along the country in 2017 (data from SERNAPESCA, 2018). In this regard, the fishing industry is estimated to indirectly generate around 26,500 job positions at the national level (SUBPESCA (2018b)). Finally, commercialization of fisheries products is another activity supported by fisheries that supply employment and for which estimates are less available. The main point of commercialization of fishing products in Chile is the Terminal Pesquero and there are several other formal and informal points along the country.

Income in fisheries varies widely depending on the type of job position. Income of artisanal fishers is usually unstable and highly variable while people working in facilities or industrial vessels face more stable incomes. Estimates from the Employment and Social Security Ministry indicate are shown in **Table 4**.

Table 4: Incomes of fisheries sector. From SENSE, 2016. Elaborated with data from NESI, 2014

Type	Employer	Independent	Dependent with contract	Dependent without contract	Mean income
Full time	1,022.8643	310.1225	780.3514	336.3473	594.0543
Part time	623.2083	227.4325	409.8627	254.6065	266.4019

In this section we will use records from SERNAPESCA to address which are the main species contributing to employment and income in Chile.

Methods

We used the RPA (provided to us by SERNAPESCA, 2018) to compute the number of permits issued for different species in each region. We use this as a proxy of the contribution of specific fisheries to direct employment in the artisanal sector. This approach assumes that if a fisher holds a permit for a given species then, he or she targets that species.

To estimate the contribution of particular types of species to employment in processing facilities we use data on the number of employees in each marine processing facility in the country and the type of products they generate. Both data-sets are available at SERNAPESCA's website. We present our results in percent of jobs

because one processing facility can generate more than one type of product but there is no way in which we can know what proportion of the workers are employed for a given product. Hence, we cannot know the number of workers working in specific products but we can have an idea of the relative importance of different products in number of jobs.

Results

At the national level the most targeted species in the artisanal sector are algae species like Luche (*Porphyra columbina*) and Pelillo (*Gracilaria spp.*). This is mainly driven by the high number of fishers in the region of Los Lagos (10) in where algae like these are important resources for artisanal fishers. *Table 5* shows the most targeted species within each region. We observe that to the north most targeted species are fish while to the south they are mostly algae and selfish.

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Table 5: Most targeted species by the artisanal sector in each region based on the number of permits issued by SERNAPESCA

Region	Most targeted species (Common name)	Most targeted species (Scientific name)
1	CARACOL LOCATE	Thais chocolata
2	ALMEJA	Venus antiqua
2	CABRILLA ESPA<U+00D1>OLA	NA
3	CABRILLA ESPA<U+00D1>OLA	NA
4	ATUN ALETA AMARILLA / KAHI AVE AVE	Thunnus albacares
5	ATUN ALETA AMARILLA / KAHI AVE AVE	Thunnus albacares
6	CARACOL TEGULA	Tegula atra
7	CABRILLA ESPA<U+00D1>OLA	NA
8	CABRILLA ESPA<U+00D1>OLA	NA
9	ALMEJA	Venus antiqua
10	ANFELTIA	NA
11	CARACOL PALO PALO	Argobuccinum spp.
12	ANFELTIA	NA
14	ANFELTIA	NA
15	CABRILLA ESPA<U+00D1>OLA	NA
16	ANFELTIA	NA

Figure 1 shows the percent of jobs generated in processing facilities by different products. We observe that fish oil and fish meal are the two products generating more jobs in processing facilities. There was no data for fish meal facilities in 2016 we need to ask SERNAPESCA if this is due to lack of data collection or to the lack of production of fishing oil (probably the former option). The processing of frozen and, to a lesser extent, fresh and canned products are also important in terms of employment in the country. In 2017, the species that most contributed to fish oil and meal production were the Araucanian herring (*Strangomera bentincki*) and the Peruvian anchovy (*Engraulis ringens*) (based on data from SERNAPESCA, 2017). Therefore, this species are important in terms of employment.

Further anlayses and data gaps

We have not found yet information that allow us to link species or group of species to employment for the industrial extraction sector yet.

We are exploring an alternative approach to estimate the contribution of different species to direct employment in both the artisanal and industrial sector. This approach will combine vessel-specific landings per species

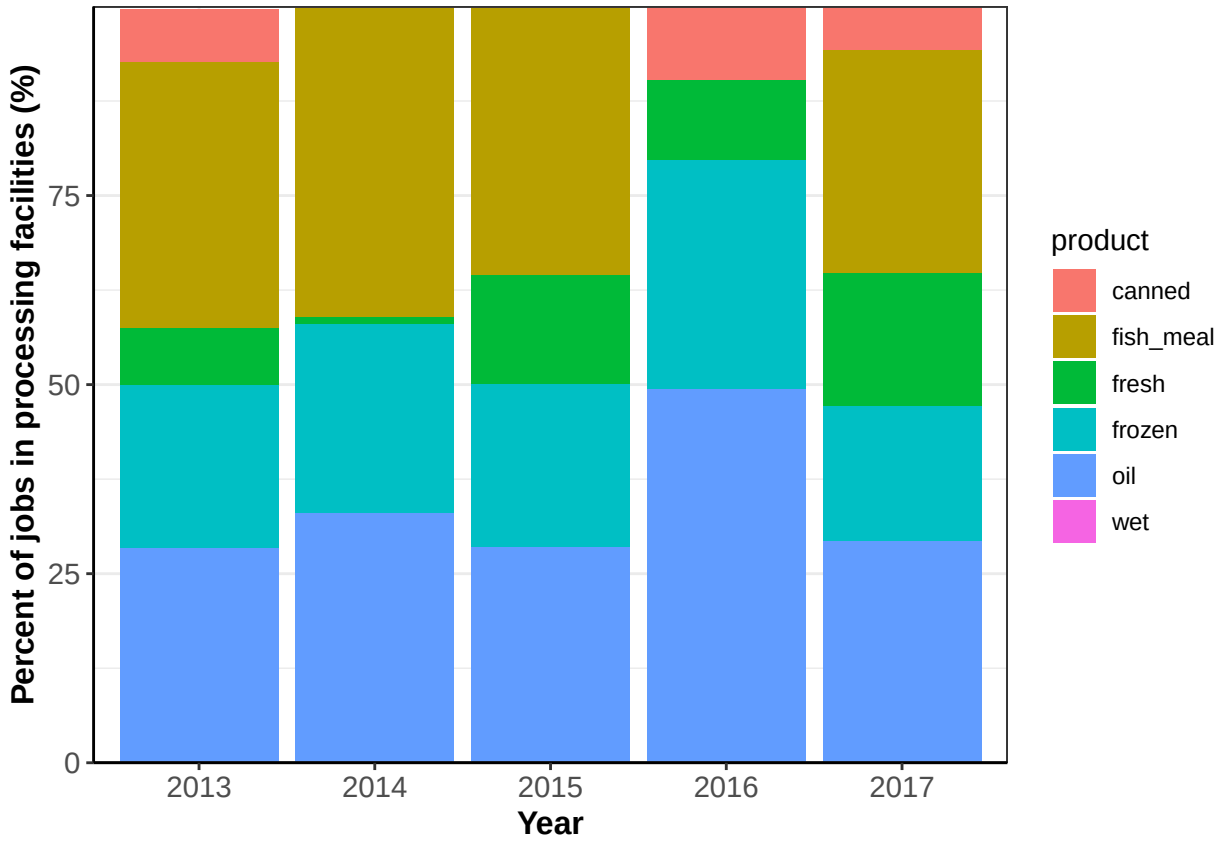

Figure 1: Percent of total anual jobs generated by the five most common types of products each year. Elaborated based on records from SERNAPESCA, 2018.

with vessels sizes that can inform us about the size of the crew. We already have this data available for the artisanal sector but not for the industrial.

To better link jobs to specific fisheries we will look at the species that contribute the most to the elaboration. of different products. We can combine that information with what we already know about type of products and proportion of jobs generated to have better idea of how species contribute to employment.

Scope 3: Domestic Food Consumption

Chile is considered one of the main countries in fishery production worldwide (FAO (2016)), however several reports and studies suggest the Chilean population does not consume as many marine products (Gonzales (2018)). On average, people consume 10-13 kg a year, compared to the 20 kg a year recommended by Food and Agriculture organization (2016). Looking into what type of seafood the Chilean population consumes, a study done in 2012 shows that 60% of the seafood consume are pelagic fishes, 12% are mollusk and 2% are crustaceans (Villena (2012)).

Methods

We combined data from Chilean Customs (ADUANAS Chile) and the National Service of Fisheries and Aquaculture (SERNAPESCA) to generate two main databases on the number of tons that are catches, harvested, exported and imported for all marine species in Chile. All the databases we use were available at the agencies' websites at the following links National Service of Fisheries and Chilean Customs, respectively and were accessed between August and September of 2018.

The specific data-sets we used are:

- Catches: annual tonnes per marine species landed in each region (SERNAPESCA, 2013-2017).
- Species contribution to different types of products: annual tons per marine species used in each region to elaborate each type of product (i.e. fish meal, oil, canned products, freeze products, dried products, smoked products, agar, col-agar, carragenina) (SERNAPESCA, 2012-2016).
- Aquaculture: annual tonnes per species harvest from aquaculture centers in each region (SERNAPESCA, 2012-2017).
- Exports: quantities of all the products exported from each Chilean region to other countries. (ADUANAS, 2013-2018).
- Imports: quantities of all marine products imported into the country. (ADUANAS, 2013-2018)

Each product in the original exports and imports data-sets is identified through an id number that matches the name of the product in a code known as the *Arancel Aduanero*. This document was only available to us in .pdf format. Thus, to identified the id of products containing domestically fished and harvest marine species we searched for the names of the fished and harvested species listed by SERNAPESCA in the document with the *Arancel Aduanero*. We searched for all the ids that refer to the species scientific name, common name or genus name as listed by SERNAPESCA and aggregated them under the species name.

We included a column that indicates the number of tonnes of each species that were used in products that are not directly ingested by humans. For this, we assumed that the following categories of products are not for direct human consumption: fish meal, col-agar, agar, carragenina, oil and alginato. Finally, to aggregate all the data at comparable levels we generated broad categories of species based on the imports-data set, which is the one that has less detail at the species level.

Because imports-data is not available at the regional level we generate two databases, (i) one describing tons landed, harvested, exported and imported at the national level per groups of species and (ii) one containing tons landed, harvested and exported at the regional level per species.

We used the R software to clean and format all the available information in long-form databases. All the scripts for replicating our work are available in "scripts/cleaning_data".

We determine the domestic human consumption of marine products through this general model: (Catch - Products not directly for human consumption) + Aquaculture + Imports - Exports. We assumed that all the products that are no exported or are not used in other elaboration process are consumed by the local population. For this report we explore database i mention above, because it has import quantities.

Results

Our preliminary results for this scope allows us to identify main groups of seafood consumed by the Chilean population as well as identify mayor data gaps and areas where we can still improve our methodology.

We first analyzed the five main species that contribute to the four main components of the model: Landings subtracting tonnes that are used for products that are not directly related with human consumption, aquaculture, exports and imports.

We looked into the landings volumes subtracting all quantities that are know to be used in products other than human consumption such as fish oil and fish meal (*Figure 2A*). This data shows that the main groups of species that go to human consumption (either domestic or abroad) are jack mackerel (*Trachurus murphy*), hake (*Merluccius spp*) , jumbo squid (*Trachurus murphyi*), crabs (*Cancer spp*) and algae. Through out the years the pattern is more or less constant, except for 2015. One possible explanation for this difference is that there is no data for how much fish (e.g. herrings) are use to produce oil for this year. In all other years, oil production is one of the main products that we account as no direct human consumption. Given this data gap, we asked SERNAPESCA to confirm that there is no data for fish oil production for 2015 and if that is the case we will gap-fill that information by doing a linear regression with the available data (years 2013, 2014, 2016, 2017).

The aquaculture activity in Chile is dominated by the production of salmon (*Figure 2B*). Other groups of species harvested in Chile are mussels, trout and algae and scallops. However the production of these four other groups is relatively small. Quantities and main groups of species harvested in Chile are relatively constant in the last 5 years. The current data shows that Chilean exports are dominated by pelagic fishes (Salmon and jack mackerel, *Figure 2C*), but we know that salmon should have a larger contribution respect to jack mackerel, therefore we need to revise our methods. Most of the seafood that Chile imports are also pelagic fishes mainly tuna (Figure 2D).

According to our model, salmon would be the main fish consumed by the Chilean population (*Figure 3*). However, that does not align to our internal conversations with fishers and local consumers which perceive that salmon is mainly exported and the main pelagic fish consumed by the population could be the hake. Furthermore, according to Nacional, 66% of Chilean exports of sea products are salmon. Even though, our data shows salmon as one of the five main species exported by the country, we do not see a major difference with jack mackerel (*Trachurus murphy*) as we expected. This mean that our data is underestimating exports of salmon. One possible explanation for this issue is that through the process of matching exports' ids with the name of each product we missed salmon products therefore this products are currently not being considered within the exports values. We are currently revising our methods in order to incorporate all marine products that are not currently being accounted. We also requested information about the destination of harvest products to SERNAPESCA to have a second source of information to compare the Chilean customs data.

We run the model not considering salmon (*Figure 4*) to have a better representation of domestic seafood consumption in Chile. As mention above, there is a data gap on 2015 no human consumption products, this explains the changes compared to all other years. But also allows us to visualize that most of the demersal fisheries (other fishes and herrings) catches are mainly used to produce products not for direct human consumption (e.g.: fish meal, fish oil).

These results (*Figure 4*) show that domestic consumption is mainly dominated by algae, mussels, tuna and hake. There are two main things to remark on these results: (i) the high values on algae is probably due to our methodologies given that within our methods we did not include dry algae as a product not for human consumption. The rationale behind this decision was that subtracting dry algae from total landings would underestimate what ever is directly consumed by the population given that algae consumed by humans are mainly dry. However, we will re run our analysis discounting dry algae because most of the algae goes to the industry and only ~3% goes to human consumption (2014). The second point we want to emphasis, is the tunas are within the main group of seafood consumed in Chile. However, tunas are one of the main imported species in the country *(Figure 2D)* rather than species caught locally.

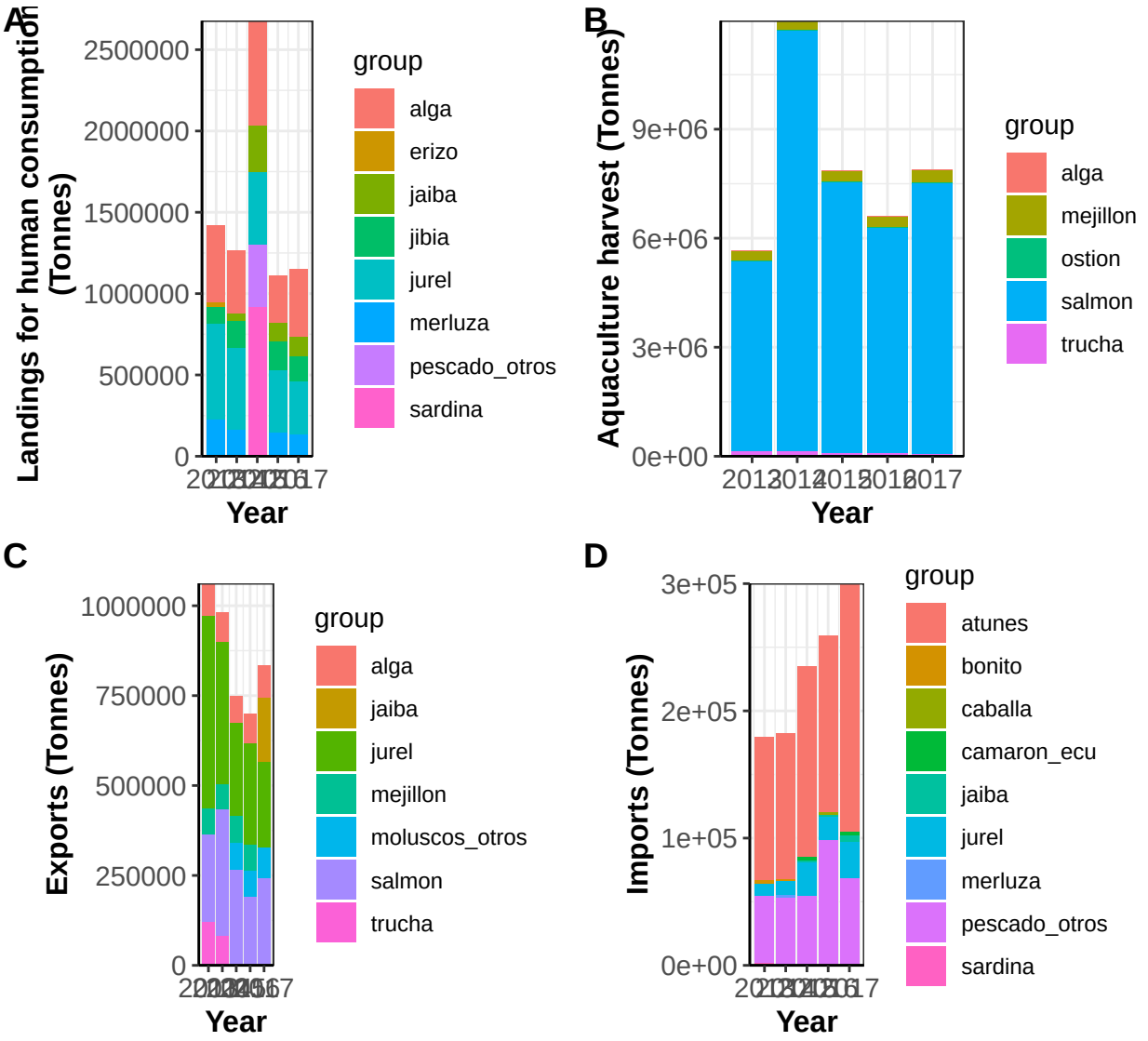

Figure 2: Relative contribution of four main componenst of the model to calulate domestic seafood consumption in Chile A) Main fisheries groups according to aquaculture, imports, exports and landings discounting tonnes that are not use for human consumption. B) Main fisheries groups according to aquaculture harvest. C) Main mairine products exported by Chile. D) Main mairine products imported by Chile

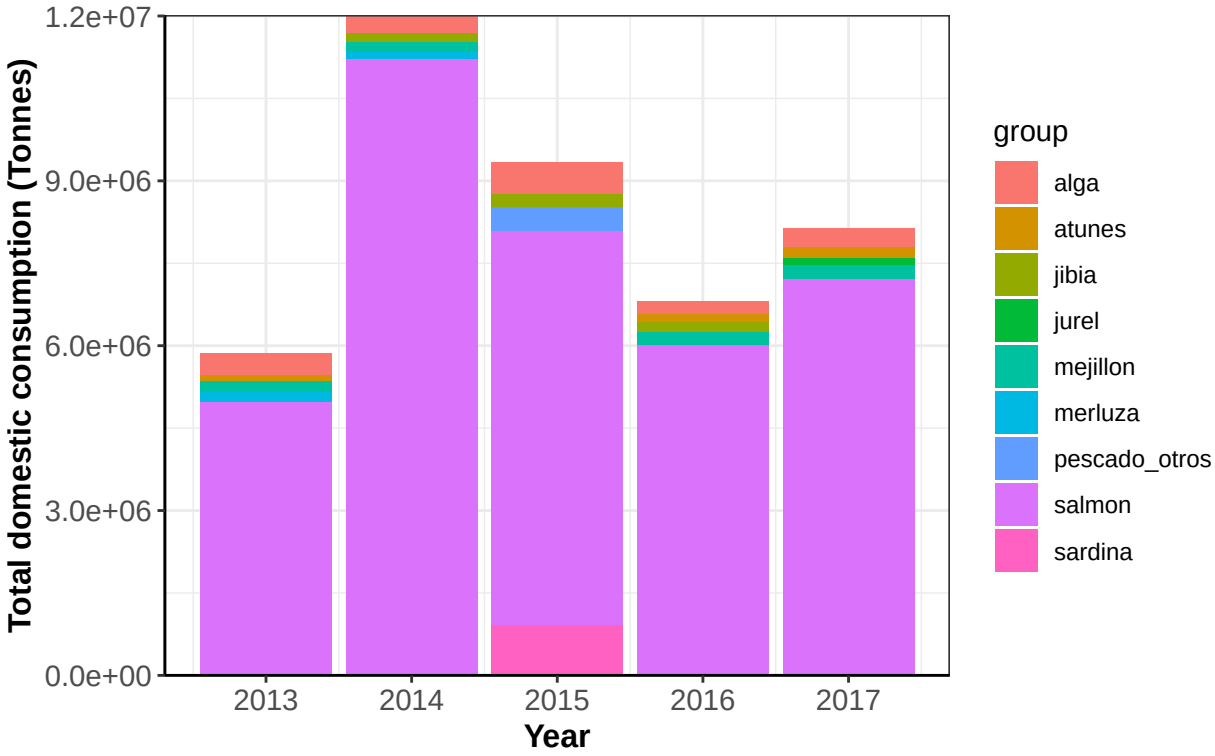

Figure 3: Total domestic consumptions according to model including salmon

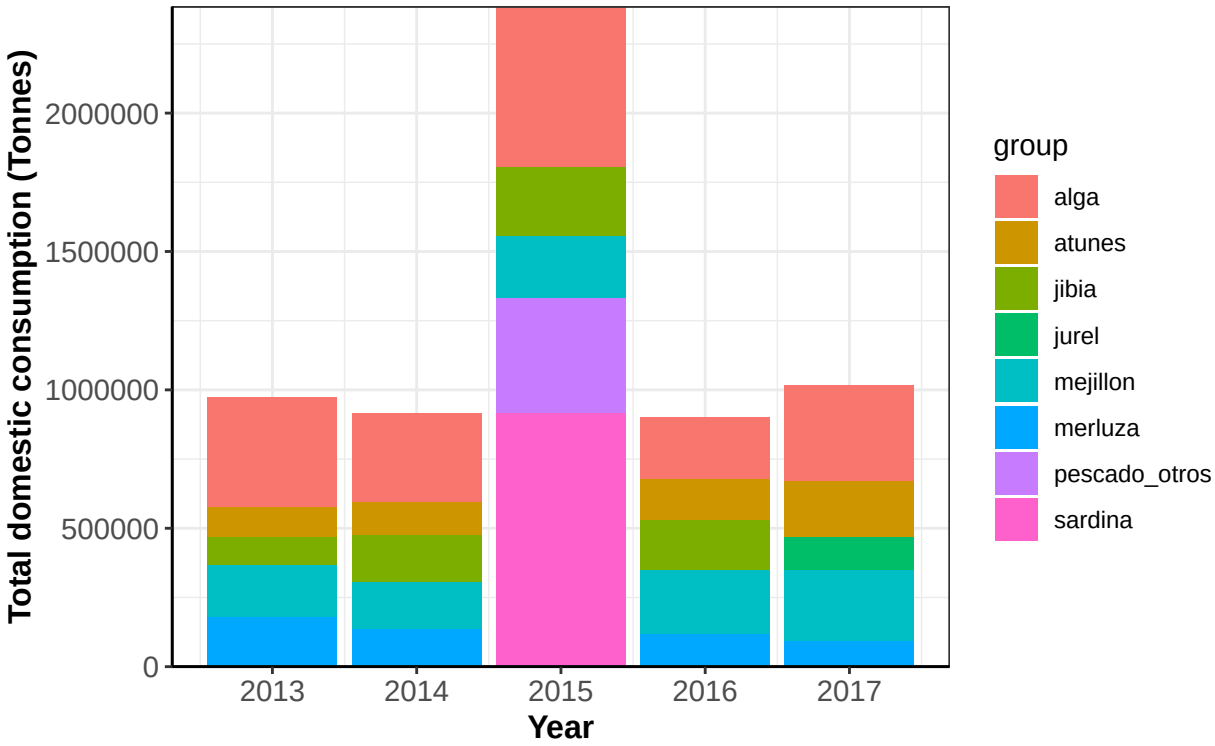

Figure 4: Total domestic consumptions according to model without slamon

Further anlayses and data gaps

The main challenge for this scope has been matching all species with the correct data. And the main data gap is that import data is only ata group of species level and not at a species level as de rest of our information.

A further analysis is to incorporate the conversion of how much of the weight of each product is actually for human consumption.

Critical Analysis

- The most important fisheries in Chile in terms of landings have been Anchovy (*Engraulis ringens*), Chilean jack mackerel (*Trachurus murphy*i) and Araucanian herring (*Strangomera bentincki*) (*Figure 1*), all three of them mainly catch by the industrial fleet. This pelagic fishes are mainly used to produce fish meal therefore not for human consumption.
- Most valuable species in terms of revenues for the artisanal sector are the Southern king crab (*Lithodes santolla*), the Chilean sea urchin (*Loxechinus albus*) and the Southern rays bream or Corvina (*Brama australis*). This, results however may vary if we take into account the fishing costs of different species.
- Most important species for local consumption are tunas, mussels and hake. However tunas are mainly imported therefore mussels and hake are the most important local resources seafood in Chile. In general this preferences have not change over time. But, comparing data from 2013 to data from 2017 the amount consumed of each of this fisheries has changed. In 2013 31% of the consumption was hake and 32% mussel and 18% tuna. In 2017, 38% of seafood consumption is mussels, 30% of fish consumed is tuna, and only 13% is hake. Interestingly, hake consumption has been decreasing over time while tuna and mussels have been increasing. We need to further explore price variation and people's preferences in order to provide an insightful explanation to this results. Note: this percentage do not include algae.
- In terms of employment, our preliminary results suggest that the most important fisheries in the artisanal sector are algae fisheries such as Luche (*Porphyra columbina*) and Pelillo (*Gracilaria spp.*) but this varies across regions. In terms of employment generated in production facilities, the Araucanian herring (*Strangomera bentincki*) and the Peruvian anchovy (*Engraulis ringens*) are the most important species given their use for fish meal and oil production.

General data gaps and further analyses

- At this point of the analysis our main focus has been in gathering and cleaning all the data. Up to now we now which information is available and we have been able to deliver preliminary results. However the next steps for this project is to improve our methodology in areas that we have identified pitfalls such as revising aduana code to include all salmon products in the exports, not include dry algae as product for human consumption and incorporate to our analysis the proportion of the each product that is consumed by humans.
- Even though we recognize that Chile has wide range and detailed information available, one of the main challenges have been able to match all sources of information at a species level. Several of the documents provided by the Chilean Customs are in .pdf format which has required carefully inspection for all the information but is prone to human error. We are trying to account for that by cross checking what we are doing.
- We are still lacking data that allow us to link specific fisheries with industrial employment and income. We are in conversations to get data on vessels crew and landing which would allow us to do that.

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