

INTRODUCTION TO THE ICCAT TUNA FACTORY PURCHASES DATA FLOW AND DATABASE

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SUMMARY

Tuna factory purchases constitute a complementary source of independent information in support of ICCAT tuna fisheries analyses. A total of 34 companies have been submitting purchases quarterly reports to ICCAT secretariat since 2010. Here, we present the ICCAT tuna factory purchases data flow and database, including the different steps of data harmonization, compilation and preliminary curation undertaken on the quarterly reports to improve the overall data quality and traceability to the original information source. Between 2015 and 2020, 53% of the total number of purchases records came from the Atlantic Ocean, and the rest from the Indian and Pacific Oceans. The Atlantic Ocean 2015-2020 reports revealed that purse-seine and pole-and-line represented the majority of the tuna factory records (45% and 50%, respectively). Moreover, around 75% of the Atlantic purchases data were harmonized into four species-specific commercial weight categories for the four major tuna species. Next project steps aim to finalize data compilation and curation for the entire 2010-2020 period, and conduct analyses including comparisons of the tuna factory purchases against the ICCAT fisheries statistics by species and gear.

RÉSUMÉ

Les achats des usines de thon constituent une source complémentaire d'informations indépendantes à l'appui des analyses des pêcheries de thonidés de l'ICCAT. Au total, 34 entreprises ont soumis des rapports trimestriels sur les achats au secrétariat de l'ICCAT depuis 2010. Nous présentons ici le flux de données et la base de données des achats des usines de thon de l'ICCAT, y compris les différentes étapes d'harmonisation, de compilation et de traitement préliminaire des données entreprises sur les rapports trimestriels afin d'améliorer la qualité globale des données et la traçabilité de la source d'information originale. Entre 2015 et 2020, 53% du nombre total de registres d'achats provenaient de l'océan Atlantique, et le reste des océans Indien et Pacifique. Les rapports 2015-2020 sur l'océan Atlantique ont révélé que la pêche à la senne et la pêche à la canne représentaient la majorité des registres des usines de thon (45% et 50%, respectivement). En outre, environ 75% des données sur les achats dans l'Atlantique ont été harmonisées en quatre catégories de poids commercial spécifiques aux quatre principales espèces de thonidés. Les prochaines étapes du projet visent à finaliser la compilation et la conservation des données pour l'ensemble de la période 2010-2020, et à effectuer des analyses, notamment des comparaisons entre les achats des usines de thon et les statistiques des pêcheries de l'ICCAT par espèce et par engin.

RESUMEN

Las compras de las fábricas de atún constituyen una fuente complementaria de información independiente en apoyo de los análisis de las pesquerías de túnidos de ICCAT. Un total de 34 empresas han presentado informes trimestrales de compras a la Secretaría de ICCAT desde 2010. En este documento se presenta el flujo de datos y la base de datos de ICCAT en lo que concierne a las compras de las fábricas de atún, lo que incluye los diferentes pasos de armonización, compilación, tratamiento preliminar de datos llevados a cabo en relación con los informes trimestrales para mejorar la calidad general de los datos y la trazabilidad hasta la fuente de información original. Entre 2015 y 2020, el 53 % del total de registros de compras

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procedió del océano Atlántico, y el resto de los océanos Índico y Pacífico. Los informes del océano Atlántico 2015-2020 revelaron que las pesquerías de cerco y la pesquería de caña y liña respondían de la mayor parte de los registros de las fábricas de atún (45 % y 50 %, respectivamente). Además, alrededor del 75 % de los datos de las compras del Atlántico se armonizaron en cuatro categorías de peso comercial específicas para las cuatro especies principales de túnidos. Los próximos pasos del proyecto consisten en finalizar la recopilación y tratamiento de datos para todo el periodo 2010-2020, y realizar análisis que incluyan comparaciones de las compras de las fábricas de atún con las estadísticas de pesca de ICCAT por especies y artes.

KEYWORDS

Tuna fisheries, Commercial fishing, Fishery industry, Fish products, Trade, Data collections, Size composition

1. Introduction

The estimation of the species composition of tuna catch is required to provide accurate species-specific data to the ICCAT Secretariat for SCRS analysis in accordance with ICCAT Commission fishery data. In the Atlantic Ocean, the catch composition for most tuna fisheries, and in particular for tropical tuna species, is derived from tuna size samples collected during unloading operations, and possibly during the fishing activity by onboard observers, and used within a processing procedure that has been recently challenged (Fonteneau et al., 2017; Herrera and Báez, 2018).

Data from tuna factory purchases are thought to provide a useful ancillary source of independent information to compare and validate the species and catch size category composition breakdowns by fleet, as these data are retrieved from vessels' logbooks and landings as well as from tuna size samples. Hence, the assessment of tuna factory purchases data as a potential validation tool for purse-seine catch data has been initiated in the Western-Central Pacific Ocean (Lewis and Williams, 2016; Williams, 2020) and Indian Ocean (IOTC Secretariat, 2020), and recently, the use of tuna factory purchases data has been proposed as an integral component of the purse seine data processing (Báez et al., 2020).

Since 2010, the ICCAT Secretariat has been receiving tuna factory reports on a quarterly basis from ISSF-participating companies that source tuna caught in the Atlantic Ocean. For example, a quarterly report sent by the company during quarter 2 (between April and June) of a specific year is thought to gather all tuna purchases that occurred during quarter 1 (January-March) of the same year. The tuna factory reports include species-specific data in total weight and, in most cases, by commercial categories (e.g., 1.8-3.4kg, >10kg, etc.) collected by the company, as well as information on its origin, i.e., fishing and unloading operations (dates, gear, ocean where the fish was caught, fishing and carrier vessel's name identification, unloading location, etc.). Overall, the data structure and contents of the quarterly reports vary greatly between submitting companies and years, with several data reports that appear to suffer from a generalized lack of standardization and quality control at the source, resulting in frequent inconsistencies or incomplete data (e.g., lack of mandatory information on fishing and/or unloading operations, different date formats which are used often incomplete, etc.).

To overcome these issues encountered by ICCAT and other tuna Regional Fisheries Management Organizations (tRFMOs) receiving ISSF-participating companies' tuna factory reports, different data management tools were developed (IOTC Secretariat, 2020). First, a new uniform submission template required by ISSF since 2019, generally improved the harmonization of the structure and contents of the ISSF-participating companies' quarterly reports submitted between mid-2019 and mid-2021. Second, an interactive electronic tool was developed by the IOTC Secretariat in 2020 to help harmonizing the tuna factory quarterly reports. Starting from a generalized data model of the expected information, the tool allows end-users to import original data submissions and format their content (one file at a time) to produce reports with standardized data fields and code lists. Third, a relational database (PostgreSQL) was designed to improve data quality and reusability.

In such a context, an ICCAT project was set up in March 2021 with the overall objective of assessing the use of tuna factory purchases as a complementary data source, both in terms of volume and the breakdown of catch/purchases by species, in support of ICCAT tuna fisheries analyses. This novel data source is aimed to be used by SCRS routinely for future assessment and for reducing uncertainties in the currently available statistical

data. The project is composed of three main components: (i) component 1 aims to harmonize and compile all tuna factory quarterly reports submitted by the ISSF-participating companies during 2010-2021; (ii) component 2 aims to upload harmonized reports into a relational tuna factory purchases database and proceed to further data curation so as to improve the overall data quality and traceability to the original information source; and finally (iii) component 3 aims to compare the species and size/weight composition available from the tuna factory purchases with the annual catch data reported to the ICCAT secretariat for each fishing gear.

Here, we present the preliminary results of the components 1 and 2 of the project. Focusing on the quarterly reports submitted during 2016-2021 (i.e., corresponding to purchases data for 2015-2020), we first summarize the steps required for the harmonization and compilation of the ISSF-participating companies' tuna factory quarterly reports, and present the model of the relational database. We then provide a description of the tuna factory purchases data and related metadata available at the ICCAT secretariat for the study period 2015-2020. Finally, we present the next steps, in terms of data curation, that will be undertaken as part of the ICCAT tuna factory data project, and we propose potential improvements in the data submission and processing with the aim to facilitate the work for all stakeholders and ensuring a better quality, traceability, and reusability of the tuna factory purchases data.

2. Harmonization and compilation of the quarterly reports into a relational database for tuna factory purchases

A total of 1,694 quarterly reports from 34 ISSF-participating companies were submitted to ICCAT during the study period, including 402 emails and 1,292 data files (using either .xls, .xlsx, or .xml formats).

First, a review of the ISSF-participating companies' metadata collated from the title and/or content of the emails and data files, allowed for the identification of reports duplicates. In that case, the more recent report was selected for further processing while the other reports were archived (and subsequently, not processed).

The remaining (i.e., non-archived) reports were then harmonized with the IOTC electronic tool, so that the variables were organized into tables based on their functional dependencies to fit the relational database model and provide results in reports ready to be analyzed (**Figure 1**) (IOTC Secretariat, 2020). For that purpose, each quarterly report was uploaded into the IOTC software where each column (i.e., variable) of the report was first re-defined according to standards (e.g., location, country, gear and species standardized with FAO codes and names), and then re-structured following tidy framework (each observation a row, each column a variable, each table a type of observational unit) (Wickham, 2014). The IOTC tool also allows to identify, correct and track obvious entry data errors and inconsistencies. A configuration file is thus created for each quarterly report, and the configuration files together with the submitted quarterly reports are finally uploaded into a PostgreSQL relational database composed of 13 tables (**Annex 1**).

As a result, a total of 533 reports (i.e., 42% of the total quarterly reports submitted for the study period) were successfully harmonized and compiled into the database; the rest of the quarterly reports ($n = 744$; 58%) were archived because purchases data was missing from the report or the entire report was duplicated. Among the successfully harmonized quarterly reports, 86% ($n = 461$) were processed directly and 14% ($n = 72$) required correction of the original data files before further processing. Three main types of corrections were made to fit the minimum data requirement and structure of the software: (i) correction of date format (54%); (ii) modification of sheet format (unmerged cells; 28%); (iii) other (e.g., separation of purchases data according to, for example, product type or type of unloading; 18%).

3. Description of the raw content of the tuna factory purchases database for the study period 2015-2020

The number of ISSF-participating companies providing tuna factory quarterly reports to ICCAT increased from 10 in 2015 to 23 in 2019 (**Figure 2A**). The number of successfully harmonized quarterly reports increased from 19 in 2015 to 125 in 2017-2018, and decreased to 84 in 2020 (**Figure 2B**). This resulted in a total of 68,120 raw tuna factory purchases records uploaded into the database. It includes duplicate records, i.e., records that have been repeated in several distinct quarterly reports together with non-duplicate records. The curation of the tuna factory purchases database will ensure the removal of these duplicates as well as other data quality improvements (see section 4).

Over the study period, 88% of the total number of quarterly reports to ICCAT, i.e., 53% of the total number of raw tuna factory purchases records ($n = 36,366$), came from the Atlantic Ocean, and the rest concerned other tRFMOs (IOTC, IATTC and WCPFC) (**Figure 2B**).

The analysis of the Atlantic Ocean quarterly reports revealed that 22%, 10% and 27% of the total number of reports for the 2015-2020 period came from purse-seine, longline and pole-and-line purchases, respectively, and 38% from a mix of gears (i.e., purse-seine, longline, pole-and-line, handline and troll line) (**Figure 3A**). With regards to the number of records, purse-seine and pole-and-line represented the majority of the tuna factory purchases (45% and 50%, respectively), followed by longline (4%), and handline and troll line ($< 1\%$) (**Figure 3B**).

Although the information on the type of product was missing from the reports and records (68% and 59%, respectively) for a majority of the tuna factory quarterly reports, the remaining ones included whole round tuna (25% and 40%) or tuna loins (4% and 1%) purchases (**Figure 4**). Similar information on the product was derived from the reports and records showing that, when provided, this information was accurately recorded.

Overall, the ICCAT related tuna factory purchases were dominated by skipjack tuna (49% of the total number of records), followed by yellowfin tuna (24%), bigeye tuna (14%) and albacore tuna (8%) (**Figure 5A**). The analysis per gear type revealed the dominance of albacore tuna purchases (76%) followed by other species (18%) for longline, skipjack tuna purchases (62%) followed by yellowfin tuna (15%) for pole-and-line, and a mix of skipjack (38%), yellowfin (37%) and bigeye (22%) tuna purchases for purse-seine vessels (**Figure 5B-D**).

Most of the tuna purchases data were given by commercial weight categories, although a large number of different categories and purchase units were used by the companies, as well as within the same company (i.e., for a given company, purchase and commercial weight category units may differ between the quarterly reports and within a unique quarterly report making even more challenging the harmonization and curation of the data). Most of the submitted tuna purchases were successfully harmonized into four species-specific commercial weight categories for the major tuna species (i.e., 78% of the total skipjack tuna records, 82% of the total yellowfin tuna records, 76% of the total bigeye tuna records and 68% of the total albacore tuna records); the rest was grouped as *other* when only total weight was available or when the weight category used by the company was not exploitable (e.g., the range of the weight category was too large such as $<10\text{kg}$ for yellowfin and bigeye tunas) (**Table 1**). **Figure 6** shows the composition of the tuna factory purchases for the main gears that caught bigeye, yellowfin, skipjack and albacore tuna in the Atlantic Ocean during the study period 2015-2020.

4. Next steps: curation of the tuna factory purchases database and connection with other tuna fisheries data sources

The final clean-up of the tuna factory database is essential to ensure good data quality before any further data analysis and will constitute the next step of component 2 of the project. Data curation will include automatic data standardization and compilation, and identification/suppression of the duplicate data that could not be identified and corrected with the IOTC tool. Finally, data from the tuna factory database will be connected with other tuna fisheries data sources for scientists to undertake required data analysis (component 3).

5. Recommendations for the improvement of the quality and management of the tuna factory purchases data

Here we present potential recommendations at different steps of the data management process aimed to improve the quality, traceability and reusability of the tuna factory purchases and facilitate future work from the multiple stakeholders.

5.1 Submission of the quarterly reports

The 2019 submission template for tuna factory purchases generally improved the harmonization of the structure and contents of the ISSF-participating companies' quarterly reports. However, issues remain with the quality of the data (e.g., date intervals are wrong or overlap with each other, fishing vessel and carrier information is wrong or incomplete), and additional information would be required to fit the management database requirements and maximize the quantity of information to be usable for data analysis. **Table 2** lists some recommendations proposed for the improvement of the submitted quarterly reports.

5.2 A database for the ISSF-participating companies

The increasing number of ISSF-participating companies submitting purchase information and contributing to the tuna factory database and the complexity and regular change of the companies' affiliation challenges the traceability of the submitted quarterly reports and data. A company database was created including information on the name, acronym and location of the factory and of the ownership company(ies). The company database will have to be regularly updated in collaboration with the companies and could also be completed with additional information (e.g., main processing activities in terms of product and species of interest). Moreover, an estimation of the coverage of the ISSF-participating companies compared to the total number of tuna processing companies operating in the Atlantic Ocean would inform on the limits of the tuna factory purchases database and allow to apply appropriate correction and analysis. In the Pacific Ocean, ISSF-participating companies' tuna factory purchases represented on average ~37% of the tropical WCPFC purse seine catch in recent years (Williams, 2020), and it was recommended to encourage the voluntary participation of non-ISSF-participating companies to the factory purchases data flow (Lewis, 2017; Williams, 2020). Finally, it is proposed to strengthen the collaboration and communication with participating tuna companies, for instance through annual summary reports providing an overview of the quantity and quality of the submitted quarterly data and metadata reports.

6. Conclusion

The provision of scientific management advice has been recently challenged with regards to the quality of the data currently used by tRFMOs for stock assessments. The use of complementary independent data sources, such as the tuna factory purchases already collected by the companies, would strengthen data confidence and improve tuna data analysis.

With the collaboration of the ISSF-participating companies, a large data set of more than 60,000 tuna purchases records for the 2015-2020 period, was reviewed, organized, harmonized, compiled and stored into a specifically-designed tuna factory database. Being routinely collected by the companies as part of their trading operations, tuna purchases data constitute undoubtedly a unique and essential source of complementary information for tuna fisheries stock assessment and management. The present study however highlighted the crucial step of transforming the raw data into standardized curated tuna factory purchases data before further analysis. During the next months, the project will complete the harmonization and compilation of the tuna purchases for 2010-2015, finalize the curation of the tuna factory purchases database, and proceed with the exploratory analyses work which includes preliminary comparisons of the tuna purchases against the ICCAT fisheries statistics by species and gear, both at a global level (total catches) and disaggregated level (e.g., weight commercial categories vs biological size sampling and/or catch-at-size).

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Table 1. Number of records for the ICCAT area per species and commercial weight categories.

Species	Category	Number of records	% of the total number of records
BET	<1.8kg	391	7
	>9kg	1,965	38
	1.8-3.4kg	685	13
	3.4-9kg	946	18
	other	1,235	24
YFT	<1.8kg	1,041	12
	>9kg	3,300	37
	1.8-3.4kg	1,212	14
	3.4-9kg	1,647	19
	other	1,627	18
SKJ	<1.4kg	2,908	16
	>3.4kg	676	4
	1.4-1.8kg	4,695	27
	1.8-3.4kg	5,531	31
	other	3,894	22
ALB	<4kg	10	0
	>10kg	1,233	42
	4-7kg	382	13
	7-10kg	385	13
	other	916	31

Table 2. List of recommendations proposed to improve ISSF-participating company submission reports.

Recommendation	Description of the recommendation
Design a submission template for metadata	A submission template for the metadata should be designed, and the company should submit both the metadata and data quarterly reports. Also, a unique ID should be assigned to each company and factory to facilitate reports traceability. Metadata should include information on the company name, location and unique ID, email contact, RFMO of concern, year-quarter concerned by the report, type of unloading (Direct unloading vs Transshipment-unloading), product type as required by the management tools. The format of the metadata template must be designed to directly feed the data management tools
Standardize file names of the submitted data and metadata reports	The standardization of the name of the quarterly report submitted by the company would greatly facilitate the identification of the duplicate reports and the control of regular reporting. This can be achieved by defining for example an hierarchical file name nomenclature of type “[CompanyCode][Year][Quarter][{new, rev}][...]”.
Modify the format of the data submission template for dates	The separation and formatting (yyyy-mm-dd) of the start and end dates in the 2019 data submission template greatly limited the number of date format issues encountered during the data processing, however issues still remain mainly due to Excel date formatting options. The use of a validation rule on the dates could reduce date errors and ensure better data quality and traceability. Also, the use of separate columns for Day, Month and Year for each reported date in addition to the international standard for dates (yyyy-mm-dd) could constitute an additional data verification.
Modify the format of the data submission template for vessel information numbers	The use of tidy data for the unique vessel identifier -UVI- (i.e., one column for the UVI type and one column for the UVI value) restrains the company to provide only one identifier while several may be available. The data submission report should include at least three separate columns for IMO, IRCS and other registration numbers as a maximum information is highly recommended to ensure cross-checking of the vessel information
Include essential additional information to be recorded into the data submission report	Add information on the factory that processed catch (name and location - city/country) as the quarterly report may contain catch/purchases data from more than one location (several factories for one company) Add information on the type of product as required for the normalization and comparison of purchases data with fishing data (round fish) Add information on purchases data unit to avoid errors, especially in the case of data quarterly reports that may contain purchases data with different units within a same report
Separate data submission templates for each type of unloading	Use two separate data submission templates for each type of unloading (Direct unloading vs Transshipment-unloading) to avoid data entry errors and confusion for the data curator
Modify the format of the data submission template for purchases data	The 2019 data submission template imposes the type of species and commercial weight categories to be reported by the company. Purchases data for other species are thus lost while they were provided by several companies prior to 2019. The information may be of interest for future data analysis and could be added into the data submission template Information on fishing mode (FAD/FREE) and catch certification (MSC) was provided by some companies prior to the 2019 data submission template. This information may be of interest for future data analysis and could be added into the data submission template
Define a formal workflow for the submission of corrections and updates	Currently, companies might re-submit data for factories and / or periods of times that were already submitted in the past, to account for corrections or updates. As there’s no clear indication of whether an update should be <i>partial</i> (i.e. include only records that have been updated) or <i>complete</i> , as well as how to deal with the request of <i>removing</i> records that were submitted by mistake in the past, a data submission workflow should be defined (by ISSF, with support from the t-RFMOs and / or the companies) in order to streamline the process of providing data updates in the future.

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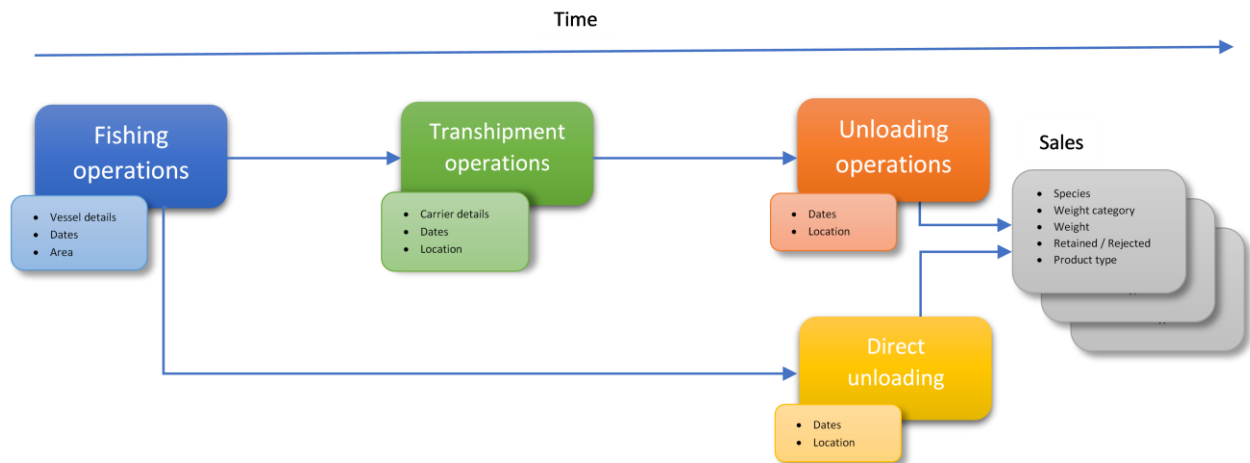


Figure 1. Overview of the tuna purchases data structure and timeline of its collection and reporting workflow.

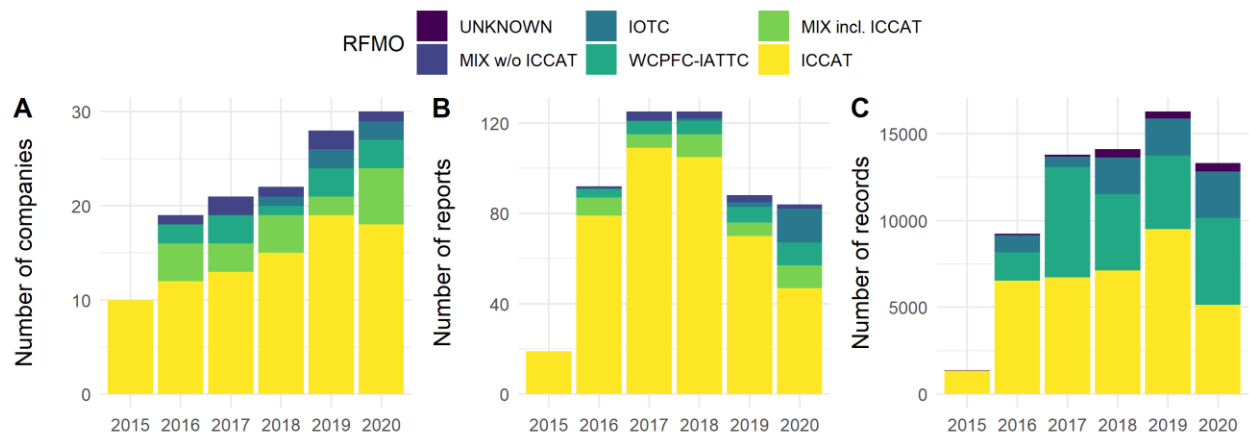


Figure 2. Number of ISSF-participating companies that provided data to the ICCAT secretariat (A), number of reports received and successfully processed (B), and derived number of raw tuna factory records (C), per year and per tRFMO area (i.e., where the fish was caught) during the study period (2015-2020).

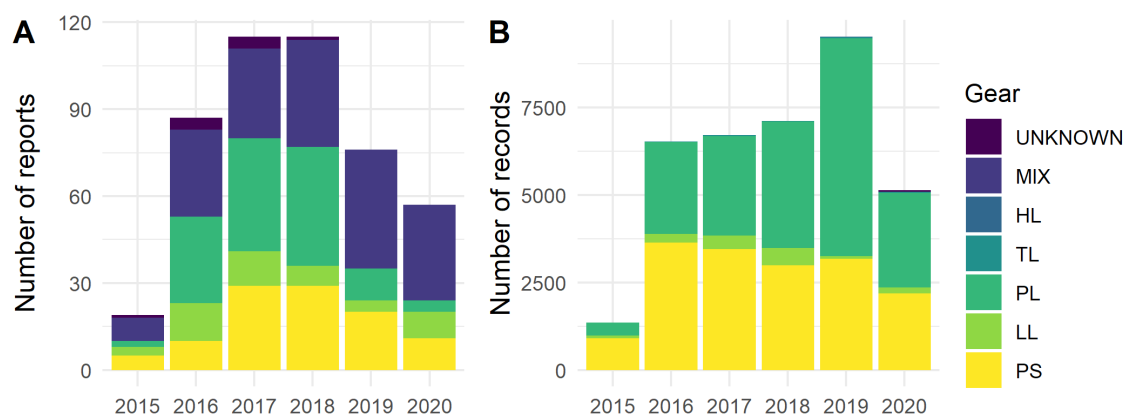


Figure 3. Number of processed reports (A) and derived number of raw tuna factory records (B) for the ICCAT area per year and per type of fishing gear during the study period (2015-2020). LL: Longline; PL: Pole-and-line; PS: purse-seine; HL: Handline; TL: Troll line.

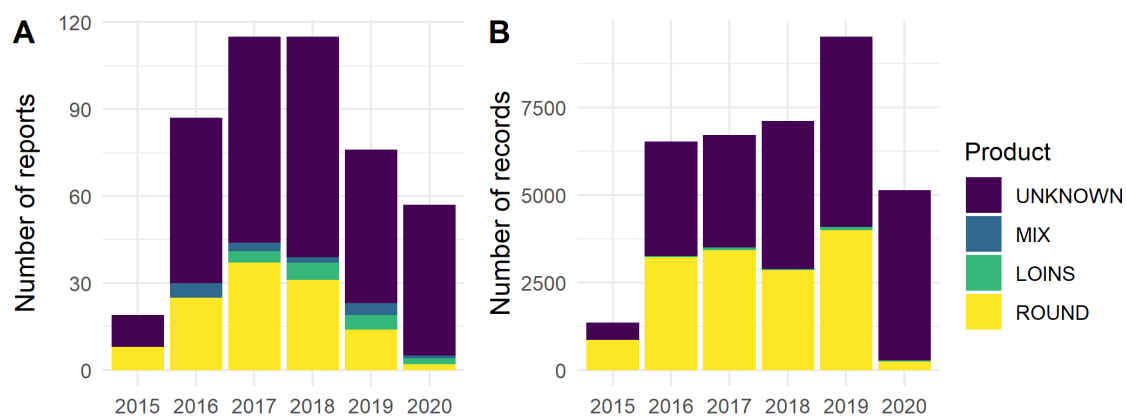


Figure 4. Number of processed reports (A) and derived number of raw tuna factory records (B) for the ICCAT area per year and per type of product (loins, round, mix -loins and round-, and unknown) during the study period (2015-2020).

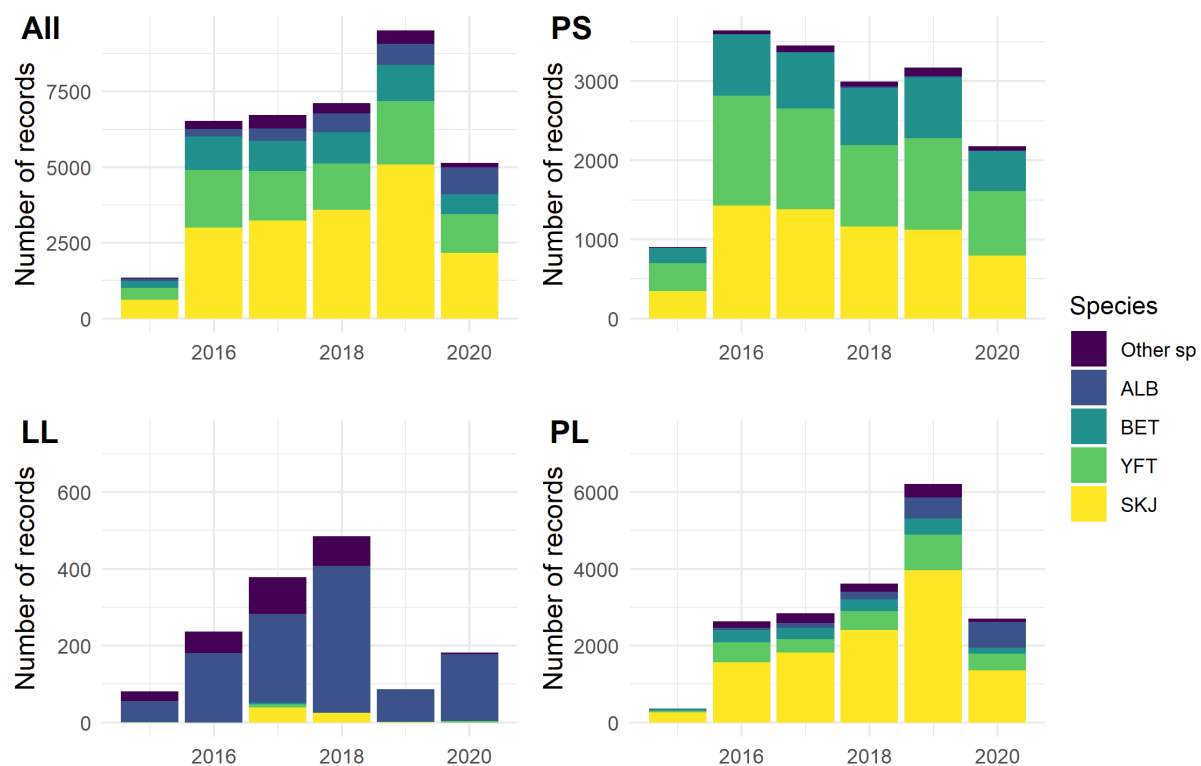


Figure 5. Number of raw tuna factory records for ICCAT area per year and per species during the study period (2015-2020). SKJ: skipjack tuna; YFT: yellowfin tuna; BET: bigeye tuna; ALB: albacore tuna; Other sp: includes frigate tuna, Atlantic bonito and other unknown species.

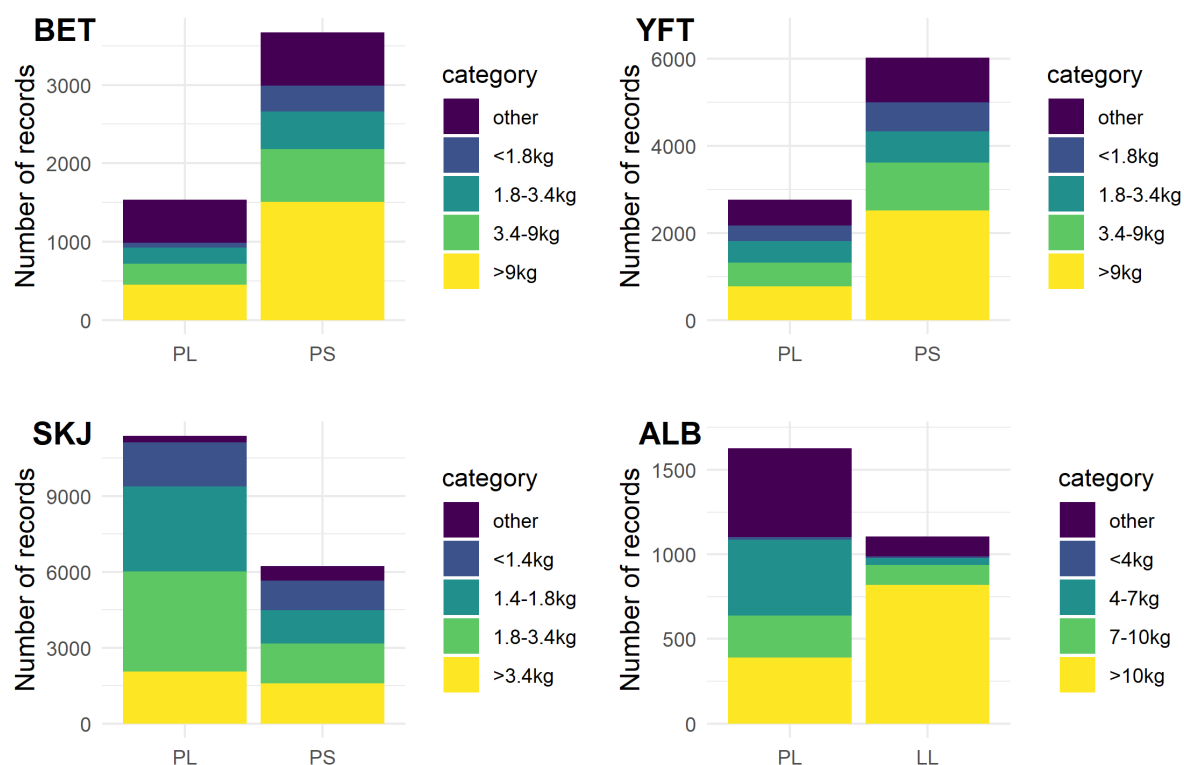
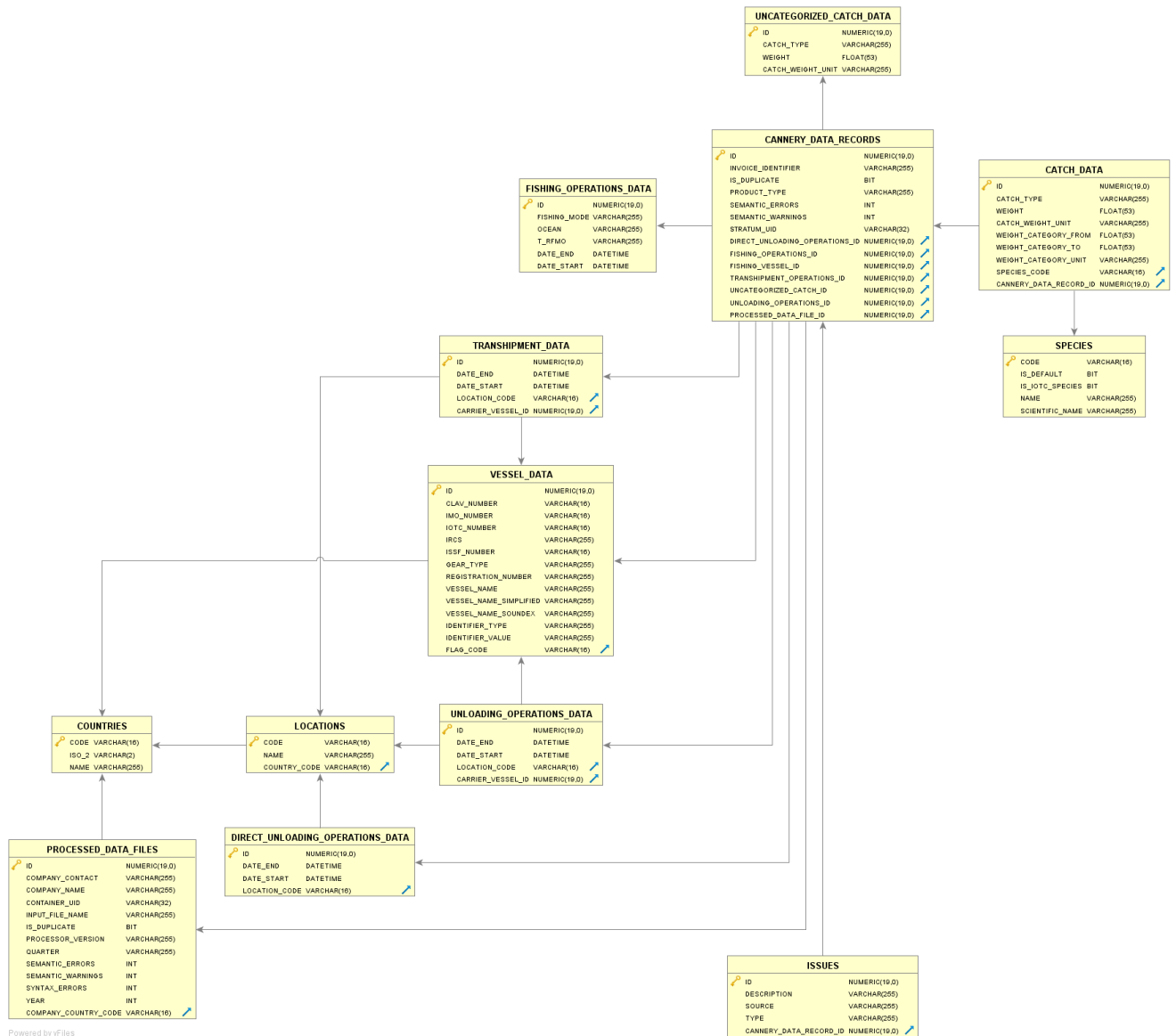


Figure 6. Number of raw factory records for the ICCAT area per species, fishing gear and weight categories during the study period (2015-2020). We represented records for bigeye (BET), yellowfin (YFT), skipjack (SKJ) and albacore (ALB) tuna only, and for the fishing gears that caught most of the fish processed by the companies (purse-seine, PS; pole-and-line, PL; longline, LL). Commercial weight categories were standardized into four categories (kg) for each species. “other” corresponds to records where only total weight was available or where the weight category used by the company was not exploitable.

Relational model of the tuna factory purchases database



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