The yearly updates of the Global Tuna Atlas and the necessity to share conversion factors datasets

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Abstract

In this paper, we present a brief overview of the current work that has been undertaken for a few years to build the FIRMS Global Tuna Atlas (GTA) which requires compliant conversion factors for the conversion of catch from numbers to weights. Indeed, the GTA aims to provide georeferenced data of captures and efforts for tuna and tuna-like species. The actual dataset for catches contains two units: Tons and Number of fish, with some data redundant because provided in both units. This dataset is not as workable as would be a dataset where units are harmonized. Thus, the next step will be to convert the data provided in number of fish to tons, with an accurate and validated dataset. This treatment is already done by IRD using a historical dataset but the resulting data will not be validated by FIRMS without further confirmation on the treatment done. This paper aims to inform about the necessity of a validated conversion factors dataset. It also aims to ask IOTC and, in a second step, other tRFMOs, for collaboration on this topic. We first discuss the current conversion factors provided by tuna Regional Fisheries Management Organisations (e.g., IOTC) and by the French Institute of research for development (IRD). Eventually, we present a plan to validate conversion factors for scientific purposes.

Keywords

Conversion Factors; Data validation; Data discovery; Data access; Fisheries; CWP; FIRMS; Fishing catch; Fishing effort

1 Introduction

The availability of harmonized catch and effort data at a global scale is instrumental to supporting applied and academic research related to tuna fisheries due to the global dimension of fishing fleets and markets (Miyake et al. (2010); Worm & Tittensor (2011); Pons et al. (2017)).

The GTA focuses on this topic and aims to create a harmonized dataset of all captures of tunas and tuna-like species from all oceans. One of the key steps of the data processing includes the conversion of georeferenced catches reported in numbers into weights for further aggregation with georeferenced catches reported in weights and raising to the total catches which are only provided in weights. For this purpose, we use conversion factors provided by tuna Regional Fisheries Management Organizations (tRFMOs) and, if not existing, we use a historical dataset used for the development of atlases of tuna fisheries in the Atlantic and Indian Oceans (Fonteneau (2009), Fonteneau (2010)).

The 2022 release of the Global Tuna Atlas (GTA) aims to include a “Level 1” dataset which corresponds to the georeferenced catch data only in “metric tons”. Details on conversion factors and on their impact on the raising will be provided in the metadata of the GTA.

However, datasets used to convert catches from numbers to weight present issues and the need for validated conversion factors is important to provide the most qualitative final dataset.

First, we will describe the issues faced with the actual conversion factors used for converting catches from number to weight. Then, in a second time, we will present the current treatment done on the GTA and

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the repercussion of these conversion factors on the final data provided. Eventually, we will present the plan to validate conversion factors to be used for scientific purposes.

2 Materials and Methods

The conversion factors datasets to make the analysis are from multiple sources:

- Calculated from data of captures when displayed in Tons and Number of fish by tRFMOs (IOTC, IATTC, ICCAT, WCPFC). This data set is first treated following the Global Tuna Atlas process of mapping, then conversion factors are deducted from the harmonized data. These conversion factors are assimilated to an average weight for the recorded capture. This dataset will be named **tRFMOs conversion factors** in the rest of the document.
- Historically provided by Alain Fonteneau while working with tRFMOs. It is currently used by IRD in the GTA raising process and was historically the only one used. This dataset will be named **IRD conversion factors** in the rest of the document.
- Provided by the IOTC secretariat while discussing conversion factors. It is the only RFMO conversion factors dataset available for now. One of the points of this document regards the availability and use of this dataset as the demand to deliver it routinely. This dataset will be named **IOTC conversion factors** in the rest of the document.

Those three datasets do not contain the same information. Thus for the comparison the only data dimension kept will be:

- spatial resolution (by squares of 1 degree, 5 degrees, and more than 5 degrees)
- gear
- species
- time resolution (by month)

3 Analysis and comparison of conversion factors

3.1 The conversion factors provided by tRFMOs:

3.1.1 Main characteristics of the dataset

The data provided by tRFMOs can be in several units which become (after mapping):

- Metric Tons (MT)
- Number of Fish (NO)
- NOMT (Number of fish having equivalent data related provided in metric tons)
- MTNO (Metric tons having equivalent data related provided in metric tons)

These units have a different weight in occurrences in the complete declaration: table 1. Indeed, around 18.7 % of the total catches are redundant i.e. declared in number of fish and in metric tons. This represents 17.93 % of data in tons and 72.76 % of data in number of fish.

However, by providing data in tons and numbers, tRFMOs provide conversion factors for some species listed in table 4. This dataset is not used as conversion factors in GTA, the redundant catch in NOMT corresponding to a catch in MTNO is for now removed, data in MTNO is transformed in MT.

Species having conversion factors provided by the 4 tRFMOs (without CCSBT which does not provide conversion factors) have the following species code : ALB, BET, BLM, BUM, MLS, SWO, UNK, YFT.

Table 1: Recap of number of rows for each unit for initial GTA data

unit	**Number of row**
MT	1,775,031
NO	1,073,491
NOMT	852,015
MTNO	851,053

However, some of the data provided in NOMT or MTNO do not have the equivalent captures in the other unit. This represents 0.13 % of the declaration in NOMT and 0.02 % of the declaration in N0MT. These issued data are only declared by ICCAT and do not create an actual problem in quality. Nevertheless, it could be useful to get the complete data if existing.

3.1.2 Issues in quality of tRFMOs conversion factors

For the following, we will focus on major tuna species i.e. Albacore (*Thunnus alalunga*; ALB), bigeye tuna (*Thunnus obesus*; BET), Atlantic bluefin tuna (*Thunnus thynnus*; BFT), skipjack tuna (*Katsuwonus pelamis*; SKJ), and yellowfin Tuna (*Thunnus albacares*; YFT). CCSBT does not provide data in both units for Southern Bluefin Tuna, thus it is not part of the following analysis.

A total of 850,892 values of conversion factors are deducted from the data provided, corresponding to combinations of species, gear, fishing fleet, statistical square, and time (in month-year). Among them, 0.25 % (i.e., 872 occurrences) were found to be higher than the maximal weight recorded for the species concerned (Collette & Nauen (1983), Claro (1994), IGFA (2001), Anonymous (1994), Frimodt (1995)), Froese & 2000. (table 2). This represents 12,497.18 tons of fish.

Table 2: Maximum recorded captures for the specie

species	**Maximum recorded weight (kg)**
ALB	60.3
BET	210.0
BFT	684.0
SKJ	34.5
YFT	200.0

Most of these inconsistent conversion factors are provided by ICCAT (figure 1), 32% result of IOTC declaration (i.e. 276). These conversion factors concern mainly Skipjack, Bigeye tuna, and yellowfin (figure 2).

The two other datasets do not contain conversion factors higher than the maximum recorded weight for the species.

3.2 The conversion factors used by IRD

3.2.1 Main characteristics

In the workflow of GTA, IRD conversion factors dataset is used to convert catches data from number of fish tons. This dataset provides data for 12 species out of the 43 present in the data supplied by tRFMOs after global mapping (26 for IOTC).

3.2.2 Limits of the accuracy of this dataset: Comparison with tRFMOs dataset.

First, IRD conversion factors neither contain data for WCPFC captures nor for Skipjack in the Indian Ocean (figure 5).

In second time, the values of conversion factors derived from tRFMO data show long-tailed distributions compared to the ones used by IRD, mostly because tRFMO conversion factors are defined at finer spatio-temporal resolutions and thus more different from one to another (figure 4). Indeed, there are no differences in conversion factors between gears for a given triplet species, time, geographic_identifier (figure 3). Most of the variability remains in the time series evolution and the tRFMOs. Eventually, for a few years, data are duplicated from the last provided year which results in losing time variability.

3.2.3 Comparison with tRFMOs dataset in value

For the following analysis, conversion factors higher than the maximum recorded catches for the specie are removed from the tRFMOs dataset.

The median conversion factors are similar for BFT and close for the other species except for YFT (figure 4). For SKJ, the median used by IRD is slightly higher than the tRFMOs one, also still a lot of declarations are close to the maximum catch declared.

A Wilcoxon test ran on data for IOTC, ICCAT, and IATTC (when available) gives significant differences in conversion factors for each species (table 5). (The non-normality of distribution does not allow to perform t-test) (table 6).

Differences are significant for all species that can be compared (figure 6). However, a more accurate comparison would be to run an analysis adding the gear dimension, which is a variable having significant differences between levels.

A majority of the triplet presents differences between the two datasets (table 7). Thus, the coverage of these two datasets is similar but not the values (figure 7).

3.3 The conversion factors provided by IOTC

IOTC secretariat shared with IRD the conversion factors dataset (without fishingfleet dimension) that they use. This dataset does not match conversion factors provided in double unit declarations neither in dimension coverage nor in values.

3.3.1 Main characteristics

The dataset provides conversion factors for 5, which are Albacore, Bigeye, Skipjack, Yellowfin, and Swordfish Swordfish (*Xiphias gladius*; SWO).

The values of official conversion factors from IOCT data show long-tailed distributions compared to the ones used by IRD. The median conversion factors are higher except for ALB (figure 9). Reminder: IRD dataset does not contain conversion factors for Skipjack.

A Wilcoxon test comparing data for IOTC and IRD gives significant differences in conversion factors for each species available. (figure 9 and table 3)

Table 3: Results of the Wilcoxon test on conversion factors of IOTC and IRD, grouped by species and source authority

species	.y.	group1	group2	n1	n2	p.adj	p.adj.signif
ALB	conversion-factor	iotc	ird	225,683	1,428	0	****
BET	conversion-factor	iotc	ird	335,017	1,428	0	****
YFT	conversion-factor	iotc	ird	517,198	1,428	0	****

3.3.2 Comparison with IRD factors

For the unique couple gear/tRFMOs for which conversion factors are provided -IOTC for 09.32 (i.e. Drifting longlines)-, we cannot conclude on differences between all conversion factors (figure 9 & figure 10). The main result of this general comparison between all the dataset concern the dimension coverage of datasets. Indeed, IOTC conversion factors is covering a larger amount of strata in number of fish than other datasets (for major tunas).

4 Impact on data provided by Global Tuna Atlas

The current GTA workflow converts catches in number of fish to tons using the IRD conversion factors. However some test has been made with the dataset provided by IOTC and then, for the remaining data in number of fish, to raise with historical conversion factors. For the remaining fish, we could also use the tRFMOs conversion factors and create a mean for conversion factors for specific species/gear/geographical categories.

The raising with IRD's dataset is always lower than with the IOTC one (figure 11), for major tunas. Moreover, the amount of converted fish is also higher during IOTC conversion factors than in IRD.

The difference between the data raised with IOTC conversion factors and the data raised with IRD Fontenau conversion factors in GTA is about 0.92 million of tons.

Eventually, the amount of non-converted data from IOTC declaration is 22,406 fish if using IOTC conversion factors, 346,568 fish if using IRD conversion factors, and 16,024 fish if using IOTC and then IRD conversion factors. Meaning, all the data is still not completely converted using both datasets, the non converted data in GTA, for IOTC declarations, corresponds mainly to Skipjack declarations (figure 12). Eventually, these missing conversion factors mainly concern a period before the year 2000 (figure 13).

For the major tuna species, the IOTC conversion factors dataset is thus much more complete and even seems sufficient to convert the data, given the little number of catches still in number of fish after conversion. However, for the all-species included dataset, more than 10 million fish are not converted by IOTC conversion factors. Thus, for other species (mostly Southern Bluefin Tuna but also for 6 other species including Swordfish), and for data from other tRFMOs, the IRD conversion factors will be preferred (figure 14). This second raise end up with 1,613,429 fish remaining, which are therefore lost during the treatment.

On top of that, neither IRD nor IOTC dataset contains fishingfleet, which could have an impact on raising. Also, it is possible to convert catches in number of fish without these dimensions. However, keeping them could create inequalities of conversion and will result in creating catches in tons for fishingfleet, that they didn't declare. Having the support of IOTC for the analysis and presentation of conversion factors to FIRMS (Fisheries and Resources Monitoring System) partnership would aim for the harmonized dataset we want to provide. In addition, this will begin the collaboration with other tRFMOs on this same topic.

5 Conclusions and perspectives

Our preliminary work for defining conversion factors shows a large variability in the values derived from the data available from the RFMO declaration, including some outliers that appear inconsistent with the biology of the principal market tunas considered in the present analysis. Hence, these results could benefit tRFMOs by identifying inconsistencies in data submissions which could be further investigated with the members concerned. The other conversion factors datasets are both useful for converting data, however, the IOTC provided dataset covers better the stratas of major tunas. Thus, this dataset is probably to be included in GTA workflow and would be a great advance if provided routinely and, if available, with more species. The exact use of this dataset, especially fishingfleet handling is to be discussed.

The next step of the work is to define the best approach to elicit the conversion factors to be used, including some imputation methods when no information is available for some strata. The method developed by Fonteneau (Fonteneau (2009), Fonteneau (2010)) relies on the availability of size-frequency data sets and some large spatial strata that aim to account for the significant differences in the habitats of each tuna species. It is important to note that some size data reported to the IOTC Secretariat for the main industrial longline fisheries have been found to show major discrepancies between data sources, i.e., between logbooks (when numbers and weights are available) and size frequency (Geehan & Hoyle

(2013); Hoyle et al. (2021)). In the case of longline fisheries from Taiwan, China, the use of size data collected by observers at sea has been recommended as an alternative to the data collected by the crews since the early 2000s (Hoyle et al. (2021)). In this context, the methodology for estimating conversion factors requires properly addressing the potential issues of data coverage, for instance with statistical models that account for the variability of mean weights in time and space (Hoyle & Chambers (2015)). This will be particularly crucial for billfish, neritic tunas, and the main elasmobranch species for which little information is available on the size composition of the catches, in particular from coastal fisheries. As the GTA database allows storing different sets of conversion factors that can be used to generate the GTA data products through the processing procedure, the influence of each set of conversion factors could then be assessed through the sensitivity of indicators such as the average weight in the catch to the input data sets.

Another next step of the GTA will be to focus on fishing efforts which may be reported to the RFMO Secretariats in different units, hindering effort-based analyzes across long time scales and between oceans.

6 Acknowledgments

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Table 4: table of species concerned by double unit declarations

tRFMOs	Number of species	Species
IOTC	24	ALB, BET, BLM, BSH, BUM, COM, FAL, LOT, MLS, MSK, OCS, POR, RSK, SBF, SFA, SKH, SKJ, SPY, SSP, SWO, THR, TUX, UNK, YFT
ICCAT	20	ALB, BET, BFT, BIL, BLM, BON, BSH, BUM, FRI, LTA, SAI, SBF, SKJ, SMA, SPF, SWO, UNK, WHM, YFT, WAH
IATTC	23	ALB, BET, BIL, BLM, BSH, BUM, CCL, FAL, MAK, MLS, OCS, PBF, RSK, SFA, SKH, SKJ, SMA, SPN, SSP, SWO, THR, TUN, YFT
WCPFC	8	ALB, BET, BLM, BUM, MLS, SWO, UNK, YFT
Total	39	ALB, BET, BIL, BLM, BSH, BUM, CCL, FAL, MAK, MLS, OCS, PBF, RSK, SFA, SKH, SKJ, SMA, SPN, SSP, SWO, THR, TUN, YFT, BFT, BON, FRI, LTA, SAI, SBF, SPF, UNK, WHM, COM, LOT, MSK, POR, SPY, TUX, WAH

Table 5: Results of the Wilcoxon test on conversion factors of tRFMOs and IRD, grouped by species and source authority

source_authority	species	.y.	group1	group2	n1	n2	p.adj	p.adj.signif
IATTC	ALB	conversion_factor	rfmo	ird	1644	490	0.00000	****
ICCAT	ALB	conversion_factor	rfmo	ird	2320	1344	0.00000	****
IOTC	ALB	conversion_factor	rfmo	ird	2211	1428	0.00367	**
IATTC	BET	conversion_factor	rfmo	ird	1770	490	0.00000	****
ICCAT	BET	conversion_factor	rfmo	ird	1673	1344	0.00000	****
IOTC	BET	conversion_factor	rfmo	ird	2518	1428	0.00000	****
ICCAT	BFT	conversion_factor	rfmo	ird	1282	1344	0.00000	****
IATTC	SKJ	conversion_factor	rfmo	ird	1209	490	0.00000	****
ICCAT	SKJ	conversion_factor	rfmo	ird	146	1344	0.00000	****
IATTC	YFT	conversion_factor	rfmo	ird	1779	490	0.00000	****
ICCAT	YFT	conversion_factor	rfmo	ird	1491	1344	0.00000	****
IOTC	YFT	conversion_factor	rfmo	ird	2609	1428	0.00000	****

Table 6: Results of the shapiro test on data grouped by species and tRFMOs

source_authority	species	source	variable	statistic	p
IATTC	ALB	rfmo	conversion_factor	0.8882644	0
ICCAT	ALB	rfmo	conversion_factor	0.9568718	0
IOTC	ALB	rfmo	conversion_factor	0.9380946	0
IATTC	BET	rfmo	conversion_factor	0.9915501	0
ICCAT	BET	rfmo	conversion_factor	0.6815555	0
IOTC	BET	rfmo	conversion_factor	0.9360595	0
ICCAT	BFT	rfmo	conversion_factor	0.9234440	0
IATTC	SKJ	rfmo	conversion_factor	0.8245369	0
ICCAT	SKJ	rfmo	conversion_factor	0.8063679	0
IATTC	YFT	rfmo	conversion_factor	0.7802293	0
ICCAT	YFT	rfmo	conversion_factor	0.8380940	0
IOTC	YFT	rfmo	conversion_factor	0.8925577	0
IATTC	ALB	ird	conversion_factor	0.7514682	0
ICCAT	ALB	ird	conversion_factor	0.7620195	0
IOTC	ALB	ird	conversion_factor	0.9255347	0
IATTC	BET	ird	conversion_factor	0.7974625	0
ICCAT	BET	ird	conversion_factor	0.9734002	0
IOTC	BET	ird	conversion_factor	0.9266132	0
ICCAT	BFT	ird	conversion_factor	0.9144535	0
IATTC	SKJ	ird	conversion_factor	0.7703094	0
ICCAT	SKJ	ird	conversion_factor	0.2936157	0
IATTC	YFT	ird	conversion_factor	0.8508960	0
ICCAT	YFT	ird	conversion_factor	0.9547777	0
IOTC	YFT	ird	conversion_factor	0.9458194	0

Table 7: Conversion factors differences for existing triplet gear/tRFMOs/species between IRD and tRFMOs datasets

gear	source_authority	species	.y.	group1	group2	n1	n2	statistic	p	p.adj	p.adj.signi
09.39	IATTC	ALB	conversion_factor	rfmo	ird	1644	70	89333.0	0.0000000	0.0000000	****
09.39	ICCAT	ALB	conversion_factor	rfmo	ird	1482	192	142029.0	0.9690000	0.9690000	ns
09.5	ICCAT	ALB	conversion_factor	rfmo	ird	418	192	60.0	0.0000000	0.0000000	****
09.32	IOTC	ALB	conversion_factor	rfmo	ird	2083	204	211664.0	0.9290000	0.9690000	ns
09.39	IATTC	BET	conversion_factor	rfmo	ird	1770	70	45605.0	0.0001780	0.0002265	***
09.39	ICCAT	BET	conversion_factor	rfmo	ird	1653	192	106142.0	0.0000000	0.0000000	****
09.32	IOTC	BET	conversion_factor	rfmo	ird	2455	204	185823.0	0.0000000	0.0000000	****
09.39	ICCAT	BFT	conversion_factor	rfmo	ird	318	192	10344.0	0.0000000	0.0000000	****
09.5	ICCAT	BFT	conversion_factor	rfmo	ird	4	192	0.0	0.0005970	0.0006965	***
09.39	IATTC	SKJ	conversion_factor	rfmo	ird	1209	70	62452.0	0.0000000	0.0000000	****
09.39	ICCAT	SKJ	conversion_factor	rfmo	ird	124	192	8679.0	0.0000064	0.0000100	****
09.39	IATTC	YFT	conversion_factor	rfmo	ird	1779	70	43504.0	0.0000186	0.0000260	****
09.39	ICCAT	YFT	conversion_factor	rfmo	ird	1483	192	66414.5	0.0000000	0.0000000	****
09.32	IOTC	YFT	conversion_factor	rfmo	ird	2471	204	169723.5	0.0000000	0.0000000	****

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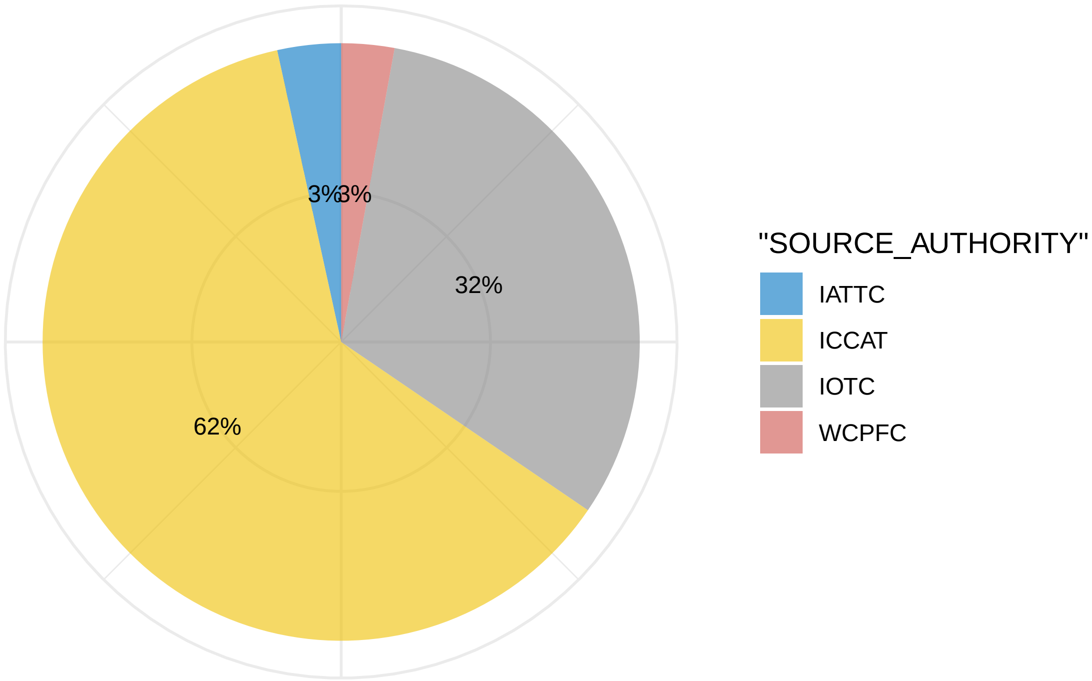


Figure 1: Repartition in source authority of declared data having conversion factor higher than the maximal recorded capture

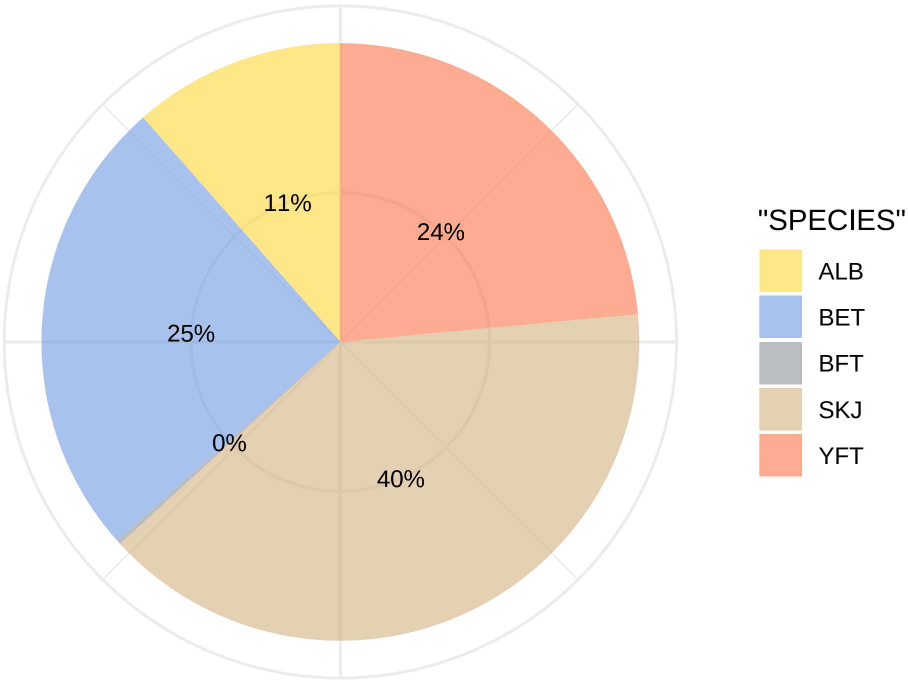
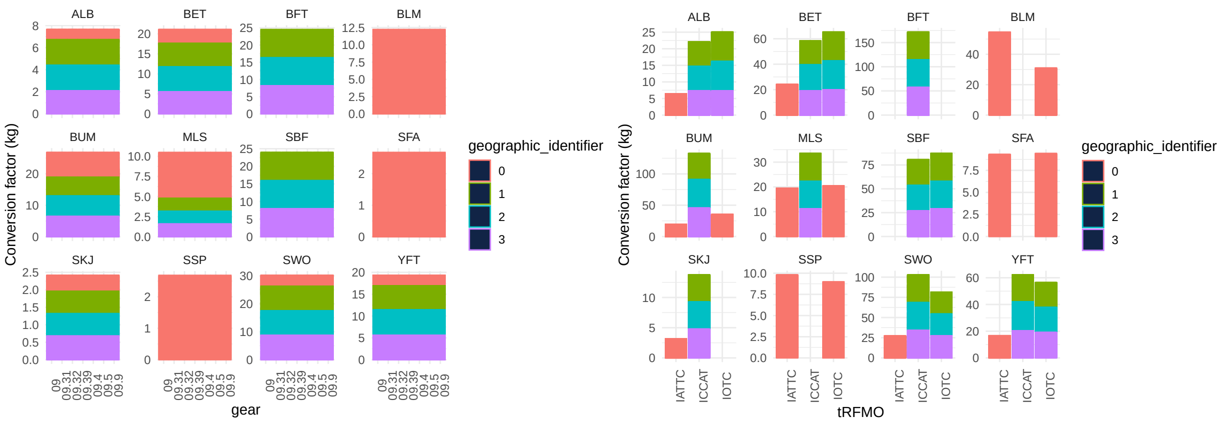


Figure 2: Repartition in species of declared data having conversion factor higher than the maximal recorded capture



(a) Unicity for same species, gear, geographic identifier

(b) Differences between tRFMOs levels

Figure 3: Barplot of IRD conversion factors grouped by several dimensions

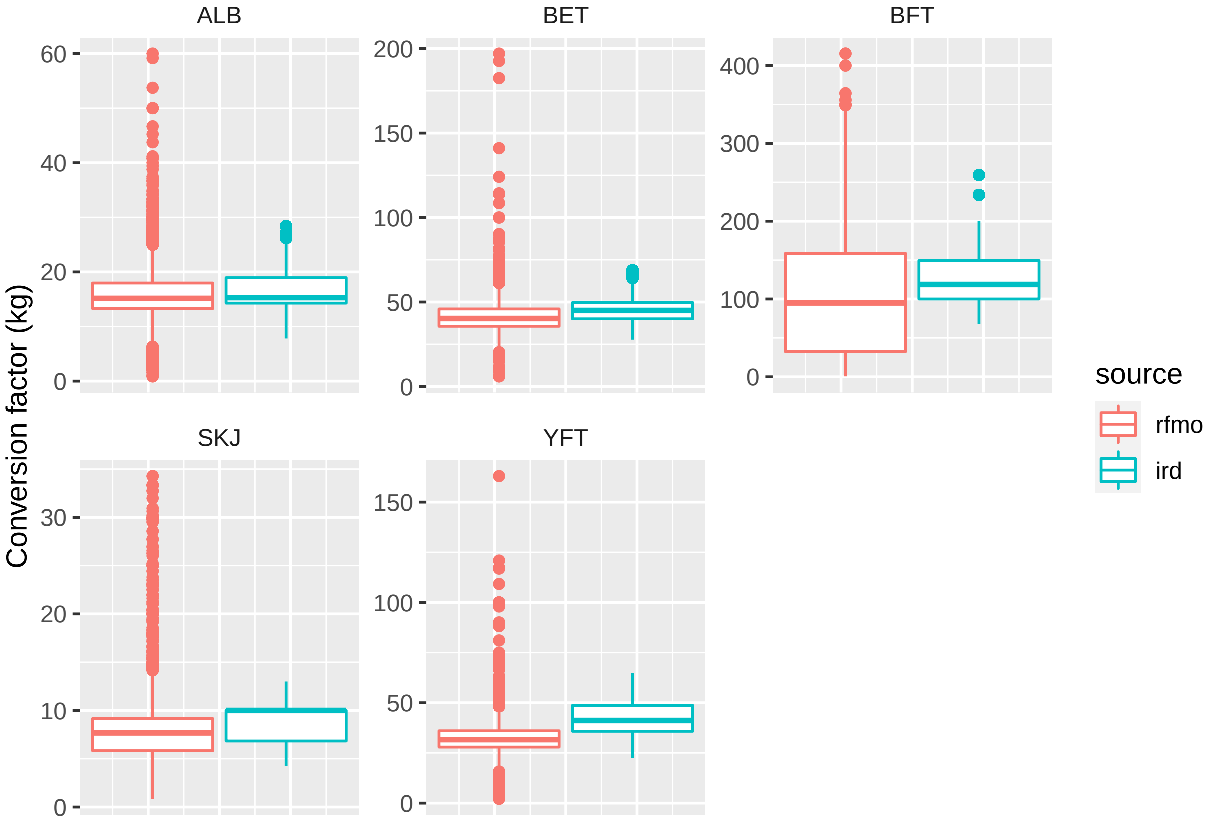
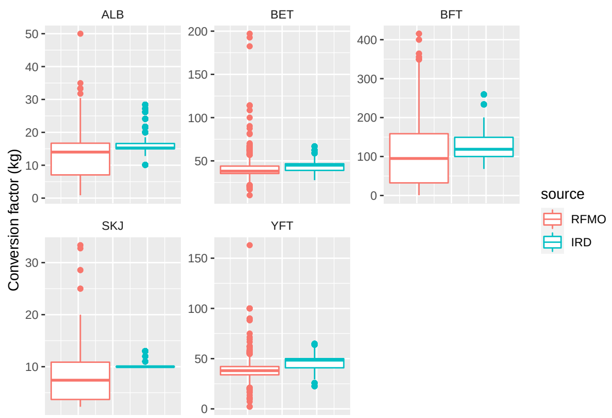
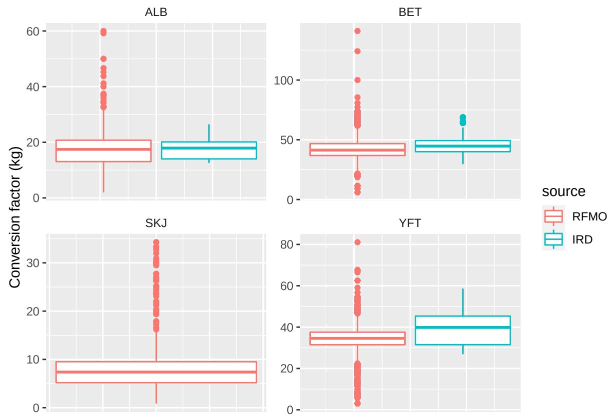


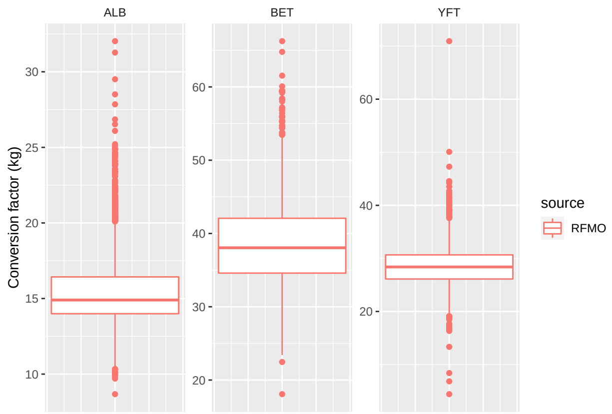
Figure 4: Comparison between plausible conversion factors provided by tRFMOs and IRD



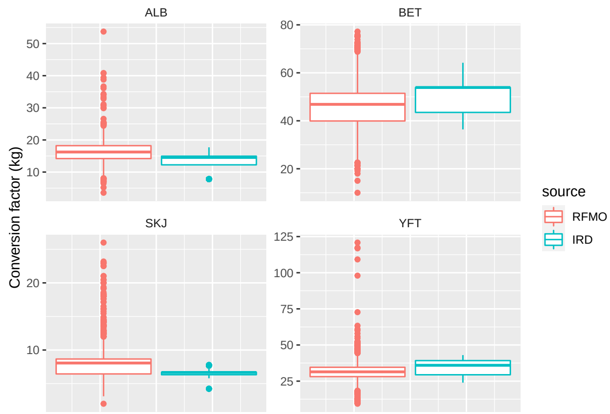
(a) ICCAT



(b) IOTC



(c) WCPFC



(d) IATTC

Figure 5: Comparison between plausible conversion factors provided by tRFMOs and IRD grouped by tRFMOs

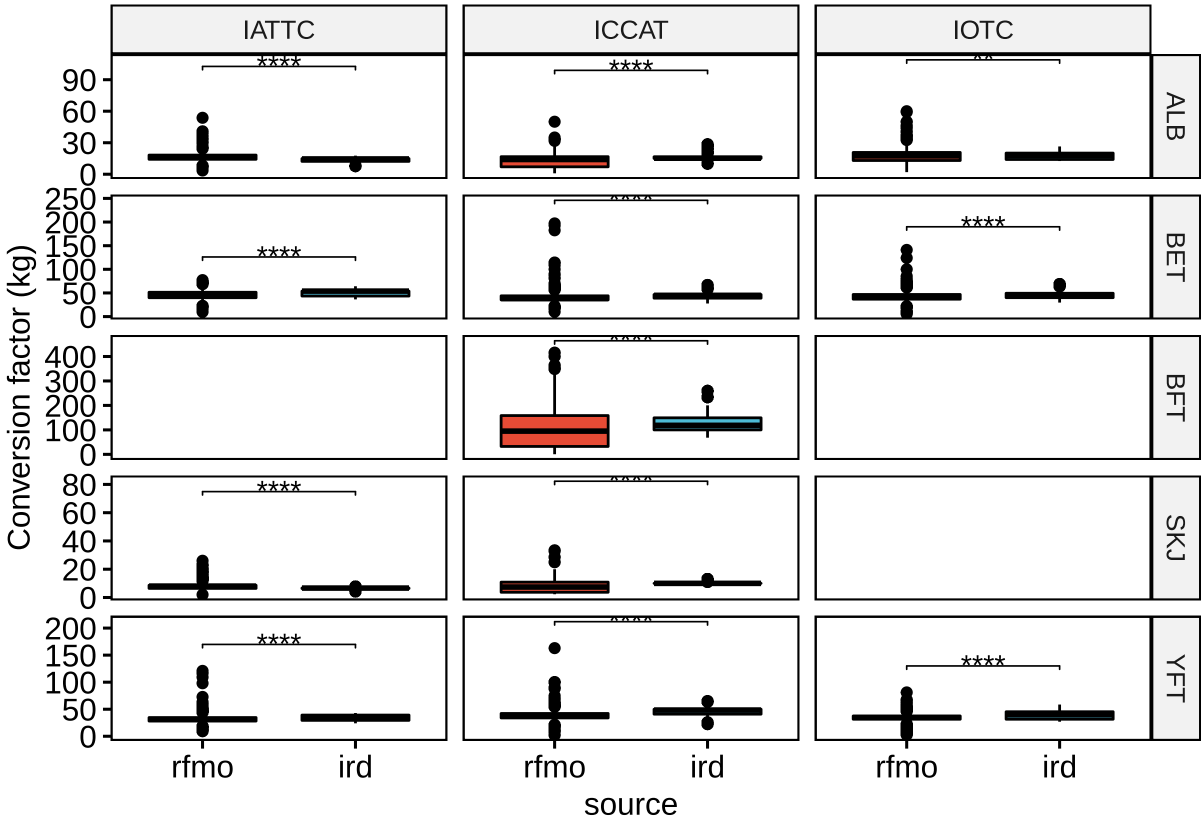


Figure 6: Boxplot and p-value of the Wilcoxon test comparison between conversion factors of tRFMOs and IRD

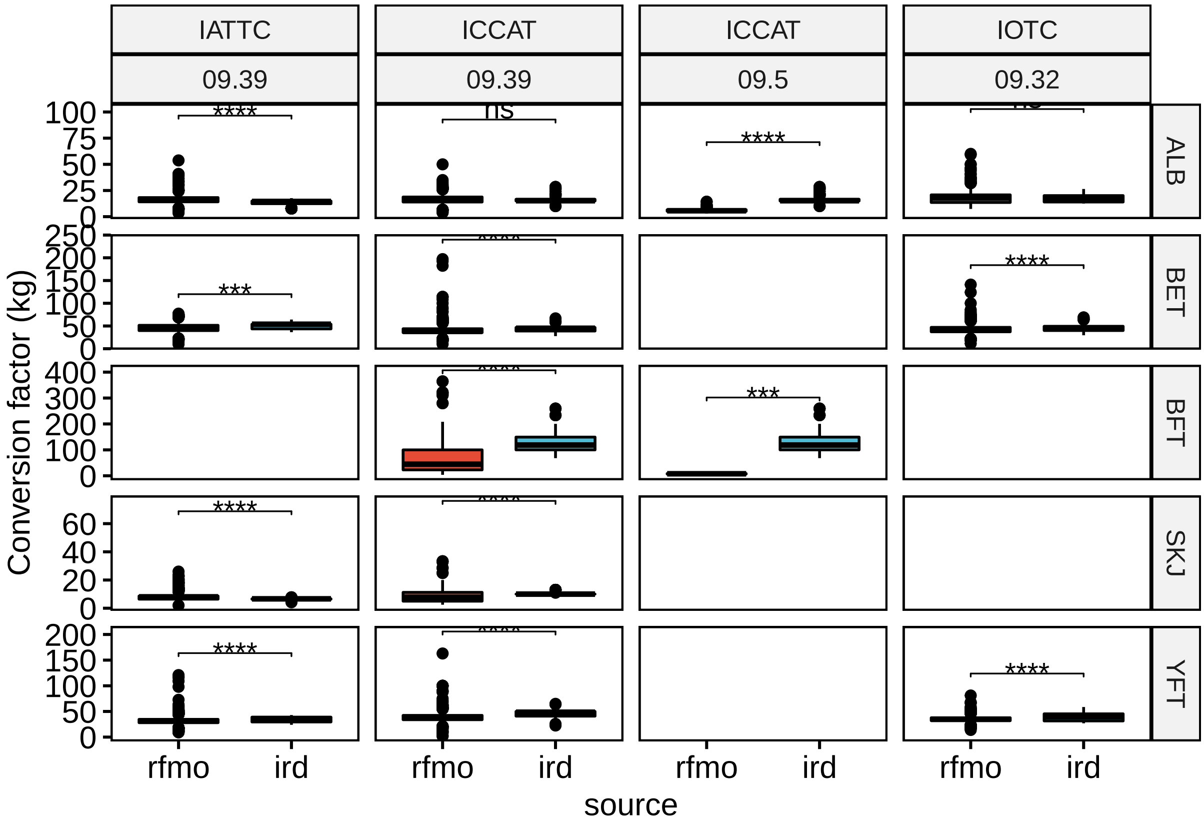


Figure 7: Conversion factors differences for existing triplet gear/tRFMOs/species between IRD and tRFMOs datasets

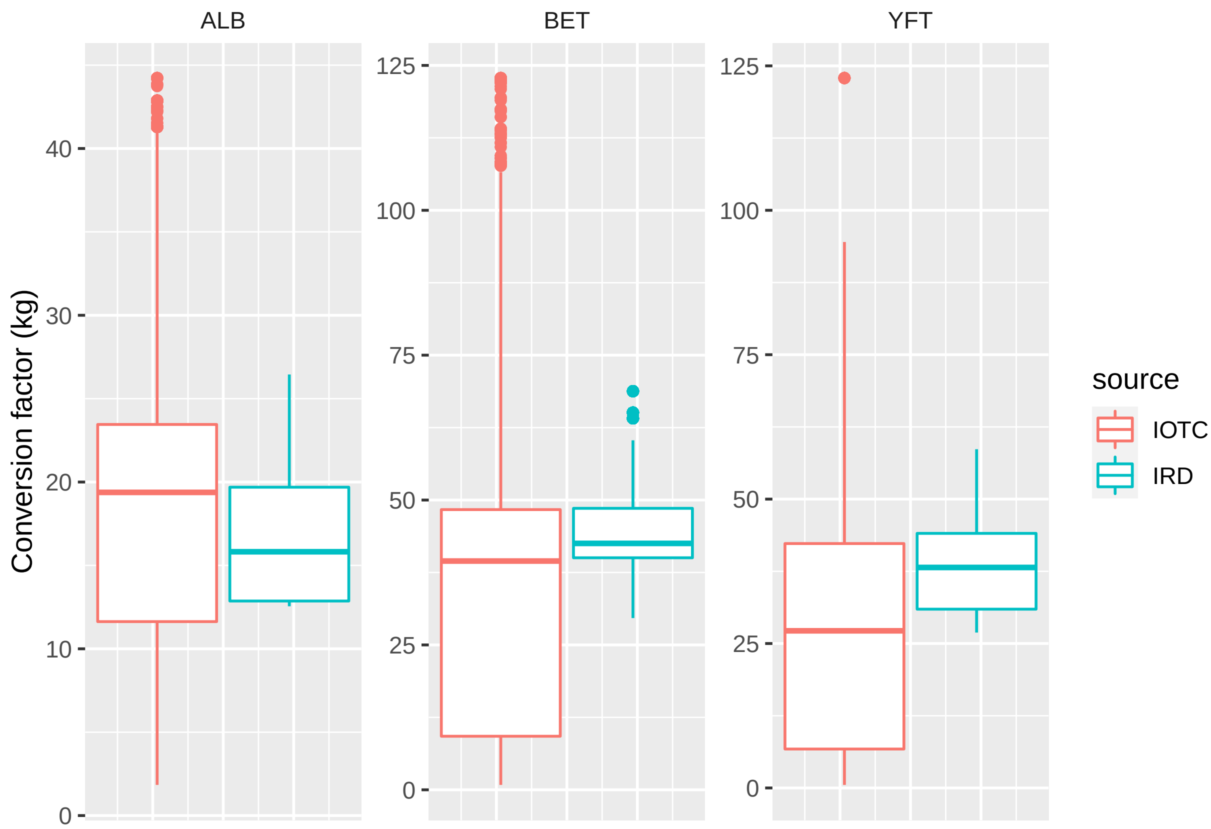


Figure 8: Comparison between conversion factors provided by IOTC and the one historically used by IRD

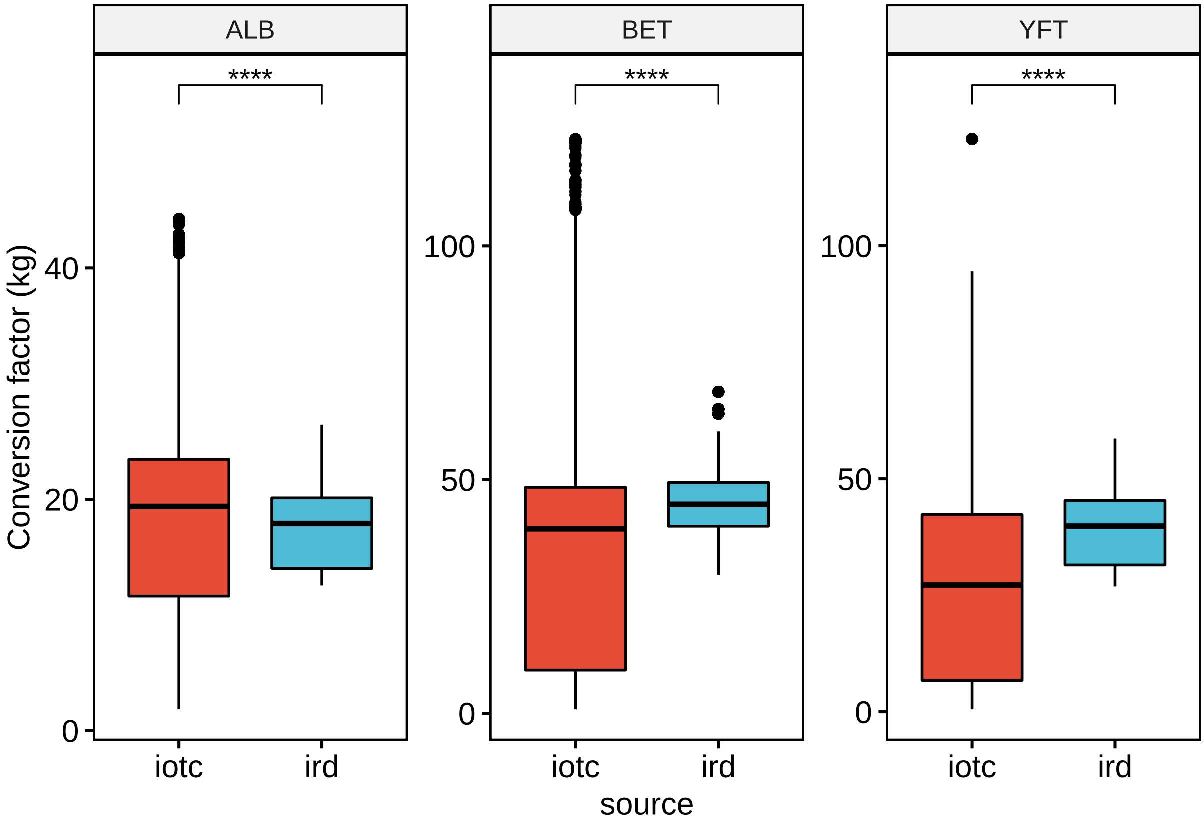


Figure 9: Boxplot and p-value of the t-student comparison between conversion factors of IOTC and used by IRD

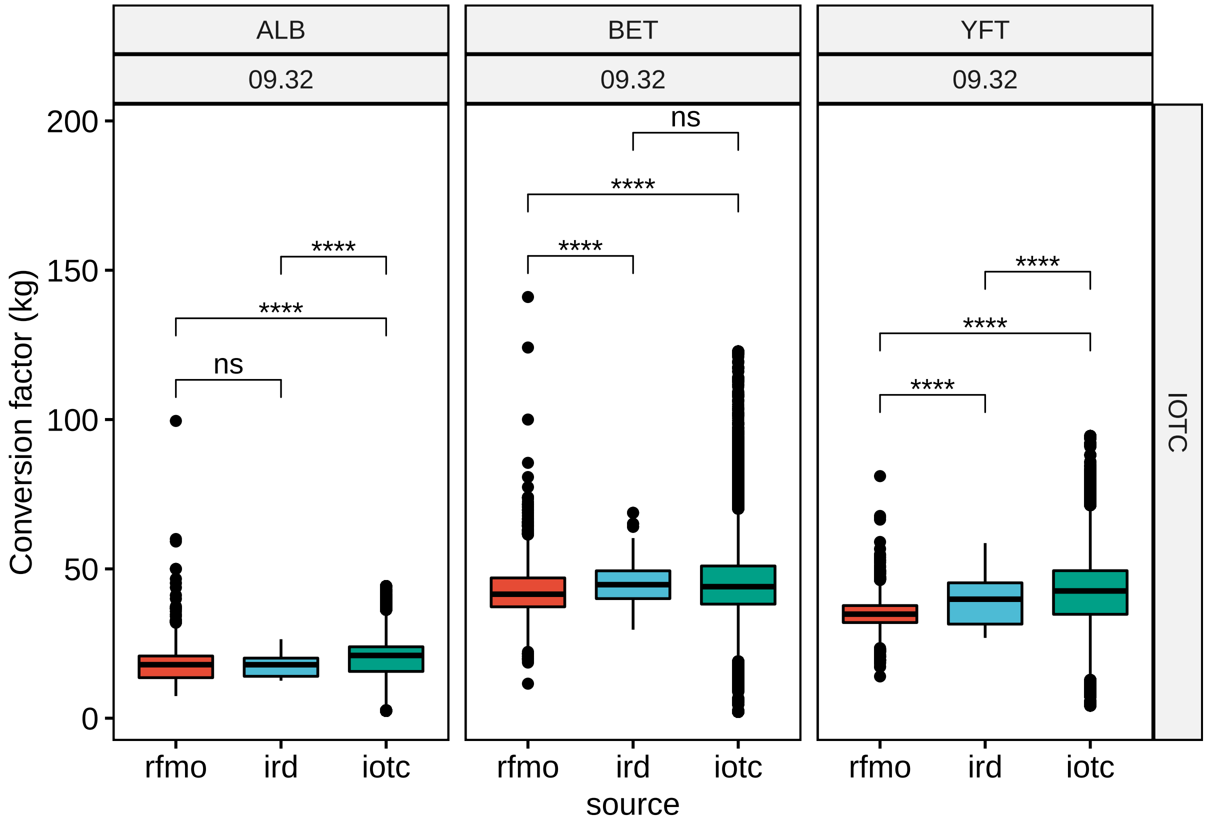


Figure 10: Wilcoxon test for paired conversion factors data

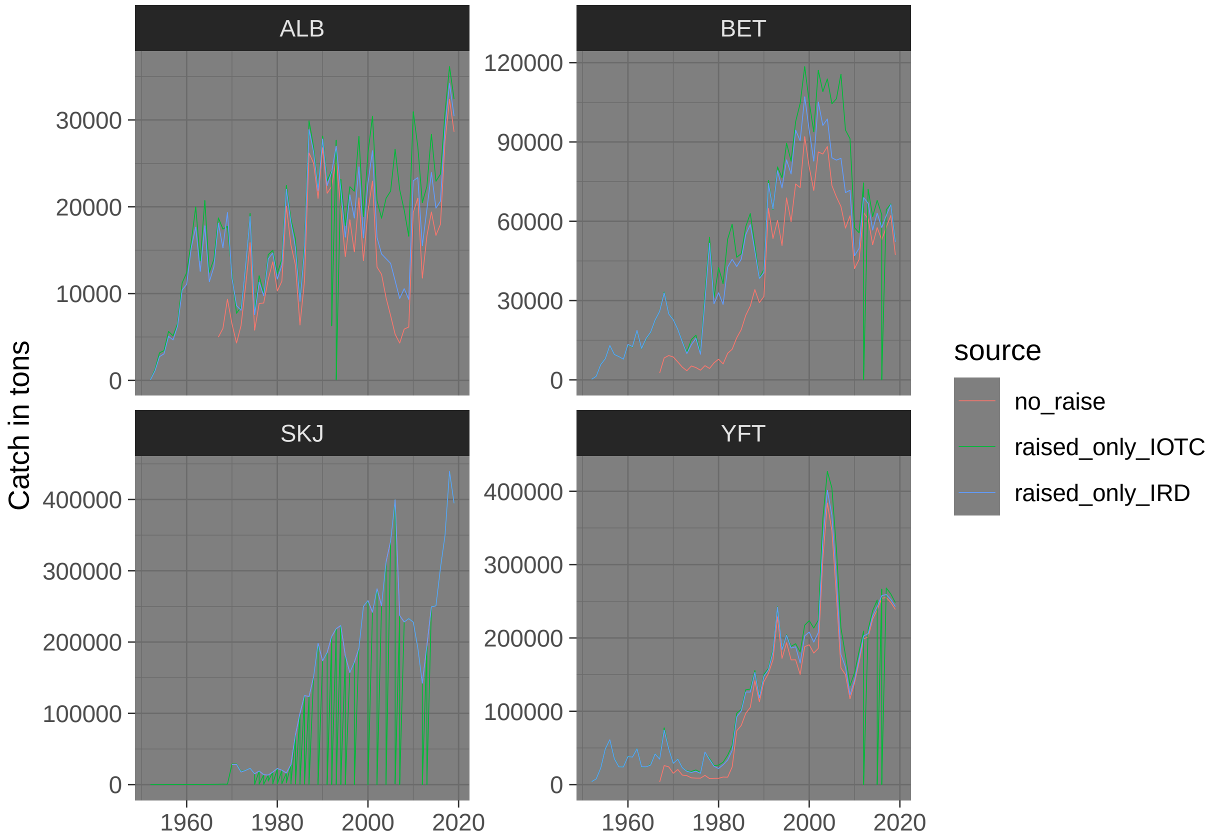
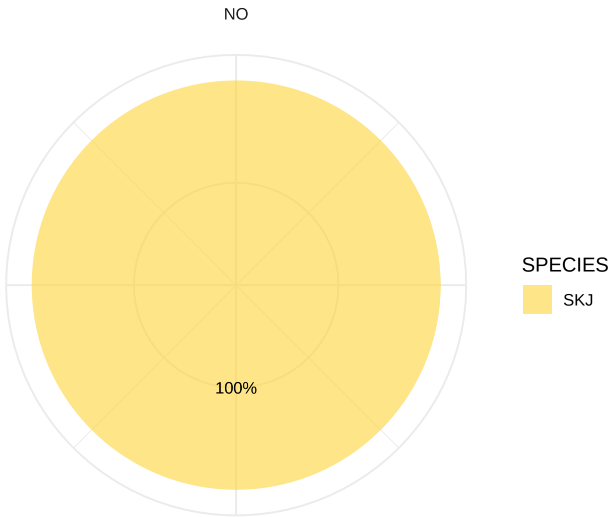
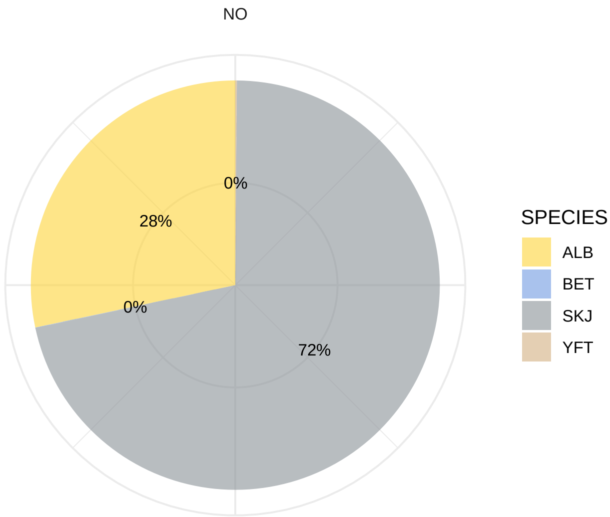


Figure 11: Temporal series of the data depending on the treatment



(a) For data raised with IOTC then with IRD



(b) For data raised only with IOTC

Figure 12: Repartition of species for data non converted with current conversion factors datasets

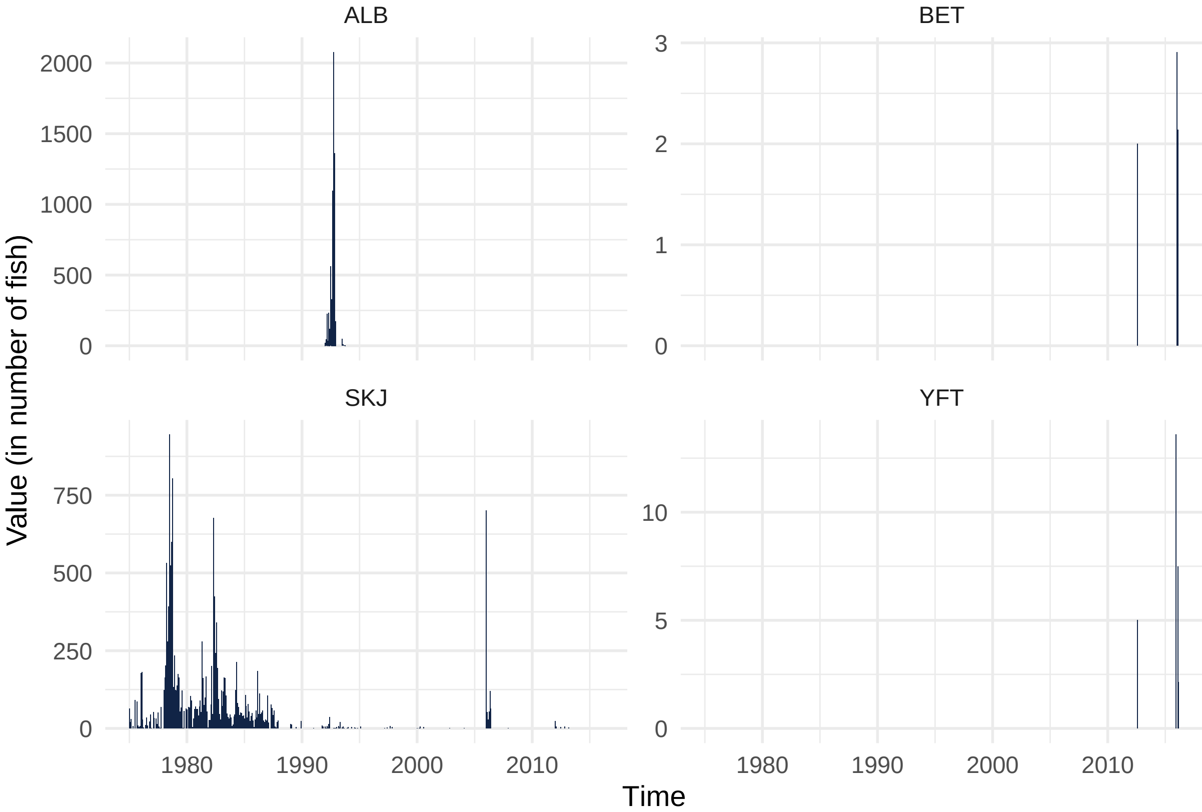
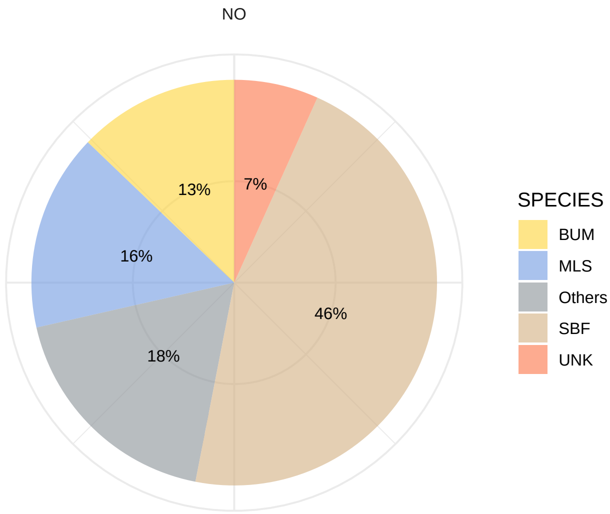
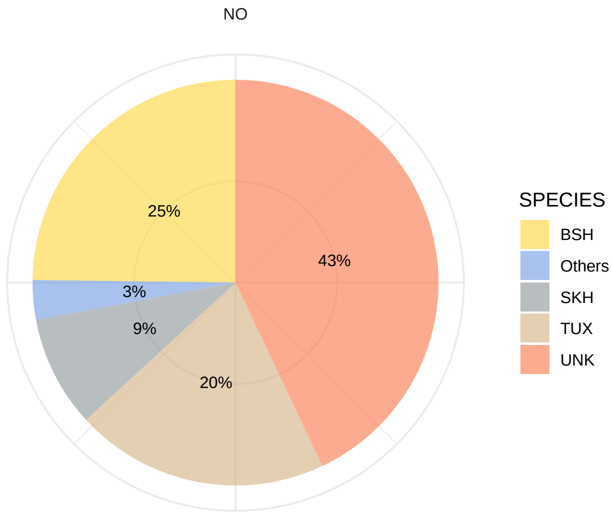


Figure 13: Time series of non-converted captures in number of fish after conversion by IOTC dataset (only 5 major tunas)



(a) For data raised only with IOTC (around 10 millions of fish)



(b) For data raised with IOTC then with IRD (around 2 millions of fish)

Figure 14: Repartition of species for data non converted