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FIRST DRAFT OF THE VALUE CHAIN OF BYCATCH FROM THE INDUSTRIAL TROPICAL TUNA PURSE-SEINE FISHERY IN SEYCHELLES IN 2024

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First draft of the value chain of bycatch from the industrial tropical tuna purse-seine fishery in Seychelles in 2024

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ABSTRACT

This study analyzes the supply chain of bycatch in the tropical purse seine tuna fishery of Seychelles, focusing on the year 2024. Based on official data and interviews with local processing companies, the study reveals that in 2024, 10,650 tonnes of bycatch were landed, of which over 90% were exported directly with relatively low value. The remaining volume (approximately 1,000 tonnes) was destined for the local market, where nearly half is used as bait for the local artisanal and recreational fishing sectors, and a smaller portion (336 tonnes) is processed locally, generating employment. Processing capacity is severely underutilized (3.2%). The responsible utilization of bycatch, excluding threatened species, presents an opportunity to improve efficiency, reduce waste, and strengthen the food security and blue economy of this island nation.

Key Words: Bycatch, supply chain, tuna fishery, Seychelles, Indian Ocean, blue economy, food security, processing.

Clasificación JEL: Q22, Q57, L66, O13

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This work is part of a doctoral thesis developed within the framework of the PhD Programme in Regional Development and Economic Integration at the University of Santiago de Compostela (Galicia, Spain), under the supervision of Gonzalo Rodríguez Rodríguez. The research was conducted during an international research stay in Seychelles, hosted by the University of Seychelles following the formal approval of the Seychelles Bureau of Standards on 14 January 2025 (Ref. A0157).

The study is also carried out in collaboration with the Ministry of Fisheries and the Blue Economy (MOFBE) of Seychelles and the Seychelles Fishing Authority (SFA), in response to the priorities of the MOFBE and the need of the fisheries and local processing sector to make their activities more visible and subject to analysis.

This document represents a first progress report of the ongoing study, subject to further analyses and potential adjustments as the project evolves.

1. INTRODUCTION

The tropical tuna purse seine fishery in the Indian Ocean represents an activity of great relevance for global food security (Mullon et al., 2017; Báez et al., 2018), as well as a socioeconomically important element for coastal communities, especially in countries dependent on tuna resources (Guillotreau et al., 2024). Seychelles constitutes a particularly significant example of this dependency, both in economic terms and in fisheries management.

This purse seine fishery primarily targets yellowfin tuna (Thunnus albacares), skipjack tuna (Katsuwonus pelamis), and bigeye tuna (Thunnus obesus). Fishing operations also generate bycatch, which includes other bony fishes, billfishes, sharks, rays, marine turtles, and marine mammals (Acevedo-Iglesias et al., 2025).

Bycatch from the tropical purse seine tuna fishery has been subject to various regulations aimed at minimizing its impact on ecosystems and promoting more sustainable fishing practices. These regulations are applied both internationally—mainly through the Indian Ocean Tuna Commission (IOTC)—and regionally, by the different countries under whose flags the fishing vessels operate. Differences among these regulations can influence bycatch incidence rates as well as retention or discarding levels of non-target species (Acevedo-Iglesias et al., 2025).

In the context of retained bycatch species, understanding the supply chain is essential to evaluate how bycatch is integrated into the national fisheries economy and its contribution to food security and economic value.

The relevance of this study lies in the fact that bycatch, although representing only a relatively small fraction of the total catch in the fishery under study, comes from one of the world's most important fisheries in terms of both volume and economic value. This gives it particular interest, as even a small proportion of the catch can have a significant impact on overall economic activity, especially in small developing island states, such as Seychelles.

Responsible utilization of bycatch—limited to non-threatened and non-protected species—can help improve the efficiency of marine resource use, reduce waste, and strengthen national food security, aspects particularly relevant in an island country highly dependent on the sea. Furthermore, detailed knowledge of the supply chain allows identification of opportunities for improvement in governance, traceability, and sustainability of the fishery, integrating bycatch as a strategic component of Seychelles' blue economy.

1.1. Why Seychelles?

Seychelles, located in the central Western Indian Ocean (WIO), possesses one of the largest maritime areas in the region. Specifically, the Seychelles' Exclusive Economic Zone (EEZ) covers 1.37 million km², which, combined with 455 km² of land area, means that oceanic waters represent 99.97% of its territory (FiTI, 2025).

Its location coincides with one of the richest tropical tuna areas (Figures 1 and 2), making the country particularly abundant in resources and a strategically central hub, serving as a main node for regional landing operations (see Ports section). This position allows for coordinated monitoring of the supply chain of captured species, including those considered bycatch. The available information provides an ideal framework for analyzing catch distribution, landing destinations, and volumes allocated for export or local processing.

Image 1: World map highlighting the Exclusive Economic Zone of Seychelles (Christ et al., 2020)

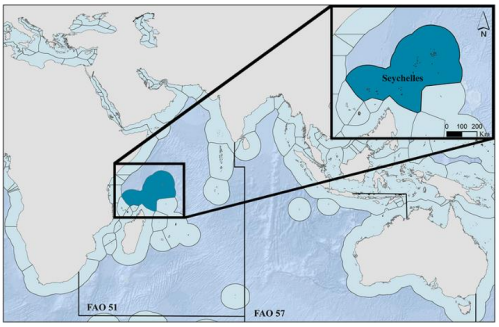
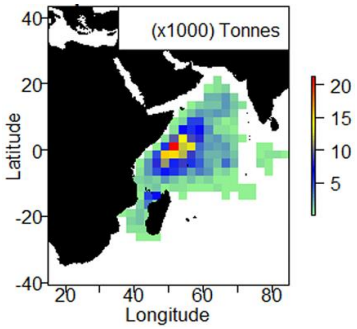
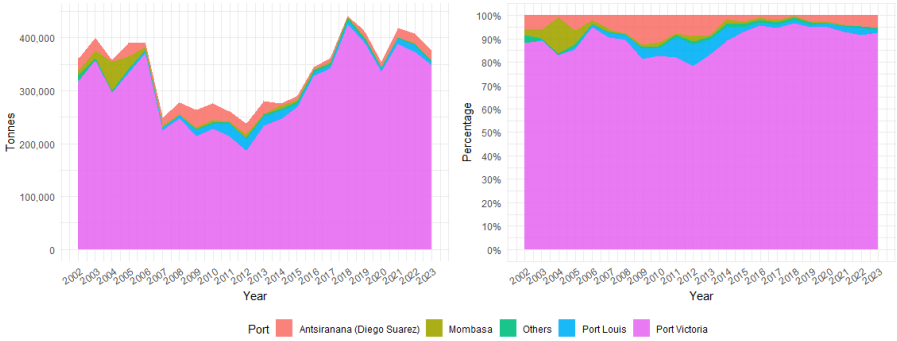


Image 2: Western Indian Ocean tropical tuna purse sine catches heat map (Acevedo-Iglesias et al., 2025)



1.1.1. Ports: Importance of Seychelles in the Western Indian Ocean

Figure 1: Evolution of port landings and transshipments in Western Indian Ocean ports between 2002 and 2023: gross volumes (left chart) and proportions (right chart)



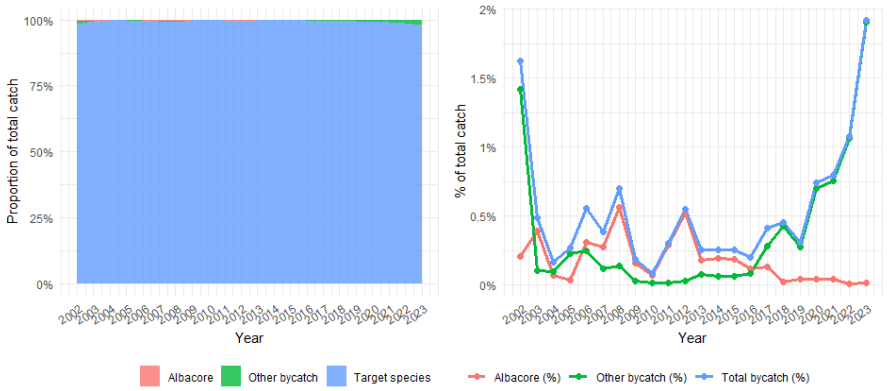
Data from the Seychelles Fishing Authority (SFA) show that Seychelles (Port Victoria) serves as the main hub for nearly all landings and port transshipments in the Western Indian Ocean. In percentage terms, the country accounts for over 90% of these operations, with volumes fluctuating between 250,000 and almost 450,000 tonnes over the 2002–2023 period.

1.1.2. Fishing in the WIO and Seychelles

Using data from the Seychelles Fishing Authority (SFA) on catches by species groups, as well as fishing effort measured in vessel-days by flag, it is possible to describe the dynamics of the fishery:

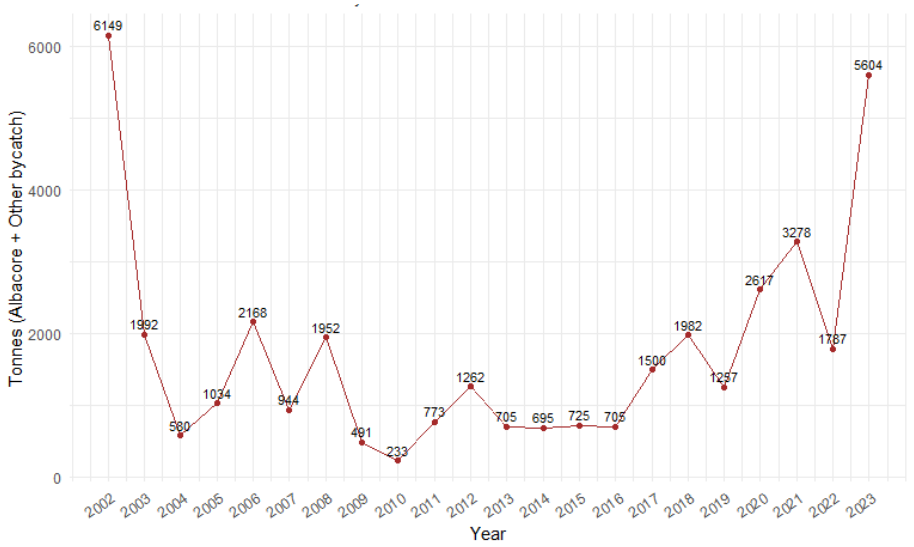
According to SFA catch data, species composition shows that nearly the entire catch corresponds to target species, while albacore tuna (ALB) and other species (OTH) account for approximately 0.25–0.50% of the fishery throughout the historical series, except on two occasions when they reached between 1.5 and 2%. These bycatch rates contrast with the results of Acevedo-Iglesias et al. (2025), which estimated an average bycatch ratio of 2.87 tonnes for every 100 tonnes of target species during the 2003–2022 period.

Figure 1: Evolution of the catch composition proportions of industrial purse-seine tuna vessels in the Western Indian Ocean (2002–2023) according to SFA data: stacked area chart (left) and bycatch evolution (right)



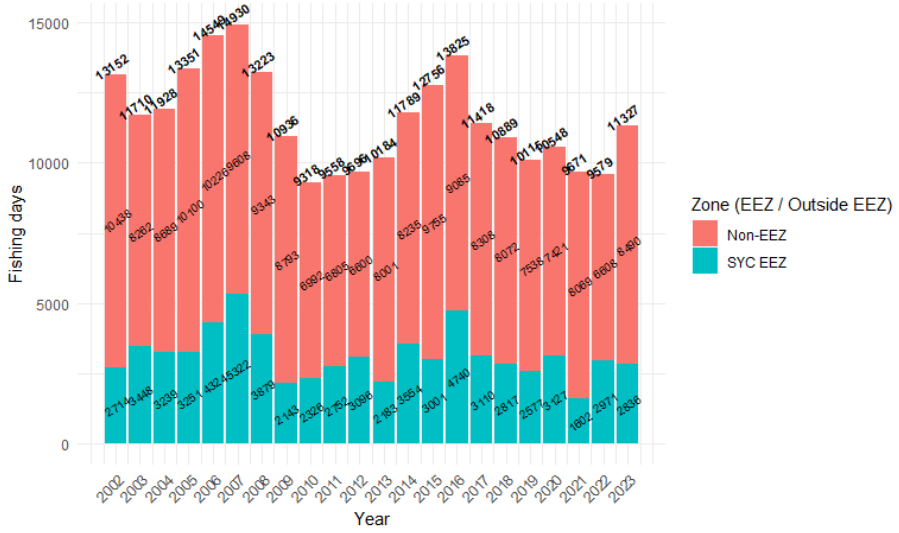
Quantifying precisely the total bycatch volumes caught according to SFA data, the following chart is presented:

Figure 2: Bycatch catch trends according to SFA data (2002–2023)



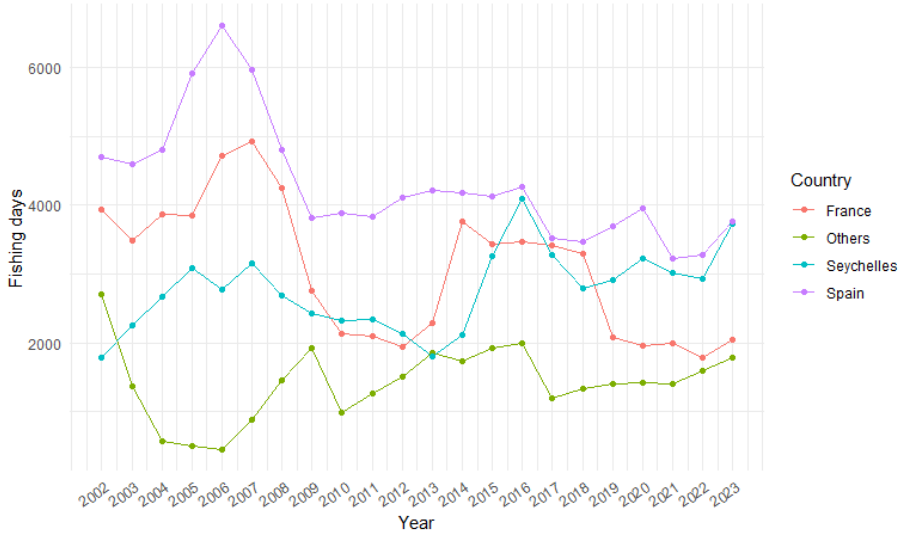
To assess the relative impact, it is necessary to consider fishing effort, measured in vessel-days according to SFA data. The chart shows fluctuations: in 2007, effort peaked at 14,930 vessel-days accumulated by all Western Indian Ocean vessels, declining to a minimum of 9,318 days in 2010, rising again to 13,825 days in 2016, and then decreasing almost continuously to 9,579 days in 2022, before experiencing a new increase.

Figure 3: Annual evolution of fishing effort, measured in vessel-days, by area type (inside and outside the Seychelles Exclusive Economic Zone) between 2002 and 2023 according to SFA data



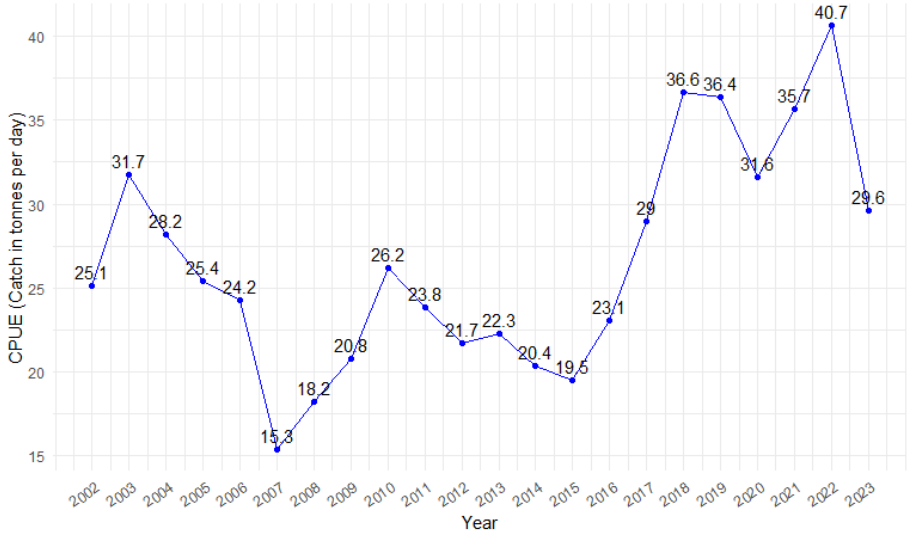
Characterizing the fleet, fishing effort by flag is shown below. The chart indicates that Spain has consistently had the highest fishing effort throughout the historical series, averaging around 4,000 vessel-days annually since 2009. France has also played a significant role, although its effort fluctuates between 2,000 and nearly 4,000 vessel-days per year. Seychelles has experienced an increasing trend in effort, becoming in recent years the second country with the most fishing days, reaching in 2023 nearly the same level of effort as Spain.

Figure 4: Annual evolution of fishing effort, measured in vessel-days, by vessel flag between 2002 and 2023 according to SFA data



With catch and effort data now available, it is possible to calculate catch per unit of nominal effort (CPUEn). In general, fluctuations are observed: before 2016, the maximum of 31.7 tonnes per day in 2003 declined to less than half by 2007 (15.3). Notably, around 2007–2009, fishing was affected by piracy, likely forcing vessels to shift to less efficient fishing areas. Subsequently, in 2010, CPUE reached 26.2 tonnes per day, decreasing almost continuously to 19.5 tonnes per day in 2016. From that year onward, a strong increase was observed, reaching 40.7 tonnes per day in 2022, followed by a downward correction to 29.6 tonnes per day—still higher than most years prior to 2016, except for 2003.

Figure 5: Annual evolution of nominal catch per unit of effort (CPUEn) in the Western Indian Ocean (2002–2023) according to SFA data



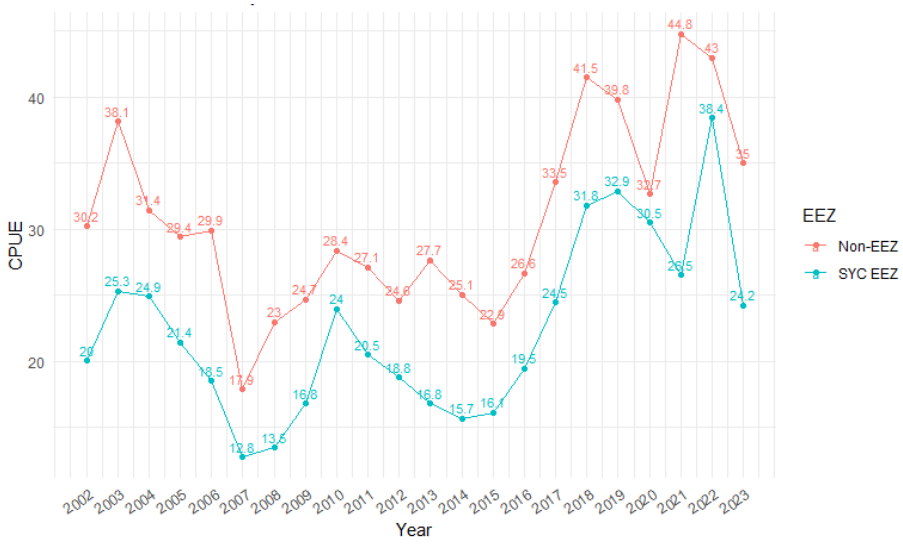
It is important to note that vessels have progressively adopted better technology: improved bird radars, greater fisher knowledge, more calculated fleet management systems, better fish-aggregating devices (FADs), etc. These technological and operational improvements allow for more efficient fishing and, consequently, higher business profitability. Therefore, the charts are presented as nominal CPUE (CPUEn); for ecosystem impact analyses, it would be advisable to calculate standardized CPUE, which would account for catchability factors, i.e., aspects related to technology and other variables.

Regarding CPUEn by vessel flag, prior to 2007, all flags showed very similar values, whereas from that year onward, Spanish-flagged vessels emerged as the most efficient, with Seychelles in second place.

Figure 6: Annual evolution of nominal catch per unit of effort (CPUEn) in the Western Indian Ocean (2002–2023) by vessel flag according to SFA data

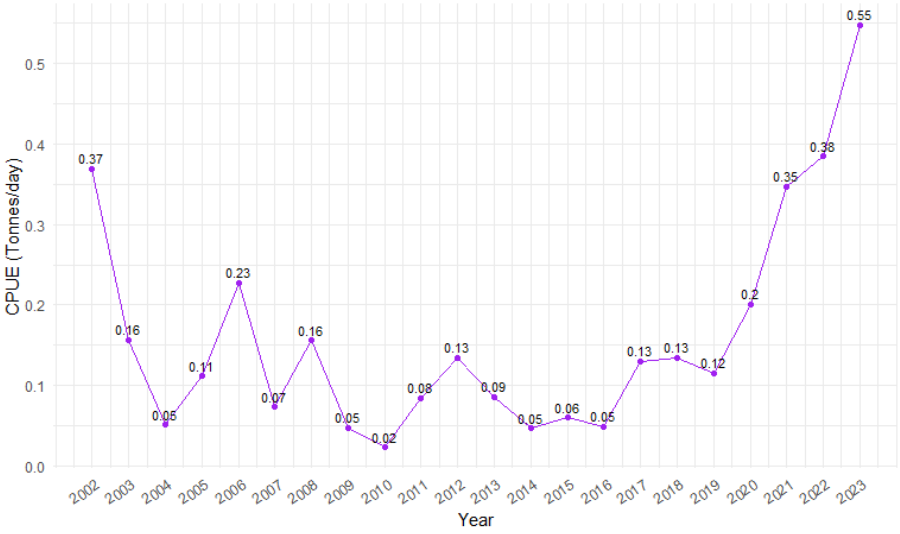
Considering the fishing region, inside or outside the Seychelles EEZ, it is observed that fishing outside Seychelles waters has been more efficient throughout the entire historical series.

Figure 7: Annual evolution of nominal catch per unit of effort (CPUEn), by area type (inside and outside the Seychelles Exclusive Economic Zone) between 2002 and 2023 according to SFA data



Finally, focusing specifically on bycatch, recorded only as albacore tuna (ALB) and other species (OTH) in the SFA databases, CPUEn fluctuated between 0.02 and 0.2 tonnes, increasing over the last three years to reach a maximum of 0.55 tonnes in 2023.

Figure 8: Annual evolution of bycatch catch per unit of nominal effort (CPUEn) in the Western Indian Ocean (2002–2023) according to SFA data



2. MATERIALS AND METHODS

2.1. Information sources

The analyses were based on a combination of primary and secondary sources, providing data on catches, landings, and retention of bycatch species, as well as on their processing and trade in Seychelles:

1. FICQU (Fish Inspection and Quality Control Unit): provided data on direct exports.
2. Direct interviews and industry data: the three local bycatch processing companies in Seychelles were interviewed:
    a) Ocean Basket (OB)
    b) Amirante Fisheries (AF)
    c) Island Catch (IC)

In addition, the only intermediary cold storage company, Central Command Cold Store (CCCS), which centralizes bycatch landings before collection or export by the three

companies, was interviewed. The Fish Inspection and Quality Control Unit (FIQCU), responsible for certifying direct exports (without processing), was also consulted.
These interviews provided information on company profiles, the importance of bycatch, employment, sales channels, processing, purchase prices, volumes handled, processing capacity, and export.

2.2. Location, analysis period and objective

This report focuses on analyzing the bycatch supply chain in Seychelles in 2024, as it is the only year with complete data allowing for detailed analysis.
The objective is to map the bycatch supply chain in Seychelles, improving the currently limited infographic to better understand the bycatch industry.

2.3. Data processing and analysis

All data processing, analysis, and visualization were carried out using the R programming language and the RStudio development environment, through reproducible documents generated with R Markdown.

3. RESULTS

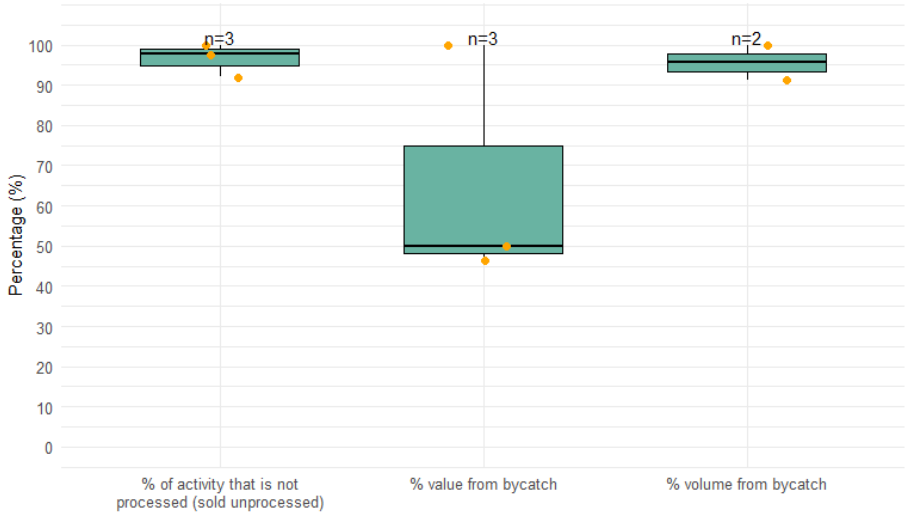
3.1. Processing capacity

In 2024, the processing capacity of bycatch companies was 40 tonnes/day. Considering 260 working days per year, the total annual capacity would be approximately 10,400 tonnes.
During that year, 336 tonnes were processed, representing 3.2% of total capacity, implying an underutilization of 96.8%.

3.2. Dependence on Seychelles

3.2.1. Economic importance for processing companies

Figure 9: Average indicators of unprocessed activity, value, and volume from bycatch for processing companies in 2024, according to interview data

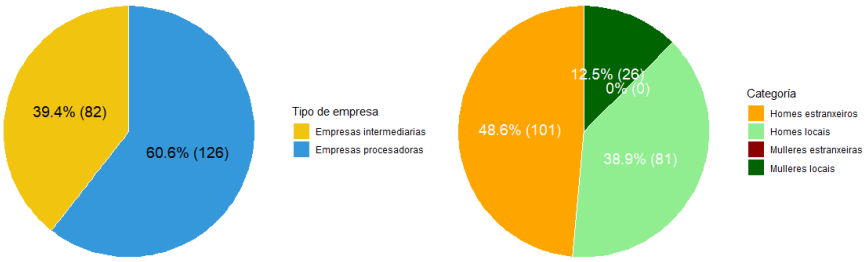


It should be noted that these percentages were calculated as the average of the individual values for each company, without weighting by the total volume or value each represents, due to the lack of all necessary data for such a calculation. Furthermore, as indicated, only two of the three companies provided the information reflected in the figure.

Nevertheless, these data provide a general overview: although bycatch accounts for more than 90% of the volume in these companies, its representation in terms of value falls to around 50% on average.

3.2.2. Employment

Figure 10: Left: distribution of the number of employees by company type in 2024 (intermediary: CCCS; processors: Island Catch, Ocean Basket, and Amirante Fisheries); Right: composition of employment in the supply chain industry by gender and origin (local vs. foreign) in 2024



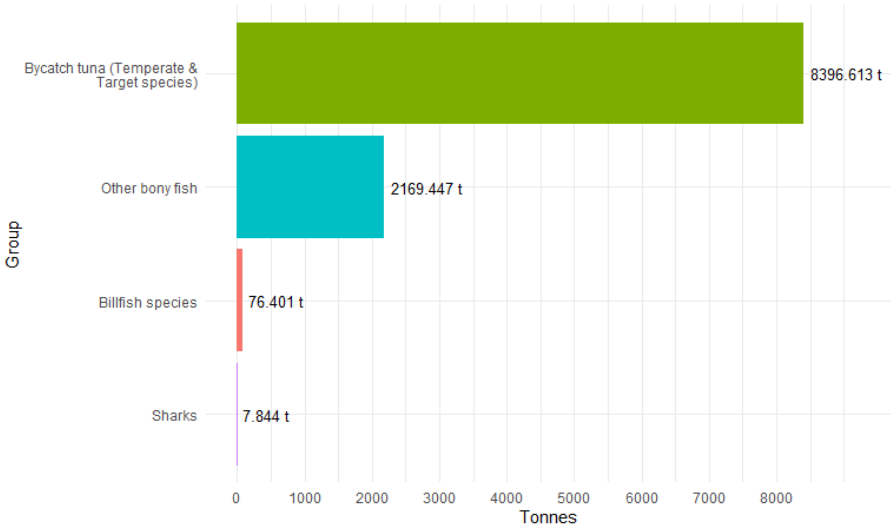
In 2024, bycatch processing companies, together with the intermediary cold storage company, directly employed 208 people, of whom 126 belonged to the processors and 82 to the intermediary. Among the staff of the processing companies, nearly 60% are local, while in the intermediary company this share is 40%. There is a clear male majority, with women representing only 11.1% and 14.6%, respectively, all of whom are local.

3.3. Trade

3.3.1. Composition of landed species (retained after catch)

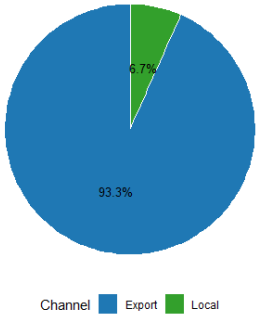
The total bycatch fish landed at CCCS—that is, retained after fishing—amounts to 10,650.30 tonnes, of which 76.4 tonnes are billfishes, 8,396.61 tonnes are bycatch tunas (either temperate tunas or target tunas of non-target sizes or quality), 2,169.45 tonnes are other bony fishes, and 7.84 tonnes are sharks.

Figure 11: Volumes, in tonnes, of bycatch landed at CCCS by species group (2024), according to interview data



3.3.2. Direct export and its species composition

Figure 12: Distribution of the destination of bycatch landed at CCCS in 2024 (exported vs. local), according to interview data (n = 2)

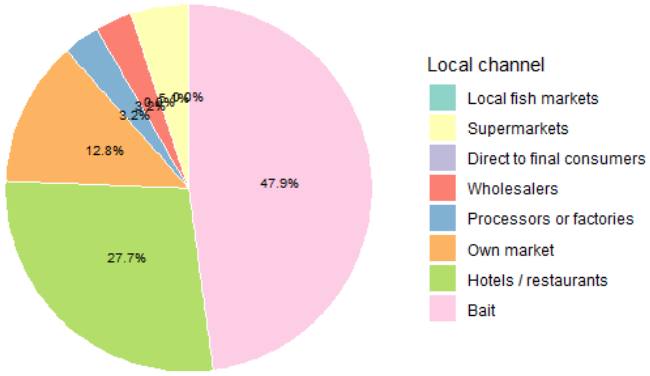


On one hand, regarding the identification of volumes or proportions destined directly for export or local trade, a relatively high agreement is observed between the data provided by the interviewees and the figures calculated through FIQCU, reaching 93.34% and 90.64%, respectively, of the volume allocated to direct export.

3.3.3. Local sales channels

Regarding the local market, according to interview responses, 47.86% of bycatch is used directly as bait, 27.74% goes to hotels and restaurants, 12.84% to local shops operated by the processing company, and the remaining share, in smaller and varied proportions, is distributed among wholesalers, processors or factories, and supermarkets.

Figure 13: Distribution of bycatch sales channels for the domestic Seychelles market in 2024 (exported vs. local), according to interview data (n = 2)



Bait, composed mainly of species from industrial tuna purse-seine fisheries, is a key input for both local artisanal and recreational fishing activities. Its availability highlights a direct link between these two subsectors and the industrial tuna fishery, as the bait largely comes from bycatch or secondary catches generated by industrial purse-seine operations. Consequently, the productivity and sustainability of local and recreational fisheries depend heavily on the supply provided by the industrial tuna sector.

3.4. Supply chain

3.4.1. Waste

For this analysis, given the limited responses, the maximum reported percentage will be considered to estimate total waste relative to processed fish, which is 12%.

3.4.2. Supply chain: volumes

Based on the above, a diagram can be developed to estimate volumes at each stage of the supply chain. Starting with the total bycatch fish landed at CCCS, which amounts to 10,650.30 tonnes: 76.4 tonnes are billfishes (marlin, swordfish, and sailfish), 8,396.61 tonnes are bycatch tunas (either temperate tunas or target tunas of non-target sizes or quality), 2,169.45 tonnes are other bony fishes, and 7.84 tonnes are sharks.

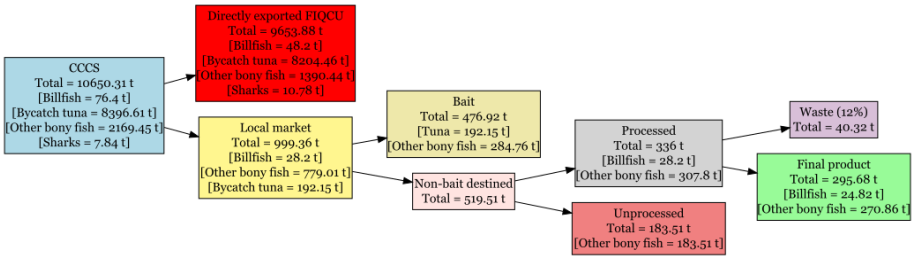
Part of this catch was exported directly according to FIQCU data, totaling 9,653.88 tonnes: 48.2 tonnes of billfishes, 8,204.46 tonnes of bycatch tunas, 1,390.44 tonnes of other bony fishes, and 10.78 tonnes of sharks. These figures highlight two issues: accidental retention of sharks and minor inconsistencies in export data.

The remaining volume stayed in Seychelles, totaling 999.36 tonnes: 28.2 tonnes of billfishes, 779.01 tonnes of other bony fishes, and 192.15 tonnes of tunas. Within this local chain, according to interview responses from processing companies, 47.86% is destined for bait, resulting in 476.92 tonnes. Interviewees indicated that nearly all bycatch tunas at the local level are sold for this use, so the 192.15 tonnes of tunas are fully included in this category. The remaining 284.76 tonnes are considered other bony fishes.

This implies that 519.51 tonnes are not used for bait. Continuing, according to interviewees, a total of 336 tonnes were processed in 2024, assuming that 100% of billfishes were processed and the remainder corresponds to other bony fishes, resulting in 28.2 and 307.8 tonnes, respectively.

The unprocessed remainder corresponds to 183.51 tonnes of other bony fishes. During processing, a loss of 40.32 tonnes occurs, approximately 12% of the processed quantity. The difference results in the final commercial product, totaling 295.68 tonnes, of which 24.82 tonnes are billfishes and 270.86 tonnes are other bony fishes.

Figure 14: Diagram of the bycatch supply chain landed in Seychelles with estimated volumes by species group in 2024



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