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PRELIMINARY BIOECONOMIC ASSESSMENT OF MACKEREL SCAD AND THREE TUNA-LIKE SPECIES IN CABO VERDE

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Djiga Thiao

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PREPARATION OF THIS REPORT

Preparation of this report was coordinated by the Value Chain Development Team of the Food and Agriculture Organization of the United Nations (FAO) Fisheries and Aquaculture Division, as part of FAO's Strategic Framework (better production, better nutrition, a better environment and a better life) and the objective of the Blue Transformation Roadmap: Upgraded value chains ensure the social, economic and environmental viability of aquatic food systems. The report was commissioned as part of the Sustainable Fish Value Chains for Small Island Developing States (SVC4SIDS) programme funded by the Republic of Korea.

The paper was written by Djiga Thiao, international fisheries expert, under the lead of Nada Bougouss, Fishery Officer. Revisions were provided by Matthieu Bernardon, fisheries management expert; Mohammed Ichibane, fish value chain expert; and Ederio Almada, fisheries economist, FAO. Assistance from Claire Ward and Tessa O'Hara for language editing, Canopy for the graphic design and Turan Rahimzadeh for the support in the publishing process are gratefully acknowledged. This work was carried out with administrative support from Vanessa Lodi, Office Assistant, and the FAO Country Office in Cabo Verde.

The preparation of this report required biological and economic data on the target fisheries. Data compilation was carried out with the support and collaboration of researchers from the Instituto do Mar (IMAR, Marine Institute), particularly Nuno Viera and Sandra Correia, under the leadership and support of Albertino Martins, President of the Board of Directors (IMAR) and with the assistance of José Lopes da Veiga, National Project Coordinator.

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ABBREVIATIONS

CPUE	catch per unit effort
CVE	Cabo Verde escudo
DNPA	Direção Nacional de Pesca e Aquacultura (National Directorate of Fisheries and Aquaculture)
FAO	Food and Agriculture Organization of the United Nations
GDP	gross domestic product
IMAR	Instituto do Mar (Marine Institute)
JABBA	Just Another Bayesian Biomass Assessment
MEY	maximum economic yield
MSY	maximum sustainable yield
SIDS	Small Island Developing States
SVC4SIDS	Sustainable Fish Value Chains for Small Island Developing States
USD	United States dollar

Exchange rate used in this document USD 1= CVE 100.80 (October 2024)

EXECUTIVE SUMMARY

The Sustainable Fish Value Chains for Small Island Developing States (SVC4SIDS-GCP/GLO/098/ROK) is a global programme implemented by the Food and Agriculture Organization of the United Nations (FAO) with funding from the Ministry of Oceans and Fisheries of the Republic of Korea (FAO, 2025a). The programme is being implemented in two Small Island Developing States (SIDS) – Cabo Verde and Kiribati – over a period of five years (2020 to 2025). SVC4SIDS follows a holistic and strategic approach to better understand the critical factors and interrelated constraints affecting value chain performance. The aim is to improve the value chains of high-value fish species, leading to significant social and economic benefits and building resilience to environmental vulnerabilities.

Within the framework of the SVC4SIDS programme, a transformative ten-year upgrading strategy (FAO, 2025b) was launched in 2023 in Cabo Verde to enhance sustainable value chains for: mackerel scad *Decapterus macarellus*, locally known as "*cavala preta*"; and (3) tuna-like species, skipjack tuna *Katsuwonus pelamis*, locally known as "*gaiado*", frigate tuna *Auxis thazard*, locally known as "*judeu*" and little tunny *Euthynus alleteratus*, locally known as "*merma*".

The report falls under Component 1 of the upgrading strategy: "environmental sustainability". The methodology used to implement the assessment was based on desk review, data compilation and analysis, as well as bioeconomic modelling. The desk review, conducted between July and October 2024, consisted of collecting relevant documents relating to the fisheries sector of Cabo Verde in general, and to the biological and economic characteristics of the fisheries for mackerel scad and tuna-like species specifically. Diverse types of data were compiled from the Instituto do Mar (IMAR, Marine Institute) database, as well as from the latest fisheries census report. This includes data on the fishing fleet, fishing effort and catch, as well as the ex-vessel fish price. Regarding the fishing costs, data previously collected as part of the value chain analysis conducted between February and December 2022 under the SVC4SIDS programme (Macías González *et al*., 2025) were used in the bioeconomic modelling. However, similar data were not available for the artisanal fisheries.

Based on data made available to the author during the conduct of this study, mackerel scad indicates signs of concern, with a biomass at only 20 percent to 30 percent of its optimum level, though displaying a 71.9 percent probability of recovery in 2023. Skipjack tuna presents recent improvement, with a biomass above optimum levels in 2021 to 2023 and a 63.8 percent probability of not being fully exploited. The situation for frigate tuna is favourable, with a 99.2 percent probability of the species not being fully exploited in 2023. Little tunny remains a cause for concern, with a biomass at 20 percent to 30 percent of its optimum level, despite a probability of recovery of 88.8 percent.

The economic analysis reveals highly variable costs in industrial fishing (CVE 63 394/ USD 629 per day at sea) and annual fixed costs exceeding CVE 9 million (USD 89 286) per vessel. Ex-vessel prices for all four species averaged around CVE 200 (USD 1.98) per kg over the past three years (2021 to 2023) for industrial fisheries. For artisanal fisheries, mackerel scad and little tunny commanded higher prices, while skipjack tuna and frigate tuna were sold at lower prices of CVE 125 (USD 1.24) per kg and CVE 109 (USD 1.08) per kg, respectively.

The author worked closely with researchers and fishery officers from IMAR and the National Directorate of Fisheries and Aquaculture (DNPA) and delivered a training workshop in September 2024, which also discussed recommendations deriving from the bioeconomic assessment.

The main recommendations include:

- improving the system for collecting and managing fisheries data;
- building capacity for bioeconomic assessment;
- developing regional collaboration on stock assessment;
- implementing strategies for adding value to products;
- reducing the costs of industrial fishing;
- increasing stakeholder involvement in fisheries management; and
- supporting alternative livelihoods for communities dependent on overexploited stocks.

These conclusions and recommendations may provide a basis for guiding the sustainable management of fisheries in Cabo Verde, with particular attention to resource conservation and the economic viability of the sector.

1. INTRODUCTION

The bioeconomic assessment was commissioned to support the implementation of the ten-year upgrading strategy (2023 to 2033) that was adopted by stakeholders in the three SVC4SIDS programme islands (Santiago, São Vicente and São Nicolau) (Macías González, *et al.*, 2024). This work focuses on key fisheries resources (**Table 1**): mackerel scad *Decapterus macarellus* and three tuna-like species, skipjack tuna *Katsuwonus pelamis*, frigate tuna *Auxis thazard* and little tunny *Euthynnus alleteratus*. Overall, the assessment aimed to evaluate the biological and economic status of these key resources and compile recommendations, including from stakeholder consultations, to inform decision-making for fisheries management.

In close collaboration with the IMAR, the assessment comprised the compilation of the available data and the collection of complementary required data. Based on that, appropriate bioeconomic models were prepared and applied. A capacity building workshop was held in September 2024, attended by staff from the Direção Nacional de Pesca e Aquacultura (DNPA, National Directorate of Fisheries and Aquaculture) and researchers from IMAR (FAO, 2024a). Participants came from various islands in Cabo Verde, including São Vicente, Santiago, Maio and Sal.

1.1 Objectives of the assessment

The overall objective of this preliminary bioeconomic assessment is to facilitate the implementation of a fisheries upgrading strategy for the key fisheries resources (mackerel scad and three tuna-like species). More specifically, it enabled:

- the compilation and organization of existing data required to evaluate the biological and economic status of the key resources;
- the preparation and implementation of bioeconomic models appropriate to the key resources, based on the available data; and
- proposed recommendations for fisheries management.

1.2 Overview of the fisheries sector

The exclusive economic zone of Cabo Verde covers approximately 800 000 km² and is 200 times larger than the surface area of all the islands combined (OECD, 2022). Therefore, the country's marine territory is essential to its development, providing food, jobs and livelihoods. The fisheries sector plays a vital role in combating poverty and ensuring food security and nutrition for thousands of people in Cabo Verde. It directly employs more than 8 600 people across the country. Fisheries products are more widely consumed than meat and are particularly important for the rural coastal population (Macías González *et al.*, 2025).

Cabo Verde's fishing fleet is made up of 1 463 artisanal boats and 127 semi-industrial and industrial vessels (IMAR/INE, 2022). Production reached a peak of 37 742 tonnes in 2015. A large proportion of these catches are tuna and pelagic fish (FAO, 2024b). Considering the primary extraction of fish, the sector contributes nearly CVE 900 million (USD 8.9 million) per year, representing 0.8 percent of the gross domestic product (GDP), and 10.7 percent of the primary sector GDP (INE, 2022). However, taking into account the post-harvest component and other related activities, this percentage could be between 7 percent and 10 percent of GDP (Macías González *et al.*, 2024). Additionally, fish and fish products account for 77 percent of total trade and are the most exported commodities in Cabo Verde, valued at USD 47 million in 2019 (ITC, 2023). Canned fish, predominantly tuna and mackerel, constitute most of these exports, destined mainly for markets in Spain, Italy and the United States of America.

Table 1. List of the study species and their corresponding names

Scientific name	English name	Portuguese/local name
Decapterus macarellus	Mackerel scad	Cavala preta
Katsuwonus pelamis	Skipjack tuna	Gaiado, atunzinho
Auxis thazard	Frigate tuna	Judeu, judeu-liso, cachorrinha, melva
Euthynnus alleteratus	Little tunny	Merma, panquil, txafarote

2. METHODOLOGY OF THE ASSESSMENT

2.1 Desk review

The desk review was an essential component of the bioeconomic assessment. It consisted of gathering and analysing documents relating to the fisheries sector of Cabo Verde in general, and to the biological and economic characteristics of the fisheries for mackerel scad and tuna-like species specifically. The desk review also provided useful methodological knowledge for conducting a bioeconomic assessment that is compatible with the fisheries context in Cabo Verde. This also included the preparation and implementation of appropriate models, taking into account the available data.

The author mainly targeted documents such as technical reports, published papers and fisheries management references. Most of these references were provided by IMAR and included results and data collected during the value chain analysis conducted in 2022 as part of the implementation of the SVC4SIDS programme. Other essential documents were collected through an online search.

2.2 Data preparation

2.2.1 Main data used in the assessment

The assessment required a combination of biological and economic data. Such data were essential to analyse the fisheries trends and to fit the bioeconomic models. Unlike the economic data that may be limited to the most recent years, biological time series of the past two decades were requested, depending on their availability. **Table 2** presents the most important data that were used to assess the bioeconomic status of the key resources included in the study.

The number of fishing vessels is related to the fishing capacity, which comprises both the industrial fishing boats and the artisanal fishing canoes. The analysis was based on the number of fishing trips made by the artisanal fishers and the number of days at sea of the industrial fishing boats. Although the studied species are mainly exploited by the industrial fisheries, the artisanal fisheries data were distinguished and analysed whenever possible. In the absence of data on fish discards and transshipment, the volume of catch was assumed to be equivalent to the landings.

The variable cost corresponds to the regular operating expenses that are incurred to conduct fishing activities. This typically comprises the fuel, lubricants, ice, food on board, cleaning, fines, vessel and gear repairs, temporary crew costs, etc. The fixed cost is made up of annual expenses incurred even if no fishing activity takes place. This is the case for vessel and gear depreciation, annual fishing license fees, wages of permanent employees, annual vessel and labour insurance, annual interest from debts and loans, annual warehouse rent, and any other annual taxes or fees (mooring fees, certificate of seaworthiness, cooperative fees, etc.).

Table 2. List of the main data required for the assessment

Biological data	Economic data
Number of fishing vessels	Ex-vessel fish price
Number of fishing trips	Variable fishing costs
Number of days at sea	Fixed fishing costs
Total catch by species	

According to Macías González *et al.* (2025), the current national legislation (Decree/Law 02/2020) distinguishes between the artisanal fleet and the semi-industrial and industrial fleet. Despite possible differentiation in terms of the length of vessels (from 8 m to 24 m for semi-industrial boats), in the existing databases and reports, semi-industrial and industrial boats are grouped into a single category. Therefore, in this study we only use the term “industrial fisheries”.

2.2.2 Data compilation and processing

Data on fishing capacity in Cabo Verde were taken from the latest fisheries census report (IMAR/INE, 2022). This includes statistics on the number of vessels and fishers counted in 2021. The compilation consisted of summarizing the data in a single table by island in order to analyse the geographical distribution of fishing capacity.

Aggregated effort and catch time series were provided by IMAR for both the industrial and artisanal fisheries (**Table 3**). These data cover the period 2004 to 2018 and comprise the total catch of the four study species. They are also related to the fishing effort, corresponding to the number of days at sea (industrial fisheries) and the number of fishing trips (artisanal fisheries). Data related to the effort of the industrial fisheries are available until 2015 and there is a missing value in 2013. The effort of the artisanal fisheries is missing for 2016 and the values for 2013 and 2018 are very low compared to the remainder of the time series. The catch data of the industrial fisheries are characterized by some strong fluctuations, particularly for mackerel scad and frigate tuna. A similar trend was noted in the artisanal fisheries catch, but in a more disparate way.

To complete the industrial and artisanal fishing effort and catch time series from 2019 to 2023, two detailed Excel files were provided by IMAR. They are related to raw data Excel files without preliminary processing. For the industrial fisheries, the Excel file from IMAR contained exhaustive records of the fishing operations. This made it possible to calculate the total number of days at sea based on the dates and times of fishing trip departures and returns. However, in terms of values and/or formats, there are several inconsistencies in the departure and return dates and times. Therefore, to estimate the fishing effort for 2019 to 2023, some corrections were made. In addition to the industrial fishing effort, the Excel file allowed the author to aggregate the total catch per species from 2019 to 2023. It also contained some data on the ex-vessel fish price of the four study species and these data made it possible to calculate the revenue generated by the industrial fisheries.

The detailed Excel file related to the artisanal fisheries comprised raw data collected from sampled fishing canoes in landing sites monitored by IMAR. In addition to numerous inconsistencies on the dates and times of fishing trip departure and return, data were not exhaustive and required extrapolations based on IMAR procedures. Because this preliminary processing task was not yet done, it was not possible to extract aggregated total effort and catch from this file. However, it was used to estimate the average ex-vessel fish price of the four study species.

The summarized effort and catch time series from 2004 to 2023 for both industrial and artisanal fisheries is presented in **Table 3**. For this purpose, each missing value (in red) was estimated by moving average considering the three previous years. Moreover, before being analysed and used in the modelling process, all catch data were converted to tonnes. To highlight the fluctuations in the time series, the effort and catch values that are out of usual ranges or trends are indicated in yellow.

Table 3. Effort and catch (tonnes) time series compiled from the Instituto do Mar (Marine Institute) database

Industrial fisheries effort (days) and catch (tonnes)						Artisanal fisheries effort (trips) and catch (tonnes)					
Year	Effort (days)	Mackerel scad (*Decapterus macarellus*)	Skipjack tuna (*Katsuwonus pelamis*)	Frigate tuna (*Auxis thazard*)	Little tunny (*Euthynnus alleteratus*)	Year	Effort	Mackerel scad (*Decapterus macarellus*)	Skipjack tuna (*Katsuwonus pelamis*)	Frigate tuna (*Auxis thazard*)	Little tunny (*Euthynnus alleteratus*)
2004	2 682	1 093	683	133	65	2004	141 718	648	26	11	69
2005	1 068	1 464	245	164	38	2005	118 854	717	43	12	21
2006	1 738	2 351	668	192	109	2006	125 094	276	27	21	43
2007	4 916	2 298	279	279	164	2007	118 501	557	22	26	128
2008	4 971	2 034	265	219	138	2008	117 369	352	91	31	12
2009	6 184	1 382	482	307	369	2009	136 001	389	109	50	33
2010	7 197	1 442	463	295	179	2010	144 752	307	67	41	17
2011	6 818	1 921	572	516	83	2011	145 282	242	98	8	28
2012	6 264	2 498	236	1 181	55	2012	146 373	145	70	15	74
2013	6 760	2 210	768	2 022	216	2013	59 055	4	108	18	60
2014	4 946	1 274	1 181	5 329	149	2015	140 269	113	38	149	88
2015	5 267	642	577	5 532	32	2015	158 542	2	13	30	23
2016	5 658	376	523	2 447	23	2016	119 289	1	13	30	23
2017	5 290	677	1 892	1 556	47	2017	113 212	2	36	92	5
2018	5 405	2 334	1 127	4 643	98	2018	59 537	28	28	128	6
2019	3 465	795	328	1 447	44	2019	97 346	11	26	84	12
2020	3 469	417	563	2 302	99	2020	90 032	14	30	101	8
2021	3 700	159	1 024	3 663	76	2021	82 305	17	28	104	8
2022	3 112	154	1 215	1 301	20	2022	89 894	14	28	96	9
2023	2 702	209	680	1 271	14	2023	87 410	15	29	101	8

Notes : Red indicates missing values estimated using a 3-year moving average; yellow highlights effort and catch values outside usual ranges or trends. All catch data were converted to tonnes prior to analysis.

Source: Author’s own elaboration based on figures provided by IMAR (Marine Institute, Cabo Verde).

In addition to the data from IMAR, other data were also gathered for the assessment. This is the case for the fishing cost for which accurate and/or updated data were not available in the IMAR database. As an alternative, cost data that were collected during the SVC4SIDS value chain analysis conducted between February and December 2022 (Macías González *et al.*, 2025) were used in the bioeconomic modelling procedure. For this purpose, two types of fishing cost were distinguished: variable cost and fixed cost. The data were only collected in the industrial fisheries through key informant interviews with fishers. Similar fishing cost data were not available for the artisanal fisheries.

In addition to the basic fishing effort, the variable industrial fishing cost (**Table 4**) was disaggregated according to the length of three types of vessels. The different types of costs per day at sea were estimated by combining the average values. This also enabled the author to calculate a single average cost per unit of effort (CVE/day at sea) for the industrial fisheries. This parameter was multiplied by the total fishing effort (**Table 3**) to generate a time series of variable industrial fishing costs that is necessary for the economic part of the modelling procedure.

Data related to the fixed fishing cost (**Table 5**) were disaggregated by different types of expenses. It is important to note that in Cabo Verde there is no fixed wage. After discounting the variable costs and the insurance cost of the semi-industrial fishing vessel, the revenue is distributed by shares (60 percent to the vessel and 40 percent to the fishers). The depreciation was calculated based on the average lifespan of each item. This was assumed to be 15 years for the vessel hull, 10 years for the engine and 5 years for the fishing gear. The reimbursement of the investment loans was obtained based on an interest rate of 9 percent applied to the total amount of borrowed money estimated at CVE 45 million (USD 446 429) per vessel. This whole process enabled the author to calculate the total fixed cost per vessel which was multiplied by the number of active vessels to obtain the total fixed cost for all the industrial fisheries. This information was necessary for the bioeconomic modelling.

Table 4. Details of the variable industrial fishing costs data collected by the Sustainable Fish Value Chains for Small Island Developing States programme

Fishing effort parameters	Vessel 11 m	Vessel 14 m	Vessel 17 m	Average	Variable costs per day
Number of fishing trips per year	48	66	45	53	
Number of days per trip	6	4	4	5	
Variable costs (CVE)					
Fuel per trip	195 000	78 000	260 000	177 667	38 071
Ice per trip	72 000	54 000	108 000	78 000	16 714
Lubricant per year	480 000	360 000	300 000	380 000	1 536
Food per trip	30 000	30 000	30 000	30 000	6 429
Costs of landing per trip	3 000	3 000	3 000	3 000	643
Total variable costs	**780 000**	**525 000**	**701 000**	**668 667**	**63 394**

Source: Adapted from Macías González, J., Ichibane, M., Inejih, C. & Oliveira Almada, E. 2025. Chaînes de valeur du maquereau noir et des espèces apparentées au thon pêchés par la flotte semi-industrielle du Cabo Verde (*Value chains of mackerel scad and tuna-like species caught by the semi-industrial fishing fleet of Cabo Verde*). Rome, FAO. https://doi.org/10.4060/cd6715fr

Table 5. Details of the fixed fishing costs data collected by the Sustainable Fish Value Chains for Small Island Developing States programme

Fixed costs per vessel	Amount (CVE)
Fixed wages	0
Maintenance	2 250 000
Insurance	900 000
Fishing licence	30 333
Depreciation vessel hull	2 333 333
Depreciation engine	200 000
Depreciation fishing gear	1 600 000
Interest on investment loans	2 025 000
Total fixed costs per vessel	**9 338 667**

Source: Adapted from Macías González, J., Ichibane, M., Inejih, C. & Oliveira Almada, E. 2025. Chaînes de valeur du maquereau noir et des espèces apparentées au thon pêchés par la flotte semi-industrielle du Cabo Verde (*Value chains of mackerel scad and tuna-like species caught by the semi-industrial fishing fleet of Cabo Verde*). Rome, FAO. https://doi.org/10.4060/cd6715fr

2.3 Data analysis and modelling

2.3.1 Descriptive analysis of the fisheries profile

To characterize the fisheries profile, data were analysed using descriptive methods. This consisted of aggregating the data and calculating key statistical parameters such as the average values and proportions. This enabled the author to describe the baselines and trends of the main fisheries indicators, such as the fishing effort and catch per species. To facilitate an understanding of the fisheries profiles, the results were summarized using statistical tables and charts.

2.3.2 The surplus production model

Considering the four study species, a stock assessment exercise was implemented using the Bayesian state–space surplus production model framework JABBA (Winker, Carvalho and Kapur, 2018). JABBA (Just Another Bayesian Biomass Assessment) is a state–space Bayesian that is based on the generalized three parameters Pella-Tomlinson surplus production model (Pella and Tomlinson, 1969) formulated as below:

$$SP_t = \frac{r}{m\text{-}1} \cdot B_t \cdot \left(1\text{-}\left(\frac{B_t}{K}\right)^{m\text{-}1}\right)$$

where r is the intrinsic growth rate of the population, K is the unfished biomass at equilibrium (carrying capacity), while m is a shape parameter that determines the level at which the B/K ratio maximum surplus production is attained. If $0 < m < 2$, SP attains the maximum sustainable yield (MSY) at biomass levels smaller than $K/2$ (Schaefer, 1954); the converse applies for values of m greater than 2.

The Pella-Tomlinson model is reduced to a Fox model (Fox, 1970) if m approaches one, resulting in maximum surplus production at ~ 0.37 K, but there is no solution for the exact Fox surplus production with $m = 1$. The shape parameter m can be directly translated into the biomass level where MSY is achieved, B_{MSY}, via the ratio B_{MSY}/K:

$$\frac{B_{MSY}}{K} = m^{\left(\frac{-1}{m\text{-}1}\right)}, \text{ meaning that } \quad B_{MSY} = K \text{ x } m^{\left(\frac{-1}{m\text{-}1}\right)}$$

and the fishing mortality at MSY is: $$F_{MSY} = \frac{r}{m\text{-}1}\left(1\text{-}\frac{1}{m}\right)$$

Considering that the fishing mortality is an annual rate defined as:

$$F = \frac{C}{B}, \text{ then } MSY = F_{MSY} B_{MSY}$$

JABBA is a Bayesian state–space model where the biomass B_y in year y is expressed as a proportion of K (i.e. $P_y = B_y/K$) to improve the efficiency of the estimation algorithm. The initial biomass in the first year of the time series is scaled by introducing model parameter φ to estimate the ratio of the spawning biomass in the first year to K. The stochastic form of the process equation is given by Winker, Carvalho and Kapur (2018):

$$P_y = \begin{cases} \varphi e^{\eta_y} & \text{for} y = 1 \\ \left(P_{y-1} + \frac{r}{(m-1)} P_{y-1} \left(1 - {P_{y-1}}^{m-1}\right) - \frac{\sum_f C_{f,y-1}}{K} \right) e^{\eta_y} & \text{for} P_{y-1} \geq P_{\lim} \ \& \ y = 2, 3, \ldots, \mathrm{n} \\ \left(P_{y-1} + \frac{r}{(m-1)} P_{y-1} \left(1 - {P_{y-1}}^{m-1}\right) \frac{P_{y-1}}{P_{\lim}} - \frac{\sum_f C_{f,y-1}}{K} \right) e^{\eta_y} & \text{for} P_{y-1} < P_{\lim} \ \& \ y = 2, 3, \ldots, \mathrm{n} \end{cases}$$

where η_y is the process error, with $\eta_y \sim N(0, \sigma_\eta^2)$; process variance ($\sigma_\eta^2$) can be either fixed or estimated. If estimated, the process variance prior is implemented using an inverse gamma distribution; $C_{f,y}$ is the catch in year y by fishery f.

The observation equation is given by:

$$I_{i,y} = q_i B_y e^{\varepsilon_{y,i}}$$

where q_i is the estimable catchability coefficient associated with the abundance index i, and $\varepsilon_{y,i}$ is the observation error, with $\varepsilon_{y,I} \sim N(0, \sigma_{\varepsilon,y,i}^2)$; $\sigma_{\varepsilon,y,i}^2$ is the observation variance in year y for index i.

Stock status estimates from the JABBA model can be visually classified based on colour-coded biplots that project the biomass (B_y) and harvest rate ($F_y = C_y/B_y$) at year y as relative to their MSY-based reference points (B_y/B_{MSY} and F_y/F_{MSY}). Using the JABBA R package, a Kobe phase plot is produced to represent the status of the stock in terms of B_y/B_{MSY} on the x-axis and F_y/F_{MSY} on the y-axis. The Kobe phase plot is divided into four quadrants, defined for the current stock biomass and fishing mortality relative to B_{MSY} and F_{MSY}, respectively:

- green quadrant if By/BMSY > 1 and Fy/FMSY < 1 (not fully exploited);
- red quadrant if By/BMSY < 1 and F/FMSY > 1 (overexploited stock);
- yellow quadrant if By/BMSY < 1 and Fy/FMSY < 1 (low mortality that may result in a recovering biomass); and
- orange quadrant if By/BMSY > 1 and Fy/FMSY > 1 (high mortality that may lead to overexploitation).

Different grey-shaded areas denote the 50 percent, 80 percent and 95 percent credibility interval for the terminal assessment year. The probability of terminal year points falling within each quadrant is indicated in the figure's legend.

In conjunction with the Kobe plot, the JABBA R package also produces the "SP-phase-plot", which plots the surplus production (SP) curve along with the catch trajectory (y-axis) over the biomass range between 0 and K (x-axis). Conceptually, if current catch falls in the area below the *SP* curve, biomass is predicted to increase, given that *SP* > catch. The maximum *SP* is equivalent to MSY, which corresponds to B_{MSY} on the x-axis. The inflection point at MSY is highlighted, together with a shaded area denoting its 95 percent credibility region. The plot background follows the colour scheme of the Kobe phase plot to facilitate interpretation. Additionally, it superimposes plot regions where biomass can recover under a constant quota while in the red overfished state ($B < B_{\mathrm{MSY}}$, $F > F_{\mathrm{MSY}}$, but $SP >$ catch). On the other hand, a constant quota would lead to overfishing if catch is above MSY despite the stock currently being in the green "sustainable" quadrant ($F < F_{\mathrm{MSY}}$, $B > B_{\mathrm{MSY}}$, but MSY < Catch).

2.3.3 The bioeconomic model

The bioeconomic model was based on a combination of the Gordon Model (Gordon, 1954) and the Bayesian Pella-Tomlinson model (JABBA model). This combination relies on three elementary functions:

- the biomass function: $\mathrm{B} = \mathrm{K}\left(\frac{q}{r} \cdot E\,(1\text{-}m)+1\right)^{\frac{1}{m-1}}$
- the catch function: $Q = q.E.B$
- the total cost function: $TC=VC+FC=c.E+FC$

where *VC* and *CF* are respectively the variable cost and fixed cost, and *c* is the fishing effort cost unit (e.g. cost per fishing day or day at sea).

With these considerations, the equations below enable the calculation of the economic indicators of the model, namely the fishing revenue (*RV*), the fishing profit (*FP*) and the fishing rent (*RT*):

$$RV=p.Q=p.q\cdot E\cdot K\left(\frac{q}{r}\cdot E\,(1\text{-}m)+1\right)^{\frac{1}{m-1}}$$

$$FP=RV\text{-}TC=\left(p.q\cdot E\cdot K\left(\frac{q}{r}\cdot E\,(1\text{-}m)+1\right)^{\frac{1}{m-1}}\right)\text{-}(c.E+FC)$$

$$RT=RV\text{-}VC=\left(pq\cdot E\cdot K\left(\frac{q}{r}\cdot E\,(1\text{-}m)+1\right)^{\frac{1}{m-1}}\right)\text{-}\ c.E$$

Based on the above equations, the bioeconomic model enables the estimation of the maximum economic yield (MEY). In relation to the fishing effort, it corresponds to the maximum fishing rent, meaning the value of the largest positive difference between total revenues and variable fishing cost. Compared to the MSY, the MEY is the most appropriate objective of fisheries management because it ensures that the net benefit to the society from the fishery is maximized.

In this study, the biological part of the modelling was implemented by considering both the industrial and the artisanal fisheries. However, only the industrial fisheries were analysed in the economic modelling. This was justified by the fact that fishing cost data are not available for the artisanal fisheries. Notably, the four study species are mainly exploited by the industrial fishing fleet, which allows a more accurate and relevant economic analysis.

3. PROFILE OF THE STUDY'S KEY RESOURCES

3.1 The fishing capacity

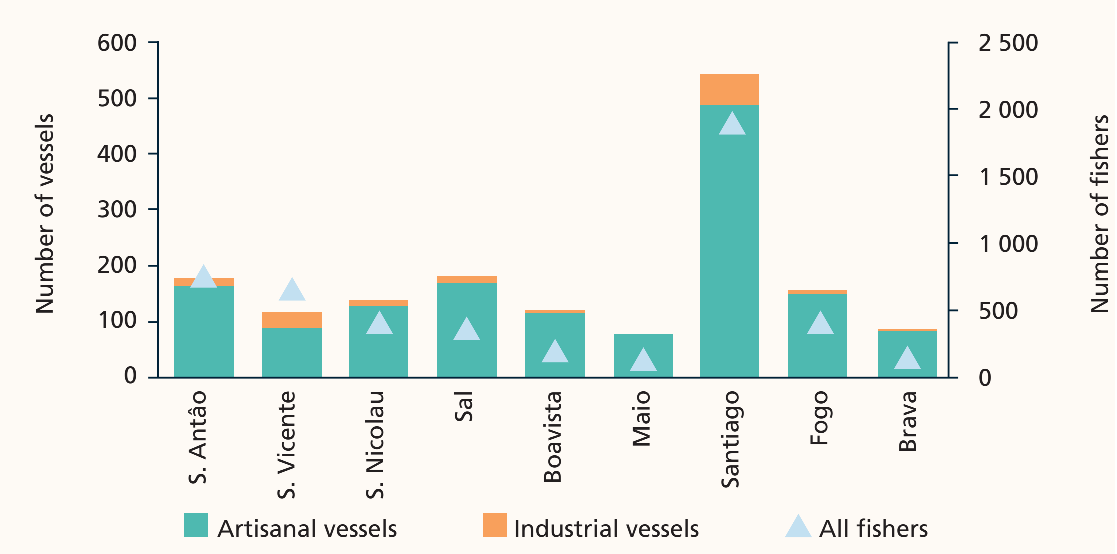
In terms of characteristics, artisanal vessels are mainly built of wood, but some of them are covered with fibreglass. They use non-mechanized fishing gears and preserve their catches with only ice. They usually have two to four fishers using handlines. The artisanal fishing fleet targets mainly demersal species and tuna on trips not exceeding half a day. In contrast, the semi-industrial fishing vessels measure between 8 m and 24 m. They are equipped with mechanical engines as well as with navigation and fishing tools such as radar, depth sounder, radio, etc. With an autonomy that may exceed 72 hours at sea, the semi-industrial fishing fleet is essentially made up of purse seiners targeting small tunas and a variety of small pelagic fish. The industrial fishing vessels measure more than 24 m and are generally longliners and purse seiners.

According to the latest general fisheries census (IMAR/INE, 2022), the number of vessels was 1 463 for the artisanal fisheries and 127 for the semi-industrial/industrial fisheries. The fishing capacity was greatest in the island of Santiago (**Figure 1**) where a third of the artisanal fishing fleet and 43 percent of the industrial fishing vessels were based. Of the total 5 083 fishers counted in Cabo Verde, 35 percent were also based on this island. At a national scale, a large proportion of all fishers (80 percent) operate in the artisanal fisheries. In some islands, including Boavista, Brava and above all, Maio, the industrial fisheries activity was almost non-existent.

3.2 The fishing effort

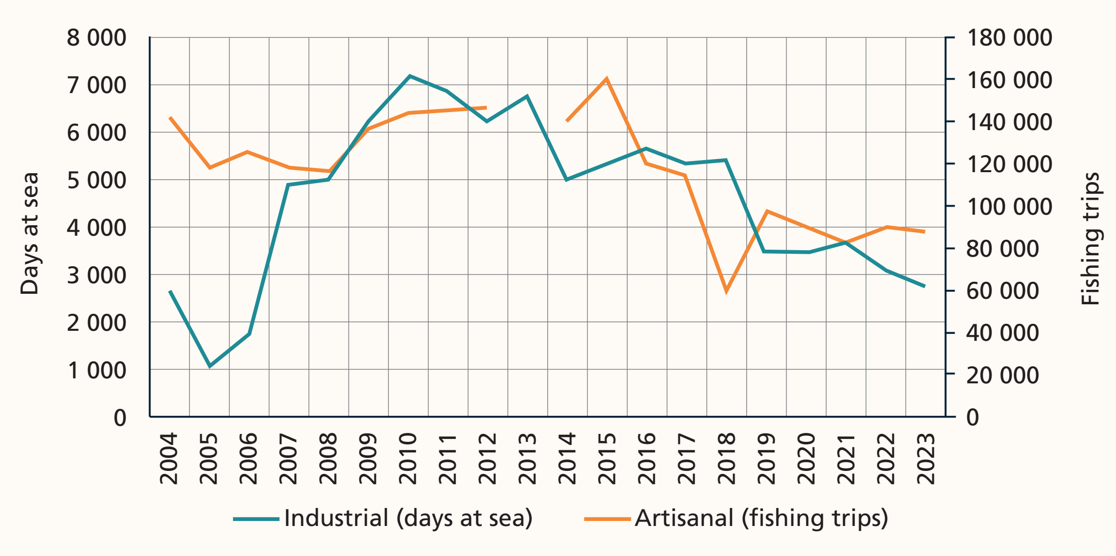
For both the artisanal and industrial fisheries, the evolution of fishing effort was characterized by two major phases over the last two decades (**Figure 2**). The industrial fishing effort was first marked by a very rapid growth between 2005 and 2010. During these five years, fishing effort increased almost sevenfold, from 1 068 to a peak of 7 197 days at sea. However, in the following years, the industrial fishing effort was characterized by a downward trend, reaching 2 702 days at sea in 2023.

Figure 1. Number of artisanal and industrial fishing vessels and fishers by island



Source: Author's own elaboration based on IMAR/INE (Marine Institute/National Institute of Statistics). 2022. *Fifth general fisheries census 2021*. Mindelo, Cabo Verde.

Figure 2. Artisanal and industrial fishing effort over the past two decades



Source: Author's own elaboration based on figures provided by IMAR (Marine Institute, Cabo Verde).

In the case of the artisanal fisheries, during the decade from 2004 to 2014, fishing effort generally fluctuated around 130 000 fishing trips per year. After reaching a peak of 158 542 trips in 2015, the artisanal fishing effort decreased. Thus, in just four years it was divided by almost three to reach its lowest level in the past decade (59 537 trips in 2018). More recently, effort has been relative stable at around 90 000 trips per year.

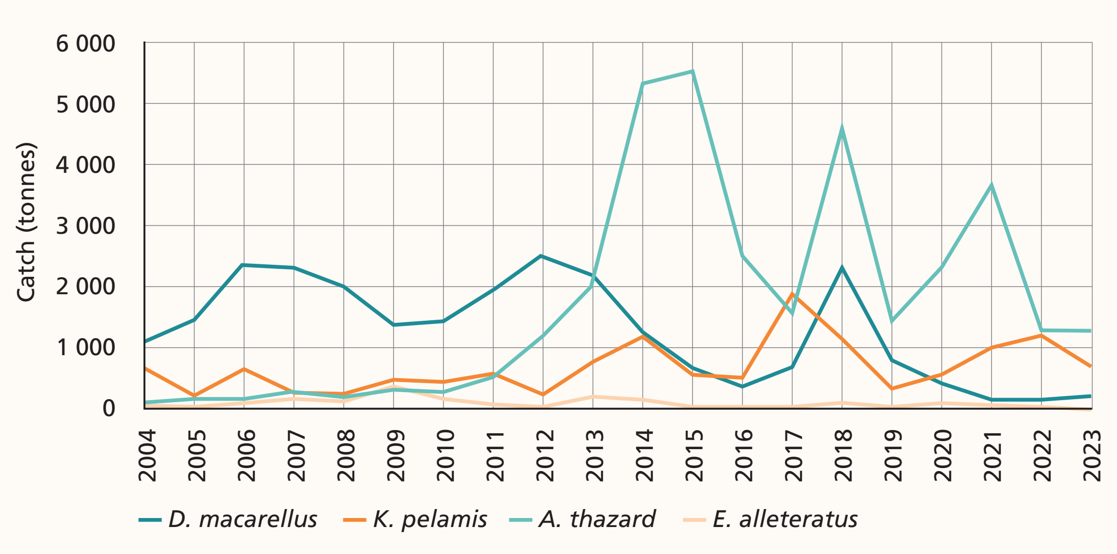
3.3 Fish catches

3.3.1 The industrial fishing catch

According to Macías González *et al.* (2025), the most recent industrial fisheries catch was essentially made up of small tunas or tuna-like fish (about 64 percent) and mackerels (27 percent). The catch of mackerel scad accounted for 92 percent of all mackerel species caught. In the industrial fisheries, the catch of the four study species was characterized by strong fluctuations, especially over the past decade (**Figure 3**).

From 2004 to 2012, the mackerel scad catch was around 2 000 tonnes per year, representing up to 77 percent of the total production of the four species. During that period, the catch of each of the three other species rarely exceeded 300 tonnes. However, over the following decade, in contrast to the downward trend noted for mackerel scad, higher but highly variable catches were recorded for frigate tuna and skipjack tuna. For instance, from only 516 tonnes in 2011, the landed catch of frigate tuna reached a peak of 5 532 tonnes in 2015, before falling to 1 556 tonnes two years later. In the case of skipjack tuna, following a peak of nearly 2 000 tonnes in 2017, the production was around 1 000 tonnes in recent years. Unlike the larger catches recorded in the early 2010s, catches of little tunny have been very low in recent years.

Figure 3. Industrial fisheries catch by species over the past two decades

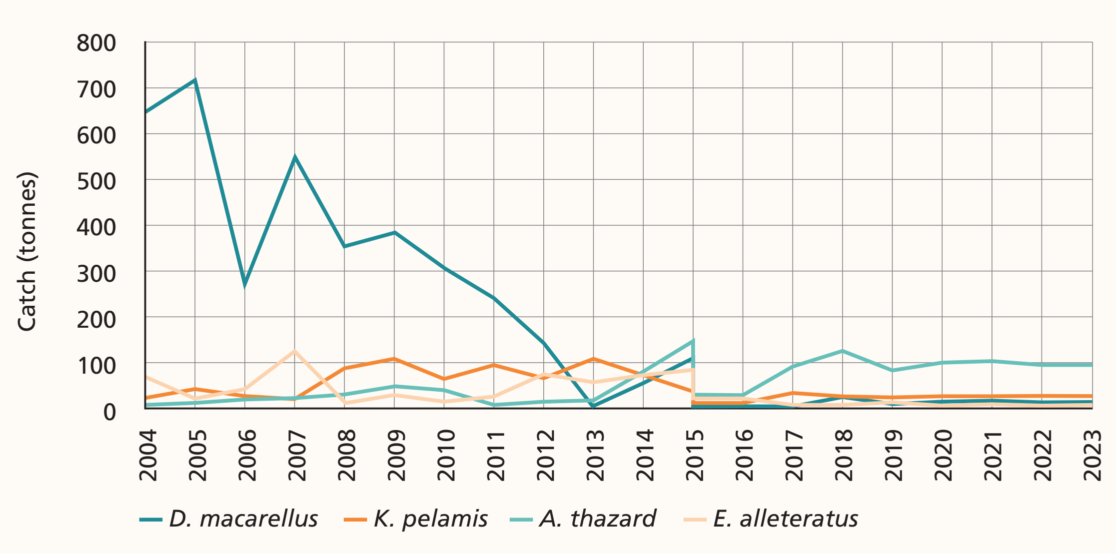


Source: Author's own elaboration based on figures provided by IMAR (Marine Institute, Cabo Verde).

3.3.2 The artisanal fishing catch

Among the four study species, mackerel scad was the dominant species in terms of the volume of catch taken by the artisanal fisheries between 2004 and 2012 (**Figure 4**). For instance, the highest level of production was achieved in 2005 with 717 tonnes, representing 33 percent of total catch (industrial fisheries included). However, at the same time, the catch of this species in the artisanal fisheries was characterized by a marked decrease. Since 2015, the production barely exceeded 15 tonnes per year, corresponding to less than 10 percent of the total catch (industrial fisheries included). In the case of the three other species, their individual catch was usually below 100 tonnes per year. Whereas catches of skipjack tuna and little tunny were very low in recent years, considerable improvement was noted for frigate tuna.

Figure 4. Artisanal fisheries catch by species over the past two decades



Source: Author's own elaboration based on figures provided by IMAR (Marine Institute, Cabo Verde).

3.4 The economic key parameters

3.4.1 The fishing costs

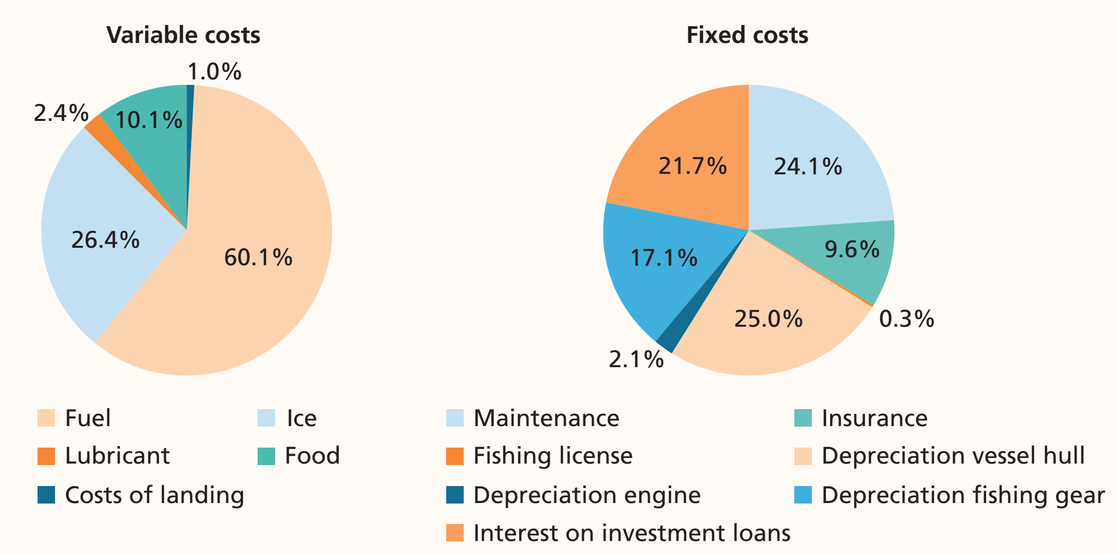
Based on available data, the total variable cost per industrial fishing effort is, on average CVE 63 394 (USD 629) per day at sea. Fuel is the most important component of the variable fishing costs, accounting for 60.1 percent of total daily expenses (**Figure 6**). The use of ice to preserve the catch is also relatively costly at CVE 16 714 (USD 166) per day, corresponding to 26.4 percent of total costs. Diverse costs are incurred during landing, but their proportion of total costs is negligible.

The total annual fixed cost exceeds CVE 9 million (USD 89 286) per vessel. The main components (**Figure 5**) are related to the depreciation of the vessel hull (25 percent) and to vessel maintenance (24.1 percent). However, the depreciation of the fishing gear and the payment of loan-related interest are also very important. Such annual fixed costs may vary from CVE 1.5 million (USD 14 877) to CVE 2 million (USD 19 841) per vessel. Because of the long lifespan of the engine, its depreciation is the lowest fixed cost.

3.4.2 The ex-vessel fish prices

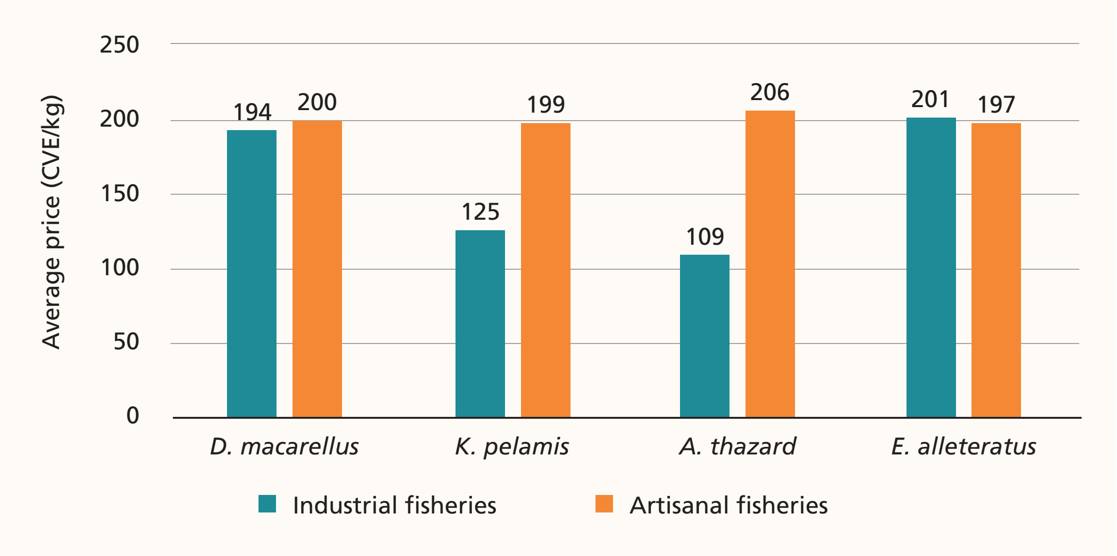
Over the past three years (2021 to 2023), the ex-vessel prices of the four study species were almost the same in the industrial fisheries, with average levels around CVE 200 (USD 1.98) per kilogram (**Figure 6**). In the case of the artisanal fisheries, the price of mackerel scad and little tunny was much higher than the price of the two other species. Their prices were almost the same as those achieved by the industrial fisheries. However, they were considerably lower for skipjack tuna and frigate tuna at CVE 125 per kg and CVE 109 per kg, respectively.

Figure 5. Components of the industrial fishing costs (in percent)



Source: Adapted from Macías González, J., Ichibane, M., Inejih, C. & Oliveira Almada, E. 2025. Chaînes de valeur du maquereau noir et des espèces apparentées au thon pêchés par la flotte semi-industrielle du Cabo Verde (*Value chains of mackerel scad and tuna-like species caught by the semi-industrial fishing fleet of Cabo Verde*). Rome, FAO. https://doi.org/10.4060/cd6715fr

Figure 6. Average fish price by species in the industrial and artisanal fisheries



Source: Author’s own elaboration based on figures provided by IMAR (Marine Institute, Cabo Verde).

4. BIOECONOMIC STATUS OF THE KEY RESOURCES

4.1 Status of mackerel scad

4.1.1 Abundance index of mackerel scad

Despite considerable fluctuations in terms of total catch, the catch per unit effort (CPUE) of mackerel scad in the industrial fisheries has been characterized by a rapidly decreasing trend since the mid-2000s (**Figure 7**). The recent value of CPUE was only about 6 percent of the highest level recorded in 2005 (1 371 kg/day at sea). This situation may be a sign of a long-term rarefaction of the fraction of the stock exploited by both the industrial and artisanal fishing fleets in Cabo Verde.

4.1.2 Stock assessment indicators of mackerel scad

The implementation of the JABBA-based Pella-Tomlinson model estimated that the mackerel scad carrying capacity (K) and its intrinsic growth rate (r) were 5 593 tonnes and 2.57 tonnes, respectively. Its estimated catchability (q) is equal to 0.16 with an MSY of 2 641 tonnes. Over the past two decades, key indicators related to the mackerel scad stock have shown signs of long-term degradation (**Figure 8**). The annual biomass (B) sharply decreased over this period. Therefore, in recent years it represented a very low proportion (about 20 percent to 30 percent) of the optimal and virgin situation (BMSY and B0). Fishing mortality (F), that was fluctuating slightly around one, decreased in recent years.

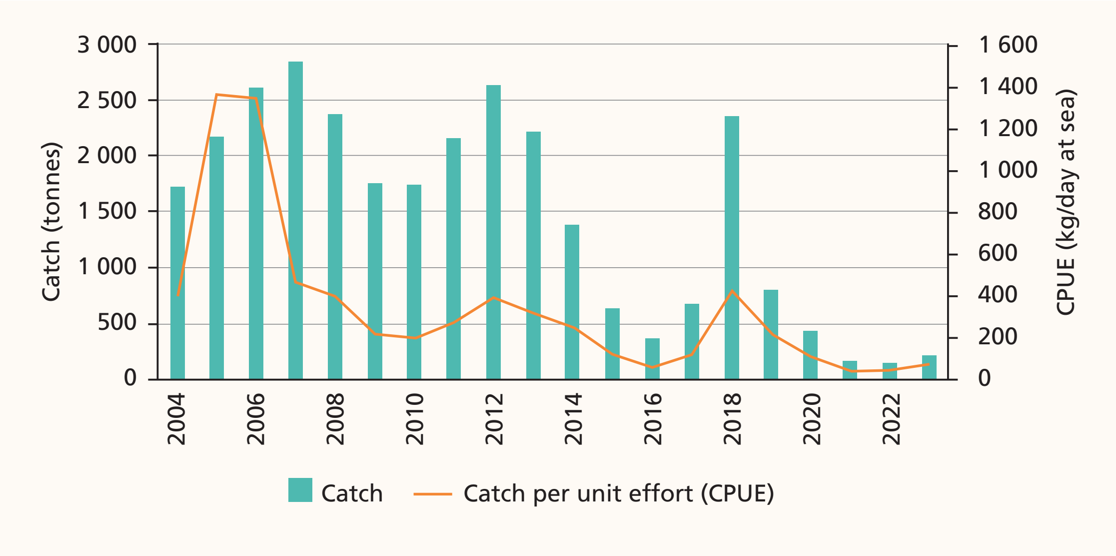
4.1.3 State of exploitation of mackerel scad

The mackerel scad exploitation trajectory shows that this species experienced intense fishing pressure and in the past decade, some annual mortality rates were beyond the sustainable yield level (**Figure 9**). Consequently, the annual biomass with regard to the surplus production indicated a critical situation for mackerel scad. However, decreasing fishing effort has generated some improvement. In 2023 the mackerel scad stock was likely in a recovering situation (probability of 71.9 percent).

4.1.4 Economic indicators of mackerel scad

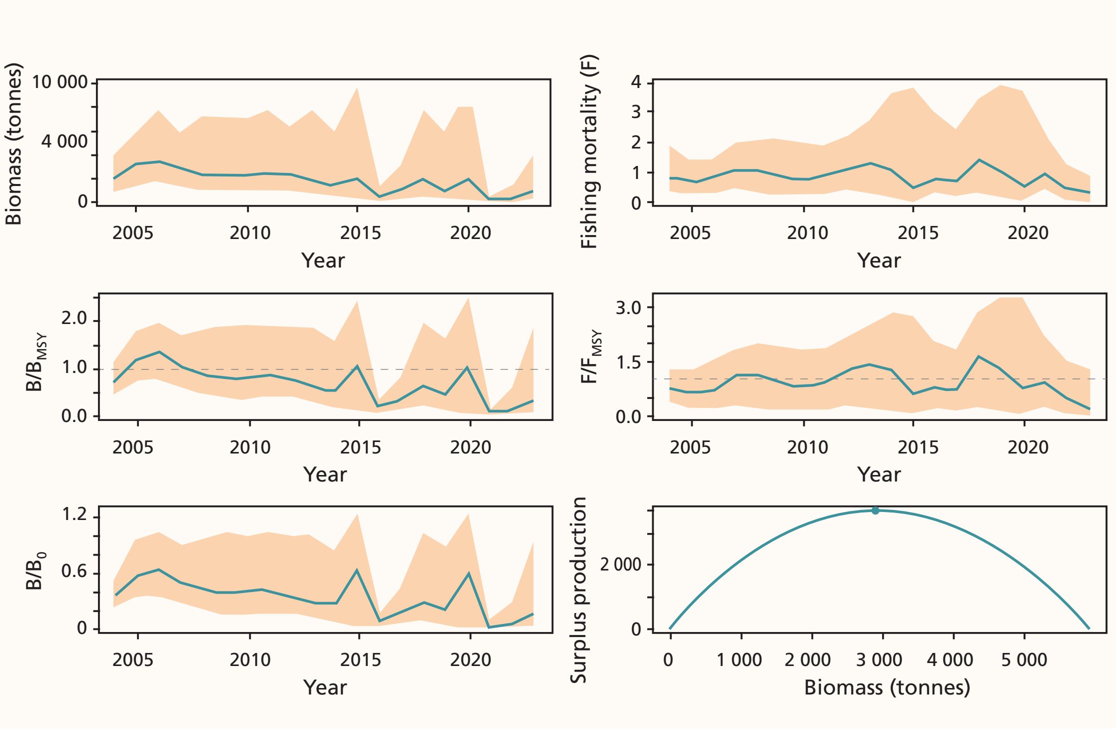
Based on the bioeconomic model, the maximum revenue that may be generated from the industrial exploitation of mackerel scad is estimated to be CVE 677 million (USD 6.7 million) (**Figure 10**). The MEY is equal to CVE 256 million (USD 2.5 million). This economic reference value corresponds to a fishing effort of 4 900 days at sea. It is almost double the level recorded in 2023 but half of the fishing effort corresponding to the MSY. Because of the high variable cost of a fishing unit, the fishing rent may become negative beyond 10 000 days at sea. On the other hand, the annual fixed cost is so significant that the mackerel scad production is unable to generate a positive profit for the industrial fisheries.

Figure 7. Total catch and catch per unit effort in the industrial fisheries for mackerel scad



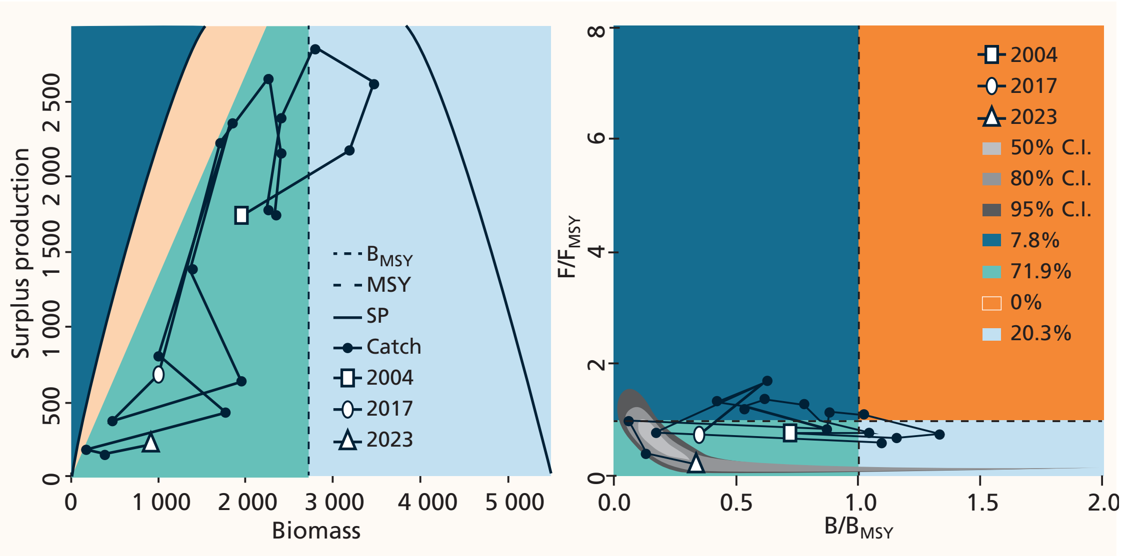
Source: Author's own elaboration based on figures provided by IMAR (Marine Institute, Cabo Verde).

Figure 8. Key indicators of exploitation of mackerel scad



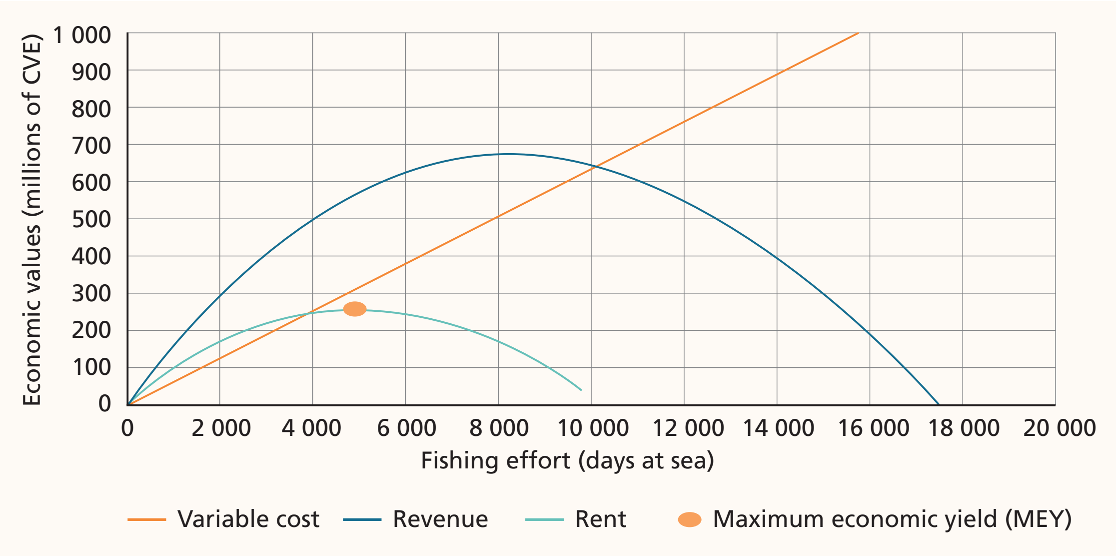
Source: Author's own elaboration based on the JABBA model.

Figure 9. Kobe phase plot of the state of exploitation of mackerel scad



Source: Author's own elaboration based on the JABBA model.

Figure 10. Major economic indicators of mackerel scad



Source: Author's own elaboration based on the JABBA model.

4.2 Status of skipjack tuna

4.2.1 Abundance index of skipjack tuna

As with the total catch, the CPUE for skipjack tuna in the industrial fisheries is characterized by strong fluctuations (**Figure 11**). Although there is no clear trend, high CPUE was noted in recent years, most notably 400 kg/day at sea in 2022. In view of the downward trend in fishing mortality over the past decade, this may mean the skipjack tuna stock has the potential to provide more catch. However, this is not always guaranteed and multiple factors that may not only be linked to the characteristics of the local fisheries may be involved in the inter-annual abundance of this species in the marine waters of Cabo Verde.

4.2.2 Stock assessment indicators of skipjack tuna

Based on the JABBA-based Pella-Tomlinson model, the carrying capacity of skipjack tuna (K) and its intrinsic growth rate (r) were estimated to be 1 900 tonnes and 2.67 tonnes, respectively. Its estimated catchability is 0.240, with an MSY of 1 220 tonnes. Signs of recent improvement were noted for skipjack tuna over the past two decades (**Figure 12**). The annual biomass (B) has increased since the mid-2010s and even exceeded its optimal level (BMSY) from 2021 to 2023. In the past, the fishing mortality rate was very high. However, with about 60 percent to 70 percent of the sustainable level (FMSY), recent fishing mortality has been relatively low.

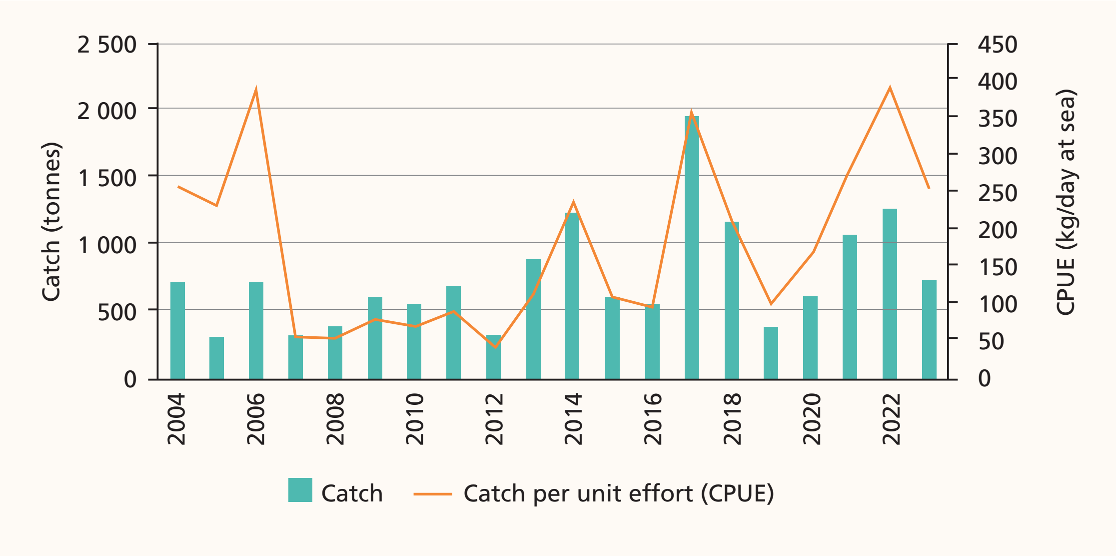
4.2.3 State of exploitation of skipjack tuna

Due to a very unstable exploitation trajectory, the status of the skipjack tuna stock is relatively uncertain (**Figure 13**). In the past, the stock was threatened by intense fishing mortality that was much higher than the sustainable level (FMSY). At the same time, the biomass was generally less than 60 percent of BMSY. However, in the recent period, the situation was much better because of lower mortality rates. In 2023, the skipjack tuna stock was classified as not being fully exploited (probability of 63.8 percent).

4.2.4 Economic indicators of skipjack tuna

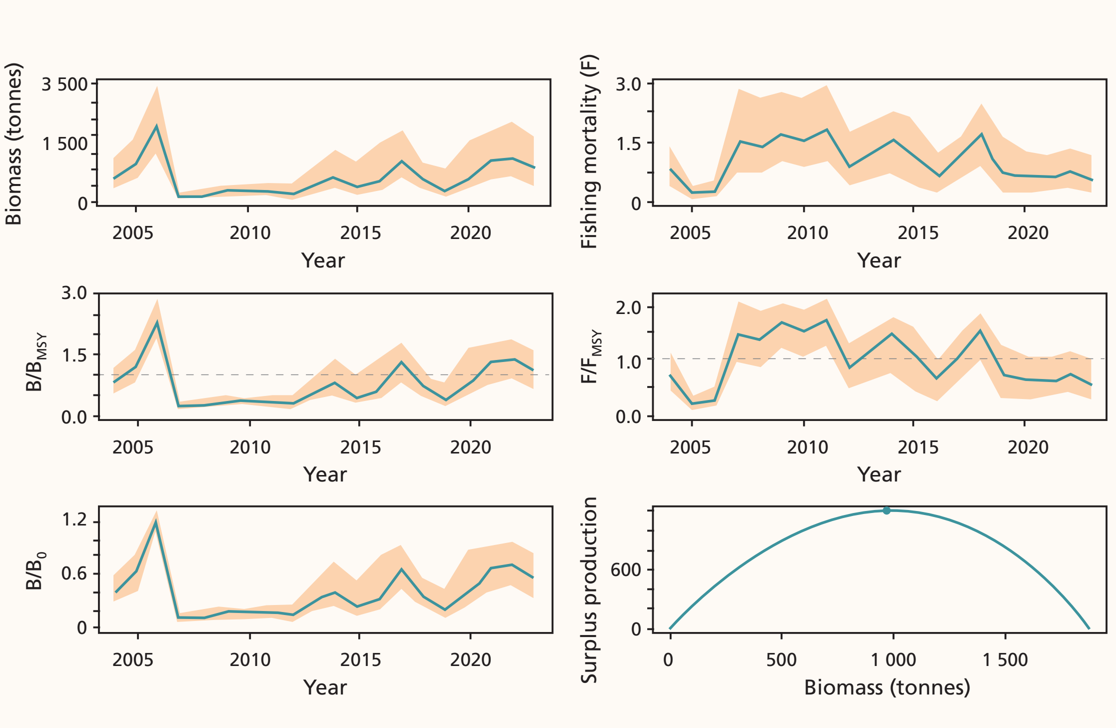
For skipjack tuna, the maximum revenue that may be generated by the industrial fisheries is CVE 183 million (USD 1.8 million) (**Figure 14**). The corresponding fishing effort is only 500 days at sea which are sufficient to achieve the MEY, estimated to be CVE 151 million (USD 1.5 million). Because of the considerable variable costs, the fishing rent may become negative in the case of the fishing effort exceeding 900 days. The fishing profit for skipjack tuna is negative because the total costs are higher than the revenue that may be generated from the catch.

Figure 11. Total catch and catch per unit effort in the industrial fisheries for skipjack tuna



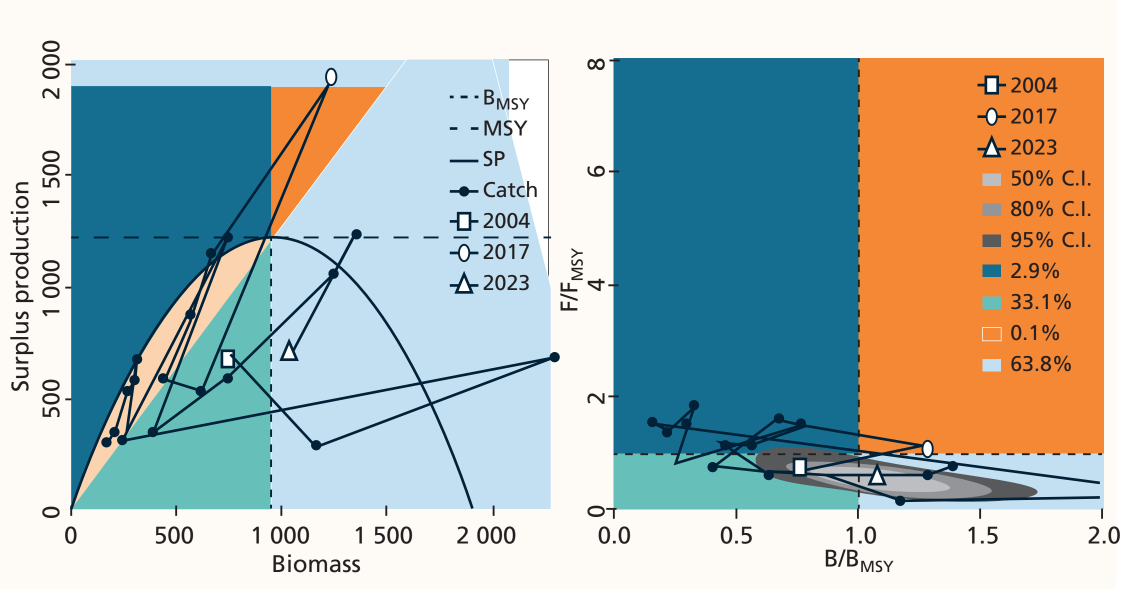
Source: Author’s own elaboration based on figures provided by IMAR (Marine Institute, Cabo Verde).

Figure 12. Key indicators of exploitation of skipjack tuna



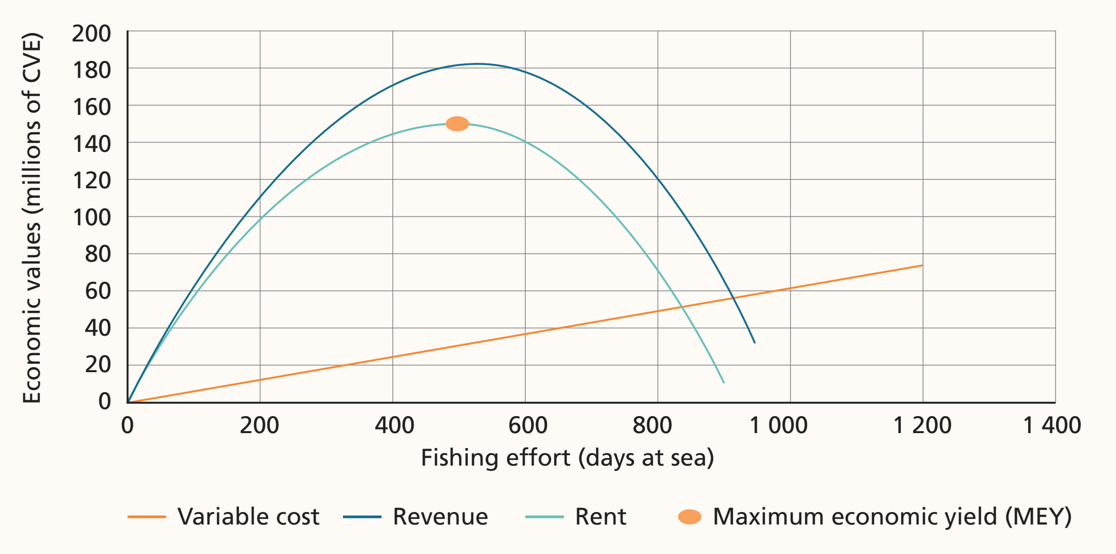
Source: Author’s own elaboration based on the JABBA model.

Figure 13. Kobe phase plot of the state of exploitation of skipjack tuna



Source: Author's own elaboration based on the JABBA model.

Figure 14. Major economic indicators of skipjack tuna



Source: Author's own elaboration based on the JABBA model.

4.3 Status of frigate tuna

4.3.1 Abundance index of frigate tuna

Both the total catch and CPUE for frigate tuna in the industrial fisheries are characterized by considerable fluctuations (**Figure 15**). While this species was not exploited until 2010, its catch and corresponding CPUE increased rapidly in the following years. The highest values of CPUE (1 000 kg/day at sea) were reached during this period. Despite the upward trend in fishing effort, the CPUE remained high in some years. This may mean that the frigate tuna stock has the potential to provide more catch, but this is not always guaranteed and factors that are external to the local fisheries may considerably influence the inter-annual abundance of this species.

4.3.2 Stock assessment indicators of frigate tuna

Using the JABBA-based Pella-Tomlinson model, the frigate tuna carrying capacity (K) and its intrinsic growth rate (r) are estimated at 17 158 tonnes and 0.64 tonnes, respectively. The estimated catchability is equal to 0.018 with an MSY of 3 885 tonnes. Despite a slightly lower biomass since 2016 (**Figure 16**), it was still higher than its optimal level (BMSY). Similarly, despite a recent increase, the fishing morality rate remained relatively low, representing about 30 percent of the sustainable level (FMSY) from 2022 to 2023.

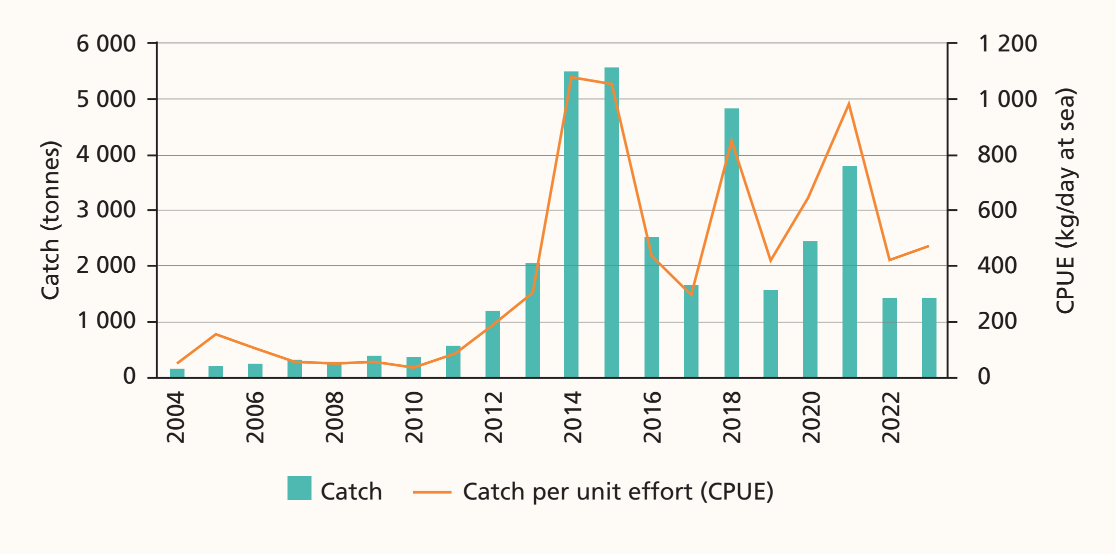
4.3.3 State of exploitation of frigate tuna

Despite a certain instability in its exploitation trajectory, over the past two decades the status of the frigate tuna stock has never been critical (**Figure 17**). While the biomass exceeded its biologically optimal level (BMSY), the fishing mortality applied to this species was low. It is highly probable (99.2 percent) that in 2023, frigate tuna was not fully exploited.

4.3.4 Economic indicators of frigate tuna

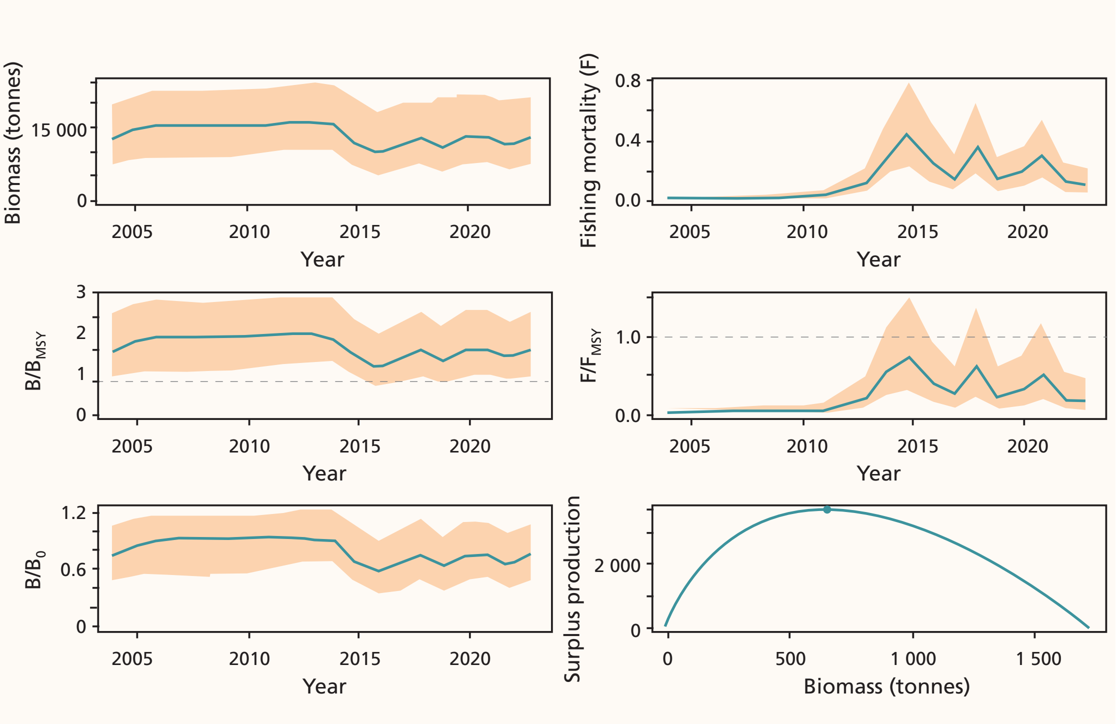
The maximum fishing revenue estimated for frigate tuna is CVE 435 million (USD 4.3 million) corresponding to about 4 000 days at sea (**Figure 18**). However, the MEY is CVE 236 million (USD 2.3 million) corresponding to 2 500 days at sea, which is below the current level (2023). While positive revenues can be obtained from a very high level of fishing effort (more than 15 000 days at sea), the fishing rent may rapidly become negative beyond 6 000 days.

Figure 15. Total catch and catch per unit effort in the industrial fisheries for frigate tuna



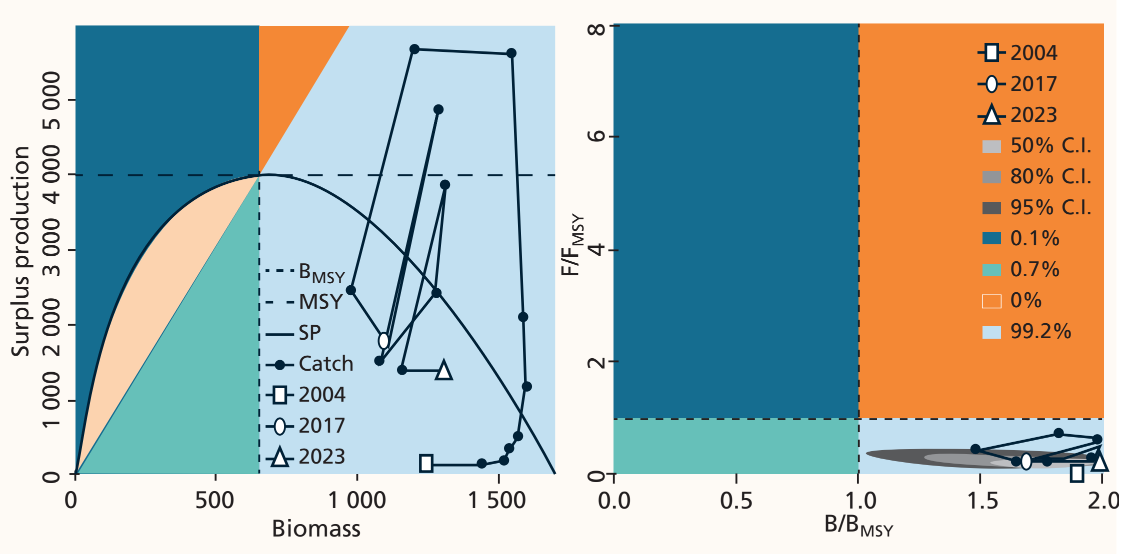
Source: Author's own elaboration based on figures provided by IMAR (Marine Institute, Cabo Verde).

Figure 16. Key indicators of exploitation of frigate tuna



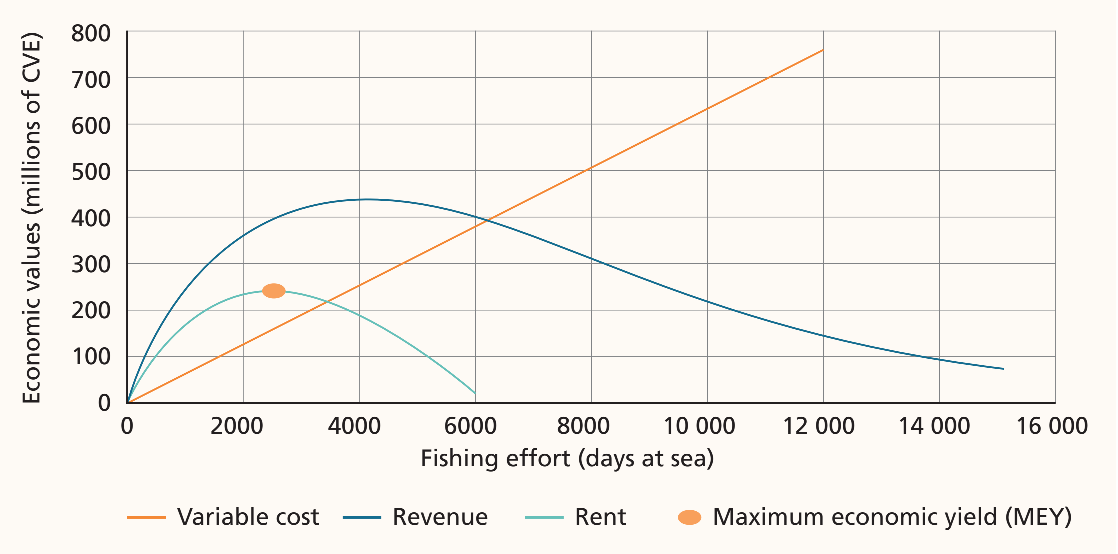
Source: Author's own elaboration based on the JABBA model.

Figure 17. Kobe phase plot of the state of exploitation of frigate tuna



Source: Author's own elaboration based on the JABBA model.

Figure 18. Major economic indicators of frigate tuna



Source: Author's own elaboration based on the JABBA model.

4.4 Status of little tunny

4.4.1 Abundance index of little tunny

Although there are important fluctuations in the total catch of little tunny, the CPUE in the industrial fisheries is characterized by a downward trend (**Figure 19**). The recent value of CPUE barely exceeded 5 kg/day at sea, corresponding to about 1 percent of its level in 2009. This situation may potentially be a sign of a long-term severe scarcity of this species with regard to the fraction of stock exploited by both the industrial and artisanal fishing fleets in Cabo Verde.

4.4.2 Stock assessment indicators of little tunny

The JABBA-based Pella-Tomlinson model estimated that the little tunny carrying capacity (K) and its intrinsic growth rate (r) are 1 217 tonnes and 0.39 tonnes, respectively. The estimated value of catchability is 0.069 with an MSY of 158 tonnes. Over the past two decades, key indicators related to the state of little tunny biomass and fishing mortality showed signs of long-term degradation (**Figure 20**). The annual biomass (B) sharply decreased over this period. In recent years, it represented a very low proportion (about 20 percent to 30 percent) of the optimal situation (BMSY). However, despite its relatively low level between 2022 and 2023, the fishing mortality (F) was very high in the past. For instance, between 2020 and 2021, the fishing mortality was twice as high as its biologically optimal level (FMSY).

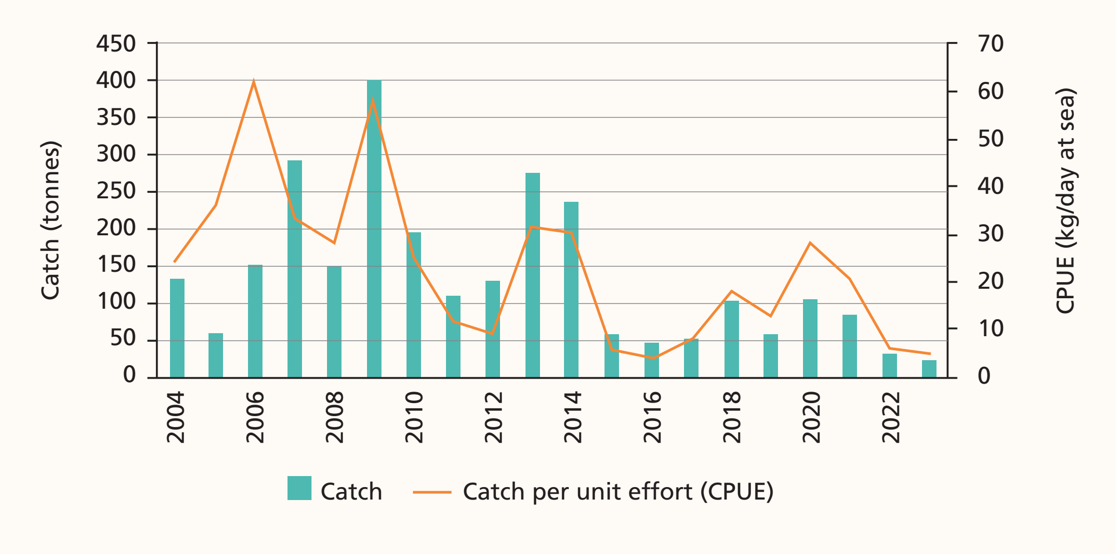
4.4.3 State of exploitation of little tunny

Little tunny experienced intense fishing pressure in the past. Over the past decade, most of the annual mortality rates were far beyond the sustainable level (**Figure 21**). The low level of biomass and surplus production also tend to confirm the past critical situation of this species. However, due to the long-term decrease in fishing effort and lower mortality rates, recent improvements have been noted. In 2023, the little tunny stock may have been in a recovering state (probability of 88.8 percent).

4.4.4 Economic indicators of little tunny

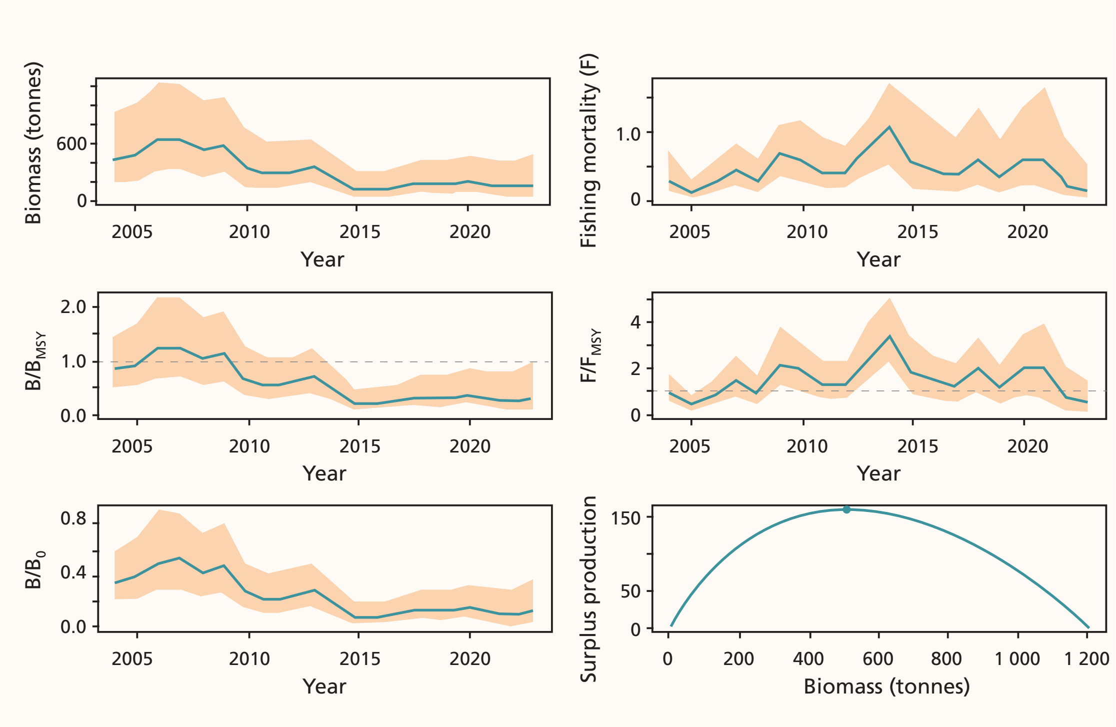
Among the four study species, little tunny in particular generates a fishing revenue below the variable fishing cost (**Figure 22**) and is a species for which the fishing rent is negative. This is due to the very low level of catch, with a maximum value estimated by the bioeconomic model of only CVE 21 million (USD 208 333). The highest revenue may be obtained from 2 500 days at sea.

Figure 19. Total catch and catch per unit effort in the industrial fisheries for little tunny



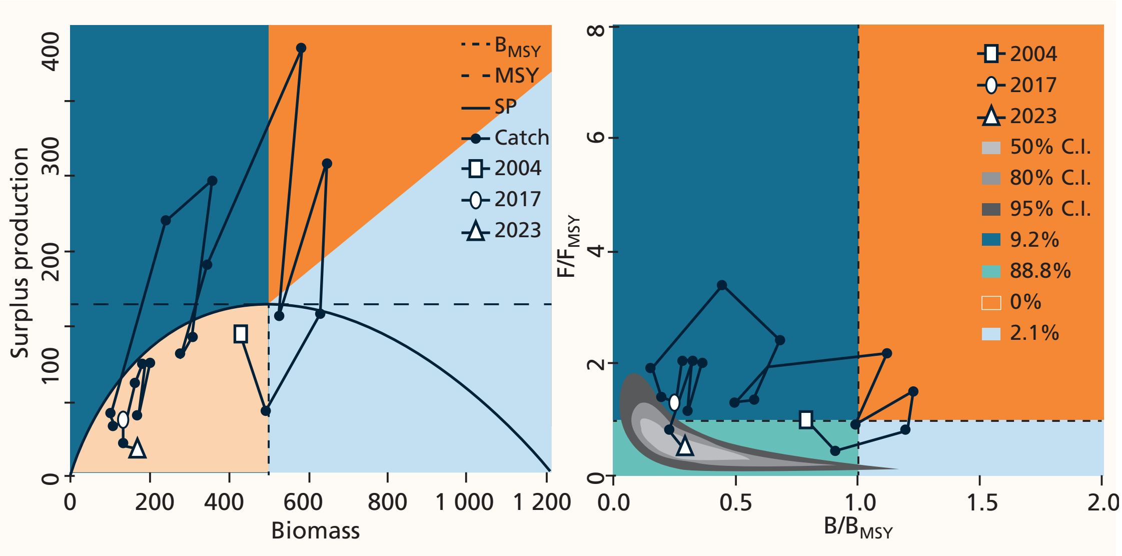
Source: Author's own elaboration based on figures provided by IMAR (Marine Institute, Cabo Verde).

Figure 20. Key indicators of exploitation of little tunny



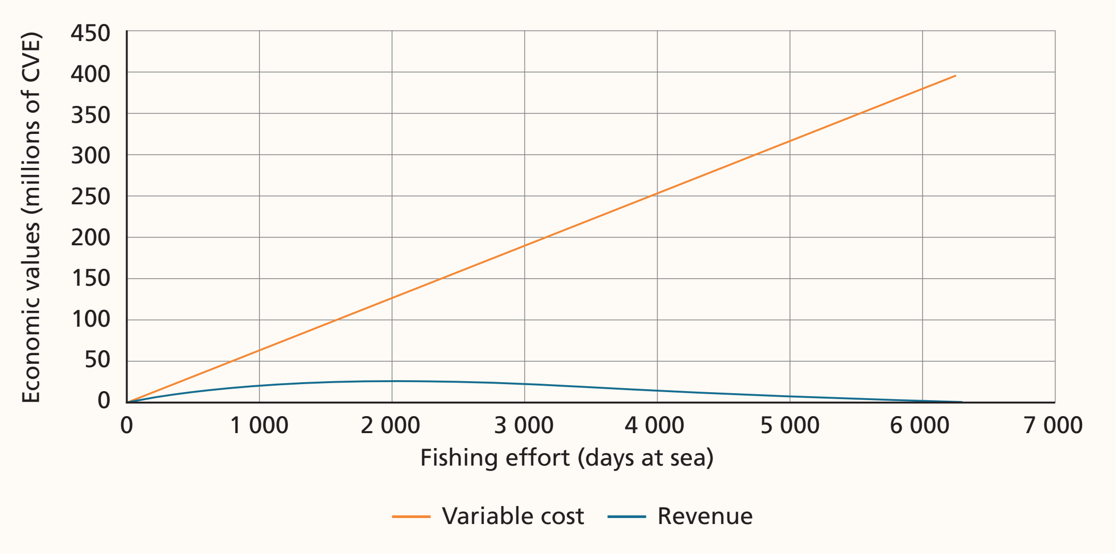
Source: Author's own elaboration based on the JABBA model.

Figure 21. Kobe phase plot of the state of exploitation of little tunny



Source: Author's own elaboration based on the JABBA model.

Figure 22. Major economic indicators of little tunny



Source: Author's own elaboration based on the JABBA model.

4.5 Study limitations

This preliminary bioeconomic assessment faced several data-related challenges that should be considered when interpreting the results. The data series for both industrial and artisanal fisheries contained temporal gaps over the study period. Data quality issues were encountered in the records of both fleets, particularly with respect to fishing trip departure and return dates and times. As a result, estimations and corrections were necessary. The economic analysis was constrained by a lack of cost data for the artisanal sector; this limited the bioeconomic assessment to the industrial fleet only. Additionally, in the absence of data on fish discards and transshipment, catch volumes were assumed to be equivalent to landings.

To address these data gaps, several methodological adjustments were applied in the analysis. Although data limitations highlight the need for improved fisheries data collection and management systems, the assessment still offers important preliminary insights to guide management considerations.

5. SYNTHESIS OF THE BIOECONOMIC REFERENCE POINTS

The bioeconomic modelling procedure enabled the author to estimate different parameters. Some of them play a crucial role in defining, implementing and monitoring policies for sustainable fisheries management. The values of such parameters are essential reference points that may guide fisheries managers towards expected objectives. Considering the study species, the following table presents a synthesis of the most important reference points (**Table 6**).

Table 6. Synthesis of the bioeconomic reference points by species

Parameters	Mackerel scad	Skipjack tuna	Frigate tuna	Little tunny
K (tonnes)	5 593	1 900	17 158	1 217
MSY (tonnes)	2 641	1 220	3 885	158
B_{MSY} (tonnes)	2 726	973	6 556	504
F_{MSY} (ratio)	1.334	1.254	0.594	0.310
B/B_{MSY} (ratio)	0.20	1.20	1.7	0.30
F/F_{MSY} (ratio)	0.80	0.55	0.20	0.50
MEY (CVE million)	256	151	237	0
Current status of key resources	Low fishing mortality that may result in a recovering biomass	Not fully exploited	Not fully exploited	Low fishing mortality that may result in a recovering biomass

Notes: K = unfished biomass at equilibrium; MSY = maximum sustainable yield; MEY = maximum economic yield

Source: Author's own elaboration based on the results of the stock assessment.

6. RECOMMENDATIONS FOR FISHERIES MANAGEMENT

Given the limited reliability of the biological and socioeconomic data used in this study, as well as the constraints of the system used to systematically collect information on fishing activities, the following recommendations should be considered as preliminary.

Based on the results of the bioeconomic assessment and subsequent discussions with researchers and fishery officers from IMAR and DNPA during September 2024 (FAO, 2024a), it is recommended to:

- Undertake a thorough diagnosis to streamline and improve the fisheries data collection system in general, and more particularly in the artisanal fisheries.
- Develop an effective fisheries database that may facilitate the storage and processing procedures of the fisheries data.
- Promote regular training and technical assistance on fisheries data collection, processing, analysis and modelling.
- Develop and implement a long-term national research programme on fisheries bioeconomic assessment.
- Ensure effective regional collaboration on stock assessment with neighbouring countries sharing the same key resources.
- Develop and implement effective policies and strategies that may improve the value of the fisheries products through better ex-vessel prices, including through a fish auction system.
- Develop and implement suitable policies and strategies to reduce the industrial fishing costs, particularly the fixed cost related to, for instance, the maintenance and investment interest rates.
- Ensure effective involvement of all stakeholders and local communities in the fisheries management process to foster support and compliance.
- Encourage and support seasonal and long-term economic incentives and alternative livelihoods for communities that are dependent on overexploited fish stocks to reduce the fishing pressure.

In addition to these general recommendations, stakeholders should be supported to jointly define management measures in keeping with the status of each stock, paying particular attention to species showing signs of overexploitation and taking into account the socioeconomic dimensions of the fisheries concerned.

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The report includes the results of a bioeconomic assessment carried out in Cabo Verde between July and October 2024 and focuses on four key fishery resources: mackerel scad (*Decapterus macarellus*), skipjack tuna (*Katsuwonus pelamis*), frigate tuna (*Auxis thazard*) and little tunny (*Euthynnus alleteratus*). The assessment showed different exploitation levels for the four species and revealed significant challenges in the industrial fishing sector. The study aimed to support the implementation of a ten-year upgrading strategy on three islands: Santiago, São Vicente and São Nicolau.

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