sustainability

MDPI

Article

Analysis of Fishery Resource Management Practices in São Tomé and Príncipe: Perception of the Dynamics of Catches from 1950–2020, Recommendations and Strategies for Future Research

Wilfred Boa Morte Zacarias [1], Xiaojie Dai [1,2,3,4,*], Richard Kindong [1,2,3,4], Ousmane Sarr [1] and Abdoulrazack Hamoud Moussa [5]

[1] College of Marine Sciences, Shanghai Ocean University, Shanghai 201306, China
[2] National Engineering Research Center for Oceanic Fisheries, Shanghai Ocean University, Shanghai 201306, China
[3] Key Laboratory of Sustainable Exploitation of Oceanic Fisheries Resources, Ministry of Education, Shanghai 201306, China
[4] Collaborative Innovation Center for Distant Water Fisheries, Shanghai 201306, China
[5] College of Information Technology, Shanghai Ocean University, Shanghai 201306, China
* Correspondence: xjdai@shou.edu.cn; Tel.: +86-156-9216-5351

Abstract: Fisheries play an important role in the socio-economic development of São Tomé and Príncipe (STP), although the exploited fishery resources have remained largely unknown due to extreme data limitation conditions, which have hindered their sustainable utilization and effective management. Fish has traditionally been seen as a crucial element in the population's dietary and nutritional security, playing a significant role as a source of 85% of animal protein. However, the sustainable management of these resources has recently been facing some challenges. Fishermen control the patterns of fishing exploitation by modifying their methods in response to shifting socioeconomic situations and the management of their resources. In the present study, we assess the dynamics and trends of catches of artisanal, semi-industrial, and industrial fleets in São Tomé and Príncipe marine waters, as well as aspects related to fishing effort, using catch data collected from 1950 to 2020. The observed results show the dynamics and importance that the fishing sectors of São Tomé and Príncipe have for the country's economic growth. According to the indices of abundance of fishery resources, the levels of exploitation during this study's period revealed a reduction in recent years of artisanal catches. Furthermore, this study also identified major problems faced in the fishing sector of São Tomé and Príncipe and makes some recommendations to address them. These recommendations would allow future studies to define the status of stocks threatened or overexploited and control fishing efforts, ensuring the legitimacy and sustainability of fishing activity in São Tomé and Príncipe.

Keywords: artisanal fishing; fisheries management; sustainability; São Tomé and Príncipe

Citation: Zacarias, W.B.M.; Dai, X.; Kindong, R.; Sarr, O.; Moussa, A.H. Analysis of Fishery Resource Management Practices in São Tomé and Príncipe: Perception of the Dynamics of Catches from 1950–2020, Recommendations and Strategies for Future Research. *Sustainability* **2022**, *14*, 13367. https://doi.org/10.3390/su142013367

Academic Editor: Tim Gray

Received: 7 July 2022
Accepted: 12 October 2022
Published: 17 October 2022

1. Introduction

With increasing knowledge of ecosystem dynamics, it has been recognized that living marine resources, although renewable, are not infinite [1] and that they require proper management if they are to continue to be exploited sustainably in a world with increasing needs [2]. The success or failure of conservation efforts has long been evaluated through the evolution of catch data due to the fact that fishing activities have affected and altered the diversity of ecosystems [1,3–5].

Worldwide, fish remains one of the food preferences that is the most traded, with more than half of exports originating from developing countries [6–8]. In these countries, fish

plays an important role as a source of food, nutrition, and income for the livelihoods of hundreds of millions of vulnerable families and can even contribute to poverty reduction and eradication [5–7,9]. Per capita fish consumption projections indicate that fish consumption is projected to increase on all continents except some countries in Africa, where population growth outstrips fish supply [7–9]. With increased knowledge and the dynamic development of fisheries, it has been realized that living aquatic resources, although renewable, are not infinite and need to be properly managed [8,10] so that their contribution to the nutritional, economic, and social well-being of the growing world population, which is expected to reach 10 billion people living on Earth by 2050, can be sustained [2,6].

Nowadays, rising unemployment and the struggle for poverty reduction have become the priority agenda of various fisheries' management agencies in the world. This is because sustainable fishing and the appropriate utilization of existing fish stocks can play important roles in improving the livelihoods of poor fishing communities [8,11–13]. Fishing activity constitutes one of the main challenges in the development process of a country, especially the need to reconcile the conservation of natural ecosystems and the rational use of resources [13–15]. From this perspective, the consequent and frequent demand for sustenance through marine resources may affect all fishery components, thereby perpetuating the Malthusian theories, making it urgent to find solutions that ensure the durability of those resources and the satisfaction of human needs [16].

According to Vasconcelos [17], no matter how infinite the oceans may seem, their fishery resources are depletable, and their ecosystems are fragile. While previously fishery resources were thought to be inexhaustible, over time it has been proven that their wealth, "although renewable", is limited and that there is a need for sustainable exploitation and innovative approaches to fisheries management [18,19].

The use of certain fishing gear can have deleterious effects on ecosystems, such as catching smaller species and discarding non-target species [1,12,15] or habitat modification by trawlers, which tends to contribute to the progressive decline in fish stocks. The decrease in fishing is also visible, marked by increases in catches through the spatial expansion of capture areas [20,21]. This is because illegal industrial fishing has serious consequences for biodiversity because of issues of competition of the catch for species that are normally captured by artisanal fisheries [12,22–24]. We can observe that almost one-third of fish stocks are fully exploited or overfished. Marine pollution and climate change have affected coastal and marine ecosystems through a variety of climatic factors; rampant development in the coastal zone causing erosion; widespread desalination in the seas; and threatening marine flora and fauna [1,3].

To enable the sustainable management of fishery resources, international legal and policy frameworks such as the Food and Agriculture Organization (FAO) code of conduct, voluntary guidelines for small-scale fisheries, and Sustainable Development Goal (SDG 14) encourage the implementation of the Ecosystem Approach to Fisheries (EAF) as a guiding principle for management [10,25–27] to maintain or restore "stocks" to the level that can produce Maximum Sustainable Yield (MSY) [9] and to develop and facilitate the elimination of destructive fishing practices by proposing the establishment of marine protected areas and the integration of marine coastal management [10,25,28,29]. The approach considers that the health of the aquatic ecosystem and associated biodiversity are a fundamental basis for the livelihoods of the fishing community, recognizing the contribution of small-scale fisheries (SSF) to global food security, nutrition, and poverty eradication [6,30,31].

Fishing activity is highly unstable, and managers of small-scale fisheries still face the challenge of managing the dynamic and unexpected dependence between resource users and fishing resources [32]. Understanding the interactions between fishers and fishery resources can provide insights to enable the comprehensive and sustainable management of SSF fisheries [6,27,33]. Fishers can reorganize and develop strategies to adapt to the changing dynamics of fish resources and opportunities and even address the uncertainty associated with fishing activities [30,34,35]. The main objective of this study is to assess the dynamics of the catches of the maritime fisheries of São Tomé and Príncipe (STP) from

1950 to 2020 based on two sources of data, namely: reconstruction data from the literature from 1950 to 1999 and those obtained by exploiting the reports available from 2000 to 2020 provided by the directorate of maritime fisheries of STP.

The exploitation of these reports allows us to review the dynamics of maritime fishing in this region during the last seven decades. A diagnosis allows us to highlight the problems related to this sector and propose recommendations to meet the future challenges of the fishing sector to implement a sustainable co-management approach to fishery resources in STP.

2. Materials and Methods

2.1. Statistical Collection Data

For this study, data collection was conducted in two different time frames. However, in the initial period (1950–1999), data were collected from different literature sources such as studies, reports, fishery surveys, academic publications (extensive literature searches on the Internet in various databases of different scientific journals), and publications in the Food and Agriculture Organization of the United Nations (FAO) [2,4,6,7,9,11,13,14,16,20,28,29,35–44], which provided information on fishery reconstruction and statistics, such as parameters of fishery management dynamics, catch trends, and fishing effort based on descriptive research methodology from a qualitative approach perspective according to Pomeroy and Andrew [27], Wirtz et al. [17], and Zeller et al. [45].

On the other hand, the exploration of official fisheries' statistical data was provided by the Directorate of Fisheries of São Tomé and Príncipe (DFSTP) for the most recent period (2000–2020), which were collected by the Department of Research, Statistics, and Aquaculture of the Directorate of Fisheries (DRSADF), which were carried out by fishery inspectors, analyzed using some key variables such as (i) the number of artisanal and semi-industrial fishermen; (ii) the evolution of the number of boats; (iii) the mode of propulsion (rowing or sailing and motorized); (iv) the most commonly used gear; (v) the number of trips per day for each pirogue; (vi) the catch per unit effort (CPUE) method; catch per unit of boats in the fishing fleet; and (vii) species catch composition. The catch-based method proposed by Froese and Kesner-Reyes [18] allowed us to obtain official information on the state of the fisheries in this region [5,30,34,46–48].

In addition, the catch statistics officially reported by the framework survey of the non-governmental organization Mar Ambiente e Pesca Artesanal [29,30], and the studies by Porriños [49] and Sy and Soares [48], were also combined with the two sets of data collected on the dynamics of São Tomé and Principe's catch effort. Assuring the independence of the data used here for fishing efforts allows us to highlight the statistics of the evolution of catches of artisanal, semi-industrial, and foreign industrial fleets operating in the Exclusive Economic Zone (EEZ) of STP.

Although CPUE has limitations and discrepancies, it is useful for monitoring long-term trends in fisheries, especially when more detailed data and stock assessments are lacking [15,45], where restrictive fishery management actions may be non-existent or inefficient [10,15]. On the other hand, CPUE estimation and its utility depend on the type of effort employed, which is attributed to differences in the catch efficiency of pirogues, fishing methods, and types of pirogues, introducing errors in abundance estimates and patterns of temporal variability [12,45].

Data collection took place throughout the year at 43 landing sites distributed across all districts, which coincides with the 19 sampling areas (Figure 1) identified in our study [34,46,47], and the information is stored in a database of the Directorate of Fisheries (DF). The Department of Research, Statistics, and Aquaculture (DRSA) extrapolated these data to all of São Tomé and Príncipe using information about relative fishing effort in unsampled landing sites obtained from irregular-frame surveys [50,51].

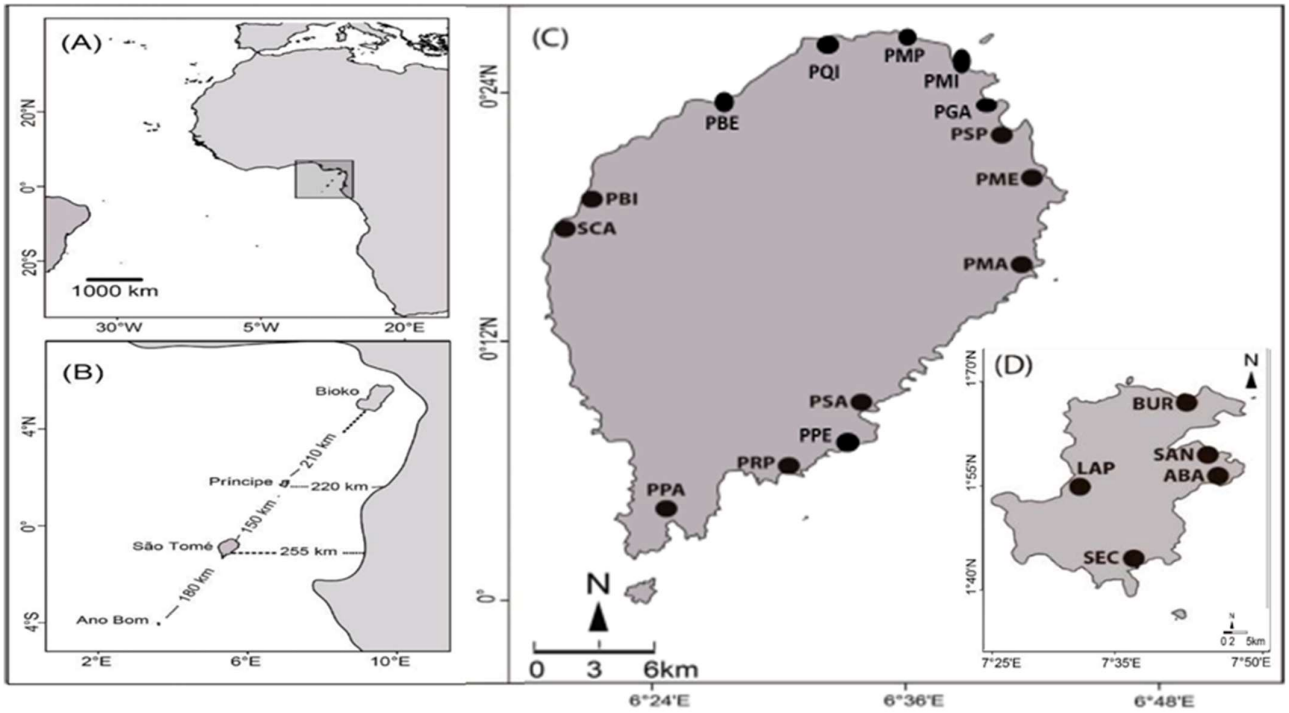


Figure 1. Location of the islands of São Tomé and Príncipe (ISTP) in the Atlantic Ocean: (**A**) Gulf of Guinea highlighted in the gray box; (**B**) STPI; (**C**) São Tomé Island; (**D**) Príncipe Island. (● = Traditional fishing communities). São Tomé: SCA—Santa Catarina; PBI—Brita beach; PBE—Benga beach; PQI—Quinze beach; PMP—Moro Peixe beach; PMI- Micolo beach; PGA—Gamboa beach; PSP—São Pedro beach; PME—Melão beach; PMA—Messias Alves beach; PSA—Angolares beach; PPE—Pesqueira beach; PRP—Ribeira Peixe beach; PPA—Porto Alegre beach. Principe: LAP—Lapa beach; BUR—Burras beach; SAN—Santo António beach; ABA—Abade beach; SEC—Seca beach.

2.2. Study Area Description

The Democratic Republic of São Tomé and Príncipe (DRSTP) is an archipelago of volcanic origin composed of two main islands (São Tomé Island—ST and Príncipe Island—PR), including six small islets, with very rugged relief 300 km away from the coast of Gabon, with a total area of 1001 km^2, of which 859 km^2 make up the island of São Tomé and 142 km^2 constitute Príncipe. Geographically, São Tomé and Príncipe lie at the limits of latitude: 0°11′58.90″ N and longitude: 6°36′38.03″ E, located at the northeastern end of the Gulf of Guinea in the west of Africa (Figure 1). This region is mainly characterized in terms of biological diversity and productivity, typical of tropical regions and reached by the cold Benguela current that gives rise to upwelling [34,41,43].

The Democratic Republic of São Tomé and Príncipe is a small island developing state (SIDS) whose estimated population was about 219,161,000 in 2020 with an annual population growth of approximately 1.91% [13,43,48], which regained independence in 1975 after five centuries of Portuguese colonization [40,43]. The maritime waters under the São Tomé and Príncipe jurisdiction, with an Exclusive Economic Zone of about 160,000 km^2, suggest that oceanic economic sectors possess a diversity of wealth that can contribute significantly to long-term economic growth [2,20,41,44]. Fishing contributes more than 85% of the animal protein consumed by the population [11,13,47]. Attempts to regulate local fishing were first implemented by Portugal through the *Port Captaincy Service* in the 1950s. At that time, a beach manager (literally, chief of the beach) was appointed to supervise fishing activities in each district (São Tomé and Príncipe have seven districts, six in São Tomé and one in Príncipe) along with the 30 main fishing communities that exist on the two islands [10,39,43].

Fishing is practiced mainly by artisanal fishermen, with fishing nets (seine, drift net, and bottom gillnet), hand lines, floating traps, spears, and submarine fishing being the more dominant gear at depths that vary between 50 m and 250 m along the entire coastal zone of São Tomé, including the island of Príncipe, and using pirogues built of wood and fiberglass with little presence of quality semi-industrial fleets, which need development [4,13,37,49]. The fish are commercialized by women called palayês (literally, sellers) [36,41,43]. Industrial fishing is practiced by foreign vessels in the Exclusive Economic Zone of São Tomé and Príncipe by European Union countries and, in the recent past, by Japan, Taiwan, and China [36,38,43].

The focus of this study centers on the approach related to the catch and effort dynamics of artisanal, semi-industrial, and industrial foreign fisheries, as well as the analysis of management practices for sustainable fisheries for traditional fishing communities. Our considered study area included a total of 19 fishing communities in the archipelago of São Tomé and Príncipe, 14 in São Tomé and 5 fishing communities on Príncipe Island (Figure 1C,D), where the various landing sites that occur are illustrated by surveys throughout the year by investigators who are technicians of the Directorate of Fisheries (DF) who record the collection of fishing data in these communities [24,29]. Considering that these communities hosted 4325 active fishermen in 2020, with 4179 assigned to artisanal fishing making up 96.5% and semi-industrial fishing 3.50%, for a total of 146 fishermen (88% in ST and 12% in PR) [13,24,48].

2.3. Data Analysis

To analyze the data, we used the trend-based analysis proposed by Froese and Kesner-Reyes [18], Belhabib [36], and Pikitch and Doukakis [1], which classifies a developing, fully exploited, overexploited, and collapsed fishery based on a time series of catch, effort, and CPUE from the fishery [4,27,38,44,47].We applied it to understand the dynamics of sustainable fishing management [11,17,29,32,45,52]. The method based on a time series of catch, effort, and CPUE was applied to two data sets: (1) survey data collected from the different literature, reports, and cross-sectional surveys covering the period from 1950 to 1999; and (2) the official fishery production statistics of São Tomé and Príncipe covering the period from 2000 to 2020, collected at the landing sites by the DRSADF, using key variables such as the number of artisanal and semi-industrial fishermen; the evolution of the number of boats; the mode of propulsion; the characteristics of the gear; and the fishing hours of each pirogue. The first set of data was supplemented with data provided by the Directorate of Fisheries to form time-series data that were used for further analysis. The selected variables were repeatedly sampled over the specified period, and this allowed for the evaluation and interpretation of effort in relation to catch trends and vice versa.

From the market supply point of view, the 10 most commercialized and threatened demersal and pelagic target species were selected from the overall landings of São Tomé and Príncipe to implement in the future fisheries co-management approach [1,2,48,49,58], which were: Atlantic flying fish (*Cheilopogon melanurus*), which has the highest occurrence rate from artisanal landings; Bony fish (*Lutjanus goreensis*), Squirrelfish (*Holocentrus adscensionis*), Mackerel (*Decapterus macarellus*); Frigate tuna (*Auxis thazard*); Bigeye snapper (*Dentey macrophthalmus*); Balao half-bill (*Hemiramphus balao*); Atlantic emperor (*Lethrinus atlanticus*); and Blue-spotted dorado (*Pagrus caeruleostictus*). Another group of species landed by artisanal fisheries with relatively high commercial value includes Yellowfin tuna (*Thunnus albacares*), Swordfish (*Xiphias gladius*), Blue marlin (*Makaira nigricans*), Atlantic bonito (*Sarda sarda*), Wahoo (*Aconthocybiun solandri*), and Swordfish (*Xiphias gladius*), which are landed occasionally.

Finally, data were organized in Excel spreadsheets to calculate frequency, position parameters (arithmetic mean), and dispersion (standard deviation), which were then separated by category and subjected to descriptive statistical analysis to interpret trends. Statistical analysis was performed using the SPSS Version 24, available at: https://www.yasir252.com/en/apps/ibm-spss-24-free-download-full-version-windows/ (accessed on 2

June 2022) and Excel 2016 for graphical presentation and table preparation, where changes in effort, catch, and CPUE were used to explain changes in fishery exploitation patterns.

3. Results

3.1. Overview of the Socio-Economic Benefits and Potentials of STP Fish Resources

The vast maritime territorial space is superior to the physical space, capable of allowing the development of artisanal and semi-industrial fishing, making maritime fishing the most important in São Tomé and Príncipe, since inland fishing is practically non-existent [13]. As the second export activity after cocoa, fishing is the main source of income and a major contributor to the General State Budget of São Tomé and Príncipe [13,24,34].

According to the FAO [6], each city's inhabitants consume an average of 30.4 kg of fish per year. The archipelago has faced a lack of financial resources because it does not export its fish on a large scale [6,13,24,48]. Another study developed by FAO in 2015 estimated that the value of national production, considering the current average price of fish, would be 45 STD/kg (=2 USD/kg) for all species combined [13,48]. Thus, fishing is considered a lever for the country's growth, with a contribution to GDP of USD 44.4 million in 2016, estimated at 5.6% in 2012, close to 6.5% from 2013 to 2017, representing 35% of non-tax revenues in the state budget [5,11,48] and just under 6% in 2020, affected by the pandemic, climate change, and fuel shortages [13,47,53]. However, pandemic disruption is expected to result in a GDP contraction of 7.5% in 2022 [24]. According to studies by Horemans et al. [41], FAO [13], Krakstad et al. [42], and Sy and Soares [48], the fishing potential of STP is estimated to be around 29,000 tons, distributed into four main groups: large pelagic, coastal pelagic, demersal species, and crustaceans, presented in Table 1.

Table 1. The trend in fishery potential in tons per year.

Resource Groups	Potential in Tons/Year	MSY (%)
Large Pelagics/Tunas	17,000	52.6%
Coastal pelagic	4000	25.4%
Demersal Species	2000	15.4%
Seafood	6000	5.6%
Total	29,000	100%

Sources: Adopted and modified from DF- DRSTP [34] and FAO [13].

The area contains an estimated 12,000 tons of artisanal fishing potential, of which approximately 8500 tons are for coastal pelagic species and 3500 tons are for demersal species (see Table 2). However, the potential has been showing signs of decline in recent years, reaching an average of 6115 tons in 2020 in the total catch trends of the country's fisheries [24].

Table 2. The trend of fisheries potential by resource category.

Location	Surface in km^2	Pelagic	Demersal	MSY/Catch %	TOTAL
São Tomé	436	1500	1500	22%	3000
Principe	1023	7000	2000	78%	9000
Total	1455	8500	3500	100%	12,000

Sources: Adopted and modified from DF- DRSTP [34]; FAO [13].

The study conducted by Krakstad et al. [42] with trawls allowed estimating a large number of demersal species compared with pelagic species around São Tomé, despite the limitation of sampling. This information requires a more comprehensive future investigation to confirm. The potentially abundant species observed were the Sparidae families (*Pagellus bellotti, Dentex congoensis*, and *Pagrus caeruleostictus*) [28,34,42]. There is, however, a relatively nutrient-poor continental shelf that limits the abundance of demersal resources, as opposed to the cold-water outcrops of the open ocean, which provide abundant varieties of pelagic species, especially from June to September and January to February [34,42].

According to studies developed by Porriños [47], the MSY predicted for the STP fishing sector was estimated at 4080 tons per year, with a maximum sustainable effort of 2826 tons per fisherman [47]. However, the sector has shown drift as a consequence of overexploitation and climate change [15,20,54]. Thus, MSY presents a great disparity in geographic distribution, including pelagic resources with about 78% for Príncipe Island and demersal resources with a proportion of 22% (Table 2), respectively, for São Tomé Island [34,49,54].

According to the DF-DRSTP [47], the catching of fish is intended for the domestic market and a small amount for foreigners. In 2015, the fishery was valued at 16,048 tons, of which 11,448 tons came from the national small-scale fishery and 4600 tons came from the catches by foreign vessels. According to artisanal and semi-industrial fishermen, the self-consumption of fishery products is estimated for artisanal fishing to be 3% and for semi-industrial fishing to be 5% [34,43,47,48]. Of the 73.1% of the national catch, the main destination is the commercialization of fresh fish, and 26.9% is used in the transformation of salted, dried, and smoked fish in the fishing communities. Everything indicates that overexploitation of fish stocks has occurred since the actual fishing volume has exceeded the maximum sustainable yield anticipated by 9771 tons of fish per year. This may be due to illegal, unreported, and unregulated (IUU) fishing in the sector or the implementation of unsustainable harvesting technology [23,25,27].

3.2. Employment Distribution in the Fisheries Sector in São Tomé and Príncipe

The fishing sector represents a key socio-economic network through its contributions to job creation, income generation, and foreign exchange earnings for the country. As indicated in Table 3 below, the study predicted the maximum number of employees to ensure the sustainability of fish production and conservation of fish resources in the São Tomé and Príncipe fishing sector. Fishery sectors and subsectors, including vessel fleet size, species composition, and employment levels, show important discrepancies between different sources. In the year 2018, there were 2996 fishers employed in the artisanal fishing sector and 2546 fish sellers [8,22,47,48,55]. The informal nature of most of the artisanal and semi-industrial fishing sectors in STP makes systematic data collection difficult and costly. However, we can infer that the artisanal sector decapitalizes, mainly due to the weakness of the local market. However, it seems to have been reversed in recent years, considering the figures for fleet size and motorization rate [34,44,48].

Table 3. Trends in employment and fleet size in the São Tomé and Príncipe fishing sector from 1950 to 2020.

Type of Work	Year									
	1950	**1960**	**1970**	**1980**	**1990**	**2000**	**2005**	**2010**	**2015**	**2020**
Number of fishermen	1000	2109	2140	2230	2427	2450	3233	2676	3132	4148
Number of women sellers (palayê)	1580	1689	1786	1889	3100	6000	893	2051	2858	2300
Number of fishing canoes	1748	1780	1805	1815	1840	2125	1613	2323	2374	2509
Motorization rate (%)	6%	7%	9%	11%	12%	13%	18%	21%	22%	24%

Sources: Adopted and modified from Belhabib [36]; DF-DRSTP [34,46,47] and Oceanic Développment et al. [44]. An estimate of 6000 fish suppliers in 2000 is mentioned in [44]. This number seems excessive compared to with the 2020 figure, even considering the variability of employment in this activity.

Small-Scale Fishing Fleet from 1950 to 2020

From 1950 to 2020, the artisanal and semi-industrial fishing sectors together reached an average of more than 1151 active motorized and non-motorized pirogues. This fishing effort was distributed as 65% for artisanal craft and 35% for semi-industrial craft, with a total of 4148 active fishermen (Figure 2a). Fishermen were distributed throughout all districts of the country; the Água Grande district containing 27% and the Lembá district about 26.44% of the fishermen (Figure 2b), with an average of 92% artisanal and 8% semi-industrial fishermen. The number of fishers, however, has increased considerably since 1952 with

small fluctuations, reaching its first peak of around 2450 fishers in 2000, followed by a decline to 1563 in 2003, associated with some old artisanal fishing fleets, low motivation on the part of fishers due to lack of fishing inputs on the national market, and the poor abundance of fish during this period [10,14–16,19,33]. In 2005, the number of fishermen increased again to 3233, and in 2007, it reached its second peak of about 5298 fishermen, again showing small fluctuations with slow growth, increasing to 4155 in 2019, with 4011 allocated to artisanal fishing making up 96.5% and semi-industrial fishing making up 3.47%, for a total of 144 fishermen. It decreased in 2020 to about 4148 fishermen, caused by the effect of the pandemic. The same trend was also observed in the level of pirogues, which had their first increase in 1994, which included about 1009 pirogues, of which about 20% were motorized. The number of motorized boats decreased to around 339 in 2003 (Figure 3). This decrease was associated with the decrease in the number of motorized pirogues due to irregular supply and shortage due to the high price of fuel that was frequent. From the following year, the number of pirogues increased in 2004 to about 2777, in 2005 to about 2977, and in 2007 to a second peak of about 3391 pirogues, except in 2006, which decreased slightly to 2132 pirogues. This was followed by a further fluctuation until 2019, which included 2808, and in 2020, with a little fewer than 2794 active pirogues. The increase in the number of pirogues was associated with the production of the new and improved Prao artisanal boat in 2010, which offered better navigability to reach better catching grounds and greater interest from fishermen in equipping their boats with an inboard engine, as well as small credits granted by the government. In addition, these periods included a huge technological revolution that resulted in more efficient and profitable fishing worldwide, and the STP was no exception [8,30,34,48].

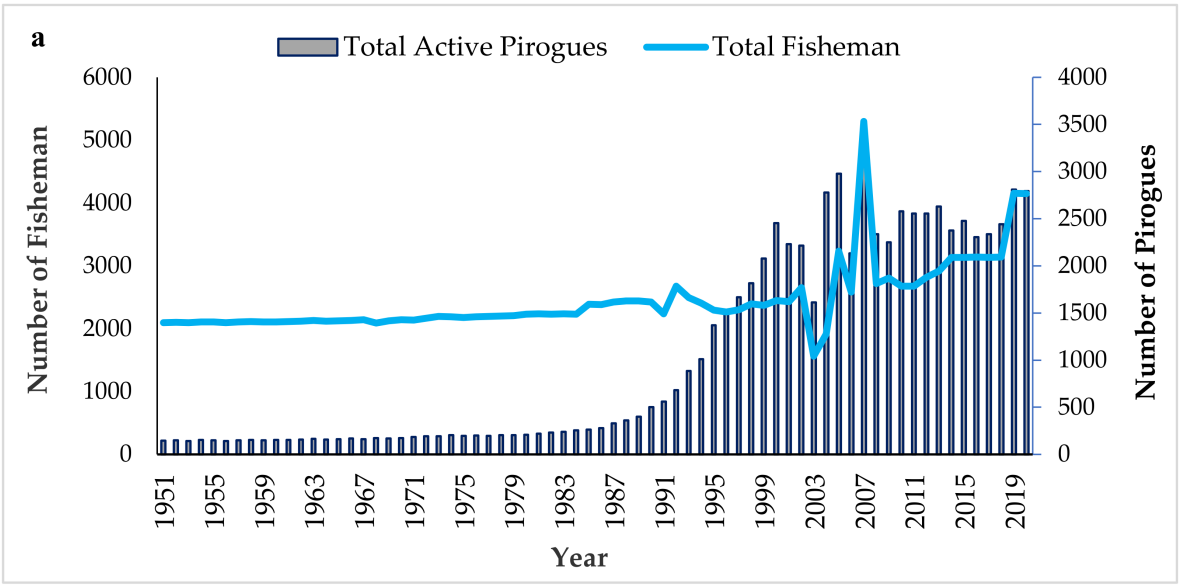


Figure 2. *Cont.*

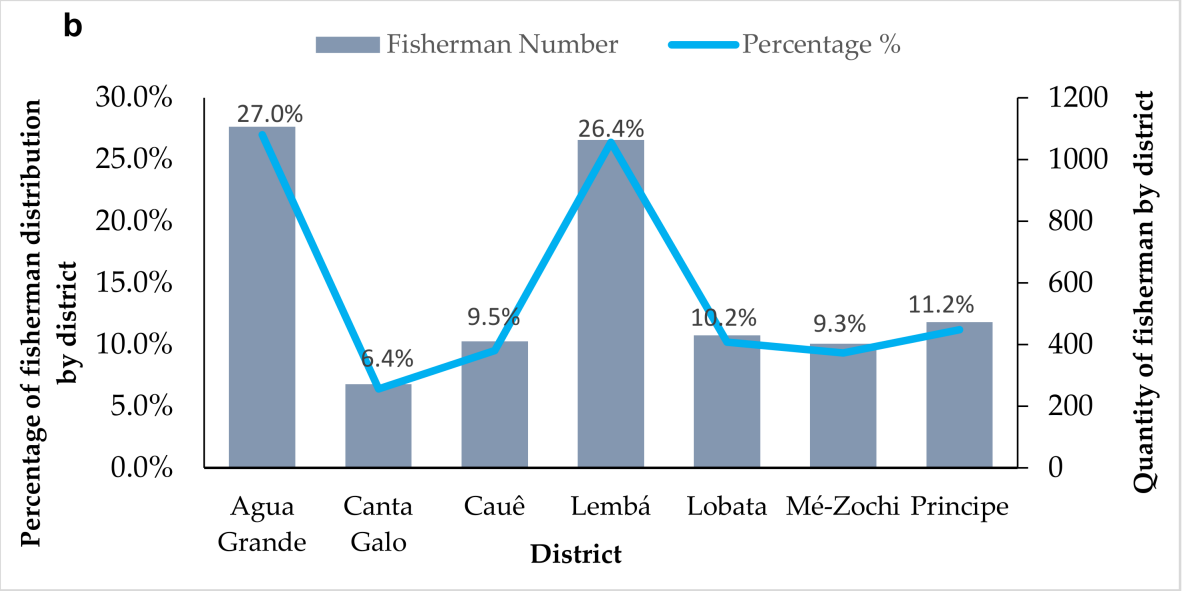


Figure 2. São Tomé and Príncipe fishing fleet profile from 1950 to 2020: (**a**) Changes in the total number of pirogues, as well as artisanal and semi-industrial fishermen. (**b**) Artisanal fishermen's distribution by district, calculated from 2019 to 2020.

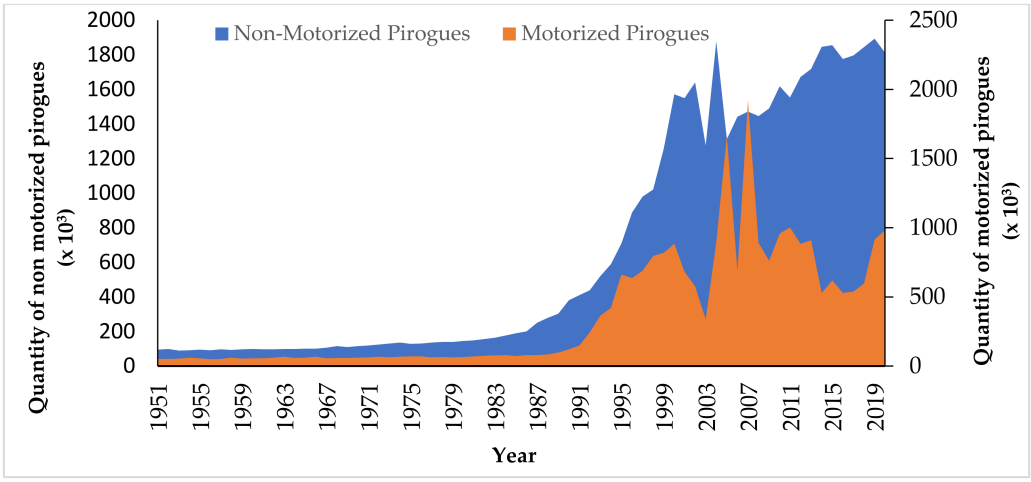


Figure 3. Evolution of the number of motorized and non-motorized artisanal pirogues of São Tomé and Príncipe from 1950 to 2020.

3.3. Ratio of Catch per Unit Effort of Vessel Type and Fishing Gear

Among all the artisanal and semi-industrial fishing vessels sampled from 2019 to 2020, 75% of which are on São Tomé and 25% on Príncipe Island. Among these sampled artisanal vessels that carried out catching activities with different fishing gears, pirogue nets showed a low CPUE in January of about 29.088 kg, the Carrioco net boats were at 23.540 kg, and Prao net improvised boats at 23.008 kg (Figure 4a). The reason for the low CPUE was that the Prao-type net pirogues were not motorized and had little mobility, exerting an estimated 8- to 9-hours effort to reach the location of abundant fish, while the Carrioco net fleets were old and seldom used and carried out capture operation activities with infrequent fishing trips. This vessel practiced fishing, especially demersal gillnet fishing, and targeted a particular species that was conditioned by the lunar phase, which generally stimulates the largest capture, and in the spawning phase [43], causing a great impact on fishing efforts, which tends to decrease production. During the 2019 period,

annual production reached a total upper value of 693.052,1 kg. The pooled production data of CPUE by vessel were significantly different by month [47].

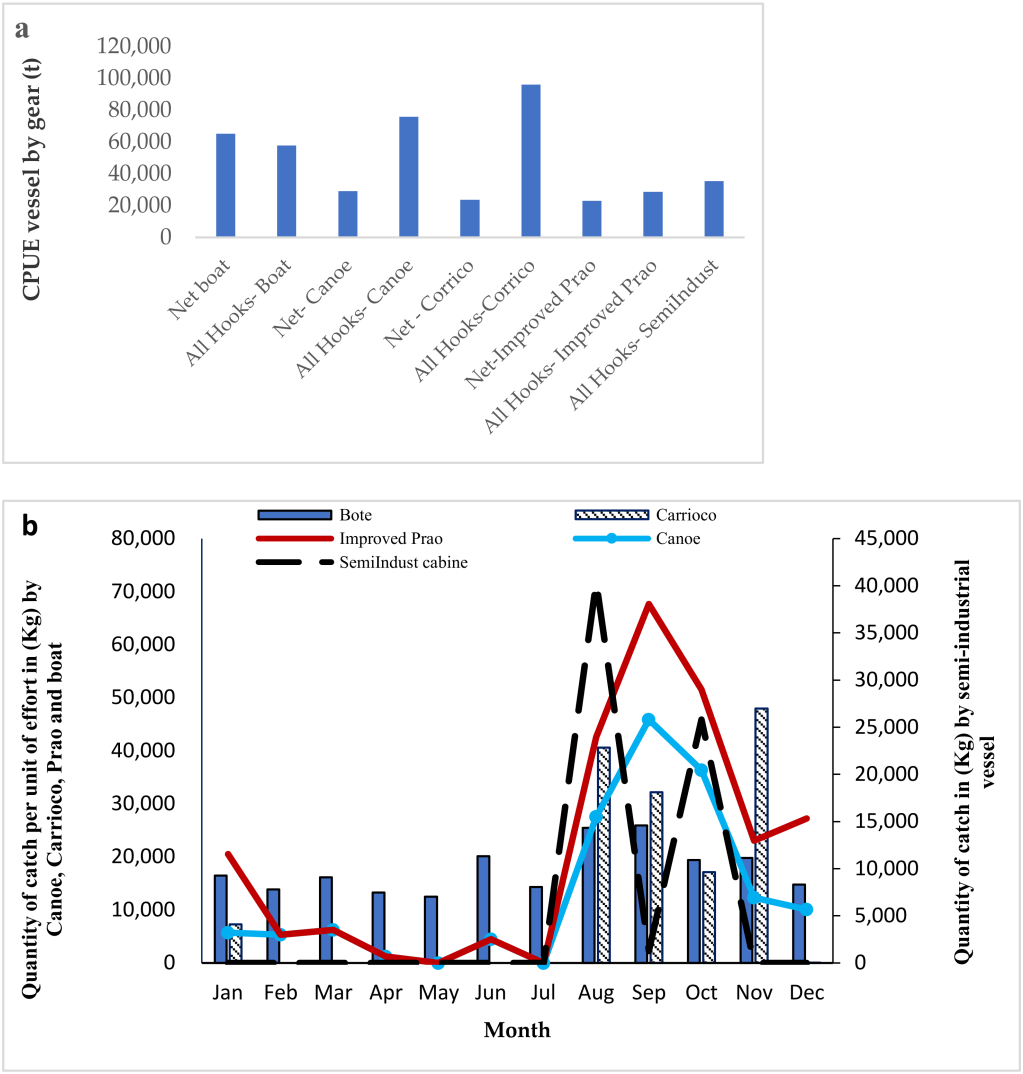


Figure 4. Calculated catch per unit effort of So Tomé and Principe fishing fleets from 2019 to 2020: (**a**) Total vessel CPUE by fishing unit type; (**b**) ratio of catch per unit effort of vessel type by fishing trip month.

The highest yields of production by vessels were recorded at higher peaks reached in August with pirogue-type vessels that reached 25.450 kg, Carrioco vessels reached 40.571 kg, and semi-industrial vessels reached 40.392 kg. In November, Carrioco vessels reached about 47.995 kg, revealing the existence of an increasing trend of efforts for these vessels, and the lowest efforts were recorded in January for pirogue-type vessels, with a CPUE of about 1.233 kg, and in September for semi-industrial cabins. In February, March, April, May, June, and July, the CPUE data showed very low values for these vessels (Figure 4b) [47,49]. The low participation of these vessels during these months was probably due to the low abundance of shoals. The gradual introduction of new technologies and new fishing techniques and access to new knowledge may have contributed to the increase in fishing pressure on the islands and the overexploitation of some species, resulting in changes in the total catches of the country. However, the relationship between catch, type of vessel, and fishing gear presents extremely important data for characteristics of demersal and artisanal fisheries influenced by specific fishing zones and those of the fishing communities of São Tomé and Príncipe.

In the same way, we observed a great tendency in the capture of some species of small tuna and other pelagic species harvested by artisanal fishermen with different fishing gears. The data collected allowed us to observe the predominance of the large-scale capture of these tuna between the years 2001 and 2020, where the peak of the catches was dominated by the PSFS seine gear (see Figure 5). This demonstrates that small-scale fisheries also have the potential to catch small tuna in small quantities to supply the shortage of fish in the domestic market. Thus, more investments are needed to improve this fishing fleet.

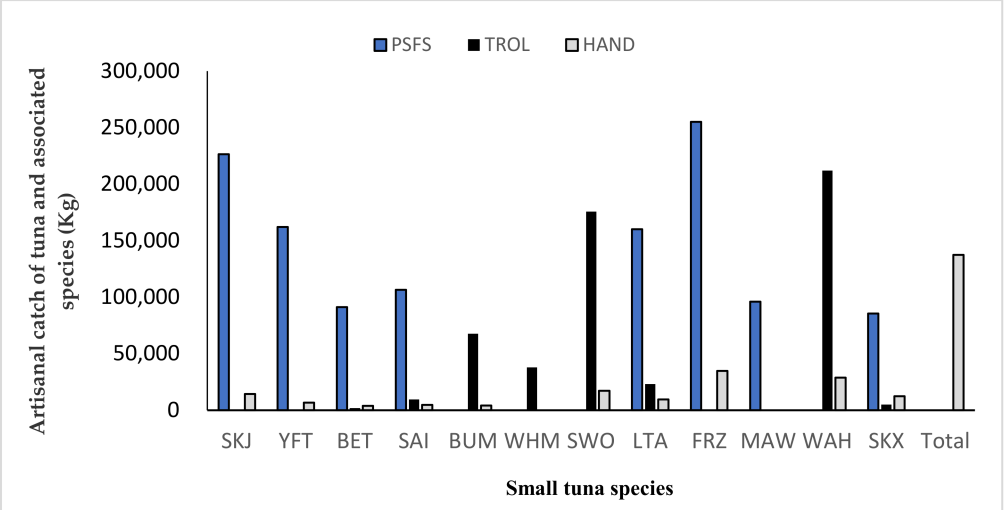


Figure 5. The trend of catches of tuna and tuna-like species by different fishing gears of the artisanal fleet from 2005 to 2018: fishing gear: PSFS = purse seine; TROL = Troll; HAND = hand line; species: SKJ—*Katsuwonus pelamis*; YFT = *Thunnus albacares*; BET—*Thunnus obesus*; SAI = *Istiophorus platypterus*; BUM = *Makaira nigricans*; WHM = *Tetrapturus Albidus*; SWO—*Xiphias gladius*; LTA—*Euthynnus alletteratus*; FRZ—*Auxis thazard*; MAW = *Scomberomorus tritor*; WAH = *Acanthocytbium solandri*; SKX = *Carcharhinidade altinus*.

Estimated Total Effort from the Total Number of Trips

Following Table 4, it is shown that line gear exerts the most effort in São Tomé and Príncipe, with a sum of 291 over the total number of trips per fishing day, which corresponds to 46.5% [49]. The fact is that about 295 kg of the total fish caught by the fishery are landed every day, coming from the line fishery (Table 5), which implies an average of 107.7 tons of fish per year, presenting a percentage of 46.5% of the other fishing gear [49].

Table 4. The trend in the contribution of the main fishing gears to the number of trips made per day (2019–2020).

Fishing Gear	Sum of Daily Trips	%	Daily Average	Daily Output	Daily Maximum
Flying Net	210	33.5%	11.7	5.2	24
Panhá Flying Net	0	0.0%	0.0	0.0	0
Purse Seine Net	33	5.3%	1.8	1.3	5
Brisa Gillnet	0	0.0%	0.0	0.0	0
Demersal Gillnet	2	0.3%	0.1	0.6	1
Spearfishing	80	12.8%	4.4	2.7	9
Line Fishing	291	46.5%	16.2	8.3	32
Shore Line Fishing	10	1.6%	0.6	1.0	3

Source: Adopted and modified from Porriños [49].

Table 5. The average catch per trip, disaggregated by fishing gear, and daily and annual estimates of fish landed in São Tomé and Príncipe.

Fishing Gear	Daily Trips	Capture (kg)	Trips Number	Average Catch per Trip (kg)	Daily Catch (kg)	Annual Catch (ton)
Surface Gillnet	11.7	2493.7	80	31.2	364.7	133.1
Voador panhá Net	0	NA	0	NA	0.0	0.0
Sena of Bolsa	1.8	1921.8	28	68.6	123.5	45.1
Gillnet	0	NA	0	NA	0.0	0.0
Demersal Gillnet	0.1	12.5	5	2.5	0.3	0.1
Deep-Searching	4.4	170	11	15.5	68.0	24.8
Line Fishing	16.2	5337.13	293	44.2	295.1	107.7

Source: Adopted and modified from DF-DRSTP [34] and Porriños [49].

The decreasing trend in fishing gear effort was observed for the panhandle fly net, at 0%, since this gear is only used in the dry season where there is a greater abundance of different species of fish, and the gillnet Brisa, which also showed 0% because fishermen have long stopped using this practice as it is a non-sustainable fishing gear that captures species of very small size, damaging the biodiversity of species, especially those of commercial importance [47,49]. The tendency towards decline in the use of fishing gear effort has been detected in other studies around the world, including in continental Africa [3,21,38,52,55]. In addition to traditional fishing gear, local fishermen have often been provided with equipment and techniques by international fishing organizations and support in the form of "workshops" [38,43,44].

The introduction of new technologies and access to new knowledge may have greatly contributed to increased fishing pressure on the islands and overexploitation of some species, resulting in changes in the total catches of the country. In this sense, monitoring artisanal fisheries in STP poses a challenge due to the variety of fishing techniques and gears (Figure 1), as well as the different local names given to the same fishing gears. In addition, the boundaries between gears and fishing techniques are still very unclear, making it difficult to subdivide them into comparable categories.

Therefore, given the importance of angling (Table 4), a comparative study of fishing gear used on São Tomé Island and Príncipe Island would be necessary to ensure that catching techniques are carried out sustainably. The average catch for an angling trip on São Tomé has an average of 44.2 kg per trip (see Table 5).

Therefore, it was estimated that a total of 851.6 kg of fish is landed each day, based on the average number of fishing trips per day and the average catch of each type of fishery on Príncipe Island (see Table 5). We assume a total catch of 310.8 tons of fish in the five permanent and temporary communities (Figure 1D) on Príncipe Island (these estimates do not include unmonitored pirogues).

3.4. Composition of the Disembarked Catch

3.4.1. Trends in the Distribution of Fishing Effort Catches by Districts

There is a lack of comprehensive data regarding the actual catch of local artisanal fisheries. Estimates are prepared from annual surveys. The only available artisanal fishing statistics for São Tomé and Príncipe cover landings of coastal species from 2000 to 2020 [39,43,44,47]. Artisanal and semi-industrial marine fisheries provided, on average, 92% of landings [47]. Production amounted to 11,855 tons for an estimated market value of EUR 15,436,592 [47,48]. Many climatic factors more or less affected the artisanal fishing effort during this period [13,14,56]. Analysis of landings showed that the Água Grande district and Príncipe district ranked first among landing locations (Figure 6). Given that the district of Água Grande landed an average of 1,412,094 tons, and Príncipe landed an average of 1409 tons of fish, the two districts accounted for 25% of total landings. The Cauê district accounted for 12% and the Me-Zochi district for 11% of the landings. Finally, the

districts of Lembá, Lobata, and Canta Galo represented 10%, 9%, and 8% of the landings, respectively [47,48].

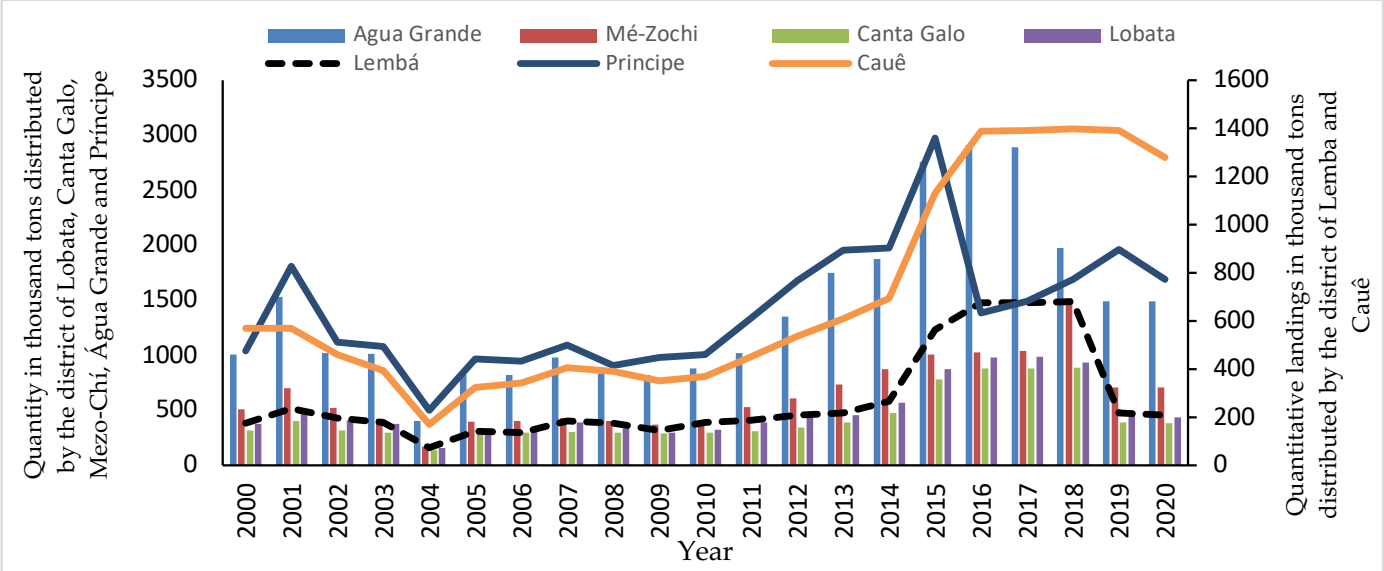


Figure 6. Evolution of the total amount of landings in tons of artisanal catch distributed by districts of São Tomé and Príncipe from 2000 to 2020.

3.4.2. The Composition of Pelagic and Demersal Landed Catches

A recent analysis conducted by FAO [13] and Fisheries and Aquaculture in Africa, the Caribbean and the Pacific (FISH4ACP) is available at https://www.telanon.info/politica/2021/11/22/35732/nova-lei-da-pesca-da-mais-liberdade-a-guarda-costeira-no-combate-a-pesca-ilegal (accessed on 15 January 2022). It reveals that coastal pelagic fishing in São Tomé and Príncipe is largely artisanal, with 97% of landings coming from artisanal fishermen and the remaining 3% of demersal by a semi-industrial fleet [24]. However, the heritage constituted by demersal resources is very important in terms of conservation and sustainable management. From the point of view of market supply, we observed during our research that the most important local fishery in the global landings of STP is the Atlantic flying fish (*Cheilopogon melanurus*), which had the highest occurrence rate, representing 35.3% of the artisanal landings, followed by Bony fish (*Lutjanus goreensis* 21.5%); Squirrelfish (*Holocentrus adscensionis* 11.5%); Mackerel scads (*Decapterus macarellus* 8.5%); Frigate tuna (*Auxis thazard* 6.5%); Large-eye dentex (*Dentey macrophthalmus* 5.5%); Balao halfbeak (*Hemiramphus balao* 4.6%) and Atlantic emperor (*Lethrinus atlanticus* 3.5%); and Blue spotted seabream (*Pagrus caeruleostictus* 2.5%) (see Figure 7). Another group of species landed by artisanal fisheries with relatively high commercial value included: Yellowfin tuna (*Thunnus albacares* with 0.2%). In the other fish category, species such as Swordfish (Xiphias gladius with 0.1%); Blue marlin (*Makaira nigricans* with 0.1%); Atlantic bonito (*Sarda sarda* 0.1%); Wahoo (*Aconthocybiun solandri* 0.1%); and Swordfish (*Xiphias gladius* with 0.1%) were landed occasionally.

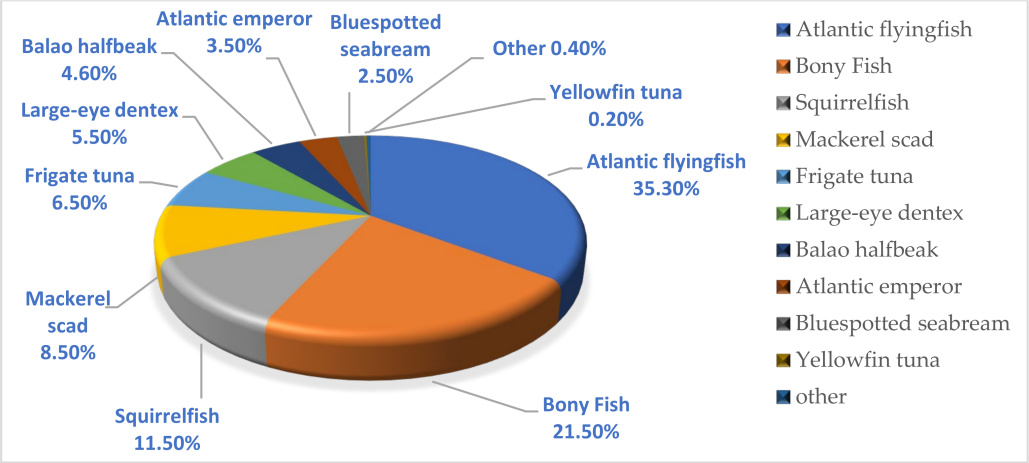


Figure 7. Relative participation of the species of landings in the artisanal fisheries associated with the marine environment of São Tomé and Príncipe from June to November 2016 to 2020.

In the view of these experts, they indicate that the species is overfished mainly in the southern part of São Tomé Island. Therefore, they proposed the rational exploitation of these resources by reducing catches and fishing efforts [28–30]. In addition, the DF-DRSTP [34] and NGO-MARAPA [30] recommended the collection of more accurate data on each of these demersal species to establish biological parameters on the size of the stock and implement more effective measures for the sustainable and rational management of these reserves.

3.5. Catch by Fishing Fleet Effort

3.5.1. Catches of the Artisanal Fishery Fleets from 1950 to 2020

There is a lack of comprehensive data regarding the actual catches of the local artisanal fisheries of STP because no regular catch statistics exist. Therefore, our estimates were based on surveys and annual reports of artisanal fishing catches from 1950 to 2020, which showed large variation (Figure 8).

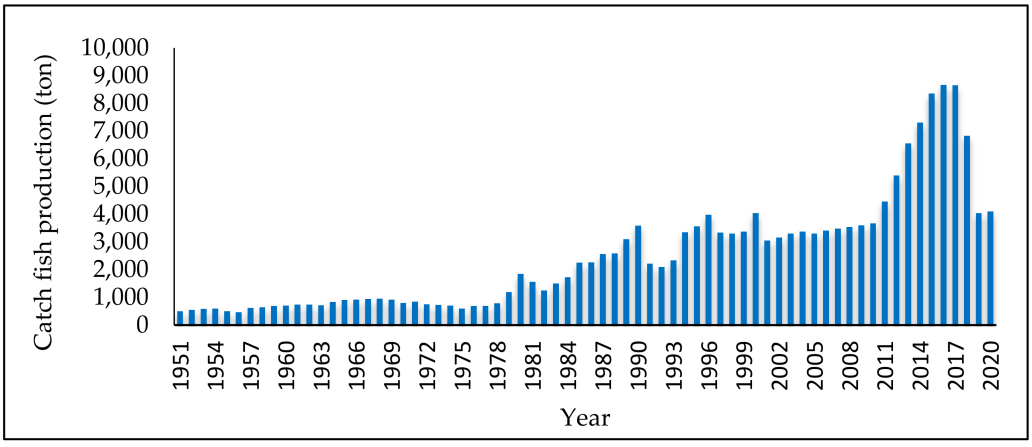


Figure 8. State of artisanal fishing in São Tomé and Príncipe from 1950 to 2020.

Since 1950, artisanal catches have been rising steadily with small fluctuations, from 500 tons to around 949 tons in 1968. After that, the catches entered a period of strong oscillations, decreasing to about 600 tons in 1975. The low production was a consequence of small political instabilities in the interior of the country; the number of boats in the artisanal fleet was reduced, and old vessels did not offer better navigability. The production increased again in 1979 and 1980, reaching 1194 tons and 1847 tons, respectively, suffering another decline that reached about 1250 tons in 1982, explained by the change in operation

strategy because the fleet was more dependent on shoals. In the following years, production increased steadily with small fluctuations until it reached about 4044 tons in 2000, about 4453 tons in 2011, and its highest production peak of about 8667 tons in 2016. These increases were caused by the availability of new fishing equipment for artisanal fishermen that facilitated the improvement of fishing technology. On the other hand, the manufacture and introduction of new motorized artisanal boats of the improved Prao type from 2010 onwards boosted the number of fishermen, which increased artisanal production. However, this increase has undergone a steep and steady decline in recent years in the catch trends of artisanal fisheries in STP, which has worried small-scale fishermen and fishery authorities, reaching a total of 6823 tons in 2018 and 4240 tons in 2020 (Figure 8). The main factors of this decline were associated with overexploitation due to the large amount of bycatch fauna caught by foreign industrial fleets, which is high compared with artisanal fishing, the presence of illegal, unreported, and unregulated fishing (IUU) in the EEZ of the country, and the effects of climate change that have conditioned the lives of fishermen and the marine ecosystem itself. With this result, we suggest that measures be taken for fishery management and conservation of marine ecosystems in Sao Tome and Principe to improve control of fishing efforts, ensuring greater legitimacy and success in the sustainability of capture activity.

3.5.2. Trends of the Capture of Semi-Industrial Fishing Fleets from 1950 to 2020

Compared with data collected in the literature, there is only data for São Tomé and Príncipe for semi-industrial fishing alone, and they are presented as estimates from 1960 to 2020. Semi-industrial catches saw their first increase to 330 t in 1960. Production has been in full growth since 1965 at 450 tons, in 1980 at a quantity of 887 tons, and in 1982 at about 888 tons, passing through periods of decrease, namely between 1981 and 1985, which reached about 455 tons, demonstrating a low increase of an average of 745 tons between 1995 and 2000, declining again to about 381 tons, dominated by the decrease in the number of semi-industrial vessels that operated during this period. From 2002 to 2016, semi-industrial catches showed a dizzying growth and gradually increased to over 2790 tons, reaching their highest production peak in 2016 at about 3201 tons thanks to the construction of new fiberglass vessels (cabinless vessels) produced in the country that improved seaworthiness and safety at sea, thus increasing the number of vessels in the semi-industrial fleet. Since 2017, the catches experienced a very slight decline at 1463 tons in 2018, rising again rapidly to about 2080 tons in 2019, with a small difference in 2020 at 2021 tons (Figure 9).

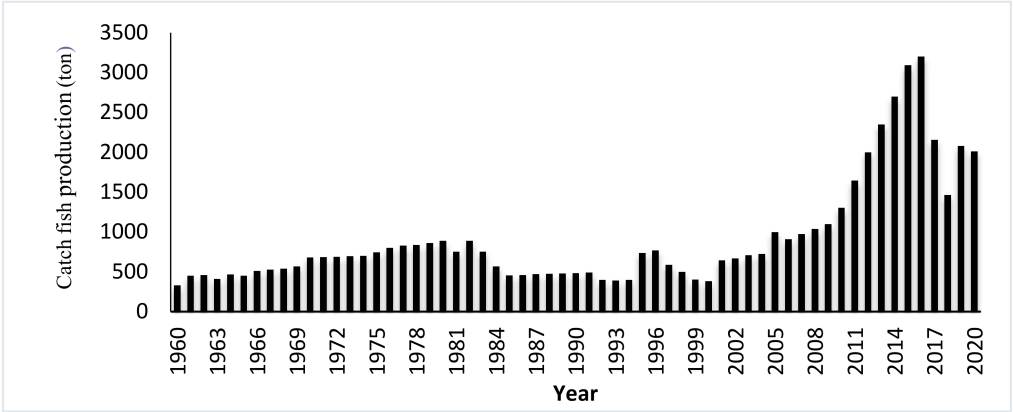


Figure 9. State of semi-industrial fishing São Tomé and Príncipe from 1960 to 2020.

The Directorate of Fisheries predicts that the decrease in catches may reach much lower values in the coming years due to constant breakdowns that could reduce the number of boats and, above all, the lack of incentive and financial conditions of the owners for possible repair. The cost of the increase in fuel in the international market due to the pandemic could affect the navigability of semi-industrial fishing vessels.

3.5.3. Foreign Industrial Fishing Fleets from 1980 to 2020

Since 1980, the foreign industrial catches have maintained a steady growth level (Figure 10), jumping from about 4000 tons to 4700 tons per year in 1989 when the agreement with the European Union, Japanese, and Chinese fishing fleets was re-established, except for in 1983, when the catch showed a slight decline, reaching about 1490 tons, influenced by the decrease in the number of vessels from the Portuguese, Japanese, and foreign fleets. From 1989 to 1994, the catches were unbalanced, maintaining a state of rising and falling, with an increase of 4000 tons in 1991 and a rapid decrease in 1994 to 2345 tons, influenced by the decrease in licenses granted to the Chinese and Japanese fleets [23,36,44]. In 1995, it was marked by the entry of new European Union (EU) longline vessels, which had a larger storage capacity, going from 5000 tons to up to 8899 tons in 1998, declining to 8400 tons, and going down to 4500 tons in 2000. This decrease was related to the reduction and termination of fishing agreements with some countries, such as China and Japan [4,36,44]. At the beginning of 2001, the catch increased again to around 7700 tons, and the effort started to reach higher peaks that were reached in 2002 at around 20,000 tons, returning to a slight decrease to 18,900 tons in 2005 [35]. We can observe a constant and decreasing behavior of catches since 2012, caused by the decline in the exploitation of tuna resources by Spanish-flagged vessels, which affected, in the same way, the increase in total production over this period, reaching 3459 tons in 2020.

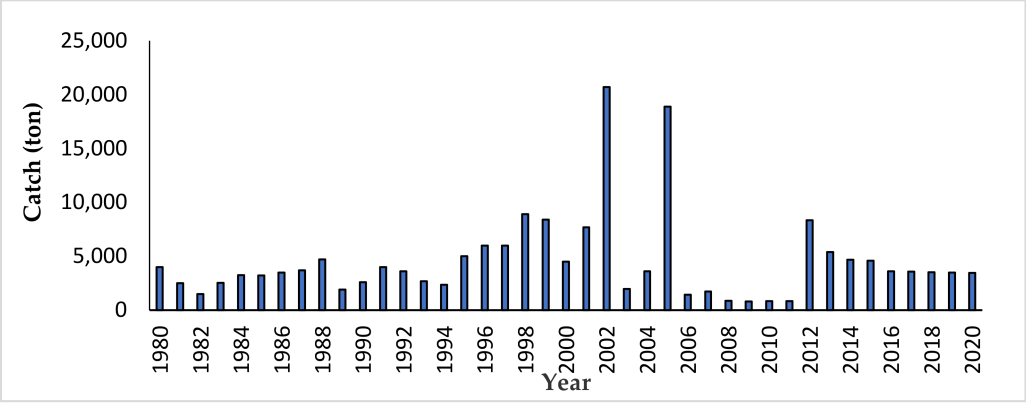


Figure 10. State of foreign industrial fishing in São Tomé and Príncipe from 1980 to 2020.

The International Commission for the Conservation of Atlantic Tunas (ICCAT) data on catches of tuna and tuna-like species by foreign vessels were specifically available for sea areas that include the São Tomé and Príncipe EEZ [35,44]. The catch data are presented in Figure 11. The average annual catches for all fleets in São Tomé and Príncipe EEZ-ICCAT were 19,202 tons of Yellowfin (44% of total catches), 18,453 tons of Skipjack (40% of total catches), 5242.2 tons of Bigeye (13%), and approximately 1053 tons of Swordfish (3%) [35,44]. The fishing season follows a distinct pattern associated with annual up-welling from May to December. Only small quantities of tuna are available in the São Tomé and Príncipe EEZ outside this season.

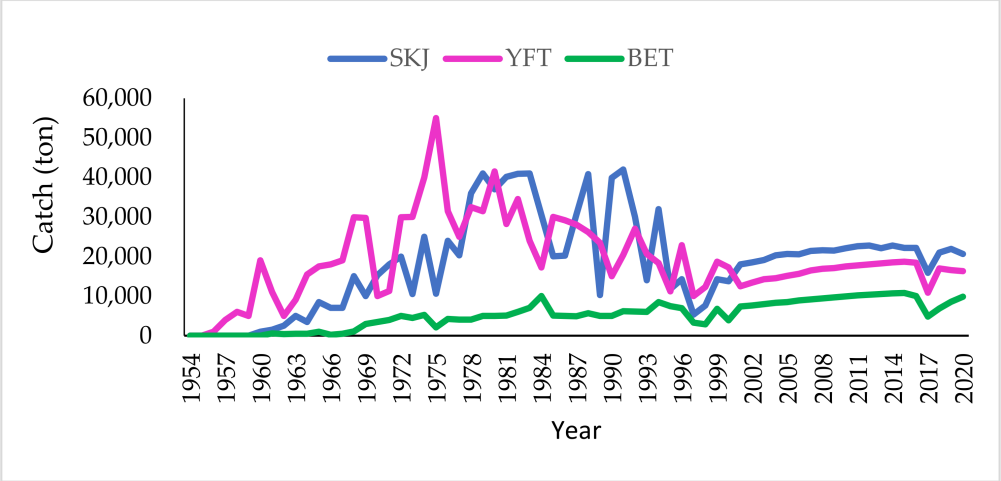
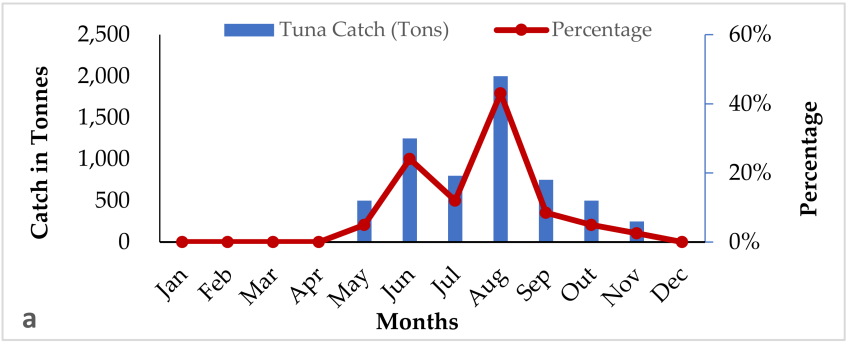


Figure 11. Catches of Skipjack (SKJ), Yellowfin (YFT), and Bigeye (BET) (in tons) in São Tomé and Príncipe in the ICCAT area, from 1954–2020.

During this phase, monthly yields were higher in August, with more than 43% for 130 fishing days (Figure 12a), except for 2003 and 2004, when yields were very low, influenced by the new changes in fishery operation strategies. From 2006 to 2011, the level of production remained low and constant, reaching about 828 tons. This indicates that there was weak participation of French and Portuguese fleet vessels (Figure 12b) during those years, and the increase in illegal, unreported, and unregulated (IUU) fishing in the EEZ of São Tomé and Príncipe originated in the decreasing effort associated with low annual upwelling from May to December [36].



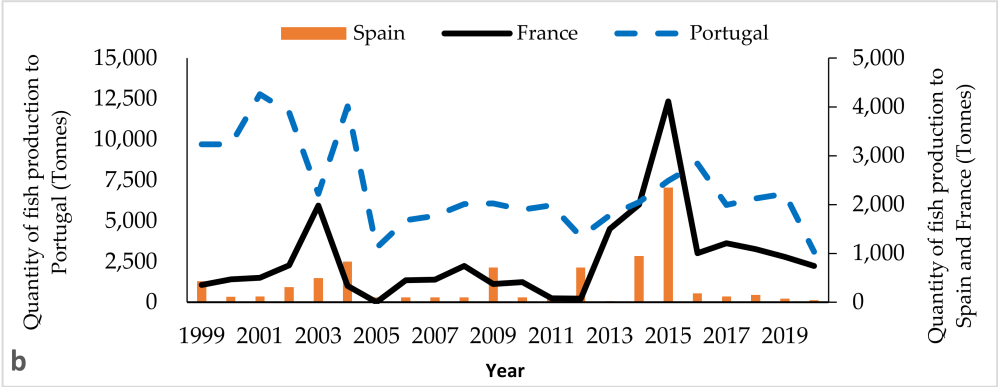


Figure 12. (**a**) Seasonality of tuna catches (in tons) by purse seine vessels in São Tomé and Príncipe EEZ from 2000 to 2005. (**b**) Catch of foreign fleets engaged in industrial fishing in São Tomé and Príncipe exclusive economic zone from 1999 to 2020.

However, it is recommended that the state decrease the number of EU vessels, which appears to have reduced some important pelagic and demersal species and be detrimental to the activities of artisanal fishermen and increase the monitoring of any changes in the catch pattern of species targeted by different fishing gears attributable to the fishing effort of the EU fleet.

3.5.4. The Overall Re-Constituted Catch Effort Trend

The total effective effort of the São Tomé and Príncipe marine catch was analyzed for the artisanal and semi-industrial fishing fleets (Figure 13) to understand the dynamics and evolution of the production capacity of the fishing sector to adopt good sustainable fishing practices under a co-management model. Marine fisheries have always shown signs of slow growth with some steady fluctuations during the 1950–2020 period, from 500 tons to just over 2312 tons in the mid-1981s, which was dominated by growth in artisanal fishing effort, except in 1975, where catch growth declined to about 1345 tons. This decline was attributed to underreporting, which was reflected in the political situation of the country, which had negative effects on fishery statistics [20,34,36,44]. In the late 1990s and early 2010, the total catch of the fishing fleets grew linearly with some fluctuations, showing a slow decline that reached 3692 tons in 2001. A few small political instabilities in the interior of the country, an old artisanal fleet that was not navigable, and a reduced number of artisanal pirogues operating during this time contributed to the unexpected reduction in production [38,39].

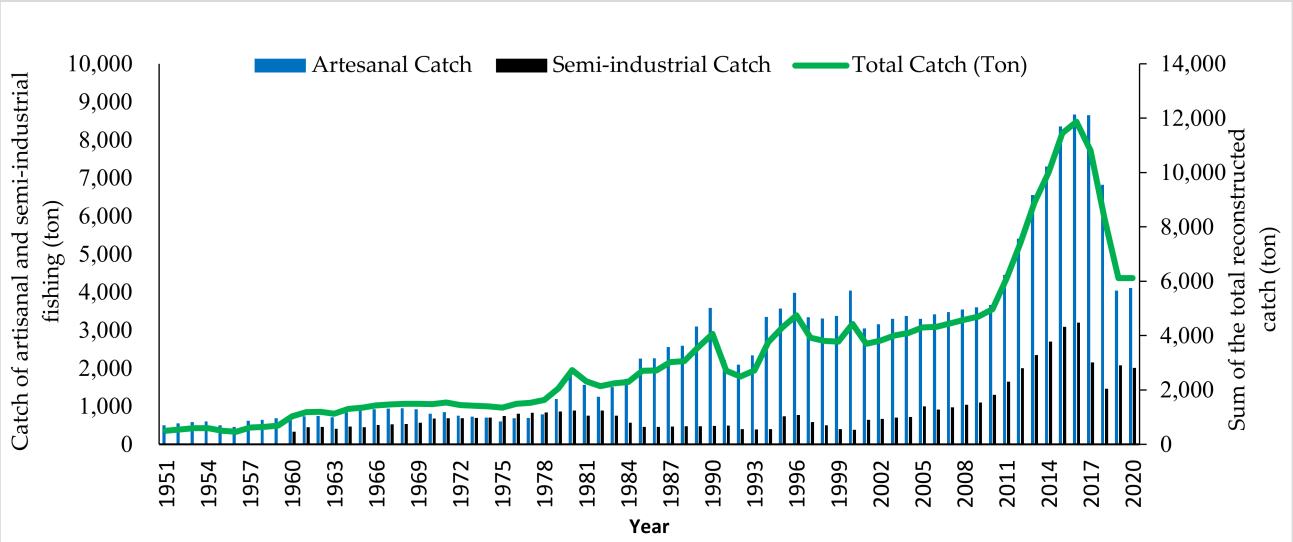


Figure 13. Total catch in tons for artisanal and semi-industrial fishing in São Tomé and Príncipe from 1955 to 2020.

From 2014 to 2016, there was an increase for the first time to initial peaks estimated at 10,000 tons, 11,448 tons, and 11,868 tons in 2014, 2015, and 2016, respectively. After that, they decreased again and greatly accelerated, reaching a total of about 6115 tons in 2020 (Figure 13). Overall, estimates indicate that the fishing potential is declining in São Tomé and Príncipe for artisanal and semi-industrial catch trends, which is in line with studies by DF-DRSTP [47], FAO [13], and Sy and Soares [48]. This is probably due to the excessive exploitation of marine resources by foreign industrial vessels in the country's EEZ, which has influenced the decline of marine biodiversity [40,47,48].

According to the fishermen surveyed, climate change was also recognized as an important factor in changing the profile of fishing catches, resulting in interference, especially in the fish breeding season. One possible topic for further investigation is to assess these perceptions of climate change scale with meteorological and oceanographic data and whether the reproductive cycles of the target species may be affected. With the increase in

demand for fish, we advise the national authorities to think about creating conditions for the development of aquaculture.

4. Discussion

To improve the understanding of the catch dynamics of artisanal, semi-industrial, and foreign industrial fishing fleets in the marine waters of São Tomé and Príncipe, a poorly studied region, this study used trend analysis based on developing, fully exploited, overexploited, and collapsed fisheries based on a time series of catch, effort, and catch per unit effort (CPUE) of fisheries, proposed by Froese and Kesner-Reyes [18] and Pikitch and Doukakis [1], to refine and update the preliminary catch and fishing effort data from 1950 to 2020 for São Tomé and Príncipe (Figure 1). In addition, this study combined the fishing fleet catch time-series data derived here with the data from the 1950–2010 fishery catch reconstruction approach presented in the study results of Belhabib [36] to develop a better understanding of the STP fishing effort trends. In general, the results of this study identify adaptive changes in the number of fishers and the number of pirogues (changes in production over time and the use of different fishing gears) as a result of changes in fish population structure, which is also in line with the results found in the studies by Belhabib [36] and Sy and Soares [48].

Our results show an increase in artisanal catches with some fluctuations from 1970 to 2010, which is in line with the studies by Belhabib [36], Carneiro [38], and Costa [4]. In the last 5 years, the trend of these catches has been constantly decreasing due to the effect of foreign industrial vessels operating in the EEZ of the country that captures a large amount of bycatch fauna, which is high compared with artisanal fishing [5,48,49]. Without undervaluing the severe impacts caused by anthropogenic factors on fisheries, climate change is widely acknowledged to be the greatest threat to fish production because it interacts with and amplifies existing non-climatic stressors [8,27,33,56]. Several researchers, such as Ndebele-Murisa et al. [53], Cheung et al. [56], Belhabib et al. [12], and Palomares et al. [31], agree that climate change is significantly contributing to declines in fish abundance in several African fishery sources. Therefore, we suggest that the number of industrial vessels be reduced so that artisanal fishing becomes more sustainable and profitable.

The comparison made between motorized and non-motorized (paddling) pirogues was derived from previous current studies compared with the study by Belhabib [36], which indicated spatial differences, with motorized pirogues operating mainly in offshore areas (EEZ), while the latter operate largely in coastal areas. The use of pirogue capacity with effort efficiency for each type of gear used daily by fishermen allowed us to obtain data that helped to compare with studies by D'almeida et al. [39], Failler et al. [40], Krakstad et al. [42], Maia et al. [43], and Oceanic Development et al. [44]. We observed throughout this study that a large component of artisanal and semi-industrial catches is intended to supply the domestic market, which also reflects the nature of the economy of São Tomé and Príncipe [11,34,36,57], but in recent years, this practice has been changing with the demand by tourists for small consignments of fish that are exported to the European market [13,34,48].

To understand the dynamics of industrial foreign catches, data from the literature [36,38,40,44] were used, to which were added the catches that were informed by ICCAT [35] and Krakstad et al. [42]. Furthermore, the foreign catches observed here show high values between 1995 and 2005, with some variation (Figure 10) compared with the values that were reported in the STP fishery reconstruction [21,36]. While the increases considered here have been steadily declining from their peak in recent decades, it appears that the exact total catches remain unknown for the country, as foreign fleets do not report their catches to the STP government. However, the fact that tuna stocks (Figure 11) are attractive to foreign fleets, and that the country depends on revenues from fishing agreements that represent 6% of the state budget [31,58], makes these agreements attractive regardless of lack of control [5,20,36] and weak enforcement (STP has no surveillance vessels) [12,21]. Although foreign industrial fleets mainly exploit offshore tuna in the São Tomé and Príncipe EEZ,

artisanal fishermen often point the finger at foreign fleets to explain the decline in coastal artisanal catches.

However, the lack of authentic data on the catches of artisanal, semi-industrial, and foreign industrial fisheries, also reported in the study presented by Belhabib [36], Anon [21], Carneiro [38], Costell and Ovando [23], Sy and Soares [48], and Téla Non [24], has been a constraint for São Tome and Príncipe fishery statistics. A decline in the capture of these legal commercial fleets, especially those of greater capacity in the EEZ, particularly some illegal industrial fishing vessels and pelagic trawlers that target small pelagic fish, contributing to a decrease in the fishing biodiversity of commercial species, could also be observed [6,38]. Hence, contributing to a decrease in catches of artisanal fishing and increasingly impoverishing the fishermen of São Tomé and Príncipe.

According to results by Belhabib [36], the consumption of small-scale-caught fish has been decreasing over time, which is in line with our study and estimates in the literature [8,27]. If this situation continues, it could threaten food security in the country, with global repercussions [7,8,12,27,55]. Furthermore, our study shows that about 35.3% of the domestic catch (Figure 7) included Atlantic flying fish (*Cheilopogon melanurus*), dominated by the artisanal fleet [7,23,34,40], in contrast to the 70% that was reported in the fishery reconstruction study by Belhabib [36].

However, other negative measures that have hindered the development of fishing are closely related to the economy of fishing, since fuel is the main cost factor of motorized canoes [22,25,38], and for future analysis, a study of value chains of exploitation of fishery resources is recommended for economic feasibility studies, agreeing with the point of view of D'almeida et al. [34], Horemans et al. [43], NGO-MARAPA [27], and Porriños [52]. Furthermore, the results of the studies carried out by Djiénouassi [5], DF-DRSTP [46], and Moniz et al. [19], as well as the studies of Porriños [49], also show that the captures of some fish species have decreased in the marine waters of São Tomé and Príncipe due to the use of illegal fishing gear, namely hand grenades, with consequences for the marine environment, and that conflicts have arisen between fishermen from different fishing communities, as reported by Belhabib [12], Kiruba-Sankar et al. [59], and Mpomwenda et al. [26]. To address this situation, and in contrast to what we have observed in other West African countries [12,37,40], fishermen in STP should use motorized pirogues as a means of ensuring better navigability to reach different areas of capture, thus avoiding clustering in the same fishing grounds, ensuring greater productivity and helping to spend less time at sea during the fishing operation [38].

However, there are several uncertainties in our analysis for estimating catch data and understanding fishing efforts. As STP official catch data is linked to a lack of precision, reconstruction methods by Belhabib [36], Pauly and Zeller [1], and Froese and Kesner-Reyes [18] provide alternatives to overcome this distortion while reducing the uncertainty related to catch and fishing effort data [3,5,12,19]. Therefore, we propose that policies be implemented that give priority to the artisanal and semi-industrial sectors, as their relative impacts on catch and the ecosystem are lower than those of the foreign industrial sector. However, we stress that routine Malthusian overfishing [16,36], driven by high labor inflows to coastal fisheries, as opposed to capital overfishing that results in increased artisanal capacity, should be established in conservation measures through the use of the new CPUE and effort metrics we address here in this study. Although the artisanal and semi-industrial sectors have less impact, less catch, and greater selectivity, their contribution is much greater relative to foreign industrial fisheries operating in marine waters, which reflects negatively on the nature of the economy of STP [49].

However, sustainable fishery management depends on the results of stock assessment studies, as cited by Barman et al. [60], Caddy and Mohon [25], and Pomeroy et al. [27], as well as management around social criteria. A fish stock assessment study and the establishment of TAC in all capture zones are paramount for STP and can provide policy-makers and fishery managers with valuable information to formulate an effective fishery management policy.

According to Airaud [28], Garcia and Prouzet [10], and NGO-OIKOS [29], community-based approaches will need to be applied through a co-management model for the fisheries and coastal resources that can decrease excessive fishing effort with responsibilities explicitly ceded from national governments to local entities. If successfully applied in conjunction with the necessary standards and measures in every aspect of catch, it will contribute to effort reduction and unrestricted access of the fishery resource in the form of recovery of many ecosystems and consequently improved yields.

It is important to note that the development of STP is based on the profiles of artisanal fisheries (Table 1 and Figure 9) and semi-industrial fisheries (Figure 10). We estimate that with better control and registration of catches, a reduction in foreign industrial vessels, good hygienic capacity for domestic processing and export markets, and policies aimed at giving priority to these two fishing fleets, we could develop the marine fishing sector and promote more jobs for the population of STP.

5. A Perspective on Fisheries Management Measures

To make sound decisions about future management to increase the abundance of fish in the STP sea, managers need to have a good understanding of how much fish has been caught over long periods. Unfortunately, current management and stock assessment processes are often flawed because they are often based on time series of data that do not represent the entire chain of change and can lead to misunderstandings about status. Compared with the literature, the management of fisheries for STP needs to be implemented accurately and consider a set of technical measures that will play a key role in making this decision and control effective. Technical changes have been occurring rapidly, making fishing less selective and more destructive, including the use of small mesh, which has reduced unwanted catches and destroyed the ecosystem of the species.

The development of an integrated plan for sustainable fishery management, as the main enforcement strategy, should contemplate all measures or actions to be implemented with greater rapprochement between the fishing industry, fishermen, and scientists to obtain a strong collaboration and recognition of each other in fishery management, which will help in the construction of constructive policies with guiding principles that ensure and improve the way to more sustainable and economically viable fisheries. Some studies argued that setting the total allowable catch (TAC) was the main management measure to conserve stocks of marine resources [14,41,61].

Another important measure is the applicability of MSY strategy evaluation to assess the performance of catch control rules (HCR) that can be sustained over time and participatory management procedures that will bring together the artisanal fishing sector and fishing community, using a co-management model [10,28,29]. This model is essential to address the lack of local knowledge about the biology of coastal species (spatial distribution in habitats), reproduction biology (reproduction periods, reproduction sites, and sexual maturity), and the presence of juvenile and adult individuals of different species in different coastal habitats [28] for decision making regarding sustainable and responsible management of fishery resources and to promote a social-ecological approach to fisheries [10].

In general, the analysis of the strengths and weaknesses of fisheries will help the country to define priorities to improve control and ensure better respect for the rules to be implemented at the level of fisheries associations. The respect of the rules (General Fisheries Act and Fisheries Regulation) and the rules of the fishery co-management approaches depends on the understanding and acceptance of the regulations and also on the existing maritime enforcement efforts and devices in the fishing communities. The guidance in this study can help future fishery managers and policymakers plan and chart a path to more sustainable fisheries and employment opportunities, thus effectively promoting a viable fishing economy.

6. Conclusions and Recommendations for Future Research Work

This study integrates updated information related to the CPUE of vessels and fishing gear; the catch effort of fishing fleets; and the state of stock in STP. The information obtained allowed us to understand the management approach and the dynamics of the evolution of the catches of the fishing fleets operating in the maritime waters of São Tomé and Príncipe from 1950 to 2020.

The results show the percentage of total biomass potential for total catches of demersal species and pelagic species caught by the fishing fleets in the sea of STP has gradually decreased. For fishery management, it is very important that detailed information on the provenance of catches can be obtained to implement a co-management approach. When this information does not exist, an approximation of the actual values can be obtained through the use of CPUE, provided that the operation of the fishery and the characteristics of the fleet are well-known. While this is not the ideal approach, it can alleviate short-term information needs by assisting in immediate management decisions. The lack of organized, up-to-date fishery data and resource assessment protocols remains the most crucial issue in the São Tomé and Príncipe fishery sector. Development programs are taken-up based on available estimates of fishing potential and fish landings. However, decisions based on unrealistic fishing data can threaten the sustainability of marine resources.

The development of alternative sectors through semi-industrial fishing sustainability activities should be promoted by following up with appropriate monitoring, control, and surveillance (MCS) systems. At-sea observation and electronic monitoring systems are important components that could be adopted in the future to analyze and identify the strengths and shortcomings in São Tome and Príncipe's ability to meet the requirements of the Agreement on Port State Measures (APSM) for fishery control [6,59].

From this analysis and opinions, we therefore suggest the following recommendations for greater discipline, effectiveness, and a sustainable management approach for the rational exploitation of fishery resources in the sea of São Tomé and Príncipe:

- Improvements in fishing catch data collection, monitoring, and updating;
- Biology research, population dynamics, stock assessment, control of fishing effort, and establishment of TACs in all catch areas are paramount and necessary for proper management. This measure will help clarify the catch potential in São Tomé and Príncipe waters and minimize pressure on the resource.
- The implementation of a community-based co-management model for commercial fisheries in São Tomé and Príncipe. This model would help the government to improve implementation capacities in the process of shared governance and decision making in local communities related to sustainable and participatory management of fisheries in the coastal zone.

The challenges and recommendations for future studies identified for the STP marine fisheries sector are enormous and require coordinated management and institutional support, so we believe the actions noted will help resolve some of these challenges in the long term.

Author Contributions: Conceptualization, W.B.M.Z. and R.K.; methodology, W.B.M.Z.; software, W.B.M.Z. and A.H.M.; validation, R.K. and X.D.; formal analysis, W.B.M.Z.; research, W.B.M.Z.; resources, X.D.; data curation, W.B.M.Z.; writing—original draft preparation, W.B.M.Z.; visualization, O.S; writing—review and editing, O.S.; proofreading and editing, R.K.; supervision, R.K.; project administration, X.D. All authors have read and agreed to the published version of the manuscript.

Funding: This study was funded by financial support for the project on the Survey and Monitoring-Evaluation of Global Fishery Resources sponsored by the Ministry of Agriculture and Rural Affairs (21-0109-02), by the National Key R&D Programs of China (2019YFD0901404) and by the National Programmer on Global Change and Air-Sea Interaction (GASI-01-EIND-YD01aut/02aut).

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data analyzed in this study is available and can be provided if needed.

Acknowledgments: We thank the Directorate of Fishing for providing us with some fishing statistical data and our institutional colleagues for their contributions to this manuscript. A special thanks to the editor and the anonymous reviewers who contributed constructive comments and detailed reviews that helped to improve the present article.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Pauly, D.; Zeller, D. Catch reconstructions reveal that global marine fisheries catch are higher than reported and declining. *Nat. Commun.* **2016**, *7*, 1–9. [CrossRef] [PubMed]
2. FAO. Programa Integrado de Reestruturação da Pesca. Relatório FAO/SFC/STP. 2009, p. 67. Available online: https://docs.wfp.org/api/documents/WFP-0000070152/download/ (accessed on 10 May 2021).
3. Belhabib, D.; Pauly, D. *Fisheries Catch Reconstructions: West Africa, Part II, Fisheries Centre Research Reports Fisheries Centre*; University of British Columbia: Vancouver, BC, Canada, 2015; Volume II, pp. 37–50.
4. Costa, F.C. *Estudos de Pescas em S. Tomé e Príncipe*; Expedition Report 8; Ministério Junta Investigação Ultramarino: São Tomé, São Tomé e Príncipe, 1959; pp. 219–271.
5. Djiénouassi, S. *Avaliação da Contribuição da Pesca Marítma Artesanal Para o PIB dos Países Membros da COREP*; Food and Agriculture Organization of the United Nations: Rome, Italy, 2016; p. 24.
6. FAO. *The State of World Fisheries and Aquaculture—Meeting the Sustainability in Action*; FAO: Rome, Italy, 2020. [CrossRef]
7. Obiero, K.; Meulenbroek, P.; Drexler, S.; Dagne, A.; Akoll, P.; Odong, R.; Kaunda-Arara, B.; Waidbacher, H. The Contribution of Fish to Food and Nutrition Security in Eastern Africa: Emerging Trends and Future Outlooks. *Sustainability* **2019**, *11*, 1636. [CrossRef]
8. Muringai, R.T.; Mafongoya, P.; Lottering, R.T.; Mugandani, R.; Naidoo, D. Unlocking the Potential of Fish to Improve Food and Nutrition Security in Sub-Saharan Africa. *Sustainability* **2021**, *14*, 318. [CrossRef]
9. Espírito Santo, S.; Carvalho, P.B. *Food Consumption, Food Chains and Market Evolution in São Tomé e Principe: A Case Study in Su-Saharan Africa*; Instituto Suprior Politécnico de São Tomé e Principe: Sao Tome, São Tomé and Príncipe, 2010; p. 18.
10. Garcia, S.M.; Prouzet, P. Towards the implementation of an integrated approach to fisheries resources management in Ifremer, France. *Aquat. Living Resour.* **2009**, *22*, 381–394. [CrossRef]
11. Adelino, F.; Moniz, E.; Nascimento, M. *Evaluation de la Contribution Socio-Economique de la Peche au PIB et au Developpement de Sao Tome e Principe*; Sustainable Fisheries Livelihoods Programme; DFID: London, UK; FAO: Rome, Italy, 2005; p. 20.
12. Belhabib, D.; Greer, K.; Pauly, D. *Trends in Industrial and Artisanal Catch Per Effort in West African Fisheries. Sea Around Us, Institute for the Oceans and Fisheries*; The University of British Columbia: Vancouver, BC, Canada, 2016; pp. 332–2202.
13. FAO. *Estratégia de Transição da Economia Azul Para SãoTomé e Príncipe*; FAO: Rome, Italy, 2021; Available online: https://www.fao.org/publications/card/fr/c/CB5913PT/ (accessed on 9 April 2020).
14. Afonso, P.F.M.; Porteiro, R.S.; Santos, J.P.; Barreiros, J.; Worms, J.; Wirtz, P. Coastal marine fishes of São Tomé Island (Gulf of Guinea). *Arquipélago Life Mar. Sci.* **1999**, *17*, 65–92.
15. Lee, Y.-J.; Su, N.-J.; Lee, H.-T.; Hsu, W.; Liao, C.-H. Application of Métier-Based Approaches for Spatial Planning and Management: A Case Study on a Mixed Trawl Fishery in Taiwan. *J. Mar. Sci. Eng.* **2021**, *9*, 480. [CrossRef]
16. Scopa, A.; Nkawambi, W.; Delbaere, J.; Salvaterra, H.; Bongi, S. Republique democratique de Sao Tome et Principe. Analyse Globale de la Sécurité Alimentaire et de la Vulnérabilité. São Tomé. 2009. Available online: http://documents.wfp.org/stellent/groups/public/documents/ena/wfp196154.pdf (accessed on 10 February 2021).
17. Vasconcelos, M. *Um Olhar Diferente para o Futuro-Os Oceanos e a 'Sustentabilidade' das Pescas*; Comunicação Apresentada no Seminário Sobre a Convenção Europeia-Convencionar ou Constitucionalizar a Reforma das Políticas; UALG: Faro, Portugal, 2003.
18. Froese, R.; Kesner-Reyes, K. Impact of fishing on the abundance of marine species. *J. Mar. Sci.* **2002**, *12*, 1–12.
19. Moniz, A.; Godinho, M.M. New Methodological Approaches for Change in Traditional Sectors: The Case of the Portuguese Fisheries Socio-Economic System. *Econ. Soc.* **2000**, *5*, 63–77.
20. Alegre, M.-C.C. *Towards a National Ocean Policy in Sao Tome and Principe*; The United Nations-Nippon Foundation Fellowship Programme 2009–2010; The United Nations: New York, NY, USA, 2009; Volume 76.
21. Anon. *Atelier Paris 21 pour l'Afrique du Centre sur l'utilisation des Statistiques dans les Politiques de Lutte Contre la Pauvrete et de Developpemen*; Democratic Republic of Sao Tome and Principe: Sao Tome, São Tomé and Príncipe, 2002; p. 26.
22. Belhabib, D.; Cheung, W.W.L.; Kroodsma, D.; Lam, V.W.Y.; Underwood, P.J.; Virdin, J. Catching industrial fishing incursions into inshore waters of Africa from space. *Fish Fish.* **2019**, *21*, 379–392. [CrossRef]
23. Costello, C.; Ovando, D. Status, Institutions, and Prospects for Global Capture Fisheries. *Annu. Rev. Environ. Resour.* **2019**, *44*, 177–200. [CrossRef]
24. Téla Non. Nova lei da pesca dá Mais liberdade a Guarda Costeira no Combate a Pesca Ilegal. Available online: https://www.telanon.info/politica/2021/11/22/35732/nova-lei-da-pesca-da-mais-liberdade-a-guarda-costeira-no-combate-a-pesca-ilegal/ (accessed on 16 January 2022).

25. Caddy, J.F.; Mohon, R. *Reference Points for Fisheries Management*; FAO Fisheries Technical Paper; FAO: Rome, Italy, 2005; Volume 347, p. 83.
26. Mpomwenda, V.; Tómasson, T.; Pétursson, J.G.; Taabu-Munyaho, A.; Nakiyende, H.; Kristófersson, D.M. Adaptation Strategies to a Changing Resource Base: Case of the Gillnet Nile Perch Fishery on Lake Victoria in Uganda. *Sustainability* **2022**, *14*, 2376. [CrossRef]
27. Pomeroy, R.S.; Andrew, N. *Small-Scale Fisheries Management: Frameworks and Approaches for the Developing World*; CABI: London, UK, 2011.
28. Airaud, F. Projeto de Cogestão das Pescas no sul da Ilha de São Tomé Kike da Mungu—Peixe para Amanha; OIKOS em Cogestão das Pescas. Technical Report. 2018. Available online: https://kikedamungu.weebly.com/ (accessed on 14 January 2020).
29. NGO-OIKOS. Sustainable Co-Management of Fisheries in the South of São Tomé Island, São Tomé and Príncipe. Available online: https://www.eeas.europa.eu/node/36523_en (accessed on 20 June 2021).
30. NGO-MARAPA. *Caracterização das Pescarias na Zona Sul de São Tomé. Projeto Kike da Mungu, MARAPA/DP/FAPP, São Tomé, São Tomé e Príncipe*. 2017. Available online: https://kikedamungu.weebly.com/uploads/1/0/7/0/107098529/relatorio_pescarias_ativas_final.pdf (accessed on 10 March 2022).
31. Palomares, M.L.D.; Froese, R.; Derrick, B.; Meeuwig, J.J.; Nöel, S.-L.; Tsui, G. Tendências de biomassa da pesca de populações de peixes explorados em ecoregiões marinhas, zonas climáticas e bacias oceânicas. Estuar, o que está com o Estuar. *Costa Prateleira Sci.* **2020**, *243*, 106896. [CrossRef]
32. Espinoza, C.; Gallardo, V.A.; Merino, C.; Pizarro, P.; Liu, K.-M. Sustainability of the Artisanal Fishery in Northern Chile: A Case Study of Caleta Pisagua. *Sustainability* **2020**, *12*, 7290. [CrossRef]
33. Hara, M.; Njaya, F. Between a rock and a hard place: The need for and challenges to implementation of Rights Based Fisheries Management in small-scale fisheries of southern Lake Malawi. *Fish. Res.* **2016**, *174*, 10–18. [CrossRef]
34. DF-DRSTP (Directorate of Fisheries—Democratic Republic of São Tomé and Príncipe). *Report of the Follow-Up Study of Demersal Species in the Coastal Zone of São Tomé and Príncipe*; DF-DRSTP: São Tomé, São Tomé and Príncipe, 2015.
35. International Commission for the Conservation of Atlantic Tunas. *Report of the Biennial Period 2002-03 Part I*; ICCAT: Madrid, Spain, 2003; Volume 2. (In English)
36. Belhabib, D. *Fisheries of Sao Tome and Principe, a Catch Reconstruction (1950-2010)*; Working Paper; University of British Columbia: Vancouver, BC, Canada, 2015; p. 67.
37. Kamphorst, B.; Teixeira, M. Características Socio-Económicas da Pesca em São Tomé e Príncipe. Programa para o Desenvolvimento Integrado das Pescas Artisanais na Africa Ocidental. Cotonou. Projecto DIPA. 1995, p. 32. Available online: https://www.fao.org/3/an183pt/an183pt.pdf (accessed on 14 June 2021).
38. Carneiro, G. They come, they fish, and they go EC fisheries agreements with Cape verde and São Tomé e Príncipe. *Mar. Fish. Rev.* **2011**, *73*, 1–25.
39. D'Almeida, A.; Anibal, O.; Bandeira, A.B.; Costa, G.; Teixeira, M.; Worms, J. La Péche Artisanale à São Tomé—Resultats de Trois Annèes de Recherche. 1993–1995. PERH—Rapport Scientifique. 1996, p. 38. Available online: https://www.fishbase.se/References/FBRefSummary.php?id=34627&speccode=1057 (accessed on 10 August 2021).
40. Failler, P.; Fonteneau, A.; Defaux, V. *Evaluation Retrospective et Prospective du Protocole de l'accord de Partenariat dans le Secteur de la Peche Entre l'Union Europeene et la Republique Democratique de São Tomé et Príncipe*; Poseidon Aquatic Resource Management Ltd.: Brussels, Belgium, 2013; p. 123.
41. Horemans, B.; Gallène, J.; Njock, J. Revista Setorial da Pesca Artesanal a São Tomé e Príncipe. Programa de Desenvolvimento Integrado das Pescas Artesanais na África Ocidental. 1994, p. 32. Available online: https://www.fao.org/3/an097pt/an097pt.pdf (accessed on 10 May 2020).
42. Krakstad, J.; Alvheim, O.; Lopes, J.D.S. Surveys of the Fish Resources of São Tomé & Príncipe Survey of the Demersal Resources. Institute of Marine Research Cruise Report. 2010. Available online: http://hdl.handle.net/11250/107339 (accessed on 1 November 2020).
43. Maia, H.A.; Moraise, R.A.; Siqueirae, A.C.; Hanazakia, N.; Floetera, S.R.; Benderb, M.G. Shifting baselines among traditional fishers in São Tomé and Príncipe islands, Gulf of Guinea. *Ocean. Coast. Manag.* **2018**, *154*, 133–142. [CrossRef]
44. Oceanic Development, Poseidon Aquatic Resource Management Ltd.; MegaPesca Lda. *Framework Contract for Performing Evaluations, Impact Analyses, and Monitoring Services in the Context of Fisheries Partnership Agreements Concluded between the Community and Non-Member Coastal States*; European Commission: Concarneau, France, 2004; p. 126.
45. Zeller, D.; Vianna, G.M.S.; Ansell, M.; Coulter, A.; Derrick, B.; Greer, K.; Noël, S.-L.; Palomares, M.L.D.; Zhu, A.; Pauly, D. Fishing Effort and Associated Catch per Unit Effort for Small-Scale Fisheries in the Mozambique Channel Region: 1950–2016. *Front. Mar. Sci.* **2021**, *8*, 707999. [CrossRef]
46. DF-DRSTP (Directorate of Fisheries—Democratic Republic of São Tomé and Príncipe). *Statistical Bulletin of the Estimated Catch Data of the Main Species of Artisanal Fisheries of São Tomé and Príncipe from 2001 to 2010*; DF-DRSTP: São Tomé, São Tomé and Príncipe, 2010.
47. DF-DRSTP (Directorate of Fisheries—Democratic Republic of São Tomé and Príncipe). *Statistical Bulletin of the Estimated Catch Data of the Main Artisanal Fishing Species*; DF-DRSTP: São Tomé, São Tomé and Príncipe, 2019.
48. Sy, A.; Soares, D.O. *Estudo do Sector dos Produtos do Mar em São Tomé e Príncipe: Descrição Qualitativa/Quantitativa das Cadeias de Abastecimento e de Valor*; FAO: Rome, Italy, 2019.

49. Porriños, G. Characterization of Artisanal Fisheries in São Tomé and Príncipe Using Participatory Methods and Smartphone Technology. 2019. Available online: http://www.gporrinos.com/uploads/1/0/8/7/108752045/baf-ls-pt_dados-pesca_projeto-blue-action_stp.pdf (accessed on 10 May 2021).
50. Khatib, H.; Jiddawi, N. Zanzibar Fisheries Frame Survey Report, Department of Fisheries and Marine Resources, Stone Town, Zanzibar. 2010, pp. 1–80. Available online: https://www.tandfonline.com/doi/full/10.1080/23308249.2020.1802404 (accessed on 10 May 2022).
51. Rehren, J.; Samoilys, M.; Reuter, H.; Jiddawi, N.; Wolff, M. Integrating Resource Perception, Ecological Surveys, and Fisheries Statistics: A Review of the Fisheries in Zanzibar. *Rev. Fish. Sci. Aquac.* **2020**, *30*, 1–18. [CrossRef]
52. Wirtz, P.; Ferreira, C.E.L.; Floeter, S.R.; Fricke, R.; Gasparini, J.L.; Iwamoto, T.; Rocha, L.; Sampaio, C.L.; Schliewen, U.K. Coastal fishes of São Tomé and Príncipe islands, gulf of Guinea (eastern Atlantic Ocean)–an update. *Zootaxa* **2007**, *1523*, 1–48. [CrossRef]
53. Ndebele-Murisa, M.R.; Mashonjowa, E.; Hill, T. The implications of a changing climate on the Kapenta fish stocks of Lake Kariba, Zimbabwe. *Trans. R. Soc. S. Afr.* **2011**, *66*, 105–119. [CrossRef]
54. Barman, P.P.; Karim, E.; Khatun, M.H.; Rahman, M.F.; Alam, M.S.; Liu, Q. Application of CMSY to Estimate Biological Reference Points of Bombay Duck (*Harpadon nehereus*) from the Bay of Bengal, Bangladesh. *Appl. Ecol. Environ. Res.* **2020**, *18*, 8023–8034. [CrossRef]
55. Baptista, A.J.M.S. Sustentabilidade da Produção Pesqueira em Cabo Verde. Available online: https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2011:0425:FIN:EN:PDF (accessed on 14 January 2020).
56. Cheung, W.W.L.; Lam, V.W.Y.; Sarmiento, J.L.; Kearney, K.; Watson, R.; Pauly, D. Projecting global marine biodiversity impacts under climate change scenarios. *Fish. Fish.* **2009**, *10*, 235–251. [CrossRef]
57. Coffey, A.; Atkinson, P. *Making Sense of Qualitative Data: Complementary Research Strategies*; Sage Publications: Thousand Oaks, CA, USA, 1996; Available online: https://us.sagepub.com/en-us/nam/making-sense-of-qualitative-data/book5617 (accessed on 14 June 2020).
58. Garcia, S.M.; Zerbi, A.; Aliaume, C.; Do Chi, T.; Lasserre, G. *The Ecosystem Approach to Fisheries. In Issues, Terminology, Principles, Institutional Foundations, Implementation, and Outlook*; FAO Fisheries Technical Paper; FAO: Rome, Italy, 2003; Volume 443, p. 71.
59. Kiruba-Sankar, R.; Kumar, K.L.; Angel, J.R.J.; Salim, S.S.; Saravanan, K.; Krishnan, P.; Ravikumar, T.; Roy, S.D. Impact evaluation of marine fisheries interventions among Tribal Fisher Commune of Car Nicobar Island, India. *J. Mar. Biol. Assoc. India* **2020**, *62*, 84–89. [CrossRef]
60. Barman, P.P.; Shamsuzzaman, M.M.; Schneider, P.; Mozumder, M.M.H.; Liu, Q. Fisheries Reference Point and Stock Status of Croaker Fishery (Sciaenidae) Exploited from the Bay of Bengal, Bangladesh. *J. Mar. Sci. Eng.* **2022**, *10*, 63. [CrossRef]
61. Pikitch, E.; Doukakis, P. *Recommendations for Fisheries Reform for São Tomé and Príncipe*; Rew Institute for Ocean Science: Washington, DC, USA, 2005; p. 14.