Characterisation of artisanal fisheries in São Tomé and Príncipe through participatory, smartphone-based landing surveys

Report prepared for the project:
"Establishing a network of marine protected areas
across São Tomé and Príncipe through a co-management approach"

© G. Porriños

Report prepared by **Guillermo Porriños**, June 2021

REVIEWED BY   **Nina da Rocha** (Project Assistant, *Fauna & Flora International*)

TEAM   **Guillermo Porriños** (Independent consultant for *Fauna & Flora International*)
Manuel da Graça (Príncipe, *Fundação Príncipe*)
Albertino Santos (São Tomé, *MARAPA*)
Lodney Nazaré (São Tomé, *Oikos*)
Sinaida Espírito Santo (São Tomé, *MARAPA*)
Nina da Rocha (Project Assistant, São Tomé e Príncipe, *Fauna & Flora International*)
Luisa Madruga (Project Coordinator, São Tomé e Príncipe, *Fauna & Flora International*)

Table of contents

Characterisation of São Tomé and Príncipe's artisanal fisheries through participatory, smartphone-based landing surveys

1. INTRODUCTION

Globally, artisanal fisheries contribute up to 50% of all landed fish, and in West Africa the fishing effort of the artisanal fishing fleet is three times higher than that of the industrial fishing fleets operating in the region[1,2]. Small-scale fisheries are also one of the main sources of protein and income for many coastal communities in rural areas globally[3]. However, despite their global importance, artisanal fisheries are often underrepresented in fisheries statistics[4]. Although understanding the socio-economic dimensions of artisanal fisheries is essential for their management, in many cases, national-level data remains scattered and incomplete[5]. In São Tomé and Príncipe, fish contributes to 75% of the animal protein intake and the archipelago is amongst the world's most fisheries-dependent countries[6,7.]

Given these set of circumstances, there is a strong need to invest in small-scale fisheries research and to develop participatory tools to involve small-scale fishing communities in data collection and the application of resulting research findings[8]. The project "Establishing a network of marine protected areas across São Tomé and Príncipe through a co-management approach", funded by *Blue Action Fund* and *Arcadia – a charitable fund of Peter Baldwin and Lisbet Rausing,* is addressing this gap by implementing participatory landing surveys across 21 fishing communities in São Tomé and Príncipe (STP), using the open-source smartphone application Open Data Kit to collect fisheries data. This report presents the results of the data collected from August 2019 to December 2020.

1.1. THE MARINE ENVIRONMENT IN SÃO TOMÉ AND PRÍNCIPE

São Tomé and Príncipe (STP) is a small-island state comprised of two main islands and several islets, located in the Gulf of Guinea and part of the Cameroon Volcanic Line. Both São Tomé and Príncipe are true oceanic islands, separated from each other and from the African mainland by a sea that is over 2000 metres deep

[1] **Belhabib**, D., **Greer**, K. and **Pauly**, D. (2018) 'Trends in Industrial and Artisanal Catch Per Effort in West African Fisheries', *Conservation letters*, 11(February), pp. 1–10. doi: 10.1111/conl.12360.

[2] **Cashion**, T. *et al.* (2018) 'Reconstructing global marine fishing gear use: Catches and landed values by gear type and sector', *Fisheries Research*. Elsevier, 206(April), pp. 57–64. doi: 10.1016/j.fishres.2018.04.010.

[3] **Jacquet**, J. and **Pauly**, D. (2008) 'Funding Priorities: Big Barriers to Small-Scale Fisheries', *Conservation and policy*, 22(4), pp. 832–835. doi: 10.1111/j.1523-1739.2008.00978.x.

[4] **De Graaf**, G. J. *et al.* (2011) 'The status of routine fishery data collection in Southeast Asia , central America , the South Pacific, and West Africa, with special reference to small-scale fisheries', *ICES Journal of Marine Science*, 68, pp. 1743–1750.

[5] **Mills**, D. J. *et al.* (2011) 'Under-reported and Undervalued: Small-scale Fisheries in the Developing World', in *Small-scale fisheries management: frameworks and approaches for the developing world*. doi: 10.1079/9781845936075.0001.

[6] **Belhabib**, D. (2015) *Fisheries of Sao Tome and Principe, a catch reconstruction (1950-2010)*, Fisheries Centre, The University of British Columbia. doi: 10.1139/xxxx

[7] **Barange**, M. *et al.* (2014) 'Impacts of climate change on marine ecosystem production in societies dependent on fisheries', *Nature Climate Change*, 4 (March), pp. 211–216. doi: 10.1038/NCLIMATE2119.

[8] **FAO** (2015) *Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries*.

(see Figure 1). São Tomé has an area of 865 km^2 and a population of ca.180,000; and Príncipe has an area of 136 km^2 and an estimated population of 8,000. Príncipe lies 150 km north-east of São Tomé and 240 km West of Equatorial Guinea, whereas São Tomé lies 280 km West of Gabon. The islands receive low wind intensity (12-16km h^{-1}), usually directly from the south, and the south-facing coastlines are more exposed to wave action[9]. The islands' shallow shelves (<25-metre deep) are narrower in the south (extending to a maximum of 1.2 kilometres from the coastline) than in the north (extending to a maximum of 5.4 kilometres from the coastline). The islands have narrow insular shelves, and depth increases sharply from 100 to 1000 metres at 2-7 km from the shelves' edge. The 100 m isobath in São Tomé is located at 3-7 kilometres from the shore, resulting in a shelf area of 485 km^2. In comparison, Príncipe's shelf is larger, with a total area of 1,085 km^2, and the 100 m isobath stretching 7 km to the north and 27 km to the south, to two small islets called the *Tinhosas*.
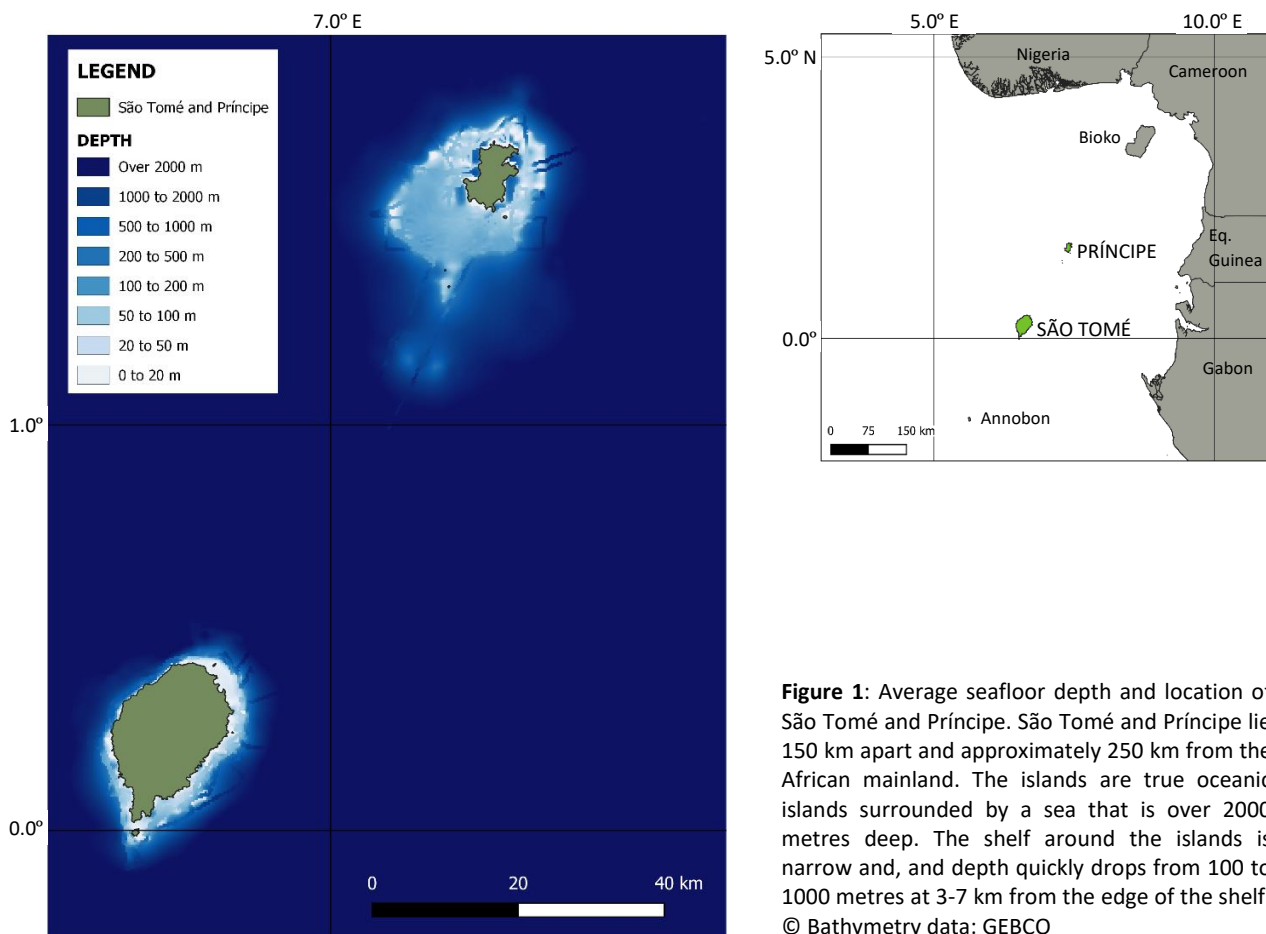
Figure 1: Average seafloor depth and location of São Tomé and Príncipe. São Tomé and Príncipe lie 150 km apart and approximately 250 km from the African mainland. The islands are true oceanic islands surrounded by a sea that is over 2000 metres deep. The shelf around the islands is narrow and, and depth quickly drops from 100 to 1000 metres at 3-7 km from the edge of the shelf. © Bathymetry data: GEBCO

1.2. FISHERIES IN SÃO TOMÉ AND PRÍNCIPE

Industrial, semi-industrial and artisanal fishing fleets all operate in STP's EEZ, with the latter dominating the national fleet by a large margin. All industrial fishing in STP's EEZ is conducted by foreign fleets since the country does not have an industrial fleet of its own[6, 10], and 40% of the non-fiscal revenues of STP come from fisheries agreements with foreign countries. The catches by these industrial fleets represent the majority of the volume of fish removed from STP's EEZ and are largely dominated by European vessels. Fisheries

---

[9] **Cowburn**, B. C. (2018) 'Marine Habitats of Príncipe , Eastern Tropical Atlantic', *Omali Vida Nón* (available here)

[10] **Tous**, P. (2015) 'Consulta para a avaliação dos recursos de peixes demersais', *Report to the Fisheries Department, Ministry of Economy and International Co-operation, São Tomé and Príncipe*.

agreements with the European Union that allow tuna longline and purse-seine vessels to operate in STP waters have been in place since 1984[11]. STP is responsible for monitoring the industrial fishing vessels operating in its waters. However, surveillance is considered to be low due to lack of resources[12]. Several instances of industrial fishing vessels engaging in illegal fishing activities (including shark finning) have been registered in STP's EEZ, most of which involve European vessels or European vessels re-flagged to African countries. Between 2016 and 2018, two industrial vessels filled with sharks were apprehended, and two more were reported as having violated fisheries rules[13].

The semi-industrial fishing fleet is composed of 15 line-fishing vessels, based in the harbour of São Tomé and capable of spending 4-7 days at sea at a time[10]. There is no updated information regarding the number of artisanal fishing vessels in the country, although the latest available census from 2007 indicates that almost 2,000 artisanal fishing vessels were registered in the country at the time[10]. Recent estimates suggest that approximately 3,000 artisanal fishers are registered in STP (500 of them on Príncipe) and that nearly 20% of the country's population (16,000-20,000 people) is employed in the artisanal fisheries sector[6, 14].

Artisanal fishing vessels in STP can be divided into three main types: dugout canoes, outrigger canoes and fiber-glass boats (Guillermo Porriños, *personal observation*). **Dugout canoes** are made of one piece of carved solid wood. They can be small canoes (4—5 metres), propelled by rowing or sailing; or larger engine-propelled canoes (7—9 metres). Bigger canoes are more stable, which allows them to bear engines, while smaller canoes are too unstable to do so. **Outrigger canoes** are called "praos" locally and are made from fibre glass or laminated wood panels. *Praos* are 5 - 7 metres-long and have a smaller hull attached to one of the sides, which improves stability and allows them to bear engines of up to 15 cv. **Fibre-glass boats** are built in São Tomé, have a standard design (10 m long x 1.5 metres wide) and can be equipped with larger and more powerful engines.

---

[11] **European Union** (2019) 'São Tomé and Príncipe. Sustainable fisheries agreements' *Official Journal of the European Union* (available here, here).

[12] **Carneiro**, G. (2019) ' "They Come, They Fish, and They Go:" EC Fisheries Agreements with Cape Verde and São Tomé e Príncipe.' *Marine fisheries review* 73.4: 1-25.

[13] **Sea Shepherd** (2018) European commercial fishing vessel busted in Africa for shark finning: São Tomé and Príncipe Authorities Pursue Legal Action

[14] **Nuno**, A. *et al.* (2015) 'Marine Conservation Priorities São Tomé and Príncipe', *University of Exeter*, (March), p. 41.

Figure 2: Main types of artisanal fishing boats used in São Tomé and Príncipe. **A)** Engine-propelled dugout canoe being pulled out of the water in Hospital Velho (Príncipe Island) (© Gisela Costa); **B)** "Prao" outrigger (Hospital Velho,© Dário Pequeno Paraíso)

1.3. FISH TRADE AND FISH VALUE CHAIN

In São Tomé and Príncipe, the types of transactions at landings sites vary depending on the type of fishing and the location in question. Fibre-glass boats are normally stored in the water, while dugouts and outriggers are stored safely on the beach, a few metres above the high-tide line. When fishers arrive with their catch, people at the landing site help them push the canoe out of the water. If the catch has been good, they will receive one or two fishes as a reward for their help (a practise locally known as "São Pedro"). The socio-economic and cultural aspects of fish trade were studied by Porriños (2020)[15].

The first step of the value chain is the division of the catch between the fisher and the owner of the fishing gear (boat, engine, and/or net), if applicable. The most common system for dividing the profit resulting from the catch in such cases consists of subtracting the cost of the fuel from the total value of the fish caught and dividing this number in two equal parts. One of the halves is paid to the owner of the fishing gear, while the other is divided equally amongst the fishers in the canoe (including the owner of the gear if they partook in the trip). Fishing lines and hooks normally belong to individual fishers and are not rented out, as these are cheap and less durable materials. Nets, on the other hand, are expensive to build and maintain and can last several years. Boats, engines, and nets are usually owned by fishers or former fishers, although they can also be owned by men or women who do not engage in fishing activities themselves.

In São Tomé and Príncipe, men are typically responsible for fishing, while women are responsible for processing, distributing, and selling fish[14]. Fish traders are locally known as "*palaiês*", a Santomean word used to refer to vendors or traders of food or other products. In São Tomé and Príncipe fish is mostly traded fresh

---

[15] **Porriños** (2020) 'Dried fish exportations in Príncipe Island. Value Chain Assessment', *Report to Fauna & Flora International* (available here: EN, PT).

or salted and dried, although smoking can also be used as a method for fish preservation. In Príncipe, fish smoking is only practised for household consumption, whereas in São Tomé, traders smoke fish to sell.

In the value chain for fresh fish, the fish passes from fishers to the *palaiês*, who are normally based at the landing site or close by. In most cases, the fish purchased by the *palaiê* is re-sold at the market and the payment to the fisher may either be upfront or upon completion of the sale. In some communities on Príncipe, fresh fish is distributed and sold as a service to the fisher, who then pays a retribution to the *palaiê*. Both in São Tomé and on Príncipe, most fresh fish is sold at the main market (Bobô Forro and Santo António respectively), although in São Tomé the large distances and scarcity of ice and cooling facilities greatly restricts the value chain. For example, in some communities in São Tomé, fish can only be sold fresh if canoes arrive before the public transport to the city leaves and must otherwise be salt-dried. In Príncipe, the value chain for fresh fish only has one trader node: the fish passes from the fisher to the *palaiê*, who then retails it to the final customer. In São Tomé, *palaiês* either sell the fish to the final customer or to a fresh fish vendor at the main market. Traders from inland towns may also commute to the main market to purchase fresh fish to resell at their local markets, creating a value chain containing up to three fish traders.

On São Tomé Island, most fresh fish is sold by unit price, using a system called "*boca a boca*" in which the price of each individual fish is set by the fisher without weighing it. Only fish species with a standard size range (such as flying fish or *Dactylopterus volitans*) have a set price, whereas those with more variable sizes do not. On Príncipe Island, however, fresh fish is normally sold by kilogram at 50 to 60 DBS (2.0 – 2.4 EUR). The price per kg does however fluctuate depending on fish abundance, availability of fuel and/or demand. Only small species with small size variation are sold by unit price, such as flying fish of the family Exocoetidae, *Dactylopterus volitans* or *Hemirhamphus balao*.

Fresh fish can also be kept for consumption or to be salted and dried. Salt-dried fish is an important product nationally, as many households and food retailers lack freezers or cooling facilities and the electricity supply is often intermittent and unreliable. In São Tomé, salt-dried fish is exclusively produced by fish traders (women) who buy fresh fish to salt and dry, reselling most of it to dried fish vendors at the main market in Bobô Forro. In Príncipe, however, both fish traders (women) and fishers (men) engage in this activity. In fact, a large proportion of the island's total catch is salt-dried and exported to São Tomé, with only a small proportion of the salt-dried fish being sold locally. The fish from Príncipe that is sent to fish traders in São Tomé is transported on cargo boats in batches of over 100 kg at a time. The fish traders who receive these cargos are normally dried fish vendors based at the main market in Bobô Forro. They take care of distributing the fish cargo to other fish vendors and only pay the fish trader in Príncipe upon completion of the sale.

2. METHODOLOGICAL APPROACH

2.1. STUDY SITES

Fish landing data is being collected across 21 communities in São Tomé and Príncipe. On Príncipe island, fish landing data is currently being collected in the communities of *Abade*, *São João*, *Unitel*, *Concom*, *Àgua Namoro*, *Santo António*, *Praia das Burras*, *Campanha*, *Ribeira Izé* and *Lapa* (Annex I and Figure 3). Another temporary landing site on the South of the island is also included: *Praia Seca*. On São Tomé Island, fish landing data is being collected in 10 permanent coastal communities in the South-East of the island. These represent the target communities of the project funded by the Blue Action Fund and include one community in the Cantagalo District (*Ribeira Afonso*) and the nine fishing communities of Caué district: *Angra Toldo*, *São João de Angolares*, *Iô Grande*, *Praia Pesqueira*, *Ribeira Peixe*, *Monte Mário*, *Malanza*, *Porto Alegre* and *Ilheu das Rolas* (Annex II and Figure 4). Since October 2020, data from five additional communities on Príncipe were included in the fish landing surveys, but this data has not been included in this analysis.

2.2. ASSESSMENT OF FISHING GEARS AND CATCH

A rapid assessment of fishing gears and fish species caught was conducted by the author in Príncipe (June 2019) and São Tomé (August 2019). In Príncipe, nine semi-structured interviews were conducted, targeting experienced fishers from the communities of *Ribeira Izé*, *Abade*, *Burras* and *Campanha* (June 2019). Fishers were invited to describe the different gears and techniques they knew and used, and the identified techniques and gear configurations were drawn with the fishers. An initial list of species caught and their common names on Príncipe was built based on the landing surveys conducted under the first phase of the project Omali Vida Nón on Príncipe Island, funded by the Darwin initiative[16] and Tous (2015)[10]. This list was then periodically updated as non-listed species were landed and additional information recorded as a result. In São Tomé, five Focus Groups Discussions (FGD) were held with the Blue Action Fund project's extension workers and fishers from the communities of *Ilheu Rolas*, *Porto Alegre*, *Malanza* and *Monte Mário* (August 2019). A slideshow with 11 fishing gear configurations/ techniques and 100 fish species was displayed during these discussions, and fishers were asked to provide the local names for each of them. Some of the fishing techniques and species included in the list were directly observed by the author using participant observation techniques (fisher-follows, 2017-2019) and informal interviews at landing sites (2017-2019). The description of gears was complemented with findings from two previous studies that characterised the active fisheries on Príncipe (see Matos and da Graça, 2019)[17] and São Tomé (see Santos *et al*., 2017)[18].

---

[16] **Omali Vida Nón** (2019) *Summary of project activities and preliminary results*. Available here.

[17] **Matos**, L. and **Da Graça**, M. (2019) 'Caraterização das comunidades piscatórias da Ilha do Príncipe (Characterisation of the fishing communities of Príncipe Island)', *Internal report for the Blue Action Project - São Tomé and Príncipe*.

[18] **Santos**, A., **Conceição**, I. and **Bolingo** (2017) 'Caracterização das pescarias ativas em São Tomé (Characterisation of the active fisheries in São Tomé)', *Report for the project Kike da Mungú, funded by the European Union*.
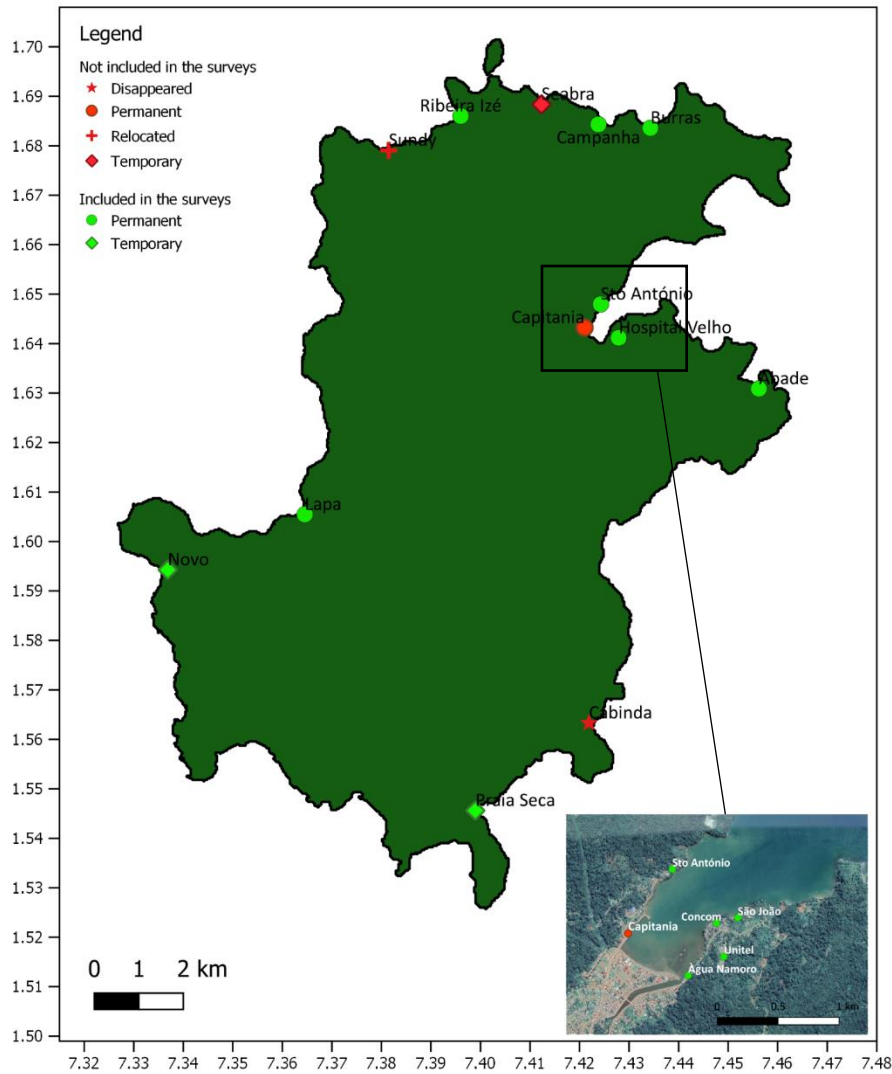
Figure 3: Fishing communities on Príncipe. Note that Hospital Velho is divided into four communities or "neighbourhoods": São João, Concom, Unitel, and Àgua Namoro.
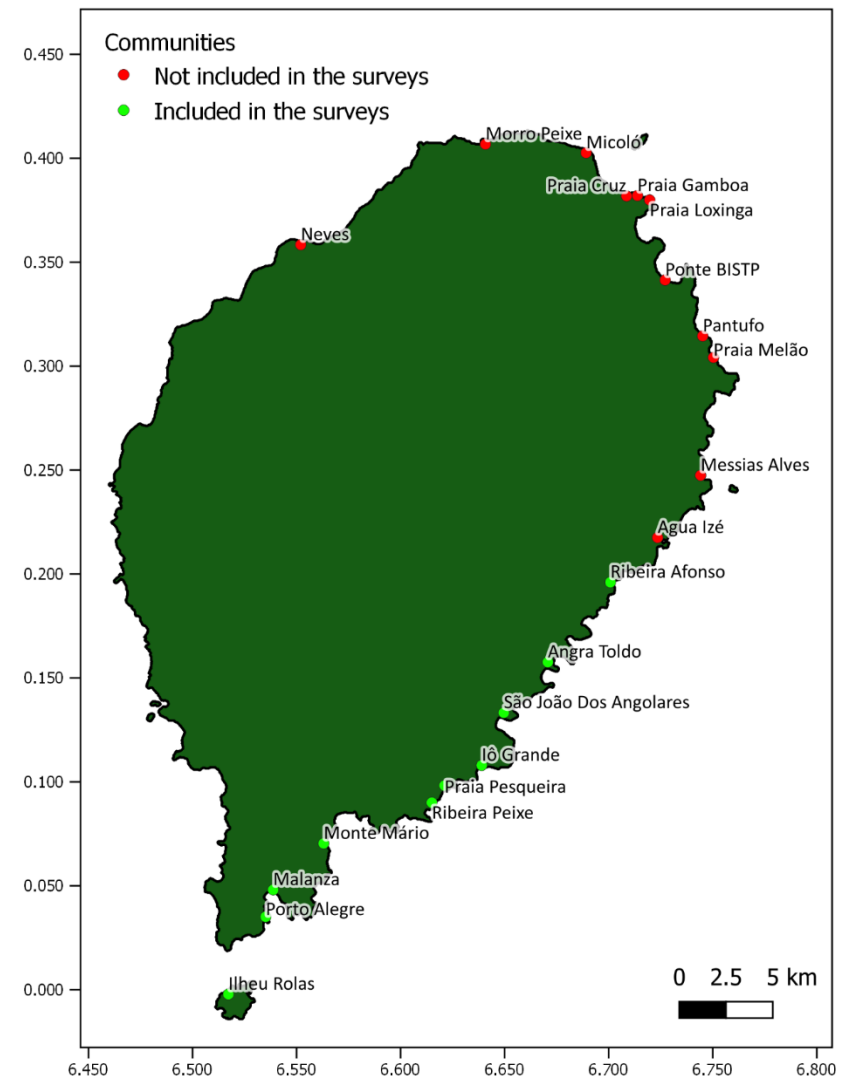

Figure 4: Fishing communities on São Tomé.

2.3. DATA COLLECTION

The protocol for collecting fish landing data for this project was based on that developed previously by the project Omali Vida Nón (Príncipe Island, 2016-2019)[16]. Fish landing data is collected by extension workers, who are typically either fishers or fish traders, on the target communities of the project on Príncipe and the south of São Tomé (see Annex I and II). Data is collected using the open-source, smartphone application *Open Data Kit*[19] on Android tablets. Questionnaires were built using a commercial spreadsheet software and converted into an *xml* file using an online converter.

Data is collected by extension workers in their respective communities twice a week (on Tuesdays and Fridays) and two questionnaires are used in the process. Questionnaire 1 (number of vessels) is used to record the number of fishing trips at the end of the day, disaggregating by fishing technique (see section 2.6). Questionnaire 2 (fish landing data) is used to interview fishers as they land their catch, collecting standard information on catch size and composition, effort, fuel consumption, and other indicators (Figure 6). At least six fishers are interviewed in each community each sampling day, and the sampling effort is distributed during the different landing times to collect information representative of all fishing gears. An interview for a trip using two or three different gear types, with several species caught takes 20 to 30 minutes to complete.

Since different types of fish often have the same local name, the species present in the catch are selected from a list of images that can be filtered by name, to improve the accuracy of fish identification. An orthogonal, scaled picture of the catch is also taken (see Figure 5) for a subset of selected indicator species (see Annex III). One picture is taken per indicator species and individual fish lengths will be measured from the picture using ImageJ. If 10 or more individuals of the indicator species are present in the catch, at least 9 randomly selected individuals are included in the picture. Criteria for selecting indicator species when building the questionnaires were: **A)** species of conservation concern (i.e., sharks and rays); **B)** commercially important species (i.e. snappers); **C)** species listed as vulnerable, nearly threatened, and threatened by the IUCN (i.e. *Balistes capriscus*, *Thunnus albacares*); **D)** species representative of certain habitats (i.e. *Dentex macrophtalmus*, only fished >80 metres); and **E)** unidentified species.
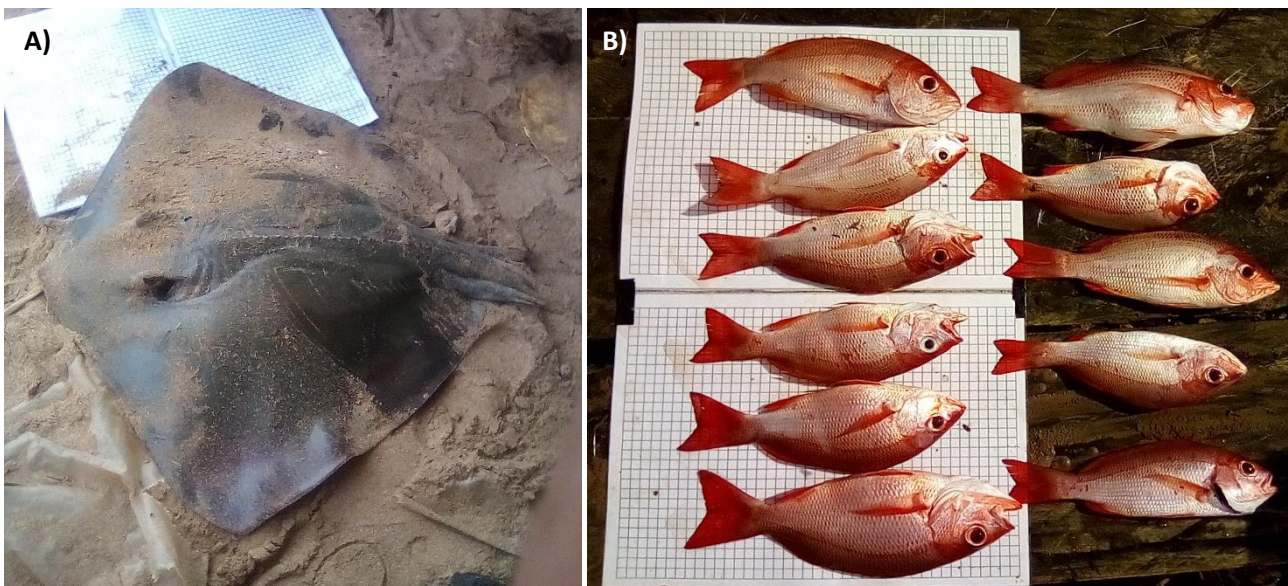
Figure 5: Examples of photos of indicator species taken by the extension workers as part of their fish landing data collection protocol. A single picture per indicator species is taken, covering at least 9 individuals in the picture (if available). Each of the cells of the grid is used as a reference for 11 mm. The species depicted here are **A)** Dasyatis sp. and **B)** *Lutjanus fulgens*.

---

[19] **Open Data Kit** (2019) *Open Data Kit Documentation*. Available here.

Figure 6: Questions in the landing surveys questionnaires. In grey, are the questions regarding *general information for the fishing trip*; in green, questions relating to *catch*; in blue, *indicator species' length* and in orange, questions relating to *gear type and effort*. White squares are questions meant to facilitate the flow of the interview and are removed in the data processing.

1 Community
2 Extension worker
3 Boat type
4 Number of fishers
5 Names of fishers (only codes are recorded)
6 Did you manage to interview the fisher?

No → *End of the survey*
Yes → 7 Did they catch any fish?

No
Yes → 8 What species did they catch?

Besides of *[SPECIES' NAME(S)]*, did they catch anything else? → Yes

9 Take a picture of the indicator species (see figure 5)

10A x *n* species
CATCH OF *SPECIES n*
- Total number of fish of *SPECIES n*
- Total weight of *SPECIES n*
- What was *SPECIES n* used for?
  - ○ Consumption   ○ Given as tip
  - ○ Used for bait   ○ Salted
  - ○ Sold

10B
Price of *SPECIES' N*
- Price (DBS)
- Unit (kg, individual fish…)

11 How many fish were kept for consumption?
How many fish were given as a tip?

12 What was the sea like (calm, rough, storm…)?
What was the direction of the current?

13 How many litres of fuel did they use?
What was the price per litre of the fuel?

14 What was the power of the engine?
Did they rent the fishing boat or use their own?

15 What gear did they use? ← Yes

Besides of *[GEAR'S NAME(S)]*, did they do other type of fishing?

No

16 **EFFORT AND CHARACTERISTICS OF GEAR *n***

Line fishing	Net fishing
Number of sets	Number of sets
Start time	Start time
Ending time	Ending time
Did they use night lights	-
Bait	-
Number of lines	Length (metres)
Number of hooks	Depth (number of mesh cells)
Hook size	Mesh size (mm)
Species caught with this gear	Species caught with this gear

17 Did the fisher have any problem while fishing?

2.4. CONSENT, CONFIDENTIALITY AND FEEDBACK LOOPS

Meetings to introduce the data collection protocol used by the extension workers were held in each of the fishing communities included in the surveys during July and August 2019, and the activity and its purpose was explained in detail. Fishers who were willing to participate were listed and allocated individual codes. Only these individual codes - not names- are recorded in the final data files to ensure the anonymity of the data. In each survey, the activity is explained to the fisher, and they are asked whether they are willing to participate or not. During the design of the questionnaires, verbal consent was considered the most appropriate, as respondents might not know how to write and survey fatigue may be exacerbated if respondents are asked to provide written consent repeatedly over a prolonged period of time. Summaries with the main findings from the fish landing data collected in each community were produced and presented to fishers and fish traders after the first 9 months of data collection[20].

2.5. RECRUITMENT AND TRAINING OF THE EXTENSION WORKERS

On Príncipe, the extension worker positions were publicly advertised in the relevant communities and applicants were selected by assessing the following criteria during the interview: **a)** literacy **b)** knowledge of fish species and gear configurations, and **c)** respectability in the community. In total, 19 people applied, of which seven were women. Seven male and three female extension workers were recruited as a result of this selection process. On São Tomé, extension workers were chosen directly by their respective communities during group discussions. Ten extension workers were recruited, all of which were men. Out of these, seven were fishers themselves and three were sons of fishers.

Training was delivered to extension workers by the author over three months (July 2019 to September 2019). In total, 64 hours of training were delivered in Príncipe and 75 hours in São Tomé. During these sessions, the newly-recruited extension workers interviewed the trainers, who represented increasingly complex landing scenarios (their progress was assessed using a score of 1—3, as described in Annex IV). The trainings were followed up by weekly visits by trainers on Príncipe and monthly visits on São Tomé, with the aim of providing feedback and technical support to the extension workers and mediate potential conflicts with fishers. Four handbooks detailing the protocol were also produced to aid data collection[21,22].

Data was cleaned bi-monthly by the author to detect and correct inconsistencies on the data. In October 2019 and February 2020, 36% of the instances were analysed in detail, and given a score using the 25 criteria described in Annex V to calculate the percentage of data properly corrected through this bi-monthly data cleaning process. The most common mistakes committed by extension workers in each community were compiled into a document and used to provide feedback to relevant individuals.

2.6. DATA ANALYSIS

Catch-Per-Unit-Effort (CPUE) was calculated using the units described in Table 1. Since several gears are often used during a single trip, the species caught using each gear type was also recorded (Figure 6). If two or more gear types caught the same species during a trip, the trip was removed from the calculation of CPUE to avoid overestimations. To compare between islands and fishing types, CPUE was log-transformed to approximate to a normal distribution. Bartlett test was used to assess the null hypothesis of homoscedasticity of the data.

---

[20] **Porriños**, G. (2020) Summaries of landing data for fishing communities, available here.

[21] **Porriños**, G. (2019) '*Manual de inquérito de dados de pesca* I *Handbook for collecting landing data*' Available here: Príncipe, São Tomé.

[22] **Porriños**, G. (2019) '*Manual de contagem de embarcações | Handbook for recording number of fishing trips*' Available here: Príncipe, São Tomé.

Fishers' F test was used when the data was homoscedastic and Welch's F Test was when the data was heteroscedastic. Post-hoc comparisons were conducted when relevant, using Tukey's method (homoscedastic data) or Games Howell method (heteroscedastic data). Finally, Akaike Information Criterion (AIC) was used to compare the goodness of fit of the different linear models.

Table 1:. Catch Per Unit Effort units (CPUE) of the main categories of fishing gears on Príncipe, adapted from recommendations about fisheries monitoring protocols by FAO (2004)[23]

GEAR	UNITS
Gillnet	Kg / 100 metres of net * hour
Seine	Kg / set
Handline (less than 25 hooks)	Kg / line * hour
Longline (more than 100 hooks)	Kg / 100 hooks * hour
Spear fishing	Kg per hour

To estimate the total number of fishing trips for each community, information from both questionnaires 1 (number of fishing trips) and 2 (fish landing interviews) was used (see section 2.3). The daily number of fishing trips on sampling days per community was recorded using Questionnaire 1 and disaggregated by the following types of fishing gear: **1)** hook & line fishing; **2)** surface gillnet; **3)** bottom gillnet; **4)** purse seine; **5)** seine gillnet; **6)** spear fishing; **7)** hook & line from the shore; and **8)** 'voador panhá', a specialised type of fishing practiced exclusively on São Tomé island (see section 3.1). The number of fishing trips per annum for each gear type was estimated based on a simple extrapolation of the daily average number of fishing trips per community. In the case of Praia Seca, a temporary community on the island of Príncipe, the extrapolation was based on 210 days of fishing activity instead of 365.

The hook & line fishing category includes several distinct types of gear configurations and techniques, targeting different habitats and species. However, it was not possible to disaggregate this information in Questionnaire 1, since the line fishing gears used could only be discerned by interviewing the fishers and, in addition, fishers often use more than one gear type per trip. To obtain an estimation of the number of trips for each fishing type in this category, the daily and yearly number of line fishing trips per community were multiplied by the prevalence (%) of each hook and line fishing type in the landing data (Questionnaire 2). The prevalence of each gear type was then estimated by dividing its occurrence by the total number of line fishing trips recorded for each community.

The estimated number of fishing trips per gear type were then used to estimate the total effort and catch per community. For these estimates, the average effort per trip was calculated for each gear type and community and multiplied by the number of trips estimated to be using that gear type for each community.

To estimate the total fish landings, CPUE was calculated for each species, disaggregating by gear type. These values were then multiplied by the corresponding effort values to estimate the daily/yearly catch for each of the target communities.

The net profit of each trip was calculated by subtracting the recorded fuel expenditure from the revenues of selling the fish, with zeros being allocated to species that were not sold. If the fishing material (boat, engine, and/or net) was listed as being rented, the net profit value calculated was divided by two and one half further divided by the number of fishers present during the fishing trip (as explained in section 1.3).

---

[23] **FAO** (2004) *Handbook of fisheries statistics | Coordinating Working Party on Fisheries Statistics*

3. RESULTS

The number of fishing trips (Questionnaire 1) on Príncipe was recorded for a total of 106 days across landing sites between October 2019 and December 2020, while on São Tomé, it was recorded between September 2019 to December 2020 across 110 sampling days. In total 7,172 landing interviews (Questionnaire 2) were conducted on both islands, 3,020 on São Tomé (September 2019- December 2020) and 4,152 on Príncipe (August 2019 to December 2020). Of these, 865 landing interviews on Príncipe and 1,033 on São Tomé could not be completed because fishers refused to participate or other reasons, and only vessel type, landing site, and number of fishers on the vessel was recorded as a result. Data from the communities of Praia Pesqueira and Angolares on São Tomé Island was removed from the analysis due to poor data quality. These corresponded to a total of 116 fish landing events.

Fishing gears and techniques were classified using qualitative techniques (FGDs and semi-structured interviews) and divided into three main categories: net fishing, hook & line fishing, and spear fishing (free divers). Although other types of fishing exist on the two islands (such as traps for spider crabs, see Santos *et al.*, 2017[18]), these were not present in the project's target communities and so were not included in the landing surveys questionnaires.

3.1. NET FISHING

After conducting interviews and FGDs, net fishing in STP was divided in the following types: **1)** gillnetting, a passive method consisting of using vertical panels that trap the fish that are passing through (Figure 7A, Figure 8D); **2)** seining, consisting of actively dragging a net to surround and trap a shoal of fish (Figure 7B, Figure 8A, B). The net panels of both these types of fishing hang from a line with regularly spaced floating devices (often made from flip-flops or other recycled materials) and are kept in a vertical position by weights attached to the lower line. The length of nets is measured in metres, while the height is measured in the number of mesh rows. A third type of net fishing uses a small conical net held open by a round rim with a handle. This technique is practised in São Tomé seasonally and offshore, and it is exclusively used to catch "*voador-panhá*", small flying fish that are attracted to the boat using ground coconut embedded in a thick brush of straws as a bait (Figure 42C). Cooking oil is also spread over the water to calm the ripples, and the flying fish is caught manually using the conical net. Although other types of net fishing have been described in São Tomé and Príncipe[18], their use is disappearing and therefore not included in the fish landing surveys.
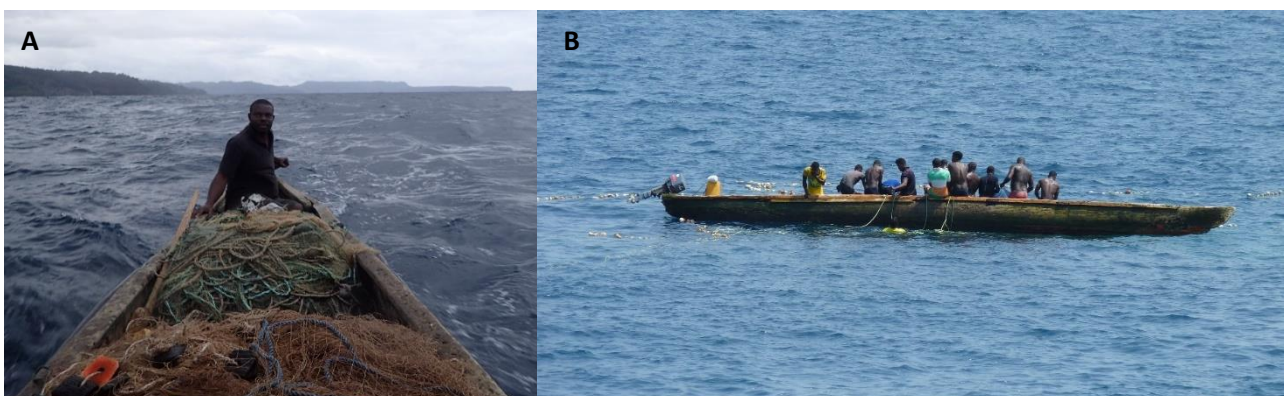

Figure 7: **A)** Fisher from Príncipe going drifting-gillnet fishing; **B)** Purse seine fishing in São Tomé.
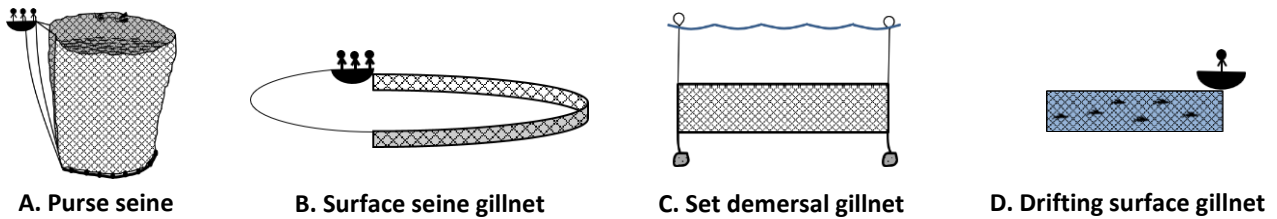
Figure 8: Schematic representation of net fishing types included in the smartphone landing questionnaires.

3.1.1. Drifting surface gillnet

The drifting surface gillnet (see Figure 8D) is the most practised type of net fishing across both islands and used to catch small pelagic fish, most of which are flying fish of the family Exocoetidae. It is called "*rede voador*" (flying fish net) on both islands, although in São Tomé can also be called "*gonga*" (when practised far from the departing site) or "*ximples*" (when practised close). In the community of Abade on Príncipe, drifting gillnet fishing was also referred to as "*pesca de linha*" (note that this name also is used to refer to hook and line fishing). Surface gillnets have a length of 1000-2500 metres and a depth of approximately one metre (Guillermo Porriños, *personal observation*). The net is kept on the surface by floating devices attached to the upper edge and kept in a vertical position by small weights. Since gillnetting is a passive fishing method, it is deployed under the cover of darkness to avoid detection and fishers explained in interviews that this type of fishing is best practised on dark nights (for example, around new moon). Moreover, net owners explained in informal interviews that surface gillnets are often built using dark red material (or painted that colour) to make it less conspicuous in the water column.

This type of fishing involves two fishers: while one deploys the net, the other moves the boat against the current to keep the net stretched. Once deployed, one end of the net is tied to the boat, and the boat is let adrift for the duration of the set. After that, the net is retrieved by one fisher, while the other moves the boat towards the current to facilitate its retrieval. The net is normally deployed for an hour (from when the net has been fully deployed), so the total soaking time (from the beginning of the deployment until retrieval) averages 2.60 hours (Príncipe) and 2.75 hours (São Tomé). Surface gillnets are normally deployed immediately after sunset and retrieved before midnight (Figure 9).

Table 2: Characteristics of the drifting surface gillnet fishing in São Tomé and Príncipe.

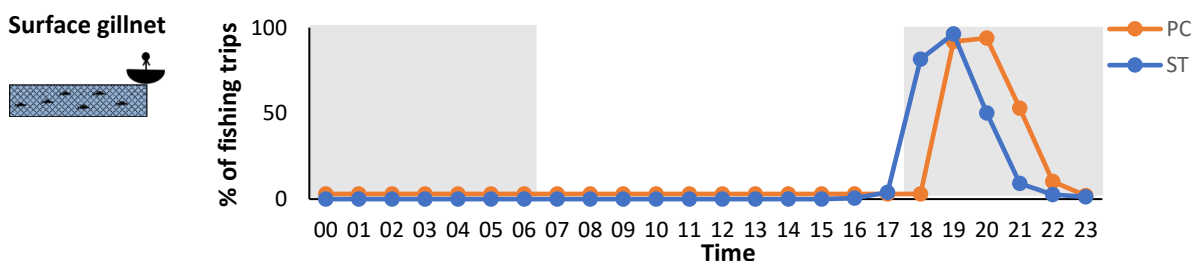| Gear / technique	CPUE units	Habitat	Site	N records	Mesh size (min, max)	Soak time (average)	N sets
Surface drifting gillnet	Kg / 100 m / hour	Epipelagic	ST-S	93	30 – 65 mm	2.75 hours (SD = 0.76)	1
			PC	452	27 – 80 mm	2.60 hours (SD = 0.77)	1

Figure 9: Distribution of effort throughout the day for the surface gillnet in Príncipe (PC) and South of São Tomé (ST), with night hours highlighted in light grey. Drifting surfacel gillnets are normally deployed after sunset and fishing is normally over before midnight.
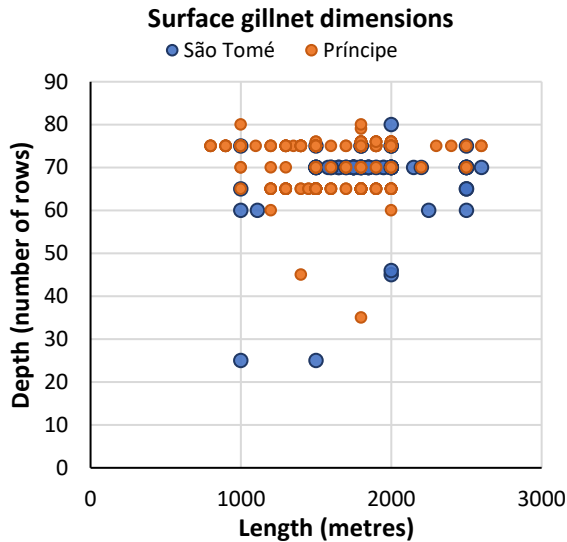
Surface gillnet dimensions

Figure 10: Length (m) vs depth (number of rows) of the surface gillnet. Most records of surface gillnet fishing trips used a net with a depth of 60-80 rows, with only a few records below that range (4.5% in São Tomé and 0.4% in Príncipe). The length of the net shows a higher variation, ranging from 800 to 2600 metres.

The catch of the drifting gillnet is overwhelmingly dominated by flying fish (family Exocoetidae), corresponding to 96.1 % of the catch on Príncipe (n= 444) and and 99.7% on São Tomé (n = 43), respectively. Flying fish are followed in abundance by *Ablennes hians* (flat needlefish), which comprise 2.7% of the catch on Principe and 0.3% of the catch on São Tomé. In Príncipe, other species have been recorded as bycatch, including one record (out of 452) of a 90-kg shark (unknown species) caught in the drifting gillnets.

3.1.2. Set demersal gillnet

The set demersal gillnet (Figure 8C) is kept at the seafloor by two anchors (often rocks wrapped in a piece of fabric or net), and the net is kept in a vertical position by small floating devices on the upper edge and weights on the lower edge. This type of gear is known as "*rede malhadeira*" on Príncipe or "*rede feijão*" on São Tomé. As in the case of the drifting surface gillnet, the set demersal gillnet is a passive fishing method, typically deployed after sunset and retrieved the next morning. The average soaking time is 11 hours, and the net is deployed immediately after sunset and retrieved after sunrise (see Figure 11). In interviews, fishers explained that they often return home after deploying the net and go back to retrieve it in the morning.

Table 3: Characteristics of the set demersal gillnet fishing in São Tomé and Príncipe.

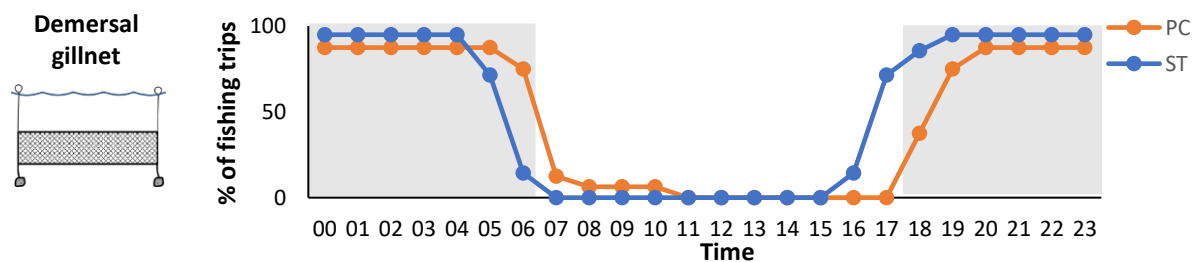| Gear / technique	CPUE units	Habitat	Site	N records	Length (min, max)	Height (min, max)	Mesh size (min, max)	Soak time (average)	Sets
Set demersal gillnet	Kg / 100 m / hour	Demersal	ST-S	7	[60 m, 500 m]	[20 rows, 40 rows]	[10 mm, 40 mm]	11.1 (SD = 3.0)	1
			PC	25	[100 m, 800 m]	[40 rows, 120 rows]	[100 m, 500 m]	11.1 (SD = 3.2)	1

Demersal gillnet

Figure 11: Distribution of effort throughout the day for set demersal gillnets in Príncipe (PC) and the south of São Tomé (ST), with night hours highlighted in light grey. Demersal gillnets are normally deployed after sunset and retrieved immediately after sunrise, with latest retrievals at 10AM.

Although the number of records for this technique is low (7 in São Tomé and 25 on Príncipe), the catch in terms of weight of this technique is strongly dominated by sharks, comprising 46% and 30% of the total catch in São Tomé and Príncipe, respectively. The catch composition for this technique is diverse, and includes large carangids and lutjanid snappers, but also other demersal species, such as the herbivorous *Kiphosus* sp.
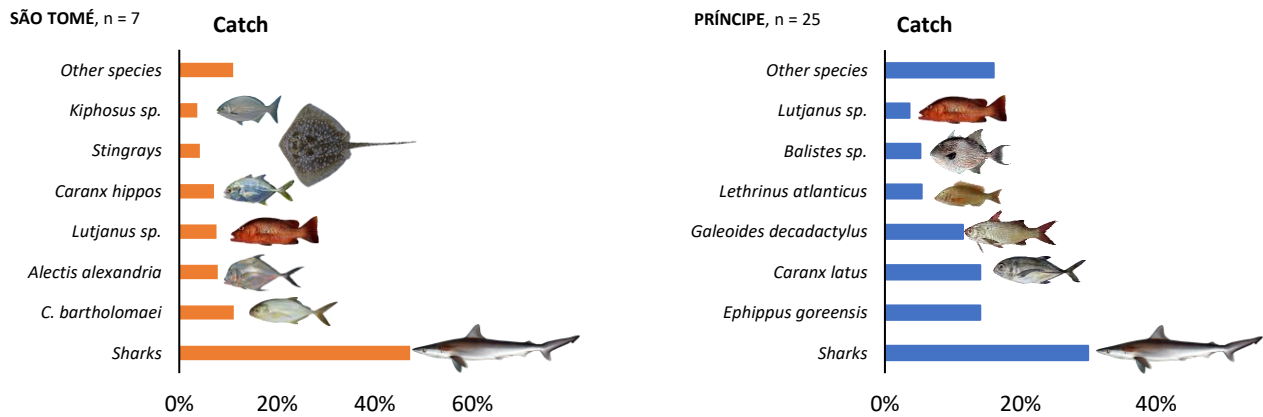

Figure 12: Catch composition of set demersal gillnets on Príncipe and São Tomé. Sharks contribute to most of the weight of the total catch for this gear type on both islands.

3.1.3. Purse seine and seine gillnet

During FGDs, fishers described two types of seine nets: purse seines (Figure 8A) and seine gillnets (Figure 8B), the latter of which is only used in São Tomé. These types of fishing may both be referred to as "*rede de brisa*" and the seine line is referred to as "*cabo de brisa*".

In purse seine fishing, a net is released to encircle a shoal of fish, which is then closed at the bottom using a seine line. This type of fishing is practised during the daytime (see Figure 14), by 4- 6 fishers on Príncipe and up to 10 fishers on São Tomé. On Príncipe it is normally referred to as "*rede maxipombo*" (net for West African halfbeak), as the net has a small mesh size that allows this species to be caught. It can also be referred to as "*rede de cerco*" or "*rede brisa de cerco*" on both islands and "*rede de mil malhas*" (net of a thousand rows) on São Tomé. During FGDs fishers explained that the net used in the purse seine fishing normally has a depth of 800-1000 rows and a length of 800-1000 metres. However, as shown in Figure 13, many records of this technique are within the range of less than 100 metres and 100 rows. In surface seine gillneting, a gillnet is deployed and ~1km long seine cable attached to one of its ends and stretched to form an 90°-angle with the net. The cable is then dragged towards the opposite end of the net, creating turbulence and noise that push the fish towards the net. This type of fishing is practised during the daytime (see Figure 14) by 4-6 fishers (70% of the records), although up to 12 fishers may sometimes be involved. During FGDs, fishers referred to this type of fishing simply as "*rede de brisa*" (seine net). Fishers in interviews described the net used in this technique as a similar one to the surface gillnet (a shallow net, with only 80-100 rows). However, the records classified as this type of fishing in the landing database are not consistent with this description, and the net used in most instances is similar to the purse seine (1000 m x 1000 rows, see Figure 13).

Considering the small sample size for this gear type on São Tomé (see Table 4) and the inconsistencies between the results from participatory methods and landing surveys, seine gillnet and the purse seine fishing in São Tomé have been aggregated into the same category ("seine nets") for all subsequent analysis.

Table 4: Characteristics of the seine nets fishing trips recorded in São Tomé and Príncipe.

Gear	CPUE units	Site	N	Mesh size (min, max)	Soak time/trip (average)	N sets/trip (average)
Seine gillnet	Kg / Set	ST	32	[12 mm, 90 mm]	3.8 hours (SD = 1.5)	3.0 (SD=1.0)
Purse seine	Kg / Set	PC	119	[9 mm, 75 mm]	3.5 hours (SD = 1.66)	2.9 (SD = 2.13)
		ST	18	[30 mm, 90 mm]	3.6 hours (SD = 1.44)	2.6 (SD = 1.33)
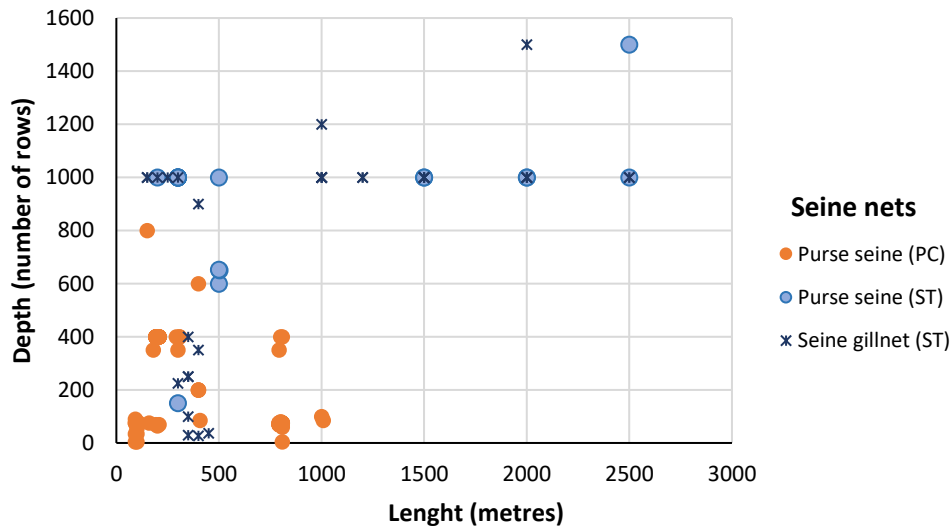
Figure 13: Length (m) vs depth (number of rows) of the purse seine and seine gillnet in Príncipe and São Tomé. The length and depth of the purse seine and seine gillnet fall within the same range in São Tomé.
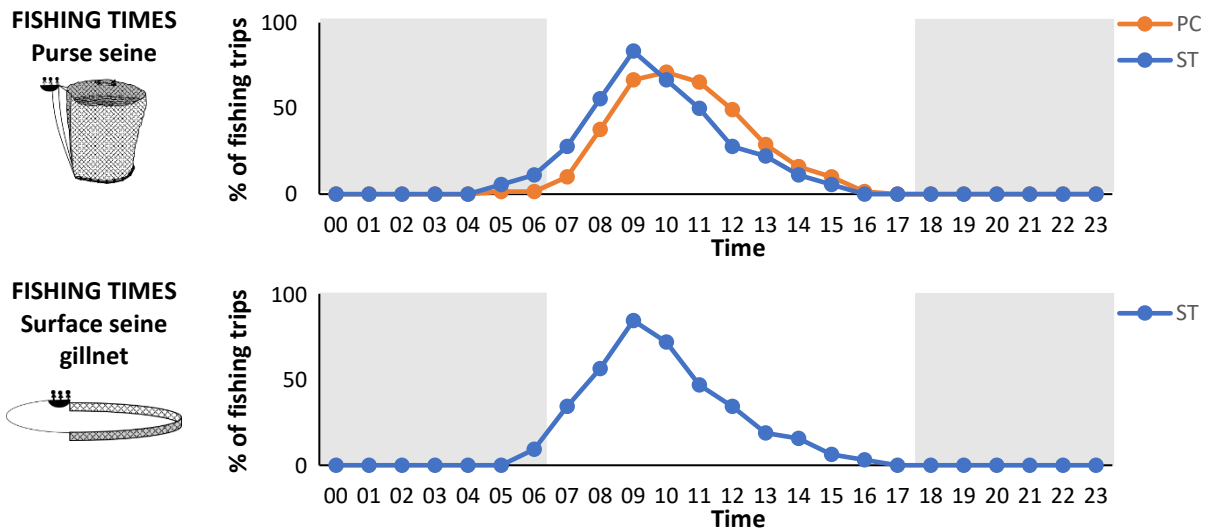
Figure 14: Distribution of effort throughout the day of the seine nets in Príncipe (PC) and São Tomé (ST), with night hours highlighted in light grey. Seine nets are normally deployed during the morning, with the earliest deployments immediately before sunrise.

The main species caught with purse seines on Príncipe is *Hemirhamphus balao* (West African halfbeak), a small pelagic species that comprises 72% of the catch. It is followed by *Euthynnus alleteratus* and *Auxis thazard*, two small tuna species locally known as "*fulu fulu*", which comprise 6.3 % of the catch. The

Carangidae species *Caranx crysos*, *Carangoides bartholomaei* and *Decapterus sp.* comprise 11.3 % of the catch altogether. *Kiphosus* sp., a herbivorous, reef-associated fish, comprises 1.9 % of the catch and small reef fish, such as *Paranthias furcifer*, goatfishes (Mullidae), *Spicara* sp., and *Acanthurus monroviae* (surgeonfish), comprise 4.7 % of the catch.

The catch of both seine net techniques (purse seine and surface seine gillnet) in São Tomé, is dominated by *fulu fulu* tunas (*E. alleteratus* and *A. thazard* make up 51.4 %), followed by *Decapterus* sp. (15.3 %) and *Hemirhamphus balao* (9.0 %). The reef fish *Paranthias furcifer* is also an important component of the catch (6.6%), followed by the rainbow runner (*Elegatis bipinnulata*, 4.9%) and *Ablennes hians* (4.2%).
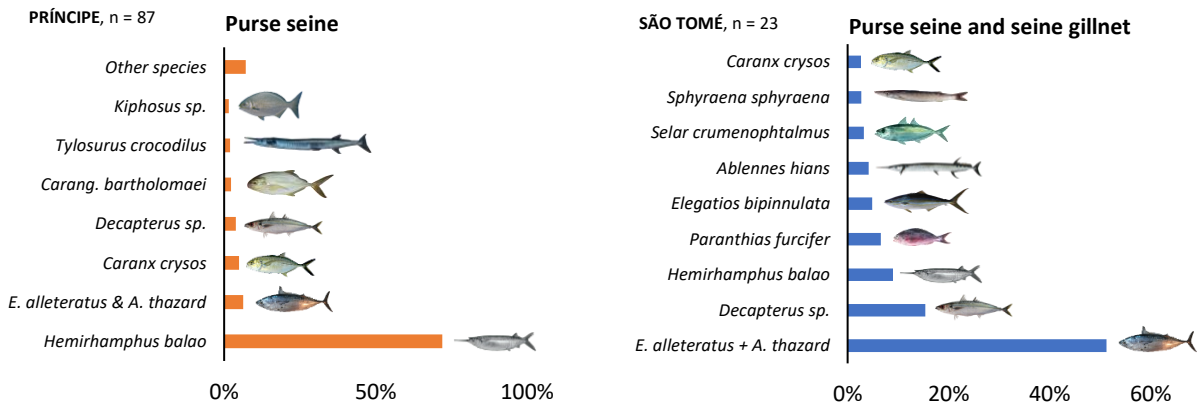
Figure 15: Catch composition of the seine nets in Príncipe (orange) and São Tomé (blue).

3.1.4. Beach seine

In this type of fishing, a net is deployed from the coast and dragged towards the shore by two people on either end. This type of fishing is rarely practised, and there are only 2 records from Príncipe island, all of which are from the community of Abade. There are no records of this practice in São Tomé, although it has been observed in the community of São João dos Angolares (*personal observation*) and at least two nets exist in the communities of Praia Melão and Baia de Ana Chaves / São Pedro (Santos et al., 2017[18]). In the community of Abade on Príncipe island, this type of net is referred to as "*rede de barbudo*" and is used to catch *Galeoides decadactylus*, locally known as "*barbudo*".

Table 5: Characteristics of the beach seine records from Príncipe island

Gear	CPUE units	Site	N of occurrences	Length	Height	Mesh size	Soak time (average)	Sets (average)
Beach seine	Kg / Set	**PC**	2	40 m	75 rows	80 mm	1.75 hours	1

3.1.5. "Voador panhá" fishing

Fishers in FGDs described this as a specialised fishing technique, only practised during the dry season, between May and August. It uses a floating device with long straws that are soaked in cooking oil with ground coconut. The oil spreads on the water, creating a film that eliminates the ripples on the surface and facilitates the detection of the fish. Small flying fish ("*voador panhá*") are attracted to the straws to eat the coconut and are caught using a small circular net which is handled manually. Generally, this technique is practised in combination with handline fishing. The small flying fish that are caught are then used as a bait on two or three handlines with large hooks targeting larger fish, such as dolphinfish. It is only practised in São Tomé (n = 57) and is exclusively a day-time activity (see Figure 16), with an average soaking time of 5.7 hours (SD = 2.3).
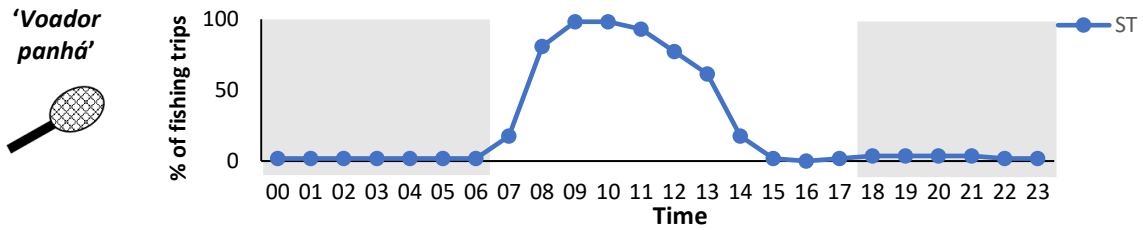
Figure 16: Distribution of effort throughout the day of 'voador panhá' fishing in São Tomé (ST), with night hours highlighted in light grey. Fishing activities do not start earlier than 6:00 and never finish later than 15:00.

Figure 17: Fishing materials used to catch small flying fish called "*voador panhá*" on São Tomé island. **A)** Circular net used to catch flying fish ("*rede solavar*", © Santos et al., 2017[18]). **B)** Wooden buoys with straws used to attract flying fish. Straws are soaked in cooking oil and ground coconut. The ground coconut acts as bait and attracts the fish, and the cooking oil spreads on the water eliminating ripples on the surface, thus facilitating the detection of fish (© G. Porriños).

3.1.6. Mosquito net fishing

This type of fishing uses mosquito nets or baskets at the mouth of rivers to catch post-larvae of the species *Sicydium bustamantei*[24], locally known as "*peixinho*", and is often practiced by women and children, albeit not exclusively. *S. bustamantei* is an amphidromous fish that spawns in freshwater areas, whose larvae drift to the open ocean with the river current. After the planktonic larvae mature, the post-larvae return to freshwater environments and migrate upstream, where is caught by the mosquito net fishers[24]. It is practised in certain seasons, and normally during full moon but was not included in the fish landing surveys.

Figure 18: **A)** Three women using a mosquito net to catch small fish known as "*peixinho*" in the river; **B)** "*Peixinho*" fish caught with a mosquito net (Papagaio river, Príncipe island, © G. Porriños).

---

[24] **Baptista, V**. et al (2020). "Feeding Ecology of *Sicydium bustamantei* Post-Larvae: The "Little Fish" of São Tomé Island". *Oceans*.

3.2. HOOK AND LINE FISHING

Line fishing gears were subdivided into handlines (less than 25 hooks) and longlines (over 100 hooks). An intermediate number of hooks (25 -100) are seldomly used. Hook and line fishing is referred to as "*pesca de linha*" or "*pesca de fio*" although the use of the latter is recommended, since the term "*linha*" is also used in some communities to refer to drifting surface gillnet. Hook sizes are referred to by a numbering system in which 1 is the biggest size. The smallest hook size recorded in the landing surveys is 22. Fishers may use "*brindado*" instead of a hook, which is a specialised device used to catch sailfish and blue marlin made with thick, long plastic threads that entangle around the beak of the fish. The primary line of the fishing gear is called "*barriga de fio*" ("belly of the line") and the hooks are attached to secondary branch lines called "*mama*" or "*costumado*" which are generally thinner than the primary line. The primary line can be weighted at different points of its length, either at the end of the line (to keep it vertical), or before the hooks (to keep it horizontal). Weights are made from scrap pieces of metal or stones wrapped ina piece of net or fabric.

The three main hook and line fishing techniques used in STP are **1)** jigging lines (handlines), consisting of vertical handlines, typically with a weight at the end of the line (Figure 19E); **2)** demersal set lines, consisting of longlines or handlines that are kept in parallel to the seafloor by one or several anchors (see figure 19 F-H). Handlines might also have a specialised device at the beginning of the line called "vega", a bent wooden stick attached to the line which acts as a spring, shaking the line and spreading the smell of the bait (Figure 19G, H; Figure 20C); **3)** troll, a technique consisting of dragging a longline or handline on the surface or mid-water by using a moving boat (Figure 19A-B).

A. Surface handline troll　　**B. Mid-water longline troll**　　**C. Artificial bait ("palha")**

D. "*Quitali*"　　**E. Jigging lines**　　**F. Set demersal longline**
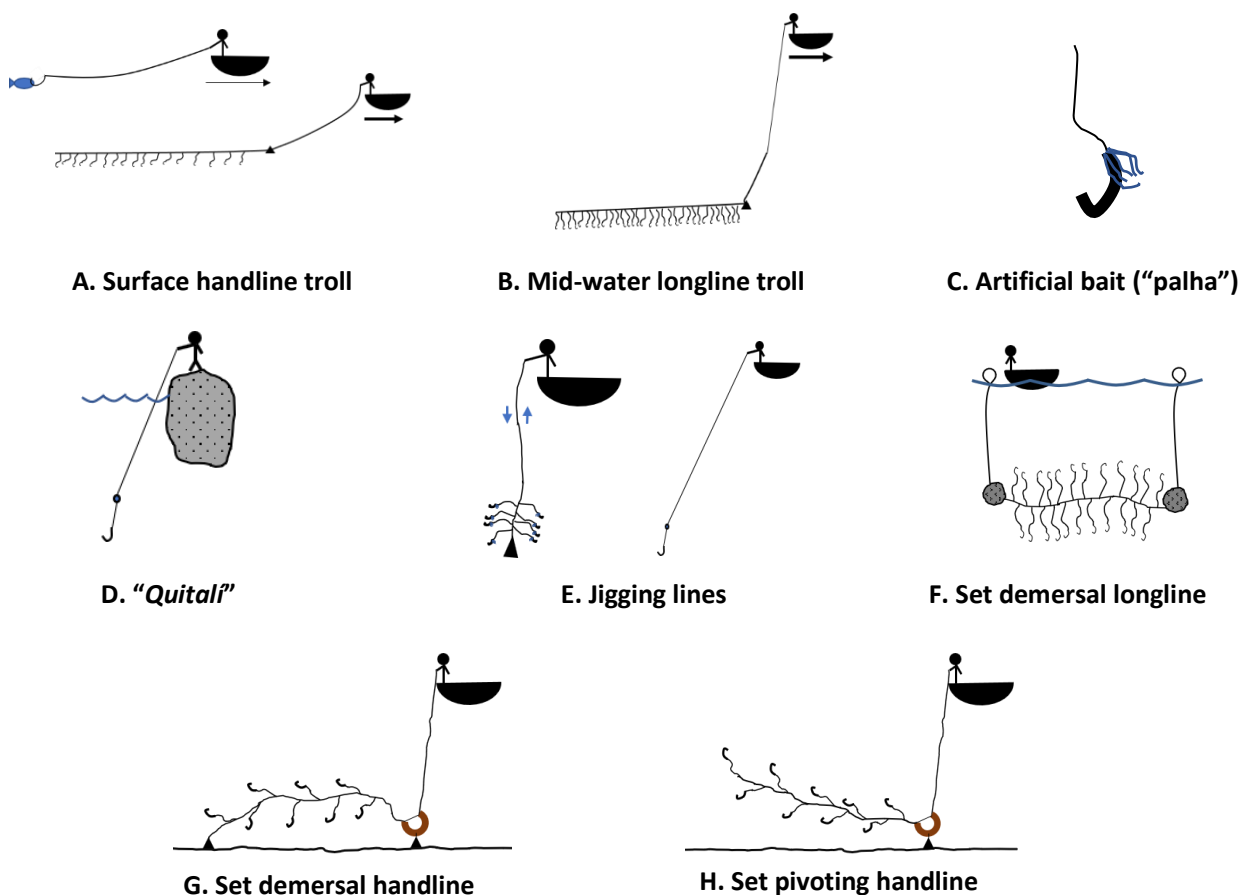
G. Set demersal handline　　**H. Set pivoting handline**

Figure 19: Schematic representation of line fishing types, drawn with fishers during FGDs and used in the smartphone landing questionnaires.

Figure 20: **A)** Hooks nailed to a wooden board, to avoid the entanglement of the longlines **B)** Fisher from Príncipe returning from a line fishing trip in Hospital Velho (Príncipe). **C)** "*Vega*", a bent wooden stick which may be attached to the anchor of demersal handlines to act as a spring, shaking the line and spreading the smell of the bait (© G. Porriños)

Fishers typically use bait or artificial lures when hook and line fishing. Two types of artificial lure have been described: **1)** "palha", made of small plastic threads tied around the hook to mimic the tentacles of a squid or octopus when the line is jigged or dragged (Figure 19C); or **2)** reflecting fish-shaped plastic sheets that mimic the movement of small pelagic fish when the line is dragged. Several types of bait have also been recorded and described by fishers, with the most common choice being finfish (alive, whole or sliced).

The choice of bait depends on its availability and performance. For example, the smell of the bait was reported to be one of the most important factors in bait performance, making "*fulu fulu*" tunas (*Euthynnus alleterattus* and *Auxis Thazard*) good bait choices. The texture of the bait was also reported to be relevant, and octopus, cuttlefish and squid were identified as good choices for demersal longlines, as softer bait often gets ripped off or eaten around the hook. Nevertheless, availability is often the determinant factor in bait choice. For example, fishers explained that flying fish is often used as bait, despite not having a strong smell, since it is cheap and readily available in many communities. In other cases, bycaught species with low commercial value may be used as bait, especially those which are not suitable or appreciated for consumption. Although bait choice appears to be somewhat opportunistic, fishers often intentionally target bait fish. For example, when fishing large predatory epipelagic species (such as wahoo or dolphinfish), surface trolling lines with artificial lure are used to catch *fulu fulu*, which is then used as live bait to catch the target species. Likewise, fishers in some communities in São Tomé use a specialised type of jigging handline with small hooks and artificial lure to catch *Sardinella*, almost exclusively for bait. Besides finfish and cephalopods, other types of bait include crabs (hermit crabs, land crabs, and river crabs), sea urchins, and even vegetables, such as breadfruit. Indeed, small hermit crabs are the second most used bait types for some gears in both São Tomé and Príncipe.

To better characterise the diversity of line fishing gears, and how these might affect catch composition, the following variables were considered in the description of the gears in this and the following section: 1) Habitat, subdivided into *epipelagic* (close to the surface) and *demersal/mid-water* (at the sea floor or close to it); in combination with *inshore* (within the insular shelf) and *offshore* (at the edge of the insular shelf, at depths of 80-200 metres); 2) Technique, subdivided into *jigging*, *trolling*, *set lines* and *set pivoting lines*; 3) Bait type, divided on *artificial lure* and *organic bait*; and 4) Hook size.

3.2.1. Jigging handlines

Jigging handlines normally carry a weight at the end to keep them in a vertical position. They have a thick primary line and thinner secondary branch lines which carry the hooks. Jigging handlines are the most practised type of hook-and-line fishing (see section 3.7) and show large variation in the number of hooks, hook size, fishing times, bait type and other features, allowing fishers to target a variety of species. Jigging handlines target demersal or mid-water habitats, within the continental shelf (inshore) or at its edge (offshore). Jigging handlines were classified in two main subtypes: 1) baited jigging handlines and 2) jigging handlines with artificial lure.

Jigging handline with artificial lure

Jigging handlines with artificial lure normally use "*palha*" (plastic threads tied around the hook, Figure 19C) to attract the target species. The line must constantly be jigged, as the fish is lured in by the movement of the artificial lure, which mimics a planktonic octopus or squid. This gear is normally referred to as "*toca*" or "*toca e puxa*" (touch and pull), referring to the movement of touching the seafloor and pulling back up. The name "*pingué*" is used in some communities on Príncipe and São Tomé to refer to this type of fishing, although this name is also used in other communities to refer to surface troll.

The hook size used for the jigging handline with artificial lure differs between São Tomé and Príncipe (Figure 19A). In Príncipe, 75% of the jigging handlines with artificial lure used hook sizes 10 -12, with 20% of the remaining records using larger hooks (sizes 6-9). On the contrary, in São Tomé, 79% of the jigging handlines used a smaller hook size (13-20), with sizes 13 and 14 being most common, and only 20% used sizes 6-12.

Likewise, the temporal distribution of effort differs between islands (Figure 21B). On Príncipe, jigging handline with artificial lure effort reaches its peak at 6h (immediately after sunrise) and drops off quickly until 10h, only resuming after sunset. In São Tomé on the other hand, the effort of this gear type remains steady throughout the night (19h – 4h), drops at 5h and rises to reach its peak at 8h, upon which it decreases steadily until 15h. The soaking time is similar between islands, with an average of 4.7 (SD = 3.2) and 5.0 (SD = 3.8) on Príncipe and São Tomé, respectively. The number of lines used simultaneously depends on the number of fishers onboard and ranges between 1-3.

Table 6: Characteristics of jigging handlines with artificial lures ("palha").

Gear	CPUE units	Site	N	N lines (min, max)	N hooks (min, max)	Soak time (average)
Jigging line (art. lure)	Kg / line / h	ST-S	306	[1 ; 3]	[2; 25] hooks	4.7 (SD=3.2)
		PC	1323	[1 ; 3]	[2; 28] hooks	5.0 (SD = 3.8)

On São Tomé, a specialised type of jigging handline with artificial lure was described by fishers in FGDs. This variation uses small hooks (17-20) to catch small bait fish of the genus *Sardinella* (locally known as "*sardinha*"). Although this sub-type was not disaggregated in the landing questionnaires, 22 instances fitting this description were recorded in the landing data from São Tomé. The fishing times of these instances were concentrated at 6h (40%) and between 15h – 17h (50%).
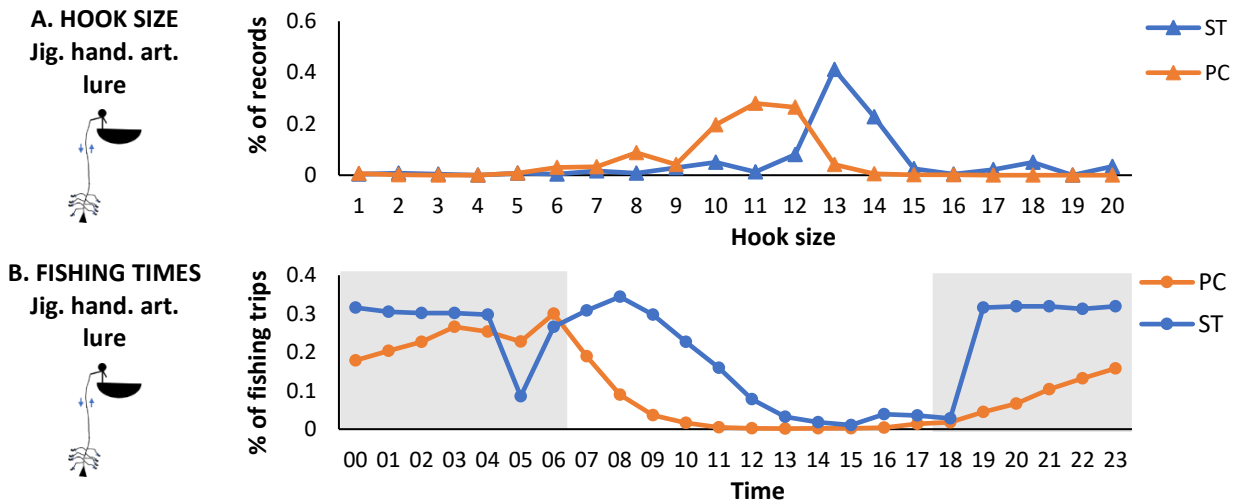
A. HOOK SIZE
Jig. hand. art. lure

B. FISHING TIMES
Jig. hand. art. lure

Figure 21: **A)** Hook sizes of the jigging handline with artificial lure in Príncipe (PC) and São Tomé (ST). Hook sizes for this gear are smaller on São Tomé than Príncipe. **B)** Distribution of fishing effort of the jigging handline with artificial lure on Príncipe (PC) and São Tomé (ST). Night hours have been highlighted in light grey.

The most abundant species present in the catch of the jigging handline with artificial lure on Príncipe are blue runner (*Caranx crysos*, 73% of the catch), big-eyed scad (*Selar crumenophtalmus*, 8.9%), and golden African snapper (*Lutjanus* 3.4%). Overall, Carangidae species comprise 89% of the catch, and young individuals of large carangid species such as *Seriola rivoliana*, *Elegatis bipinnulata*, and *Caranx latus* are frequent in the catch (around 3.7% of the total catch). "*Fulu fulu*" tunas (*Auxis thazard* and *Euthynnus alletteratus*) comprise 2.3 % of the total catch (see Figure 22).

On São Tomé, the catch composition of the jigging handline with artificial lure is also dominated by *Caranx crysos* (46.5%) and *Selar crumenophtalmus* (22.0%), but in smaller proportions (Figure 22). Small snappers of the species *Lutjanus fulgens* (7.0%) and *Apsilus fuscus* (3.2%) constitute around 10% of the catch. Small reef fish of the species *Paranthias furcifer*, *Acanthurus monroviae* or fish of the family Holocentridae, are also prevalent in the catch, comprising a total of 7.5%. This contrasts with the catch of the jigging handline in Príncipe, where small reef fish constitute only 0.2% of the total catch. Moreover, the large carangid species *C. latus*, *S. rivoliana* and *E. bipinnulata* are absent from São Tomé's catch for this gear type.

CATCH (Jigging handline with artificial lure)
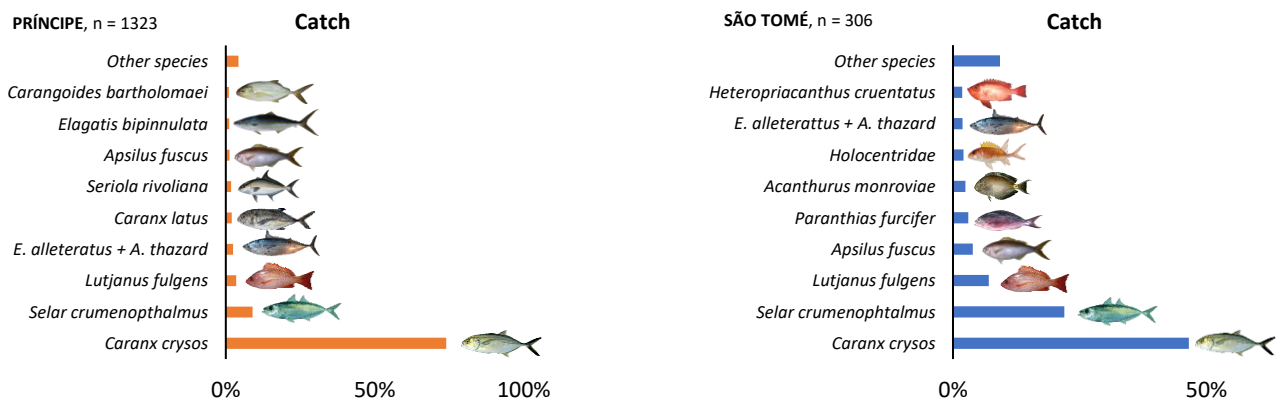
Figure 22: Catch composition of the jigging handline with artificial lure on Príncipe (orange) and São Tomé (blue). The catch in both islands is strongly dominated by *C. crysos*, followed by *S. crumenophtalmus*. Small reef fish such *A. monroviae* and fish of the family Holocentridae comprise 7.5% of the catch on São Tomé, but only 0.2% on Príncipe. Large carangid species such as *S. rivoliana*, *C. latus* and *E. bipinnulata* comprise 3.7% of the catch on Príncipe but are completely absent from São Tomé.

3. RESULTS

Baited jigging handline

Baited jigging handlines may use different types of bait, including fish, crabs and other invertebrates and sometimes even vegetable products such as breadfruit. In Príncipe, the dominant species used for bait are "*fulu fulu*" tunas (*Euthynnus alleteratus* and *Auxis thazard*, 27%), while on São Tomé *Sardinella* is the dominant bait type (28%). Hermit crabs are the second most commonly used bait type for this gear in both São Tomé and Príncipe (21% and 22% respectively). Flying fish is more commonly used as a bait on Príncipe than on São Tomé (see Figure 23).

BAIT TYPE (baited jigging handline)
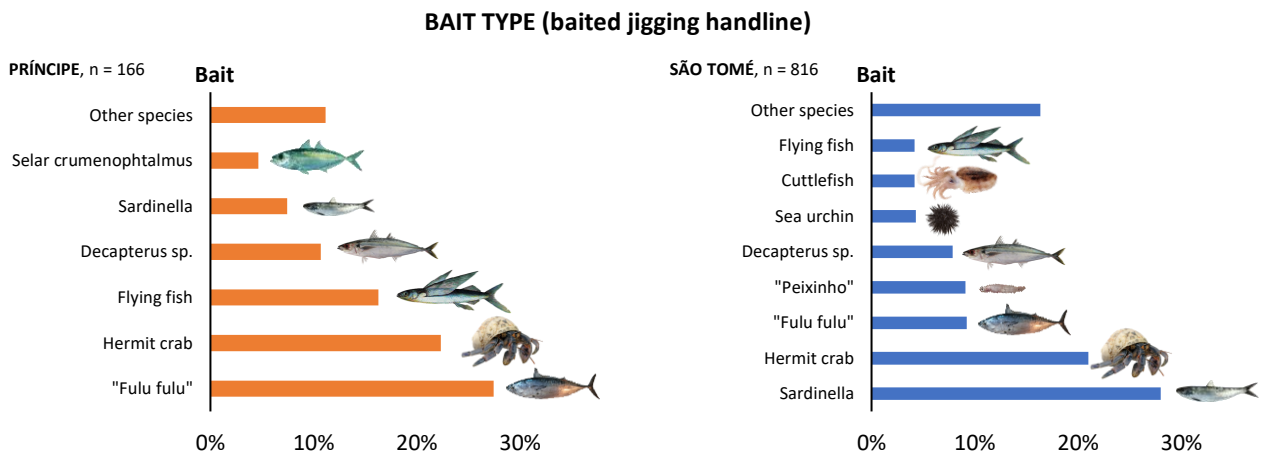
Figure 23: Type of bait used on baited jigging handlines on Príncipe and São Tomé. "*Fulu fulu*" tunas are the most commonly used bait on Príncipe and *Sardinella* on São Tomé. Hermit crabs are the second most used bait on both islands. "*Peixinho*" are small fish caught with mosquito nets and other techniques in mouth of rivers (see section 3.1.6).

Baited jigging handlines receive different names on both islands and two subtypes of jigging handlines were described by fishers during FGDs. Subtype 1 has several medium-sized hooks (10-14), a weight at the end of the line to keep it vertical and can either be jigged or kept still with the anchoring weight. On Príncipe, this type of fishing is referred to as "*costumado*" or "*cú-no-chão*", while on São Tomé it is called "*fio de fundo*", "*costumado*" or "*pingué*" in some communities (note that "pingué" is also used to refer to some types of surface troll in other communities on São Tomé). On the other hand, Subtype 2 has a single large hook (size 1-3) at the end of the line. It may bear a weight at approximately 1 metre from the hook or not; and may use live fish as bait. This gear is used to target large fish, and the last metres of the line might be made of steel wire to target sharks. This type of gear is normally referred to as "*fio grosso*" (thick line) and fishers in FGDs referred to the technique as "*sonda*" (São Tomé) and "*fio jogado*" or "*matelé*" (Príncipe). Fishers in FGDs explained that other names can be given to these techniques depending on whether the boat is anchored ("*ancorado*"), drifting ("*travessado*") or rowing slowly ("*fio remado*").

Although Subtype 1 and Subtype 2 were considered different gear types in the landing surveys, many Subtype 2 records fall within the parameters of Subtype 1 in terms of number of hooks and hook sizes used. Moreover, as shown in Figure 24, fishers may use hook sizes that fall between the parameters of the two categories (4-9). On Príncipe, 40% of the records corresponded to hook sizes 10-13, while on São Tomé 44% of records corresponded to slightly smaller hook sizes (12- 14). Large hook sizes (1-3) comprised 23% and 19% of the records on Príncipe and São Tomé respectively and intermediate hook sizes (4-9) made up 16% of the records on Príncipe and 28% on São Tomé (Figure 24).

Baited jigging handlines can be used inshore (within the continental shelf) or offshore (at its edge). On Príncipe, when the baited jigging handline is used to fish in deep offshore waters it is referred to as "*fundo*" or "*pesca de fundo*" ("deep fishing"). However, although this type of fishing is also practised on São Tomé, it is not given a specific name, and thus could not be disaggregated from inshore fishing. On Príncipe, hook

23

sizes 2-9 comprised 93% of the records of the offshore jigging handline, and *fulu fulu* tunas (*E. alleteratus* and *A. thazard*) were the most common bait type. It is also worth noting that artificial lure ("palha") was used in 15% of the records of the offshore jigging handline, with 5% of the records using hermit crab and 16% using various finfish species.

Table 7: Characteristics and sample size of the different types of the baited jigging handline

Gear	CPUE units	Site	Subtype	Habitat	N record	N lines (min, max)	N hooks (min, max)	Soak time (average)
Baited jigging line	Kg / line / h	PC	I (small hooks)	Demersal inshore	92	[1 ; 3]	[2 ; 20]	3.4 (SD=3.0)
			II (large hooks)	Demersal inshore	69	[1 ; 3]	[1 ; 5]	3.5 (SD=3.2)
			I (small hooks)	Demersal offshore)	85	[1 ; 3]	[1 ; 25]	4.9 (SD=2.6)
		ST	I (small hooks)	Demersal	626	[1 ; 3]	[6; 15]	3.8 (SD=2.1)
			II (large hooks)	Demersal	53	[1 ; 3]	[1 ; 5]	3.5 (SD=1.8)

HOOK SIZE Baited jig. handline
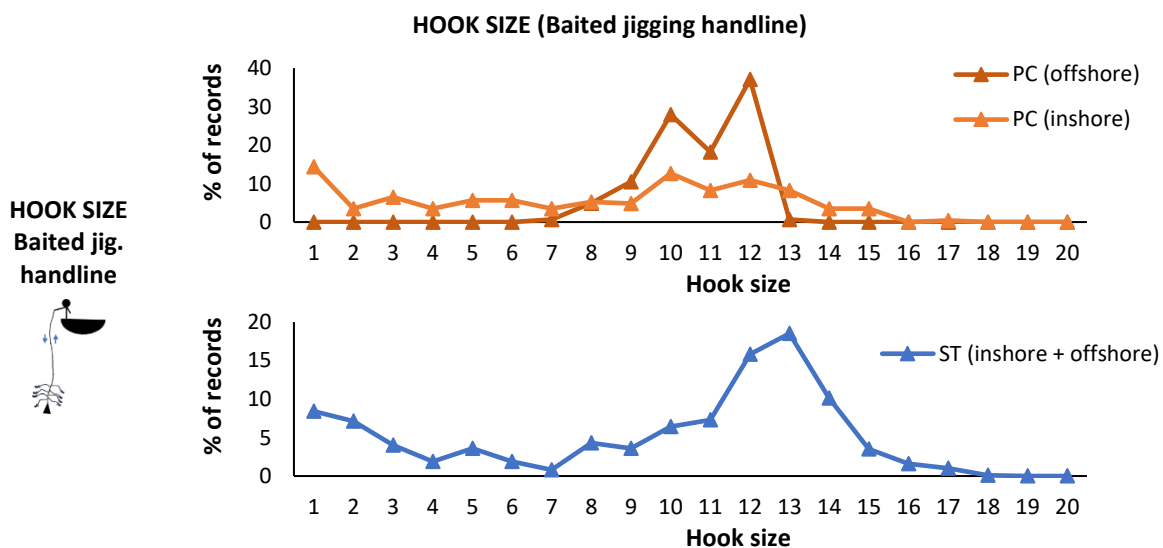
Figure 24: Hook sizes used for the baited jigging handlines on Príncipe and São Tomé. On Príncipe, fishers distinguish between baited jigging handlines in deep and shallow waters, giving them different names. In São Tomé no such distinction is made, thus making it impossible to disaggregate the records.

On Príncipe, the effort of the inshore baited jigging handline is distributed throughout the day, being at its highest between 3h and 9h and tapering off until 16h. However, the effort of the offshore jigging handline is strongly concentrated in the morning (between 6h-13h), reaching its peak at 9h (Figure 25). During interviews, fishers explained that this type of fishing is physically demanding, since the long line used at greater depths creates more resistance and is therefore practised opportunistically (when the moon phase does not favour other types of fishing) or as a last resort (if the other types of line fishing have not yielded enough catch during a trip).

On São Tomé, the effort of the baited jigging handline is strongly concentrated in the morning. It starts off being low during the night and rises from 6:00 until it reaches its peak at 9:00. It then decreases steadily until 18:00, when it ceases completely (Figure 25).

FISHING TIMES Príncipe

FISHING TIMES São Tomé
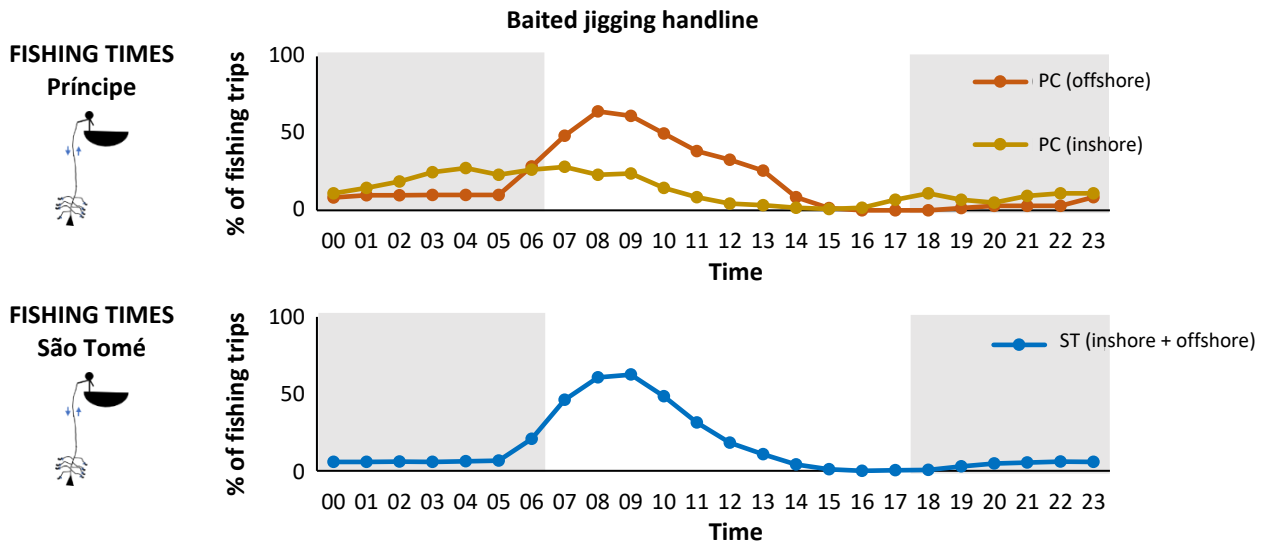
Figure 25: Temporal distribution of effort of the baited jigging handline on Príncipe and São Tomé.

On Príncipe, the catch of the <u>inshore baited jigging handline</u> is mostly comprised of large predatory fish, such as *Seriola rivoliana*, lutjanid snappers (mostly *Lutjanus endecacanthus* and *Lutjanus agennes*), barracudas (*Sphyraena barracuda*) and large carangid species (such as *Caranx latus*, *Elegatis bipinnulata*, or *Caranx hippos*). However, the proportion of each of these depends on the hook size, which often also corresponds to small differences in the fishing technique used. In the case of the <u>Subtype 1</u>, which has a weight at the end of the line and 6-10 medium to small hooks (size 7-14), the demersal, bottom-dwelling species *Pagrus caeruleostictus* and *Lethrinus atlanticus* comprise 13% of the catch, and sharks are completely absent from the catch. However, in the case of the <u>Subtype 2</u>, which might not have a weight and has 1-5 larger hooks (size 1-6) these demersal species are not present, and sharks comprise 5% of the catch (Figure 26).

On Príncipe, the hook size of the <u>offshore baited jigging handline</u> falls within the range of <u>Subtype 1</u> (with hook sizes 9-12). However, the catch composition is markedly different from the catch of the Subtype 1 of the inshore jigging handline (see Figure 26). As shown in Figure 27, the catch of this technique is strongly dominated by *Dentex macrophtalmus* (42.9%), followed by *Seriola rivoliana* (15.3%), *Erytrocles monodii* (13.6%), *Pontinus kuhlii* (9.2%), and *Polyprion americanus* (6.1%), which are species with a depth range below 100 metres (except for *Seriola rivoliana*).

Baited jigging handline inshore (Príncipe)
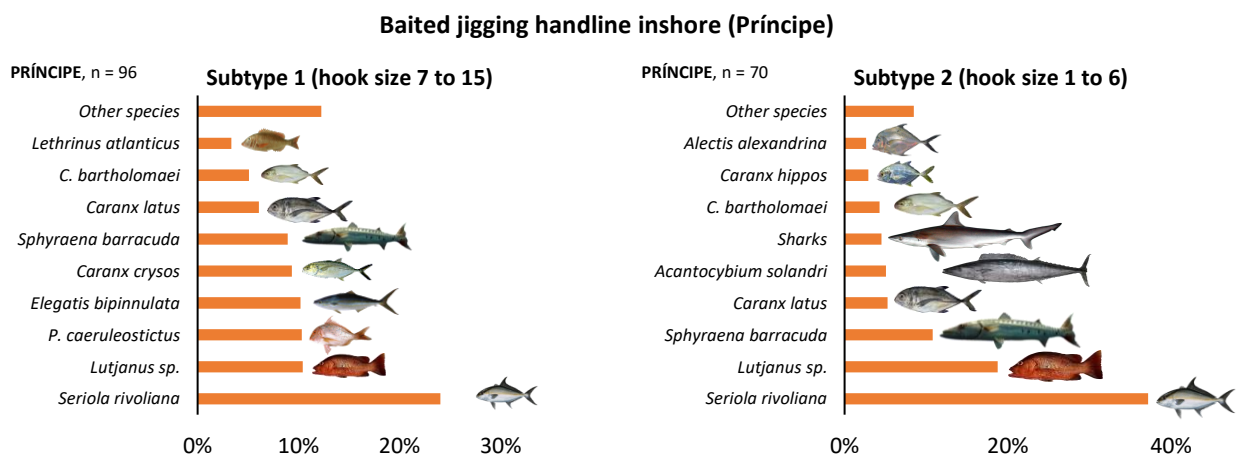
Figure 26: Catch composition of baited jigging handlines on Príncipe, disaggregated by hook size. *Seriola rivoliana* and large lutjanid snappers (mainly *L. agennes* and *L. endecacanthus*) are the dominant species, regardless of hook size.

Jigging handline, deep demersal offshore (Príncipe, bait & art. lures)

PRÍNCIPE, n = 85   **Subtype 1 (hook size 9 to 12)**
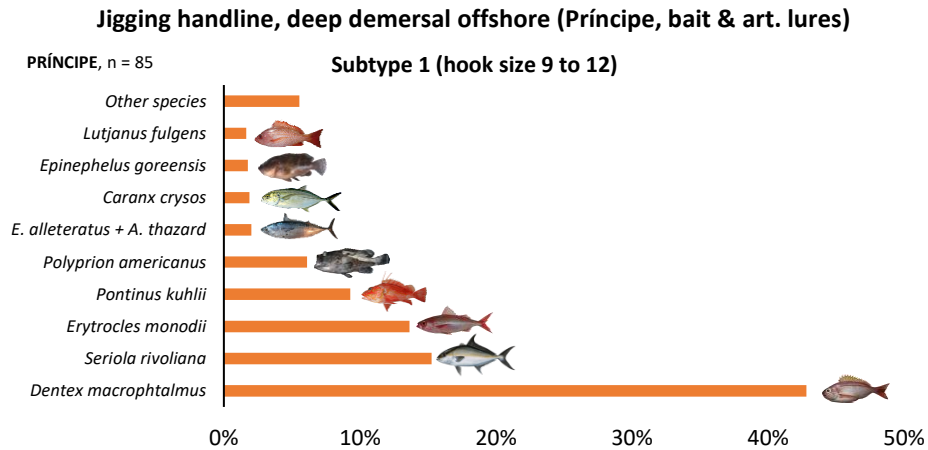
Figure 27: Catch composition of the jigging handline for deep-water fishing in Príncipe.

The catch of the baited jigging handline on São Tomé does not show a clear dominance by any species (see Figure 28). For both the Subtype 1 and Subtype 2, the most abundant species are the carangids *Caranx crysos* (representing 15% and 12 % of the catch respectively) and *Elegatis bipinnulata* (8% and 11% for each subtype). Lutjanid snappers (*L. endecacanthus*, *L. agennes*, and *L. goreensis*) comprise less than 10% of the catch of Subtype 2 and are completely absent from the Subtype 1 on São Tomé. Small reef fish of the families Holocentridae (squirrelfishes) and Acanthuridae (surgeonfishes) and the species *Paranthias furcifer* comprise 11% and 7% of the catch of the Subtype 1 and 2 respectively. Triggerfishes of the species *Balistes punctatus* and *Balistes carolinensis* comprise 4% and 2% of the total catch for these subtypes and yellowfin tunas (*Thunnus albacares*) and bigeye tunas (*Thunnus obesus*) comprise 3% of the catch for both. Sharks comprise 4% of the catch of Subtype 2 but are completely absent from Subtype 1. On the other hand, smooth pufferfishes (*Lagocephalus laeviagatus*) comprise 4% of the catch of Subtype 1 but are absent from the Subtype 2 (see Figure 28).

Since offshore and inshore jigging handlines could not be disaggregated for São Tomé, the catch recorded for Subtype 1 is likely to contain offshore records, as indicated by the presence of *Congo dentex*, *Dentex macrophtalmus*, and *Erythrocles monodii*, which are species with depth ranges below 80 m. However, these species comprise only 3% of the catch.

Baited jigging handline in São Tomé (offshore and inshore)

SÃO TOMÉ = 620   **Subtype 1 (hook size 7 to 15)**   SÃO TOMÉ = 53   **Subtype 2 (hook size 1 to 6)**
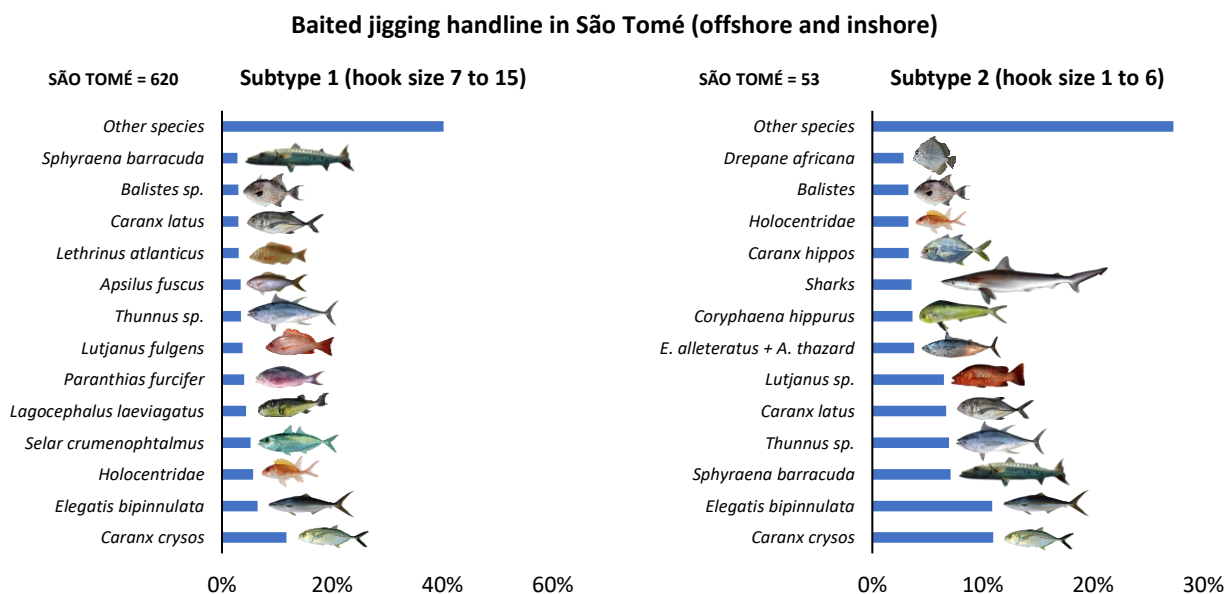
Figure 28: Catch composition of baited jigging handlines on São Tomé.

3.2.2. Demersal lines

Demersal lines in São Tomé and Príncipe can either be longlines or handlines, all of which use bait to attract the fish. Demersal longlines, known on both islands as "*palanque*", have 100-800 baited hooks kept at the seafloor by one or several anchors which is attached to a buoy at the surface to mark its position. Fishing is done at night, normally by two fishers: one who deploys the gear and another who moves the boat forward to avoid entanglement of the line. After deployment, the fishers return to the first buoy and start retrieving the line after a set amount of time.

A variant of the demersal longline is the demersal handline, which has anchors at the beginning and at the end of the hook-bearing part of the line and has less hooks than the demersal longline (Figure 19). It is normally handled manually by the fishers onboard, who shake the line to spread the smell of the bait. The line is typically equipped with a specialised device called "*vega*", a bent wooden stick attached to the line and attached to the first anchor, that acts as a spring and shakes the line underwater (see Figure 20C and Figure 19G). This type of fishing is called "*palim*" on Príncipe (although many fishers use this term as a synonym for "*palanque*") and "*xitô*" on São Tomé.

Another variation of the demersal line is the demersal pivoting handline. Fishers described this as being the same as the demersal handline, but with a single anchor at the beginning of the hook-bearing part of the line (Figure 19H). This configuration keeps the line parallel to the seafloor and allows the hook-bearing part of the line to be dragged by the current and pivot around the anchor. Fishers in FGDs explained that this type of fishing is normally used on nights when the current is too strong to use the previous two types.

In São Tomé and Príncipe, most records of demersal set lines are longlines with 100-400 hooks (85% and 77% respectively, see Figure 29). Lines with 400-800 hooks constitute 17% of the sample on Príncipe and 9% on São Tomé, whereas lines with less than 100 hooks constitute 5% of the sample on Príncipe and 9% on São Tomé. The demersal pivoting handline was not recorded on São Tomé. On Príncipe, this gear type was always recorded as having <30 hooks, with 84% of the records having 5-15 hooks (Figure 30) and 68% of the records using hook size 8-10 and 20% of the records using hook size 5-7.
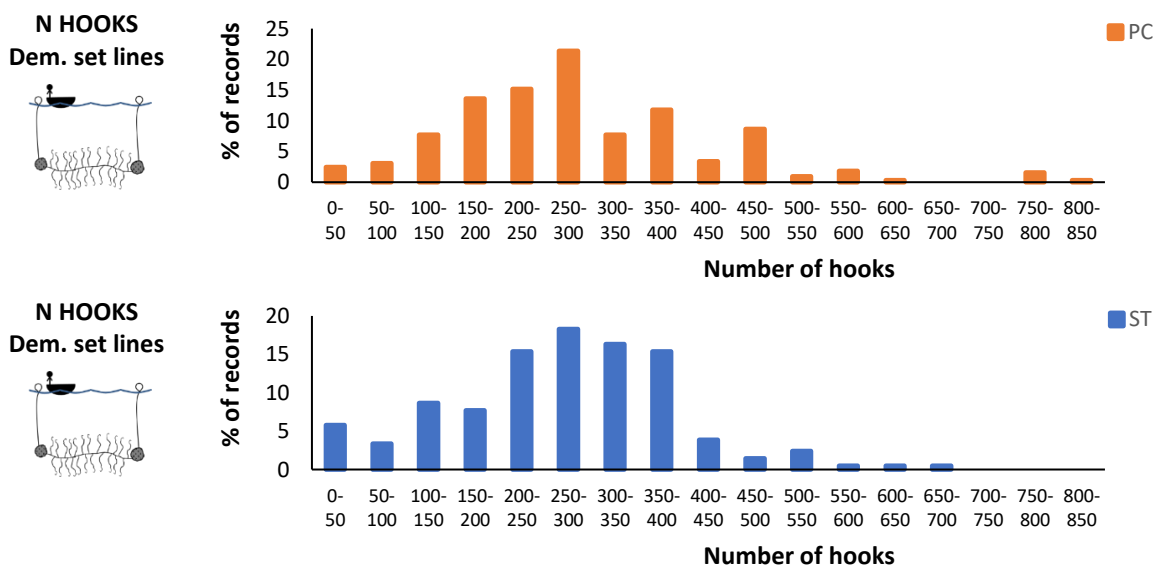
Figure 29: Number of hooks of the demersal set lines (handlines and longlines), on Príncipe (PC) and São Tomé (ST).
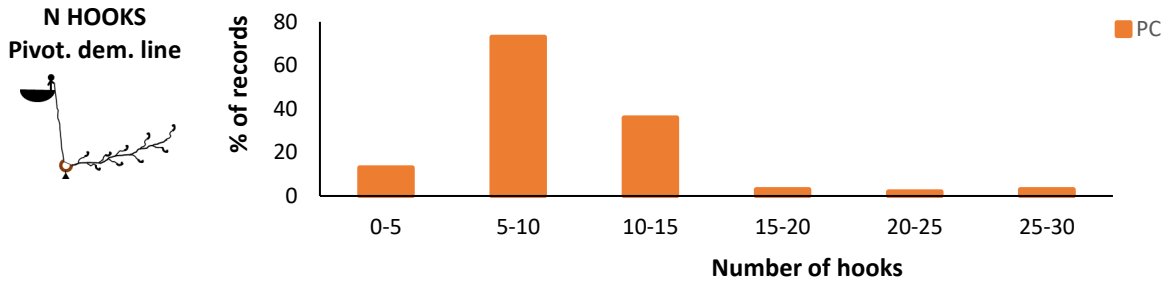
Figure 30: Number of hooks demersal pivoting handline (handlines and longlines) on Príncipe (PC).

Table 8: Characteristics and sample size of the different types of demersal lines.

Habitat	Gear / technique	Site	CPUE units	Subtype	N hooks	N records	N lines (min, max)	Soak time (average)
Demersal	Set line	ST	Kg / lines / h	Handline	Below 100	12	1	2.7 (SD = 1.3)
			Kg / 100 hooks	Longline	Over 100	133	1	3.1 (SD = 1.8)
		PC	Kg / lines / h	Handline	Below 100	8	1	5.9 (SD = 2.9)
			Kg / 100 hooks / h	Longline	Over 100	320	1	4.0 (SD = 2.3)
	Pivot. line	PC	Kg / lines / h	Handline	Below 100	169	1	5.0 (SD=3.2)

The hook size used for the demersal set lines (including both handlines and longlines) is fairly constant, with most records having hook size 11, 12 or 13 (89% of the sample on São Tomé and 86% on Príncipe, respectively). Hook size for the demersal pivoting lines used on Príncipe is also constant, with most records having hook sizes 8, 9 and 10 (68% of the sample) and a maximum hook size of 5 and minimum of 12.
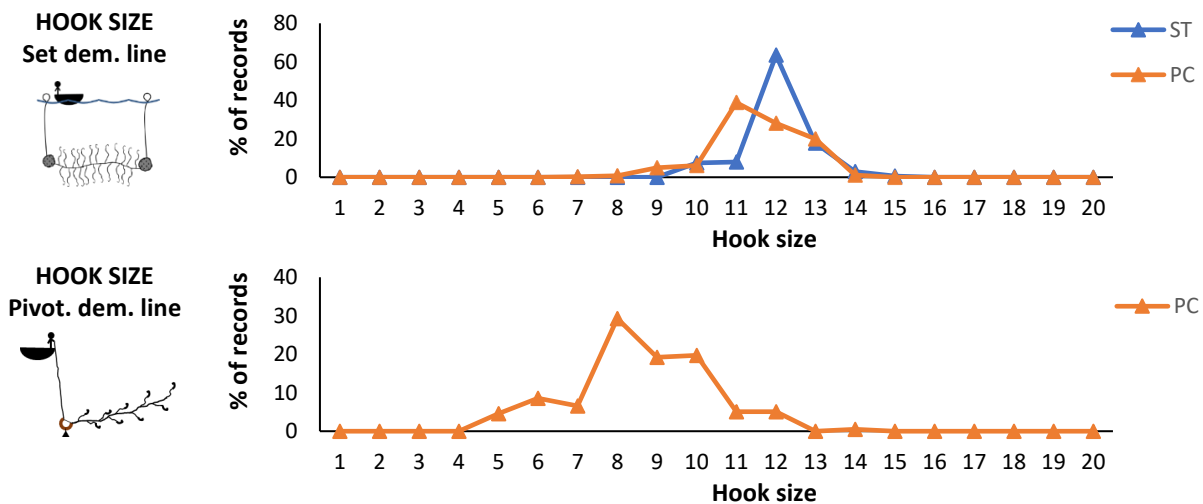
Figure 31: Catch composition of the baited jigging handline on São Tomé.

Demersal set line fishing effort is mostly concentrated at night across both islands (Figure 32). In the case of the demersal longline, the average soaking time is 3.5 hours, concentrated between 3AM and 7AM on both islands, with a clear peak at 5AM. The demersal pivoting handline, only recorded on Príncipe, is practised throughout the night with the highest effort occurring between 12 AM and 4 AM (Figure 32).

Bottom longline

Pivoting bot. handline
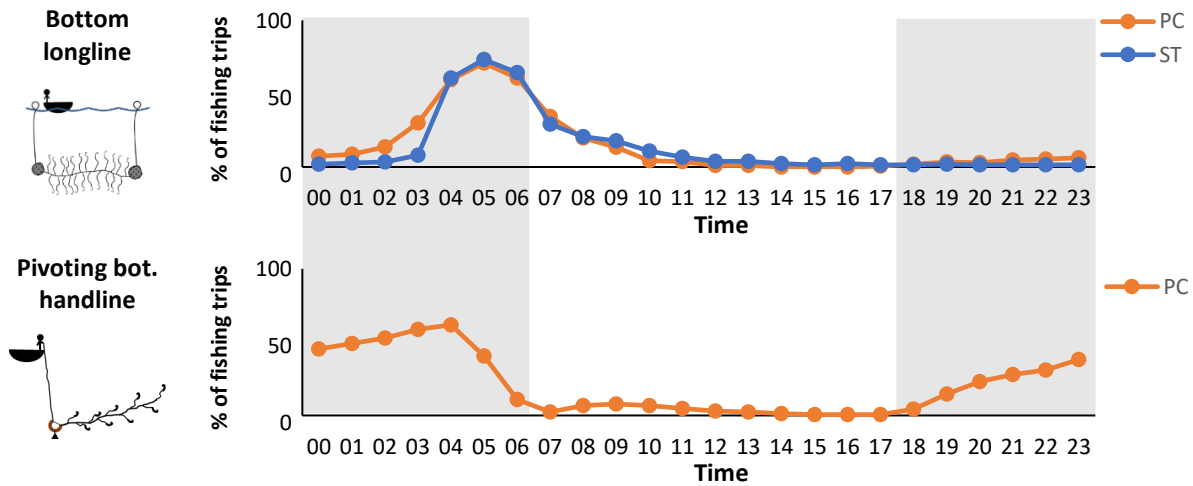
Figure 32: Temporal distribution of effort of the demersal fishing lines on São Tomé and Príncipe. Hours of darkness have been highlighted in grey.

On Príncipe, the catch of the <u>set bottom lines</u> is strongly dominated *Pagrus caerulosticteus*, followed by *Dactylopterus volitans*, with the opposite being true for São Tomé. The Atlantic emperor (*Letrhinus atlanticus*) is also often caught with this gear on São Tomé and Príncipe, comprising 9% and 6% of the catch, respectively. On Príncipe, lutjanid snappers (*Lutjanus* sp.) and Almaco jacks (*Seriola rivoliana*) comprise 9% and 7% of the catch of this gear respectively, while on São Tomé they only comprise 3% and 2 % of the catch. The catch of the <u>pivoting bottom handline</u> (Figure 33) shows strong similarities with the catch of the jigging baited handline (subtype 1, Figure 26), with lutjanid snappers, *S. rivoliana* and *P. caeruleostictus* being the dominants species. *D. volitans* is completely absent from the catch of the pivoting bottom handline and the jigging baited handline.
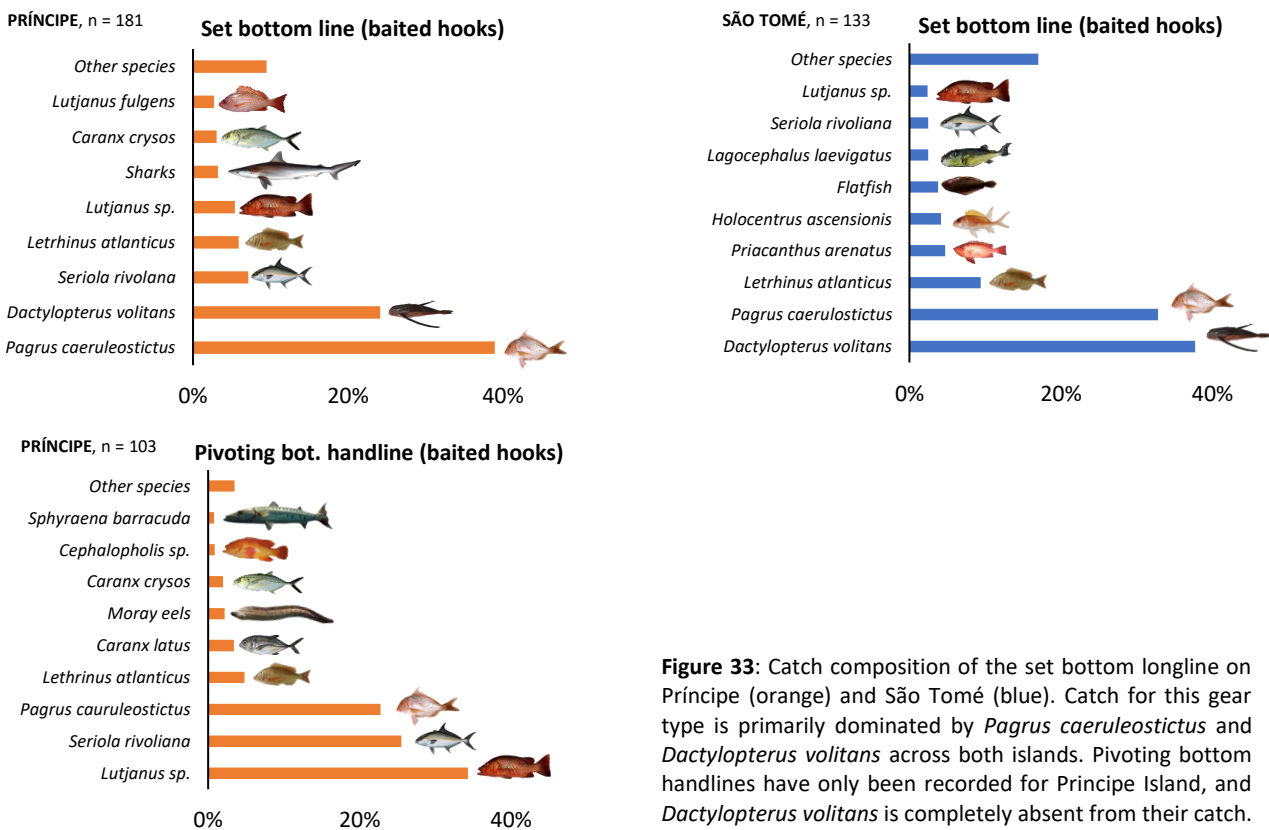
Figure 33: Catch composition of the set bottom longline on Príncipe (orange) and São Tomé (blue). Catch for this gear type is primarily dominated by *Pagrus caeruleostictus* and *Dactylopterus volitans* across both islands. Pivoting bottom handlines have only been recorded for Principe Island, and *Dactylopterus volitans* is completely absent from their catch.

3.2.3. Demersal troll

As described in section 3.2, trolling is a technique which consists of dragging a fishing line through the water by a moving boat. The gear configuration of demersal trolls consists of 20-300 hooks, with a weight before the hook-bearing part of the line to keep it in a horizontal position while the boat moves forward. In this form of trolling, the line is dragged at low velocity to keep it close to the seafloor and "palha" is used as bait (an artificial lure made of small plastic threads that mimic the tentacles of small squid or octopus, see Figure 19C). This is one of the most practised fishing techniques on Príncipe, comprising 30% of all line fishing records, while on São Tomé it is rarely used (2% of line fishing trips). On Príncipe, this technique was referred and "*arrastão*" during interviews and on São Tomé the terms "*arrastão*" and "*samba*" were both used.

Table 9: Characteristics and sample size of demersal troll fishing

Gear	Habitat	CPUE units	Site	N records	N lines (min, max)	Soak time (average)
Demersal troll	Demersal	Kg / line / h	PC	708	1	2.6 (SD = 1.8)
			ST	32	1	2.5 (SD = 1.2)

On Príncipe, 90% of the records of demersal troll fishing had 100-350 hooks, with 70% of these having 100-200 hooks. The hook size used in this type of fishing shows few variations on Principe, with 75% of the records using hook sizes 9-10 and a maximum size of 7 and a minimum size of 12 (Figure 34). This type of fishing is practised solely at night, increasing steadily from 23h to 5h, when it reaches a peak. The effort drops quickly after sunrise at 6h and continues to taper off until 10h upon which it ceases completely (Figure 35). On São Tomé, only 32 trips have been recorded using demersal troll. Half of these records used ≤50 hooks in the troll and most used hook sizes between 12-15 (Figure 34). The distribution of effort throughout the day is the same as on Príncipe (Figure 35).
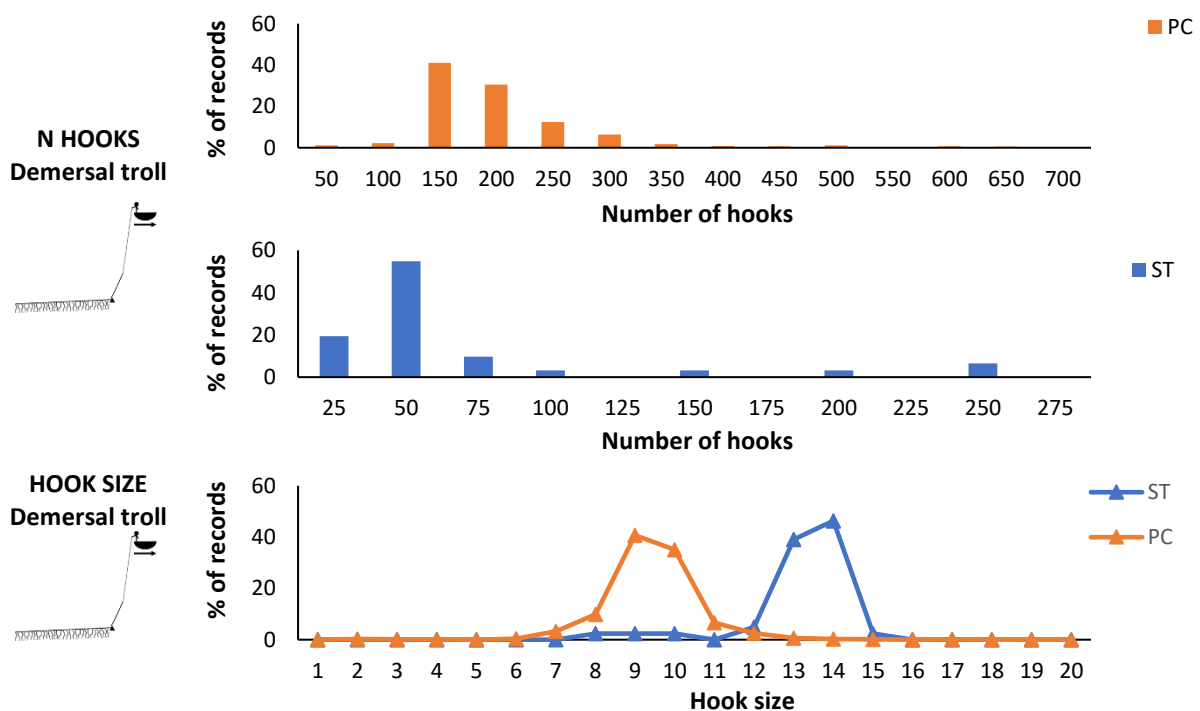
Figure 34: Number of hooks and hook size of the demersal troll on Príncipe and São Tomé.

FISHING TIMES
Demersal troll
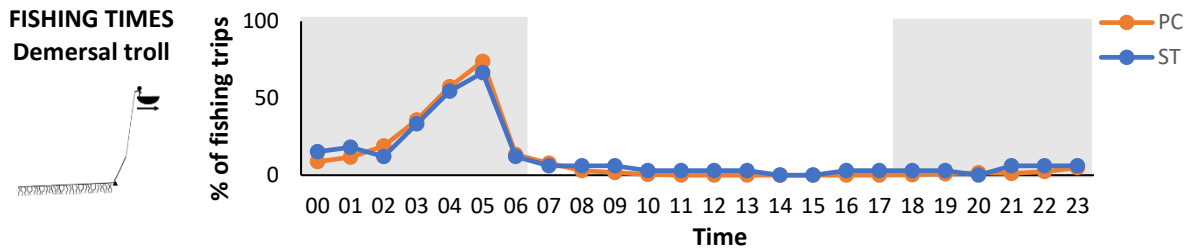
Figure 35: Temporal distribution of effort of the demersal troll on Príncipe (PC) and São Tomé (ST).

On Príncipe, the catch of the demersal troll with artificial lures (Figure 36) is remarkably similar to the catch of the jigging handline with artificial lures (Figure 22), with small differences in the abundance of the different species. Catch for both techniques is dominated by Carangidae (83% for the demersal troll and 89% for the jigging handline), with *Caranx crysos* comprising 66% and 73% of the total catch respectively. *Fulu fulu* tunas (*A. thazard* and *E. alletteratus*) are more abundant in the catch of the demersal troll (9.8%) than in the jigging handline (2.3%). The small carangid *S. crumenophtalmus* is also an important part of the catch of the demersal troll, comprising 7.1% of the catch (compared to 8.9% in jigging handlines). The large carangid species *C. latus*, *S. rivoliana*, and *E. bipinnulata* comprise 7.2% of the catch of the demersal troll altogether (vs. 5% in the jigging handline), and the small snapper *Lutjanus fulgens* is also often caught with this technique, comprising 3.4% of the catch (vs. 2.4% in the jigging handline).

On São Tomé the catch of the demersal troll with artificial lures is strongly dominated by *Heteropriacanthus cruentatus*, a small reef associated fish (Figure 36). This species was present in 70% of the fishing trips using this technique and was always cau ght in large shoals (mean = 65, SD = 46), with the average weight of each individual fish being ~100 g. *Erythrocles monodi* was present in 10% of records and comprised 9% of the total catch, indicating that, in São Tomé, this technique is also practised in deeper fishing grounds.
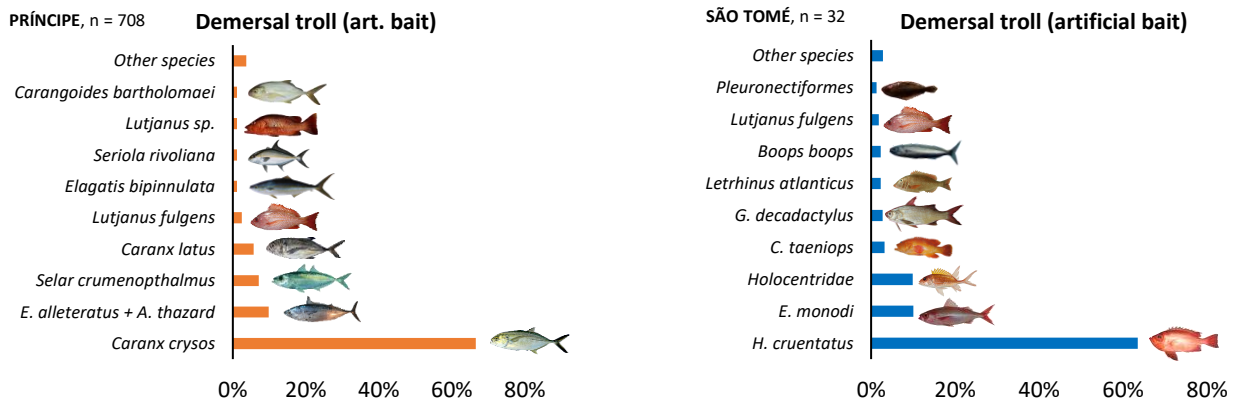
Figure 36: Catch composition of the demersal troll on Príncipe (orange) and São Tomé (blue). On Príncipe, the catch composition of the demersal troll with artificial bait is remarkably similar to the catch composition of the jigging handline with artificial bait, with *C. crysos* being the dominant species. The catch of the demersal troll on São Tomé is strongly dominated by small individuals of *H. cruentatus*, and the presence of *E. monodi* indicates that this type of fishing is also practised on deep waters.

3.2.4. Surface troll

This form of trolling also consists of dragging a line through the water using a moving boat. In many Portuguese-speaking countries, the terms "*corico*" or "*coricar*" are used to refer to the technique of trolling. However, in STP, these terms are normally used to refer almost exclusively to different types of surface troll, whereas demersal trolls ("*arrastão*") is rarely referred to as "*corico*", despite the technique itself being called "*coricar*" (trolling).

During interviews and FGDs two subtypes of surface troll were described by fishers. Subtype 1 uses several small/medium hooks, often with artificial lures, and targets small pelagic fish such as *fulu fulu* tunas (*E. alleteratus* and *A. thazard*). The artificial lures used for this technique might be **1)** plastic threads tied around the hook ("palha") to mimic the tentacles of a small cephalopod (Figure 19C) or **2)** small sheets of shiny plastic tied to the hook to mimic planktonic fish. Additionally, fish bait is often used on this type of gear (43% and 59% of all surface troll records on Príncipe and São Tomé, respectively¸ Table 10). The most common fish bait for Subtype 1 on São Tomé is *Sardinella* (75% of baited surface troll records), while on Príncipe it is *fulu fulu* tuna (37% of baited surface troll records). As in the case of the demersal troll, this gear configuration might also have a weight before the hook-bearing part of the line. Fishers explained that, in such cases, the only difference between the demersal and surface troll is the speed at which the boat is travelling, thus creating ambiguities in the data. In the demersal troll, the boat travels at low speed to allow the line to sink, whereas in the surface troll the boat travels at higher speed to keep the line closer to the surface. To distinguish between these two fishing techniques during data analysis, the records with typically demersal fish (*H. cruentatus*, Holocentridae and flatfishes) were reclassified as demersal troll, while others were classified as surface troll. On both islands, this gear configuration was referred to as "*corico de fulu fulu*" (troll for *fulu fulu* tunas) when used wih artificial lures and "corico" when used with fish bait. On São Tomé, when the line has a weight before the hooks, the names "samba" or "pingué" were also used. Records were classified as Subtype 1 when they had a hook size 7 to 20.

Subtype 2 of surface troll normally uses one large hook with fish bait or, instead of a hook, a device comprised of long plastic threads ("*brindado*") which visually attract sailfishes and marlins, whose beaks become entangled. Although this type of fishing is practised throughout the year, fishers explained during interviews that it is more commonly practiced in specific months, to catch Atlantic sailfish (*Istiophorus albicans*), blue marlin (*Makaira nigricans*) and wahoo (*Acanthocybium solandri*). Records were classified as Subtype 2 when they had a hook size 1 to 6 or used *brindado*.

As shown in Figure 37, *brindado* is used in almost 40% of all surface troll records on Príncipe. In São Tomé, however, it is not as common, and hooks of sizes 9 and 12 were present in almost 80% of the records of surface troll. As shown in Table 10, a maximum of 3 lines can be used simultaneously in the same trip by one fisher, by using two long poles attached to the hull to hold the lines in place and keep them separate.

Table 10: Characteristics and sample size of the different types of surface troll.

Gear / technique	Habitat	CPUE units	Site	Subtype	Hook size	N records	N lines (min, max)	N hooks (min, max)	Soak time (average)	Bait
Surface troll	Epipelagic	Kg / line / hour	PC	II (large hooks)	1 to 6	162	[1,3]	[1 ; 3]	2.7 (SD = 2.2)	-
				I (small hooks)	7 to 20	54	[1,3]	[8 ; 25]	2.7 (SD = 2.4)	Art (57%) Fish (43%)
			ST	II (large hooks)	1 to 6	141	[1,3]	[1 ; 4]	3.6 (SD = 2.5)	-
				I (small hooks)	7 to 20	220	[1,3]	[4 ; 28]	2.4 (SD = 2.0)	Art (41%) Fish (59%)

HOOK SIZE
Surface troll
(all subtypes)
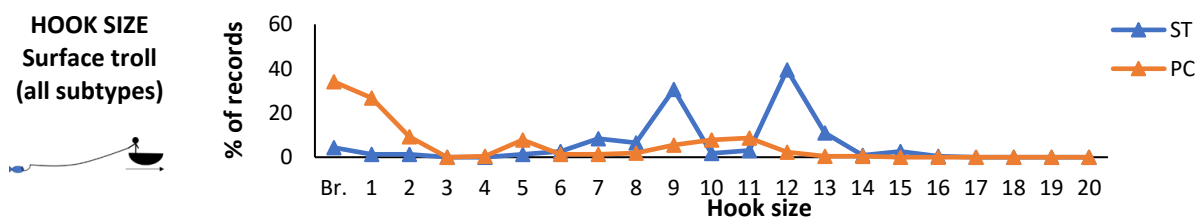
Figure 37: Hook sizes for the surface troll on Príncipe (PC) and São Tomé (ST). Brindado marked as "Br" on the x axis.

As shown in Figure 38, surface troll is practised exclusively during the daytime, starting no earlier than 6h and never finishing later than 18h. On São Tomé, there is a peak at 7h, and the effort starts decreasing until it reaches a minimum at 15h. On Príncipe, however, there is a peak in effort at 7h, a minimum at 13h, and another peak at 4h, when it starts decreasing until it reaches zero at 6h.
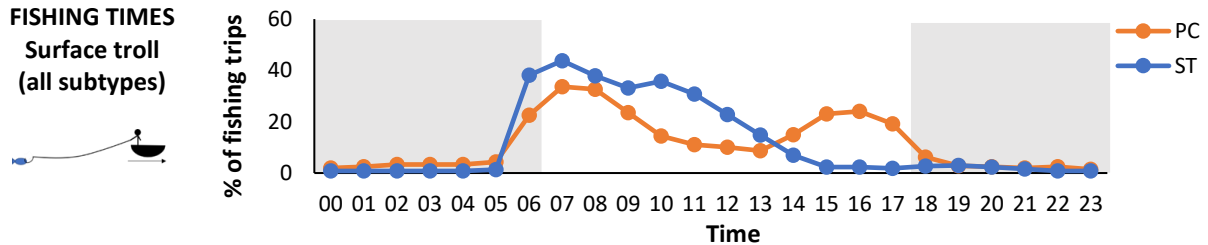
Figure 38: Fishing times of the surface troll on Príncipe (PC) and São Tomé (ST). Surface troll is practised exclusively during the daytime.

On **Príncipe**, the catch of the Subtype 1 is dominated by *fulu fulu* tunas (*Euthynnus alleteratus* and *Auxis thazard*, 23%), while in the Subtype 2, *fulu fulu* tunas are completely absent and Atlantic sailfish (*Istiophorus albicans*) comprises 51% of the weight of the catch (Figure 39). *Sphyraena barracuda*, lutjanid snappers, wahoos (*Acantocybium solandri*) are present in the catch of both subtypes and are the most abundant species after those previously mentioned. *Seriola rivoliana* is also present in the catch of both subtypes, although less abundant, and dolphinfishes (*Coryphaena hippurus*) and large tunas (*Thunnus albacares* and *Thunnus obesus*) are also present in the catch of Subtype 2. Note that Subtype 1 was not disaggregated by bait type due to the small sample size.

Surface troll (Príncipe)
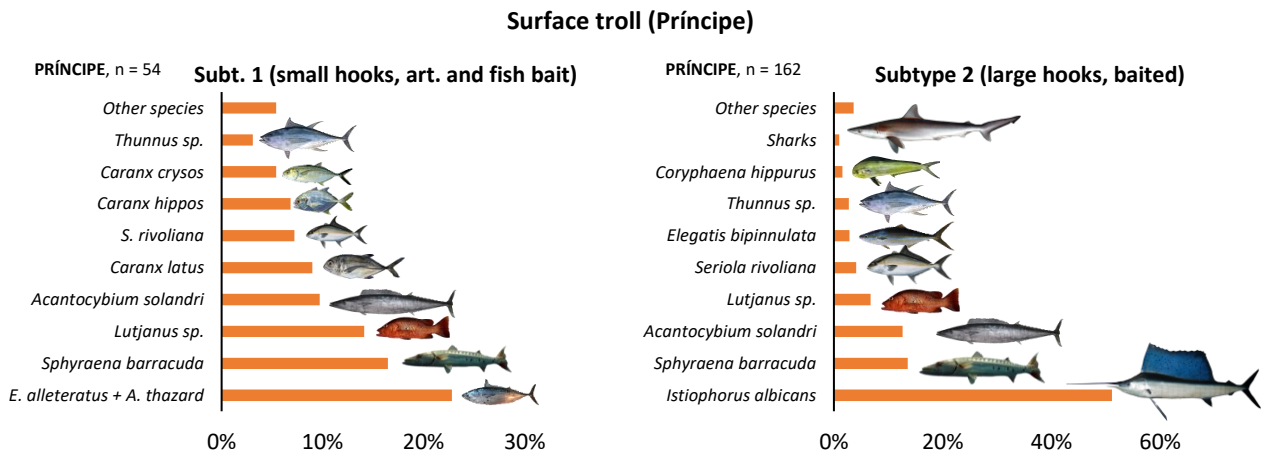
Figure 39: Catch composition of the surface troll on Príncipe. The most abundant species present in Subtype 1 are 'fulu fulu' tunas (*E. alleteratus* and *A. thazard*) and Atlantic sailfish (*I. albicans*) in Subtype 2. These species are followed in abundance by *S. barracuda*, wahoos *(A. solandri)*, and lutjanid snappers in both subtypes.

On **São Tomé**, the catch of Subtype 1 shows strong differences between bait types. On the one hand, 90% of records of Subtype 1 surface troll with artificial bait caught *fulu fulu* tunas (*E. alleteratus* and *A. thazard*, 63 % of the catch), followed in abundance by *Caranx hippos* (27 % of the catch). On the contrary, the Subtype 1 surface troll with fish bait has a more diverse catch, dominated by the needlefish *Ablennes hians* (27%), followed by *Caranx hippos* (17%), and *S. barracuda* (11 %, Figure 40). Large tunas (*T. albacares* and *T. obesus*, 9%) and dolphinfishes (*C. hippurus*, 4%) are also present, albeit in a small proportion. The catch of the Subtype 2 is strongly dominated by blue marlin (*Makaira nigricans*, 22%) and wahoo (*A. solandri*, 21%), followed by large tunas (*T. albacares* and *T. obesus*, 15%), and Atlantic sailfish (*I. albicans*, 7%).

Surface troll (São Tomé)

SÃO TOMÉ, n = 92

Subtype 1 (small hooks, art. bait)

SÃO TOMÉ, n = 128

Subtype 1 (small hooks, fish bait)

SÃO TOMÉ, n = 141

Subtype 2 (large hooks)
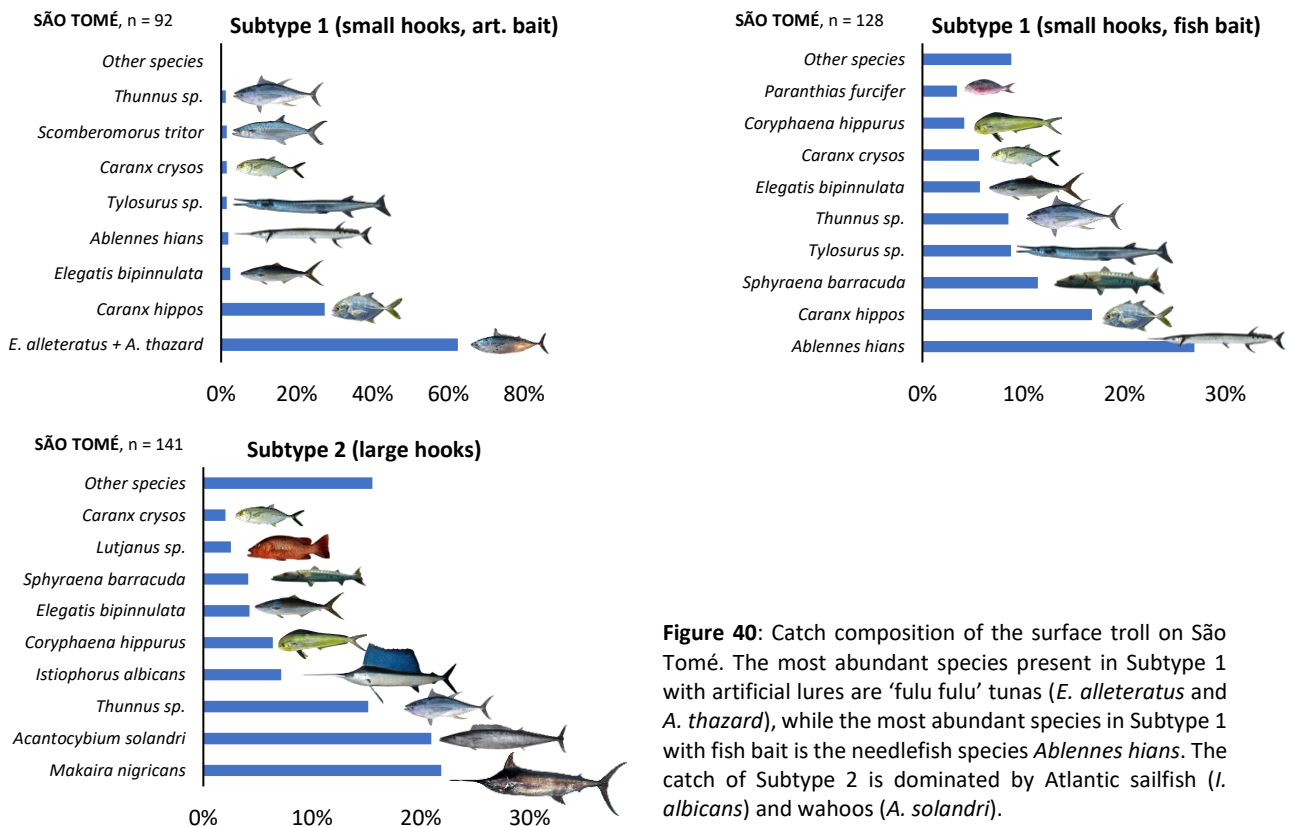
Figure 40: Catch composition of the surface troll on São Tomé. The most abundant species present in Subtype 1 with artificial lures are 'fulu fulu' tunas (*E. alleteratus* and *A. thazard*), while the most abundant species in Subtype 1 with fish bait is the needlefish species *Ablennes hians*. The catch of Subtype 2 is dominated by Atlantic sailfish (*I. albicans*) and wahoos (*A. solandri*).

3.3. SPEAR FISHING

Spear fishing is the third main type of fishing in STP, practised by free divers who are locally called "*submarinos*". These divers may either use a spear gun (*arpão*) to catch cuttlefish or large finfish or an iron rod bent at one end ("*croco*") to catch octopus (see Figure 42). Spear fishing is exclusively practised in the morning. The effort starts increasing on both islands at 7AM, reaching a peak at 10 AM and then decreasing steadily until it reaches a minimum at 4 PM (see Figure 41).

Table 11: Characteristics and sample size of the different types of surface troll.

Gear	Habitat	CPUE units	Site	N records	Soak time (average)
Spear fishing	Demersal / Midwater	Kg / h	**PC**	708	3.5 (SD = 1.8)
			ST	32	4.1 (SD = 1.4)
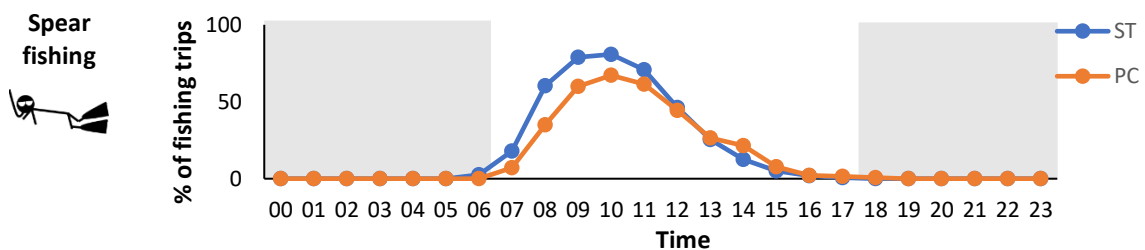
Spear fishing

Figure 41: Temporal distribution of spearfishing effort on São Tomé and Príncipe. Hours of darkness have been highlighted in grey.

Figure 42: Diver catching octopus with an iron rod (*croco*) at Agulhas' Bay (Príncipe Island). © G. Porriños.

The catch of spear fishing is dominated by octopus (unknown spp.) on both islands, comprising 25% and 75% of the catch on Príncipe and São Tomé, respectively. Most of the octopus catch recorded on São Tomé comes from the community of Malanza, where groups of 5 to 8 fishers can catch up to 100 to 500 kg of octopus in a single fishing trip. Snappers (*Lutjanus* sp.), *Sphyraena barracuda*, rainbow runners (*Elegatis bipinnulata*), moray eels and gastropods and sea snails are also important components of the catch, and stingrays are also often targeted by spear fishers. One nurse shark (*Ginglymostoma cyrratum*) was also recorded in the catch of spear fishers at *Ilhéu das Rolas* (São Tomé).
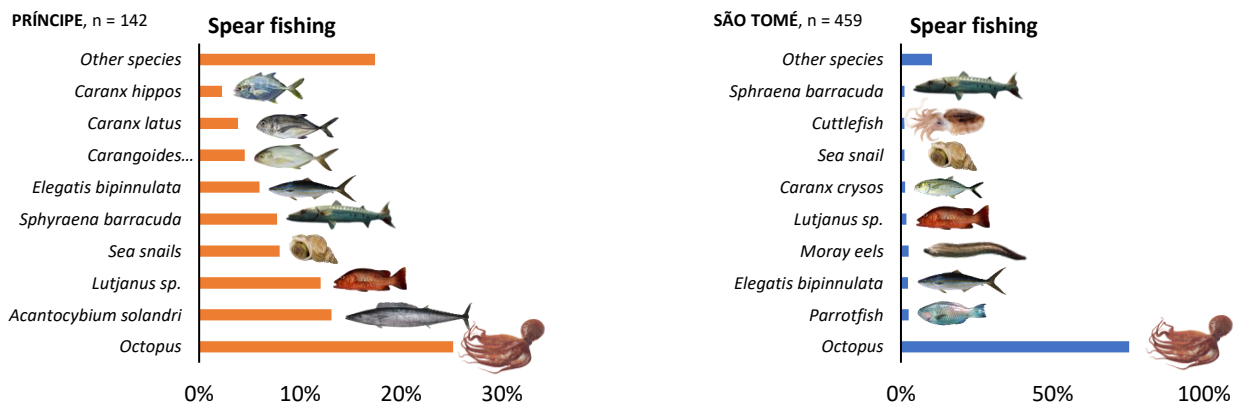
Figure 43: Catch of spear fishing in Príncipe (orange) and São Tomé (blue).

3.4. CATCH PER UNIT EFFORT (CPUE)

In order to create comparable categories for catch per unit effort estimations, hook and line fishing types were categorised according to the results presented in section 193.2. The parameters used for this classification were technique, habitat (shore, epipelagic, demersal inshore, deep demersal offshore), number of hooks used, bait type (artificial lures or bait), and hook size (Subtype 1 – small hooks; or Subtype 2 – large hooks). In total, 13 categories of line fishing were created, in addition to the 5 categories of net fishing, spear fishing, described in sections 3.1 and 3.3 (see Table 12). '*Voador panhá*' was not included in the surveys due to difficulties defining the CPUE units, and mosquito net fishing ('*peixinho*') was not included either due to lack of data on this technique from landing surveys (see section 3.1 for further details).

A positive correlation was found for all gear types between the length of the net (for gillnets) or number of hooks (for longlines) and total catch per hour. This correlation was positive for all gears, although the

relations between the variables were not linear, best fitting to a model of the type *catch* = **a** x **log(*n hooks* or *length*) + b.** This implies that, although the length or number of hooks significantly increases the weight of the catch, this effect diminishes as the length of the net or the line increases.

The CPUE of the jigging handlines was significantly affected by hook size on both islands. Subtype 2 (S2), consisting of jigging handlines with large hooks, had a significantly higher CPUE than all Subtype 1 (S1) jigging handlines (with small hooks), regardless of the habitat targeted or bait type used (Games-Howell, $p<0.01$, see Figure 44). Habitat and bait type also had a significant effect on the CPUE of S1 jigging handlines, although this effect was smaller than hook size. On Príncipe, CPUE was significantly higher when artificial lures were used and significantly lower when fishing was practised from the shore (Games-Howell, $p<0.01$). The CPUE of baited S1 jigging handlines did not show significant differences when practised inshore (demersal) or offshore (deep demersal, Games-Howell, $p=0.12$). On São Tomé, bait type and habitat did not affect the CPUE of S1 jigging handlines.

Hook size also affected the CPUE of the different types of surface troll. On São Tomé, the CPUE of Subtype 2 handline trolls was significantly higher than that of Subtype 1 handline trolls. However, bait type did not significantly affect the CPUE of Subtype 1 handline trolls. On Príncipe, this analysis could not be conducted due to an unbalanced sample size between the different subcategories.
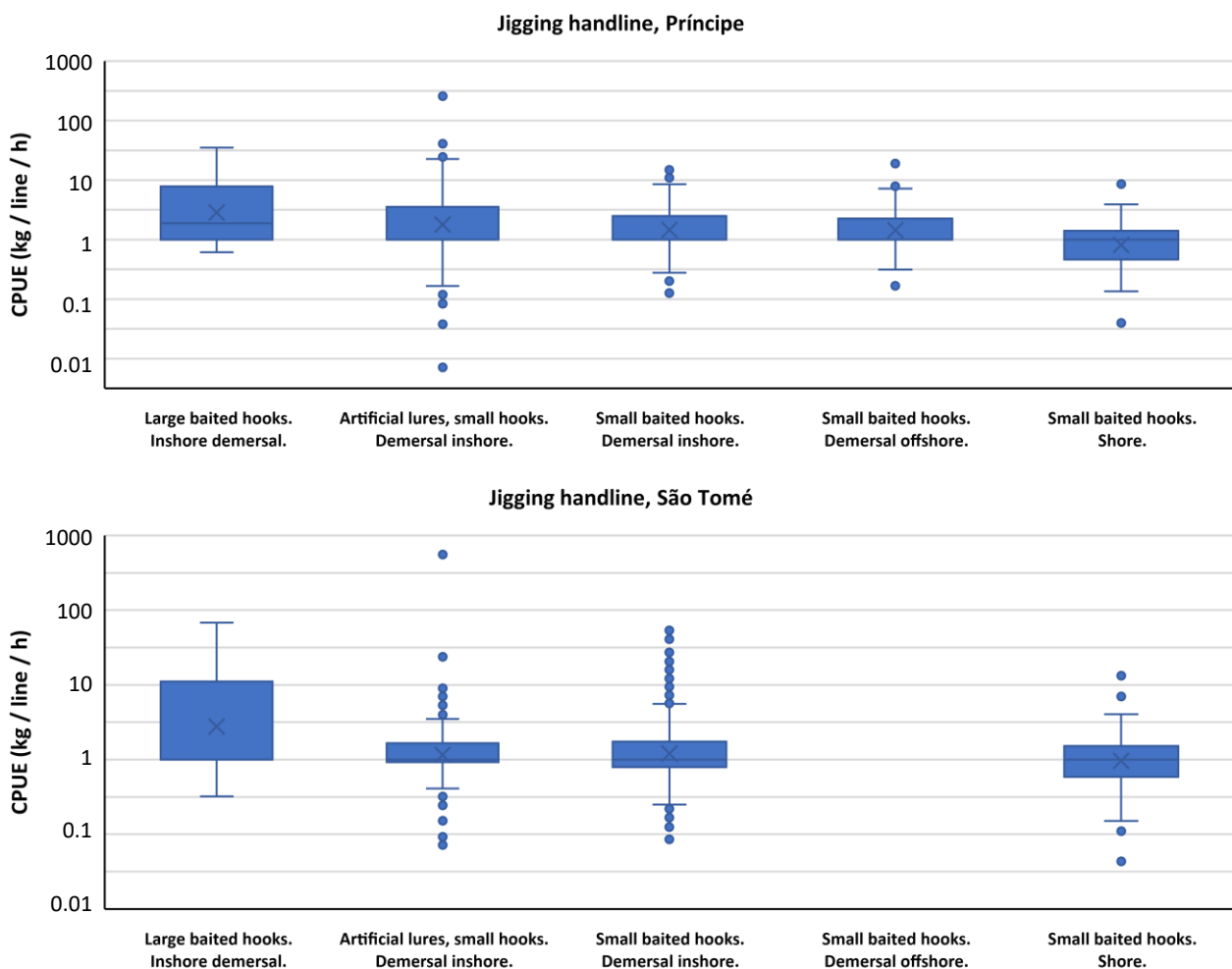
Figure 44: Comparison of Catch Per Unit Effort for jigging handline. Hook size has the biggest influence on the CPUE of the gear.

Table 12: <u>Catch Per Unit Effort</u>. Line fishing gears have been categorised according to: <u>technique</u> (jigging, pivoting, trolling, set); <u>habitat</u> (demersal, epipelagic, and deep demersal offshore); <u>number of hooks</u> (handline <300 hooks or longline >300 hooks); <u>bait</u> (artificial lures or fish); and <u>hook size</u> (S1: small; S2: large). **CPUE units**: <u>Handline</u>: kg / line / h; <u>Longline</u>: kg / 100 hooks / h; <u>Gillnet</u>: kg / 100 m / h; <u>Seine</u>: kg / set; <u>Spear fishing</u>: kg / h

| CODE | Tech. | Hab. | N hook | Bait / Art. lures | Hook size | Príncipe | | | | | São Tomé | | | | | P-value ANOVA, log(CPUE), PC vs ST |
| | | | | | | N records | Catch | | CPUE | | N records | Catch | | CPUE | | Fisher / Welch |
							Average (kg/trip)	SD	Average	SD		Average (kg/trip)	SD	Average	SD	
LIN_JDH_A1	Jigging	Dem.	Handl.	Art.	1	1320	27.6	25.9	4.7	10.2	305	21.4	42.3	1.9	2.4	>0.01
LIN_JDH_B2	Jigging	Dem.	Handl.	Bait	2	69	23.9	32.4	9.0	9.1	53	57.9	33.0	15.1	17.1	0.07
LIN_JDH_B1	Jigging	Dem.	Handl.	Bait	1	92	13.5	14.8	3.4	3.6	626	13.2	24.3	2.7	5.5	>0.01
LIN_JOH_01	Jigging	Off.	Handl.	A/B	1	85	13.0	10.2	3.0	3.3	0					
LIN_JSH_B1	Jigging	Shore	Handl.	Bait	1	49	2.7	2.0	1.2	1.5	109	4.9	5.2	1.4	1.8	0.22
LIN_PDH_B1	Pivot.	Dem.	Handl.	Bait	1	169	14.1	14.7	3.1	3.0	0					-
LIN_SDH_B1	Set	Dem.	Handl.	Bait	1	8	30.4	24.7	5.1	4.7	12	6.8	8.7	2.0	1.5	-
LIN_SDL_B1	Set	Dem.	Longl.	Bait	1	320	25.0	26.8	2.1	1.7	201	8.7	22.4	1.1	1.9	>0.01
LIN_TDH_A1	Troll	Dem.	Handl.	Art.	1	10	26.7	21.2	26.4	33.6	22	8.2	5.7	3.3	2.6	-
LIN_TDL_A1	Troll	Dem.	Longl.	Art.	1	698	28.7	23.3	5.4	4.6	11	6.2	3.9	2.8	2.2	-
LIN_TEH_A1	Troll	Epip.	Handl.	Art.	1	30	6.5	6.5	3.0	2.4	91	3.7	3.5	1.8	1.7	-
LIN_TEH_B1	Troll	Epip.	Handl.	Bait	1	21	13.9	16.4	3.6	4.6	108	4.9	11.2	1.7	2.7	-
LIN_TEH_B2	Troll	Epip.	Handl.	Bait	2	161	19.7	24.5	6.7	6.9	131	37.0	47.6	7.6	11.8	0.63
CODE	**Tech.**	**Hab.**	**Type**			**Príncipe**					**São Tomé**					**p**
NET_GD	Gillnet	Dem.	Demersal gillnet			25	17.3	19.0	19.8	49.5	7	48.3	48.3	881.0	1500.3	-
NET_GE	Gillnet	Epip.	Surface gillnet			452	27.2	31.6	7.4	12.4	93	45.0	55.5	9.2	11.5	0.58
NET_SB	Seine	-	Beach seine			2	15.0	-	7.5	-	0					-
NET_SG	Seine	-	Seine gillnet			0					32	198.8	554.7	57.3	139.4	0.05
NET_SP	Seine	-	Purse seine			119	67.3	103.0	27.6	51.8	18	140.6	136.0	66.4	83.4	
CODE			**Type**			**Príncipe**					**São Tomé**					**p**
SUB			Spear fishing			141	20.4	20.4	3.6	3.2	458	29.1	36.5	3.0	4.2	0.10

To compare CPUE between islands, the two types of purse seine nets in São Tomé were pooled together (see section 3.1.3. On the other hand, S1 baited jigging handlines on São Tomé could not be disaggregated by habitat (demersal inshore or deep demersal offshore, see section 3.2.1, page 23). Due to the low prevalence of deep-sea species (less than 3%, see Figure 28), all records were classified as demersal inshore for the purpose of this analysis.

Demersal gears showed a significantly lower CPUE in São Tomé than in Príncipe (Figure 45). S1 jigging handlines practised inshore (demersal habitats) had a significantly lower CPUE on São Tomé than on Príncipe regardless of the bait type used. Likewise, the CPUE of the set demersal longline was significantly lower on São Tomé (1.1 kg / 100 hooks / h) than on Príncipe (2.2 kg / 100 hooks / h). S2 jigging handlines and S1 jigging handlines practised from the shore did not return significant differences in CPUE on either island.

Epipelagic gears (surface gillnet and S2 baited handline troll) did not show significant differences on CPUE between the islands (Figure 46). This was also the case of the CPUE for spearfishing. However, the CPUE of seine nets was significantly higher on São Tomé (60.5 kg per set) than on Príncipe (27.6 kg per set).
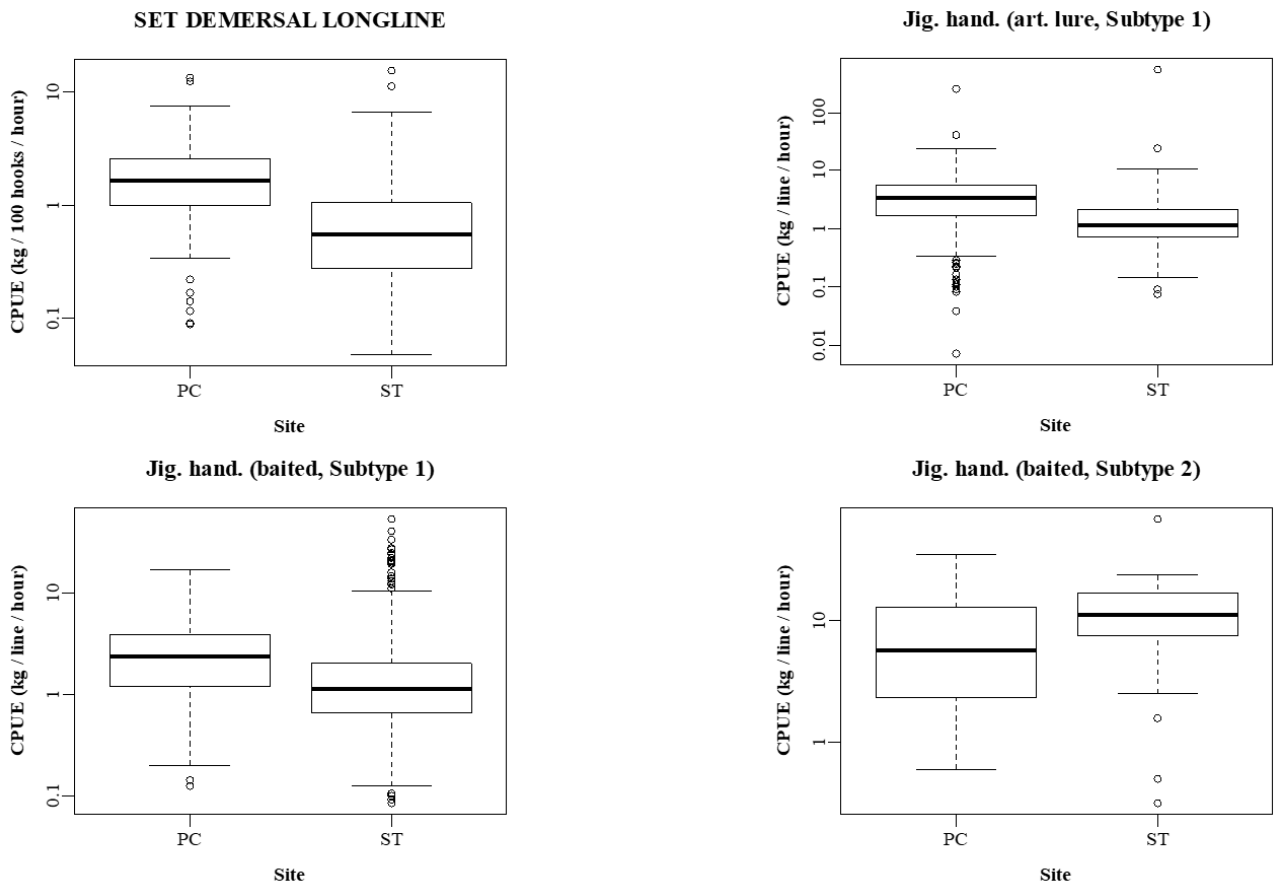
Figure 45: Comparison of CPUE of demersal gears on São Tomé and Príncipe Islands.
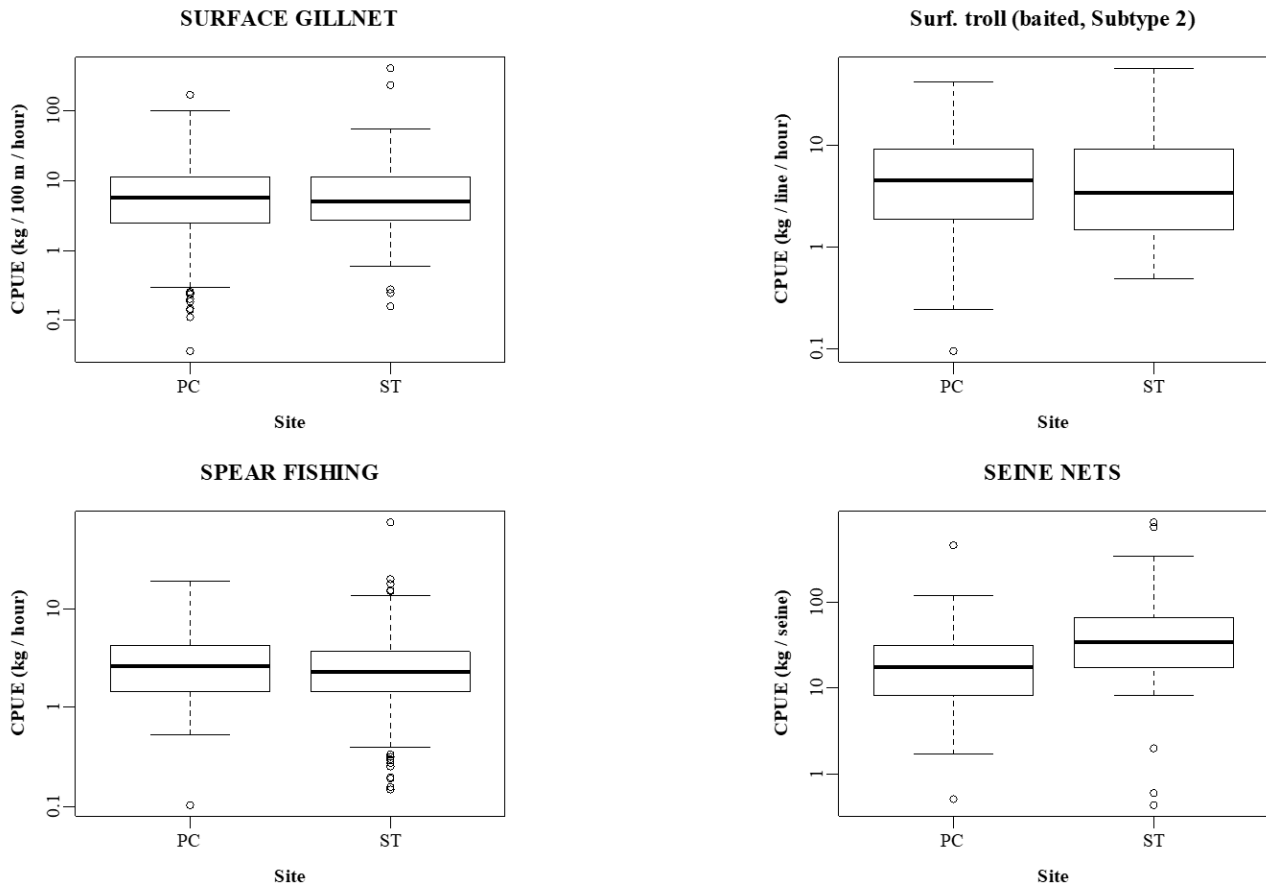
Figure 46: Comparison of CPUE of epipelagic gears, spear fishing and seine nets on São Tomé and Príncipe Islands.

3.5. FISHING EFFORT (NUMBER OF FISHING TRIPS)

The daily number of trips of the main fishing categories (see Figure 47 and Figure 48) were estimated using the data from Questionnaire 1 of the landing surveys (with records of the number of fishing trips in each community, disaggregated by main gear type, see section 2.3). On average, 33 and 108 fishing trips are estimated to depart every day from the monitored fishing communities on Príncipe and São Tomé, respectively. Line fishing with boats is the most practised type of fishing in the target communities, with 19 and 45 fishing trips per day on both Príncipe and São Tomé, respectively (57.1% and 41.3% of all fishing trips, see Figure 47 and Figure 48). This is followed by surface drifting gillnet, with 9 and 26 fishing trips per day on Príncipe and São Tomé (26.1% and 24.1% of all fishing trips on each island, respectively). Spear fishing was found to be more prevalent in the South of São Tomé (20 trips per day, 18.1% of all recorded fishing trips) than on Príncipe (3 trips per day, 8.3% of fishing trips). This was also the case for line fishing from the shore, with 9 fishing trips per day in São Tomé (9.2%), and only 1 trip per day on Príncipe (3.2%). On both islands, approximately one purse seine fishing trip is conducted per day (which comprises 3.7% of all fishing trips on Príncipe and 0.7% on São Tomé). Seine gillnet is absent from Príncipe but comprises 4.8% of all fishing trips departing from landing sites in the South of São Tomé (5 trips per day). Note that this is not the number of seiners operating in the South of São Tomé, as boats from the north of São Tomé travel daily to the South to fish. *Voador panhá* is not practised on Príncipe and on São Tomé only constitutes 0.1% of all recorded fishing trips. Set demersal gillnet constitute less than 1% of all fishing trips on both islands (with an average of 4.4 trips/week on Príncipe and 2.1 trips/ week in the South of São Tomé).
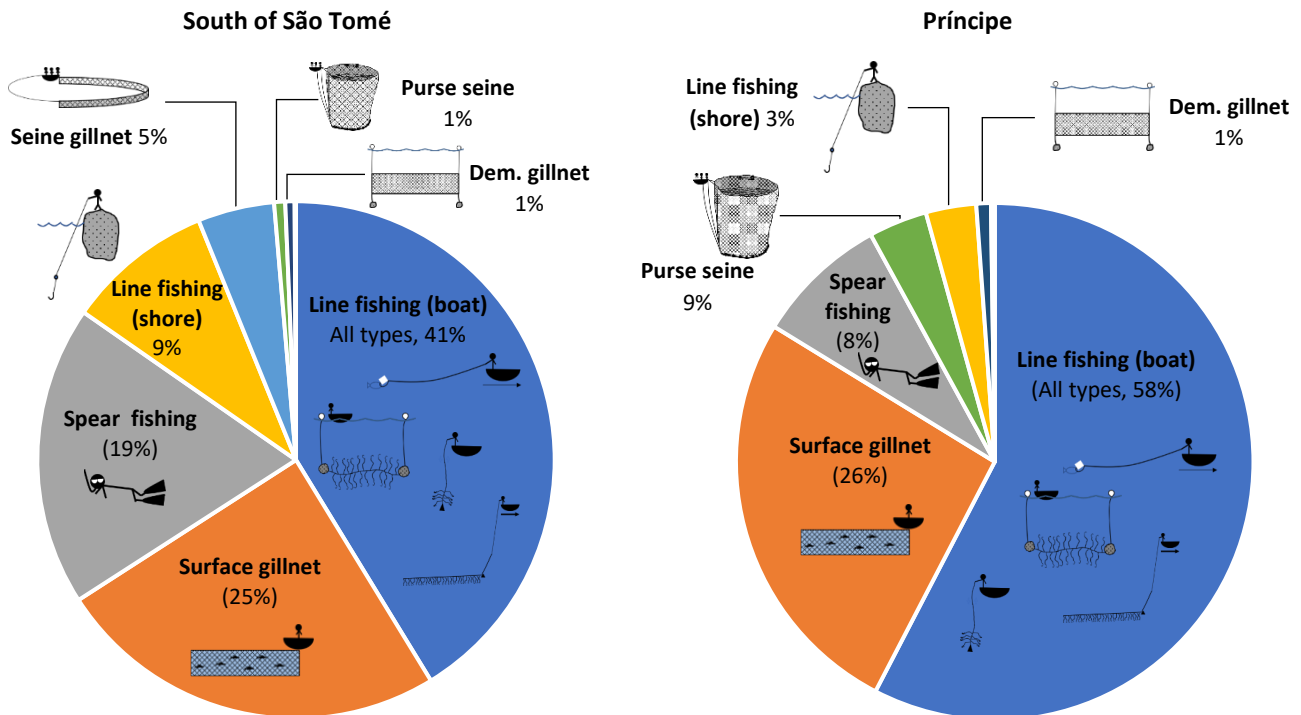
Figure 47: Prevalence of main fishing types in target communities on Príncipe and São Tomé. The estimation was obtained by counting the number of fishing trips at each community on the sampling days (see section 2.3).
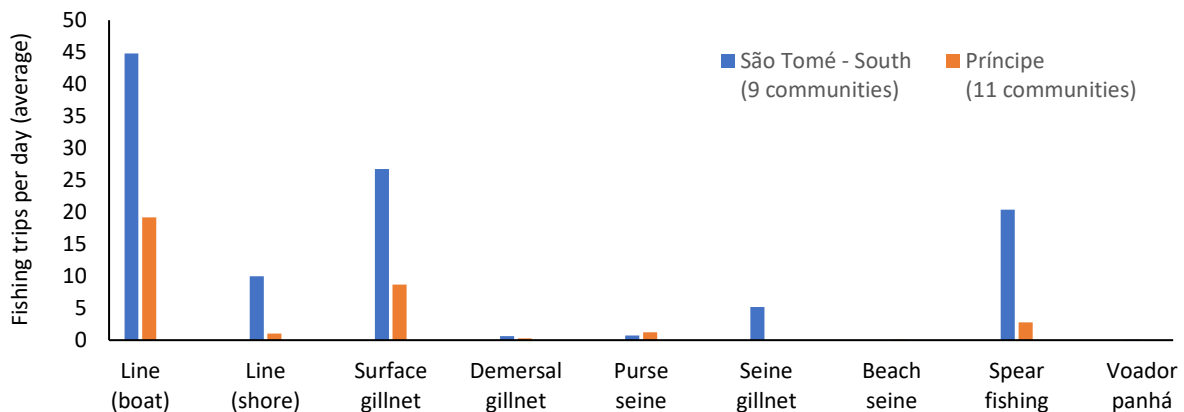
Figure 48: Average number of fishing trips per day in target communities on the islands on São Tomé and Príncipe. The estimation was obtained by counting the number of fishing trips at each community on the sampling days (section 2.3).

As shown in Table 13, fishing effort and the use of various gear types is not evenly distributed across target communities on São Tomé and Príncipe. For example, in all communities on Príncipe, hook and line fishing is the most practised type of fishing, with the exception of Àgua Namoro, where surface gillnets are used in 86% of all trips. The communities of Praia das Burras, Abade, and Àgua Namoro concentrate most of the surface gillnet effort on Príncipe.

Out of the 20 sampled communities, only São João, Praia das Burras and Abade on Príncipe, and Ribeira Afonso, Angolares and Porto Alegre practice purse seine fishing. On São Tomé, the community of Angolares concentrates 90% of the trips using seine gillnets, and seine gillnets are not used on Príncipe. Set demersal gillnets are only used on São João and Praia das Burras on Príncipe and Ilhéu Rolas and Ribeira Peixe on São Tomé. *Voador Panhá* is only practised in the communities of Porto Alegre, Ribeira Afonso and Ribeira Peixe (all of which are on São Tomé).

40

Table 13: Number of fishing trips recorded between November 2019 and November 2020 in target communities on São Tomé and Príncipe, disaggregated by per gear type and community.

DAILY NUMBER OF FISHING TRIPS

Island	Community	n	Hook & line		Surface gillnet		Spear fishing		Purse seine		Surface seine gillnet		Demersal gillnet		Beach seine		Voador panhá		Hook & line (shore)	
			Avrg.	SD	Avrg.	SD	Avrg.	SD	Avrg.	SD	Avrg.	SD	Avrg.	SD	Avrg.	SD	Avrg.	SD	Avrg.	SD
Príncipe	Abade	117	**3.2**	2.7	**1.5**	2.4	**1.2**	1.8	**0.4**	0.6	**0.0**	0.0	**0.0**	0.0	**0.1**	0.3	**0.0**	0.0	**0.3**	0.8
	Água Namoro	117	**0.5**	0.7	**3.0**	2.1	**0.0**	0.0	**0.0**	0.0	**0.0**	0.0	**0.0**	0.0	**0.0**	0.0	**0.0**	0.0	**0.0**	0.0
	Burras	108	**1.5**	1.7	**1.6**	1.8	**0.2**	0.4	**0.4**	0.6	**0.0**	0.0	**0.1**	0.4	**0.0**	0.0	**0.0**	0.0	**0.0**	0.4
	Campanha	117	**1.8**	1.5	**0.0**	0.2	**0.0**	0.2	**0.0**	0.0	**0.0**	0.0	**0.0**	0.0	**0.0**	0.0	**0.0**	0.0	**0.2**	0.7
	Concom	124	**3.1**	2.1	**0.3**	0.7	**0.0**	0.2	**0.0**	0.0	**0.0**	0.0	**0.0**	0.0	**0.0**	0.0	**0.0**	0.0	**0.0**	0.0
	Lapa	107	**1.5**	1.4	**0.0**	0.2	**0.4**	1.1	**0.0**	0.1	**0.0**	0.0	**0.0**	0.2	**0.0**	0.0	**0.0**	0.0	**0.3**	0.9
	Ribeira Izé	117	**2.1**	1.4	**0.0**	0.2	**0.6**	1.4	**0.0**	0.0	**0.0**	0.0	**0.0**	0.0	**0.0**	0.0	**0.0**	0.0	**0.0**	0.0
	Santo António	115	**1.0**	1.1	**0.0**	0.1	**0.0**	0.0	**0.0**	0.0	**0.0**	0.0	**0.0**	0.0	**0.0**	0.0	**0.0**	0.0	**0.0**	0.0
	São João	34	**1.6**	1.3	**0.3**	0.8	**0.2**	0.5	**0.2**	0.4	**0.0**	0.0	**0.1**	0.3	**0.0**	0.0	**0.0**	0.0	**0.1**	0.4
	Praia Seca	85	**1.1**	1.2	**0.3**	1.0	**0.3**	0.5	**0.0**	0.0	**0.0**	0.0	**0.0**	0.0	**0.0**	0.0	**0.0**	0.0	**0.1**	0.2
	Unitel	118	**3.2**	2.0	**0.0**	0.2	**0.0**	0.2	**0.0**	0.2	**0.0**	0.0	**0.0**	0.1	**0.0**	0.0	**0.0**	0.0	**0.0**	0.1
São Tomé	Angolares	13	**7.5**	6.9	**4.5**	4.8	**0.6**	1.0	**0.3**	1.1	**3.1**	3.4	**0.0**	0.0	**NA**	NA	**0.0**	0.0	**0.0**	0.0
	Angra Toldo	75	**3.7**	2.9	**0.1**	1.3	**0.5**	0.8	**0.0**	0.0	**0.0**	0.0	**0.0**	0.0	**NA**	NA	**0.1**	0.2	**0.7**	0.9
	Iô Grande	96	**4.6**	4.1	**0.0**	0.1	**0.0**	0.0	**0.0**	0.0	**0.0**	0.0	**0.0**	0.1	**NA**	NA	**0.0**	0.0	**0.3**	0.8
	Ilhéu Rolas	66	**0.8**	1.4	**1.5**	1.2	**4.6**	3.5	**0.0**	0.0	**0.1**	0.4	**0.5**	0.7	**NA**	NA	**0.0**	0.1	**5.0**	3.8
	Malanza	82	**2.7**	3.0	**1.4**	1.3	**8.2**	4.8	**0.0**	0.0	**0.0**	0.0	**0.0**	0.0	**NA**	NA	**0.0**	0.0	**1.2**	1.4
	Monte Mário	68	**0.9**	0.8	**0.0**	0.0	**0.4**	0.7	**0.0**	0.0	**0.0**	0.0	**0.0**	0.0	**NA**	NA	**0.0**	0.0	**0.1**	0.3
	Porto Alegre	77	**3.1**	2.4	**14.9**	9.5	**10.3**	5.3	**0.4**	0.6	**0.4**	0.6	**0.1**	0.4	**NA**	NA	**0.6**	2.1	**2.8**	2.2
	Ribeira Afonso	95	**10.5**	6.0	**1.1**	3.0	**0.8**	1.1	**0.1**	0.2	**0.0**	0.1	**0.0**	0.0	**NA**	NA	**0.7**	2.6	**1.1**	2.3
	Ribeira Peixe	82	**5.6**	2.5	**1.5**	1.4	**1.9**	1.3	**0.0**	0.0	**0.0**	0.0	**1.1**	0.7	**NA**	NA	**0.4**	1.3	**2.2**	1.3

Spear fishing is practised in approximately 50% of the target communities on Príncipe, and it is not the dominant type of fishing in any of them. On the contrary, in São Tomé, spear fishing is practised to some extent in all communities, except Iô Grande. In fact, in the communities of Malanza, Porto Alegre, and Ilhéu das Rolas spearfishing is the most practised (or second most practised) type of fishing, comprising 35- 83%of all recorded trips. These three are the southernmost communities of the island and located a few kilometres apart from each other (see Figure 4). Interestingly, line fishing in these communities comprises less than 30% of all trips, in contrast with the other six communities on São Tomé where line fishing represents 60 - 100% of fishing activity.

3.6. SEASONAL VARIATION IN NUMBER OF FISHING TRIPS (NOV-19 TO NOV-20)

In the target communities on both São Tomé and Príncipe, the seasonal variation in the number of daily fishing trips for **line fishing (using boats)** and **surface gillnets** show similar patterns (Figure 49). Effort for both these gear types reaches a minimum around December-January and peak between February-March. Their use then decreases steadily until June – the middle of the Gravana season – when the rough weather conditions become increasingly less favourable for this type of fishing. Fishing effort for these gear types shows a second peak again in September on Príncipe and in November for São Tomé. Nevertheless, despite these variations, line fishing effort remains elevated throughout the year.
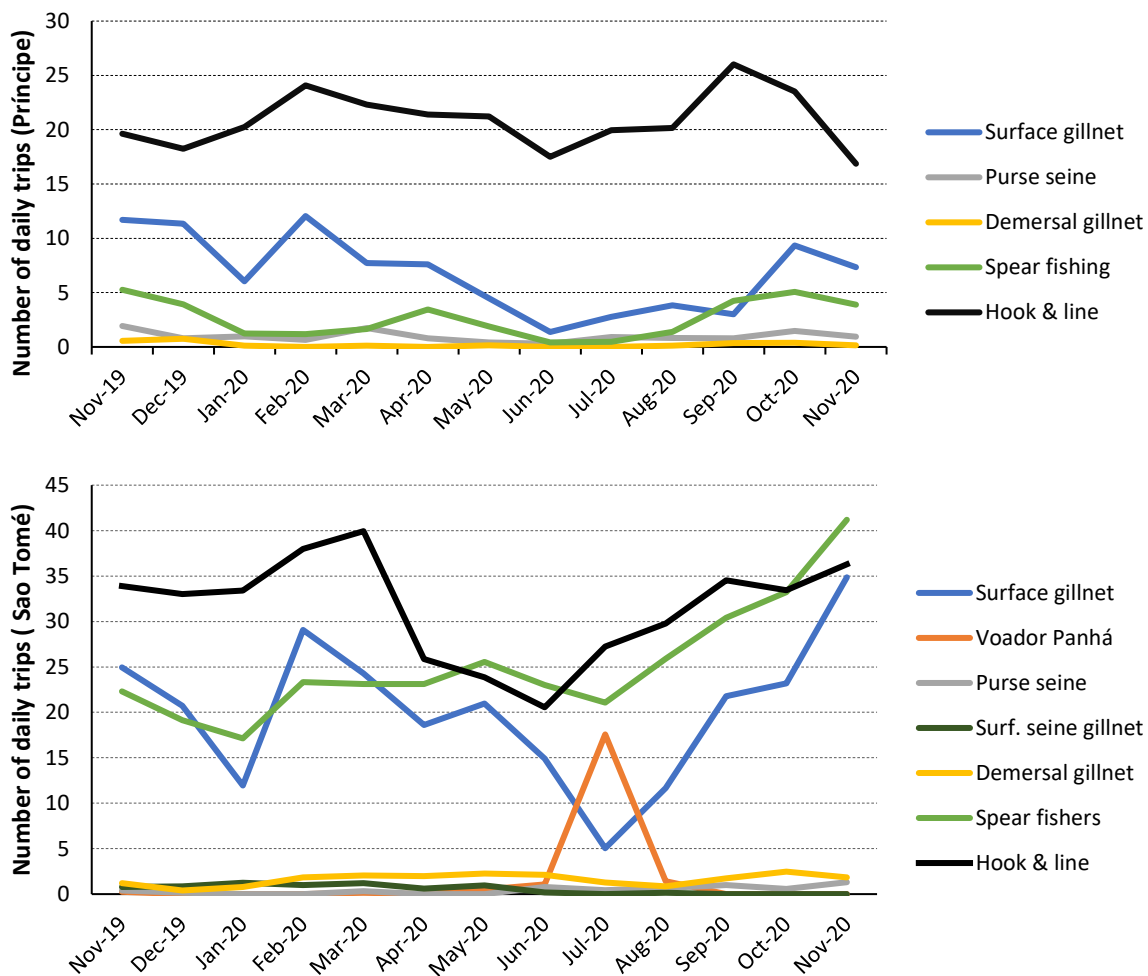
Figure 49: Seasonality of fishing effort for different gear types on São Tomé (top, 7 permanent communities in Caué district and 1 in Cantagalo District) and Príncipe (bottom, 1 temporary and 10 permanent communities) based on total number of fishing trips recorded per sampling day between November 2019 and November 2020.

The **spear fishing** effort displays a similar seasonal variation for both Príncipe and southern São Tomé, with a minimum in January, a first peak in April – May, another minimum in July and a second, larger peak around October – November. Figure 49 shows the importance of spear fishing in the communities of Southern São Tomé, as its effort exceeds that of the surface gillnet for most of the year, even surpassing the effort for line fishing gears in some months.

The effort of **demersal gillnets** and **purse seine fishing** is low in target communities on both Príncipe and São Tomé, never surpassing three trips per day. The same is true for **surface seine gillnet** in southern São Tomé. The *voador panhá* effort is strongly concentrated in July, when it reaches a peak with up to 17 trips per day on São Tomé, being virtually absent during the rest of the year.

3.7. PREVALENCE OF GEAR CONFIGURATIONS AND TECHNIQUES USED FOR LINE FISHING

As explained in section 3.5, 57.1% and 41.3% of all recorded trips in the target communities on Príncipe and São Tomé used line fishing techniques of some kind. Line fishing is practised in all the surveyed communities, and is the dominant type of fishing in most of them (see Table 13 and Figure 48). Of the 5,261 trips included in the analysis, 3,685 records (70%) reported using exclusively line fishing gears, with a maximum of four different gear configurations or techniques used during a single trip and an average of 1.27 gear configurations or techniques used per line fishing trip. In addition, line fishing gear was sometimes used alongside net fishing within a single trip, especially in the case of the surface gillnet fishing (in which 10% of the trips also used some type of line fishing technique).
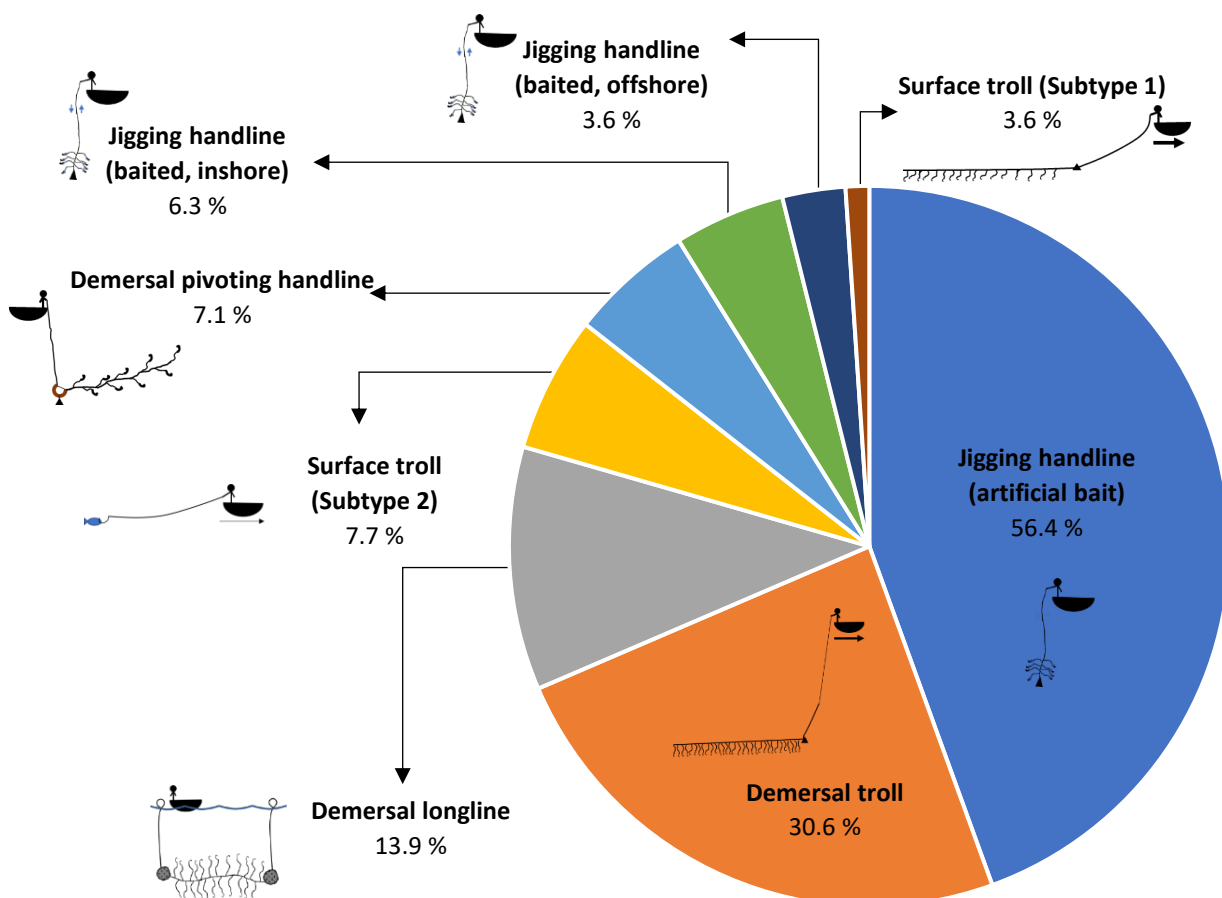
Figure 50: Prevalence of the different types of line fishing and gear configurations in target communities Príncipe Island.
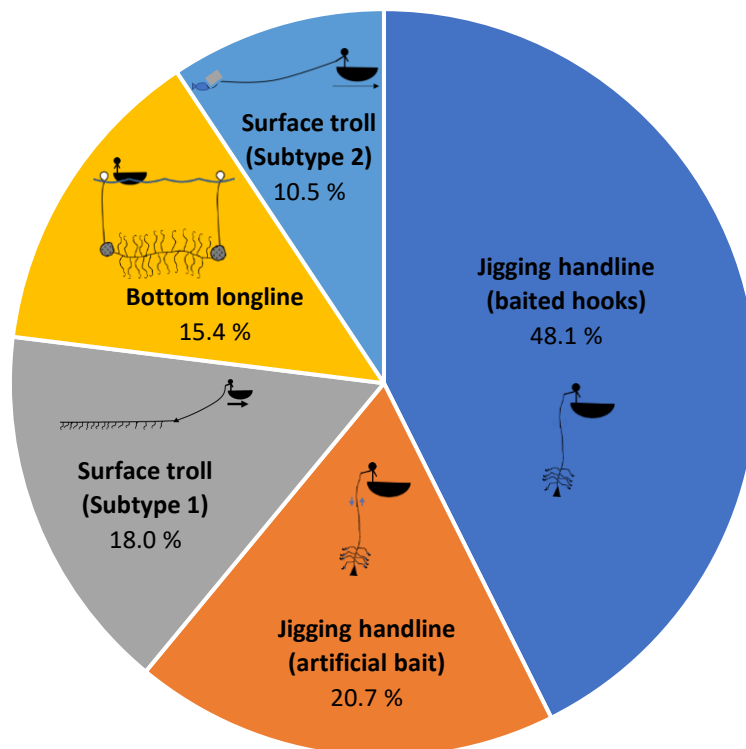
Figure 51: Prevalence of the different types of line fishing and gear configurations in target in southern São Tomé

On Príncipe, the most used gears were the jigging handline with artificial lure ("*toca*") used on 56.4% of all trips and the demersal longline troll with artificial lure ("*arrastão*") representing 30.6% of trips (see Figure 50). In total, 9.9% of all trips on Príncipe used jigging handlines with baited hooks (6.3 % inshore and 3.6 % offshore). Demersal set longlines with baited hooks were used in 13.9% of all trips on Príncipe and 7.1% of trips used bottom pivoting handlines. Surface trolls with medium-to-large, baited hooks (S2) were used during 7.7% of trips and surface troll with small hooks (S1) and artificial lure during 3.6% of trips.

In target communities on the South of São Tomé, the dominant type of fishing was jigging handlines with baited hooks, used in 48.1% of all recorded fishing trips (see Figure 51). Twenty-one percent of all fishing trips in the target communities on São Tomé used jigging handline with artificial lure and 18% used surface troll (S 1, small to medium hooks). This contrasts with Príncipe, where the Subtype 1 of the surface troll is rarely used. Set demersal longlines were used in 15.4 % of all fishing trips and surface troll (S2, large hooks) represented 10.5% of trips. Demersal pivoting handlines were not recorded in any of the target communities on São Tomé.

3.8. DURATION, FUEL USE AND REVENUES OF FISHING TRIPS

3.8.1. Seine net fishing (purse seine and seine gillnet)

Both in Príncipe and São Tomé, seine net fishing is always conducted using engine-propelled boats and most of the trips are conducted on rented boats (the boat owner was present on only 10% and 2.5% of the trips on Príncipe and São Tomé respectively, see Table 14). Seine net fishing trips have an average duration of 5.5 hours on Príncipe (SD = 3.2), while on São Tomé they last 6.8 h on average (SD =3.9). Fuel consumption is also higher on São Tomé (9.9 L) than on Príncipe (4.9 L).

Table 14: Average return of a single fishing trip in Príncipe and São Tomé islands, disaggregated by gear.

Gear	island	n records	% trips with rented boats	% trips using engines	Time sea	Fuel (L)	Catch (kg / trip)	Boat owners (revenue / trip)		Fishers (revenue / trip)		Fishers (revenue / h)	
								DBS	€	DBS	€	DBS	€
Seine nets Purse seine and seine gillnet	PC	118	97.5%	100.0%	5.5	4.9	67.8	1773 DBS	71 €	393 DBS	16 €	88 DBS	4 €
	ST	50	90.0%	100.0%	6.8	9.9	204.3	6055 DBS	242 €	1090 DBS	44 €	177 DBS	7 €
Demersal gillnet	PC	25	52.0%	12.0%	13.1	0.8	17.3	527 DBS	21 €	431 DBS	17 €	30 DBS	1 €
	ST	7	0.0%	85.7%	12.1	1.4	43.9	1564 DBS	63 €	954 DBS	38 €	251 DBS	10 €
Surface gillnet	PC	452	58.2%	97.0 %	5.3	4.1	35.0	765 DBS	31 €	514 DBS	21 €	95 DBS	4 €
	ST	93	69.9%	100.0%	5.8	3.0	44.1	1005 DBS	41 €	542 DBS	22 €	94 DBS	4 €
Spear fishing	PC	139	54.7%	45.3%	6.0	2.0	22.7	630 DBS	25 €	280 DBS	11 €	68 DBS	3 €
	ST	457	4.4%	21.7%	6.1	0.4	29.9	1180 DBS	47 €	542 DBS	22 €	141 DBS	6 €
'Voador panhá'	ST	57	59.6%	56.1%	11.3	3.8	43.2	780 DBS	31 €	383 DBS	15 €	33 DBS	1 €
Handline fishing (shore)	PC [1]	48	0.0%	0.0%	4.0	0.0	5.7	NA	NA	NA	NA	NA	NA
	ST	109	0.0%	0.0%	4.7	0.0	4.9	NA	NA	105 DBS	4 €	24 DBS	1 €
Handline fishing (boat) Trolling and jigging	PC	1305	51.2%	70.9%	9.2	3.9	28.5	599 DBS	24 €	413 DBS	17 €	57 DBS	2 €
	ST	1152	12.4%	28.0%	6.4	1.1	21.2	518 DBS	21 €	368 DBS	15 €	128 DBS	5 €
Demersal longline troll [2]	PC	702	46.9%	84.9%	8.7	5.0	32.7	706 DBS	28 €	503 DBS	20 €	68 DBS	3 €
Demersal set longline [2]	PC	318	42.1%	69.2%	7.6	3.2	26.5	533 DBS	21 €	346 DBS	14 €	46 DBS	2 €
	ST	212	2.4%	9.9%	5.1	0.5	19.4	260 DBS	10 €	233 DBS	9 €	48 DBS	2 €

[1] On 45 out of the 48 records the catch was exclusively used for consumption. The revenue was therefore not calculated.

[2] Often used in combination with handlines.

The catch per trip of seine nets (purse seine and seine gillnet) is the highest of all fishing types, with an average catch per trip of 204 kg on São Tomé and 67 kg on Príncipe. This translates to the highest revenue per trip, making this type of fishing the most profitable for boat owners. Boat owners are rarely present in this type of fishing yet obtain on average 3800 DBS per trip (€155) on São Tomé and 1700 DBS per trip (€69) on Príncipe Seine nets on São Tomé are usually larger than on Príncipe (see Figure 13), and the crew is composed of 6 fishers on average (max. 12, min. 5). Fishers participating in these activities on São Tomé earn an average of 832 DBS per trip (34€), equating to 180 DBS (7.5 €) per hour at the sea, making this type of fishing the most profitable also for fishers, with the best ratio of earnings per time spent at the sea. On Príncipe, the average revenue per trip for fishers is 400 DBS (16€), which is lower than other types of fishing. However, the short length of the trips compensates for this, with the earnings per hour of the seine fishing on Príncipe being amongst the highest for fishers, with an average of 90 DBS (3.6 €) per hour at the sea.

3.8.2. Demersal gillnet

On both islands, the longest duration of a fishing activity corresponds to demersal gillnets, with an average duration of 12 to 13 hours. This time, however, does not correspond to time spent at the sea, since fishers return home after deploying the gear and return to retrieve it the following day (see section 3.1.2). On Príncipe, only 12% of the recorded trips for this gear type used engines (total n = 25), while on São Tomé, 87% of the trips used engine-propelled vessels (total n = 7). This activity is rarely practised in target communities on both islands. For further details about the average revenue for this type of fishing in target communities, see Table 14.

3.8.3. Surface gillnet

The duration of surface gillnet trips on Príncipe and São Tomé is fairly regular, with trips lasting an average of 5.3 and 5.8 hours (SD = 1.1 and 1.7), respectively. On Príncipe and the south of São Tomé, 97% and 100% of the fishing trips use engine-propelled vessels. The fuel consumption and catch per trip is similar on Príncipe and São Tomé, with 4.0 and 3.1 litres of fuel per trip and 35 and 40 kg of fish per trip, respectively. More than half of the fishing trips are conducted on rented boats (70% on São Tomé and 58% Príncipe), which conversely means that boat owners are present in 30% and 40% of the fishing trips, respectively.

The average revenue of the surface gillnet for fishers is around 500 DBS per trip on both islands (20 €), with a return per hour of approximately 100 DBS (4 € / hour). The return for the boat owners is 1000 DBS (40€) on São Tomé and 750 DBS (30 €) on Príncipe per trip. On each island, only 2% of the fishing trips did not catch enough fish to cover fuel expenses and, on average, fishers take 10 fish (São Tomé) or 7 fish (Príncipe) home for consumption, in addition to the revenue of the sold fish.

3.8.4. Spear fishing

The length of spear fishing trips is similar across target communities on both islands (average = 6.0, SD = 3.5 on Príncipe and 6.1, SD = 4.0 on São Tomé, Table 14). On Príncipe, 45% of the spear fishing trips use engine propelled boats, and 55% of the fishing trips are conducted on rented boats. In total, 30% of the spear fishing trips on Príncipe do not use any vessels and the trips is started swimming from the coast. On the contrary, on São Tomé, engine-propelled boats are used on 22% of the trips, and only 4.4 % of the trips are conducted on rented boats. Moreover, 74% of the spear fishing trips on São Tomé do not use any vessels. This results in a lower average fuel consumption for spear fishers on São Tomé (0.4 L / trip) than on Príncipe (2.0 L / trip).

The catch per fisher per trip is slightly higher on São Tomé (29kg/trip) than on Príncipe (22 kg / trip). The revenue per trip is, however, double on São Tomé (540 DBS / trip; 22 € /trip) in comparison to Príncipe (280 DBS / trip; 11 € / trip), which also translates on a higher earnings per hour (see Table 14).

3.8.5. *Voador panhá*

Voador panhá is only practised on São Tomé (see section 3.1.5), and the average duration of its trip is 11 hours (Table 14). Most trips are conducted using engine-propelled vessels (56 %) and on rented boats (60 %), with an average fuel consumption of 3.8 litres / trip. The average catch per trip is 43 kg per fisher, which translates into a revenue of 380 DBS per trip (15 € / trip) for the fishers and 780 DBS per trip (31 € / trip) for the boat owners. The average earning per hour is amongst the lowest compared to other gear types, with 33 DBS / trip (1 € / hour), due the long duration of the trips.

3.8.6. Line fishing for the coast

The shortest fishing trips recorded correspond to line fishing practised from the shore (without boats), with an average duration of 4 hours on Príncipe and 4.7 hours on São Tomé (Table 14). On Príncipe, 93% of the records corresponded to fishing trips where the catch was used exclusively for consumption, so the average revenue per trip was not estimated due to low sample size. On São Tomé, the catch was often sold, with an average return of 100 DBS per trip (4 € / trip) and 25 DBS per hour (1 € / hour).

3.8.7. Line fishing

During a line fishing trip, fishers often use several gear configurations and techniques, using an average of 1.27 different types of fishing per trip, with a maximum of 4 (see section 3.7). On Príncipe, the average duration of a line fishing trip from a boat ranges from 7-9 hours at sea, with the longest trips recorded lasting up to 15 hours (see Table 14). This contrasts with the shorter line fishing trips on São Tomé, which have an average duration of 5.1 hours (demersal longline) or 6.4 hours (handlines).

Motorisation of the vessels used for line fishing is high on Príncipe, ranging from 70- 85% of the fishing trips depending on the type of fishing. However, only 28 % (handline fishing) and 9 % (demersal longline) of the fishing trips on São Tomé are motorised. Likewise, about 50% of the line fishing trips on Príncipe are conducted on rented boats, while on São Tomé only 3 % (demersal longline) and 12 % (handline fishing) of the fishing trips are conducted on rented boats.

As a result of the higher use of engine-propelled vessels and longer distances travelled for this type of fishing on Príncipe, fuel costs are more elevated when compared to São Tomé. The highest fuel consumption recorded on Príncipe (5L / trip) corresponds to demersal troll fishing trips. Handline and demersal longline trips use on average 3.9 L and 3.2 L per trip, respectively. This is markedly higher than in São Tomé, where the average fuel consumption for the handline fishing and demersal longline is 1.5 L and 0.5 L per trip, respectively.

Both the catch and total revenue per line fishing trip is higher on Príncipe than on São Tomé. The average catch of a handline fishing trip on Príncipe is 28.5 kg, which returns an average profit of 413 DBS per trip for the fishers (17 € / trip). These values are slightly lower on São Tomé, with an average catch per trip of 21 kg, and a return of 370 DBS per fishing trip for fishers (15 € / trip). However, due to the longer duration of the trips on Príncipe, the revenue per hour is lower than on São Tomé.

The demersal longline troll on Príncipe has the highest revenue of all line fishing gears, with 500 DBS return for fishers per trip (20 € / trip) and an average revenue per hour of 70 DBS (3€ / h). The catch of the demersal longline on Príncipe (26.5 kg/ trip) is higher than on São Tomé (19.4 kg / trip), which translates into a higher revenue per trip for fishers on Príncipe (350 DBS / trip, 14 € / trip) than on São Tomé (233 DBS / trip, 9 € / trip). However, since fishing trips on Príncipe are also longer, the revenue per trip is the same across both islands (50 DBS / trip, 2 € / trip).

3.9. CATCH RECONSTRUCTION

3.9.1. Total landings in target communities

The total landings per year and the proportion of the catch sold, consumed, salted, or given were estimated by extrapolation, combining information collected by extension workers in each community on the number of fishing trips per sampling day (disaggregated by fishing type) with catch and effort information from the landing surveys (see section 2.6).

On Príncipe, **372 tonnes of fish** are estimated to be landed every year across the 11 target fishing communities. Out of the total landings, 280 tonnes (75%) are estimated to be sold fresh (Figure 52), generating an estimated gross revenue of **€ 634,396** per year (see Table 15). In total, around 10% of the catch is kept for household consumption and thus not sold (corresponding to 44 tonnes per year). An additional 8% of the total catch (28 tonnes) is estimated to be salted by fishers to be sold at a later stage, with the primary market being São Tomé (note that this only includes the fish salted by the fishers themselves and not the fish bought by traders to be salted, which falls under the sold category, see Porriños, 2020[15]). Most of the fish salted by fishers is caught using hook and line fishing techniques (15 tonnes/year) and surface gillnets (12 tonnes/ year). Finally, 12 tonnes (approximately 3%) of the fish are given to people in the community, in exchange for their help pushing the boats out of the water when the fish is being landed (a practice locally known as São Pedro). As shown in Table 15, over 80% of the catch from the hook & line fishing practised from shore is almost exclusively destined for household consumption. However, in the case of hook & line fishing using boats, 75% of the catch is sold fresh, 12% is consumed and the remainder either given or salted. Approximately 70% of the spear fishing catch is sold fresh and 20% is kept for consumption, and 90% of the catch from purse seine is sold fresh. Finally, 70% of the catch from surface gillnets is sold fresh, while 20% is salted and dried by fishers.

On São Tomé, **813 tonnes of fish** are estimated to be landed every year across the 8 target communities (Table 16). Of these, almost 650 tonnes per year (80%) are estimated to be sold fresh (Figure 52), generating an estimated gross revenue of **€ 1,469,641** per year. In total, almost 140 tonnes (18%) are estimated to be kept for consumption. Approximately 14 tonnes per year are given to the people at the community in exchange for pushing the canoes out of the water (locally known as São Pedro), most of which comes from hook and line fishing vessels. Only 3 tonnes per year (0.4 %) are salted and dried by fishers on São Tomé, all of which comes from surface gillnet fishing. Around 65% of the catch of line fishing (both from the shore and from a vessel) is sold, while the remaining 35% is kept for consumption. Half of the catch of voador panhá fishing is kept for consumption and half is sold, whereas for spear fishing, 20% of the catch is kept for consumption, while the remaining 80% is sold. In the case of the net fishing (surface gillnet, bottom gillnet and seine nets) only 3% of the catch is kept for consumption, less than 2% given to the people at the community, with the remaining 95% being sold.

In the target communities on Príncipe, 70% of the landings come from hook and line gear, followed by surface gillnets (20%) and purse seine nets (6%). In the target communities in southern São Tomé, surface gillnets contribute to most of the catch, representing approximately 40% of the total yearly landings. Hook and line fishing contributes to 30% of the total catch, although it is the most practised type of fishing in terms of number of fishing trips (Figure 48). Spear fishing contributes to 12% of the total catches on São Tomé, while seine nets contribute to approximately 10%.

Table 15: Estimated yearly landings and revenue obtained from fresh fish sales in target communities on Príncipe, by . Note that the salted fish does not represent the total fish that is salted on Príncipe, but the proportion of the catch that is salted within the fishers' household.

Estimated yearly landings on Príncipe Island (11 communities)

GEAR	CATCH (T/year)	CONSUMED (T/year)	GIVEN (T/year)	SALTED (T/year)	SOLD (T/year)	FRESH FISH SALES (€/year)
Surface gillnet	69.9	5.6	2.4	11.8	49.1	€ 109,877
Purse seine	24.6	1.6	0.4	0.3	22.0	€ 49,667
Bottom gillnet	1.5	0.1	0.0	0.3	1.2	€ 2,603
Beach seine	0.4	0.1	0.0	0.0	0.3	€ 742
Spear fishing	9.5	1.7	0.1	0.6	7.0	€ 15,852
Hook & line	265.0	33.8	9.4	14.9	200.5	€ 455,614
Hook & line (shore)	1.3	1.0	0.0	0.1	0.0	€ 41
TOTAL	372.1	44.0	12.2	28.1	280.0	€ 634,396

Table 16: Estimated yearly landings and revenue obtained from fresh fish sales in target communities on São Tomé, disaggregated by gear. Note that the proportion of fish salted by fishers is considerably lower than on Príncipe.

Estimated yearly landings in Southern São Tomé (8 communities)

| GEAR	CATCH (T/year)	CONSUMED (T/year)	GIVEN (T/year)	SALTED (T/year)	SOLD (T/year)	FRESH FISH SALES (€/year)
Surface gillnet	304.6	10.0	6.0	3.0	285.7	€ 640,278
Purse seine	20.4	0.5	0.0	0.0	19.7	€ 45,400
Seine gillnet	59.3	1.4	0.0	0.0	57.1	€ 131,683
Bottom gillnet	16.8	0.6	0.6	0.0	15.5	€ 35,072
Voador panhá	13.6	6.4	0.0	0.0	6.4	€ 14,479
Spear fishing	110.9	23.4	0.9	0.0	86.6	€ 199,103
Hook & line	265.0	93.1	7.2	0.0	164.7	€ 369,311
Hook & line (shore)	23.0	8.0	0.0	0.0	15.0	€ 34,314
TOTAL	813.5	143.3	14.6	3.0	650.8	€ 1,469,641

END USE O FISH LANDINGS
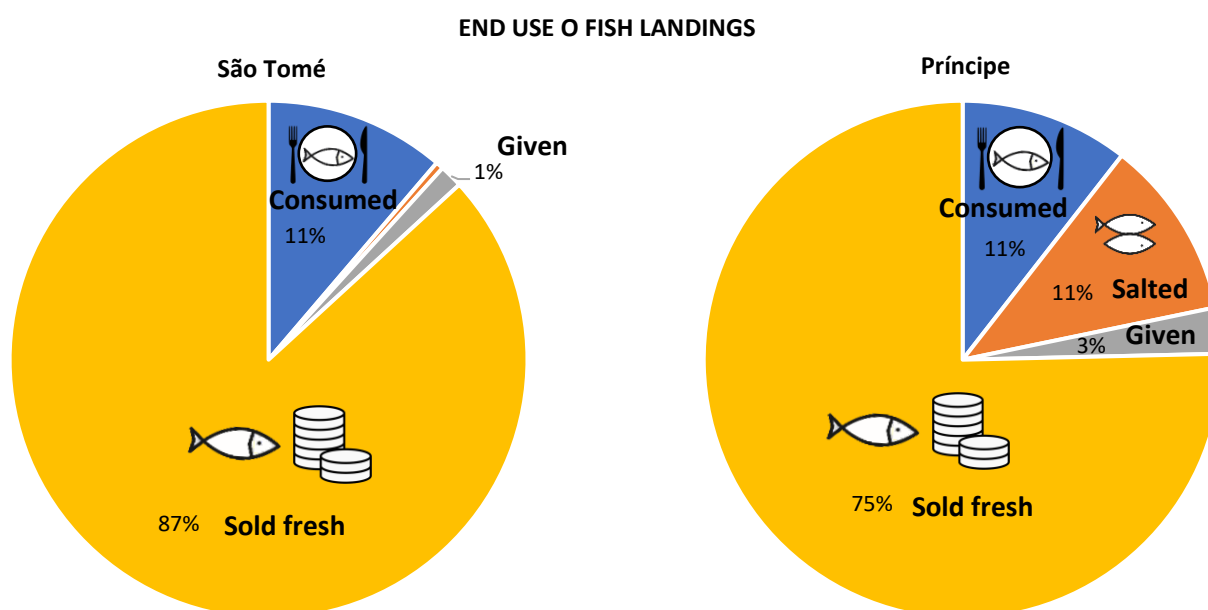
Figure 52: End use of the fish caught on São Tomé and Príncipe: sold fresh, consumed by fisher, salted and dried by fisher, or given to members of the community in exchange for help with pushing the boat out of the water.

3.9.2. Total catch reconstruction per species

On Príncipe, the most landed fish are two small pelagic species: *Caranx crysos* (35%), caught with line fishing techniques and flying fish (Exocoetidae, 21%), caught with surface gillnets. The small pelagic *Hemirhamphus balao* constitutes 5% of the total catch, all of it caught using purse seine nets. *Selar crumenophtalmus* (3%) and *fulu fulu* tunas (*E. alleteratus* and *A. thazard*, 2%), are also small pelagics that are frequently caught using demersal longlines. The demersal species most caught on Príncipe are *Pagrus caeruleostictus* (4%), large lutjanid snappers (*L. agennes*, *L. endecacanthus*, and *L. goreensis*, 3%), and *Dactylopterus volitans* (2%). The large carangid *Seriola rivoliana*, which can be caught using several types of line fishing, constitutes 3% of the total landings on Principe.

However, in the South of São Tomé, flying fish (Exocoetidae) caught using surface gillnets constitutes 37% of the total catch, followed by octopus (9%) which is exclusively caught by spear fishers. Almost 15% of the catch on the island is comprised of the small pelagic species *Caranx crysos* (5%), *fulu fulu* tunas (*E. alleteratus* and *A. thazard*, 5%), and *Hemirhamphus balao* (4%), *Selar crumenophtalmus* (1%). The large carangid species *Elegatis bipinnulata* comprises almost 3% of the catch, the small predatory demersal species *Lethrinus atlanticus* and *Lutjanus fulgens* comprise 4% of the catch and the small reef fishes *Paranthias furcifer* and squirrelfishes (Holocentridae) comprise another 4% of the catch. Flatfishes are also common, comprising 2% of the total catch.
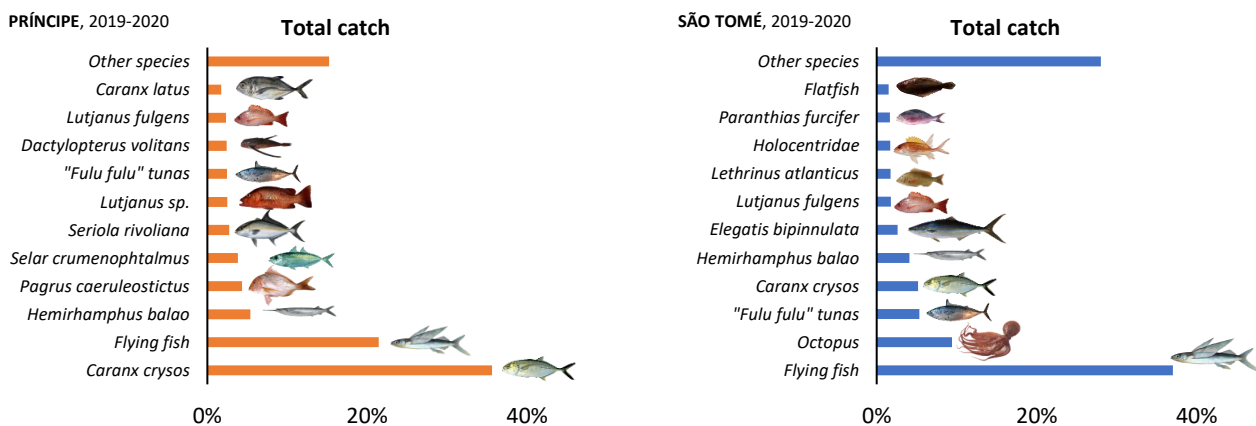
Figure 53: Reconstruction of total landings on Príncipe and South São Tomé.

4. DISCUSSION

4.1. Methodological considerations

In São Tomé and Príncipe, local names used to refer to different gears and species show polysemy (the same name being used for several different species or gears) and synonymy (different names being used for the same species or gears). This tendency was observed in the South of São Tomé, where the same names were used to refer to different types of hook and line fishing techniques and gear configurations. In this study, this was partially resolved during data collection by adding questions to describe the gear, such as "*what was the position of the weight on the line? (no weight / before the hooks / after the hooks)*". However, the same gear configuration can also be used for different fishing techniques, such as in the case of "samba" (a type of trolling line with a weight before the hooks) used for both surface trolling and demersal trolling. Working with fishers to develop questions that allow to unambiguously identify the different types of fishing techniques and gear configurations is essential for this type of study. To do so, we use a framework that

allows different types of line fishing techniques to be classified into comparable categories according to **1)** characteristics of the gear (number of hooks, bait type, hook size), **2)** the fishing technique used (such as jigging or trolling), and **3)** the habitat targeted (epipelagic, inshore, demersal and deep demersal). When developing questioning techniques to explore the characteristics of artisanal fishing practices, it is important to consider data collection protocols that rely less on potentially ambiguous local names, and instead focus on collecting information about diagnostic variables such as those described above, to accurately distinguish different gear types and fishing techniques to each other.

4.2. Gear specificity

The different fishing techniques used on São Tomé and Príncipe are taxon-specific, with certain species only being caught using certain gear configurations and fishing techniques. In the case of hook and line fishing, four main factors seem to influence the catch composition: **1) bait type** (fish or artificial lure); **2) fishing technique** (jigging, trolling or set lines); **3) habitat** (epipelagic, demersal, deep demersal); and **4) hook size**. The combination of these variables affects the catch composition differently.

Artificial lure is normally used on small and medium-sized hooks and requires the line to be in motion (either through jigging or trolling). The fishing technique used does not seem to have a significant effect on the catch composition. Indeed, on Príncipe, the catch composition of the jigging handline "toca" and the mid-water troll "arrastão" (both used in inshore demersal habitats) is remarkably similar, strongly dominated by small carangids (mainly *Caranx crysos* and *Selar crumenophtalmus*). However, when artificial lures are used in epipelagic habitats, as in the case of the surface troll, the catch is dominated by small tunas of the species *Euthynnus alleterattus* and *Auxis thazard*.

On the other hand, when **bait** is used, fish appear to be attracted to the smell of the bait rather than its movement. When using baited hooks, the fishing technique used (set, jigging, or "pivoting" lines) has a significant effect on catch composition. In set demersal lines, the catch is strongly dominated by *Pagrus* sp. and *Dactylopterus volitans*, comprising almost three quarters of the total catch. On the contrary, *Dactylopterus volitans* is absent from the catch of gears that allow movement of the line, such as pivoting and jigging handlines. Instead, the catch on these gear configurations is dominated by *Lutjanus endecacanthus* and *Lutjanus agennes*, *Pagrus* sp., and *Seriola rivoliana*.

Hook size also appears to have a strong influence on the catch composition. For example, in the case of the baited jigging handlines, the proportion of sharks in the catch is higher when using a gear configuration with large hooks (Subtype 2) when compared to small hooks (Subtype 1). Likewise, the catch of surface trolls with larger hooks (Subtype 2) is strongly dominated by large species such as blue marlin (*Makaira nigricans*) and Atlantic sailfish (*Istiophorus albicans*), while the catch of the surface trolls with small hooks (Subtype 1) is mainly composed of small *fulu fulu* tunas (*E. alleteratus* and *A. thazard*).

Deep demersal habitats are only targeted using baited jigging handlines on São Tomé and Príncipe and the resulting catch is dominated by species that are absent in the catch of other gear configurations and fishing techniques (namely *Dentex macropthalmus*, *Pontinus kuhlii*, *Erythrocles monodi* and *Polyprion americanus*).

In addition to influencing catch composition, hook size, bait type and fishing technique also have significant effects on the CPUE of hook and line gear configurations used by fishers on São Tomé and Príncipe. Hook size has the biggest impact on CPUE, with larger hooks significantly increasing CPUE. Furthermore, even within the same type of gear, significant differences in CPUE were found between bait type (artificial or fish bait) and targeted habitat (shore, demersal inshore, deep demersal offshore) the case of the jigging handlines. Therefore, in order to compare CPUE between sites (Príncipe and São Tomé) and over time, we recommend that effort data is disaggregated into comparable categories using the parameters described above.

4.3. Effort

In the eight target communities in the South of São Tomé, the total effort (108 trips per day) was three times higher than the total effort in the target communities on Príncipe (11 communities, 33 trips per day). However, it is important to note that, across both islands, our data sets do not include the total fishing effort as there are fishers from other communities that land their catch at other locations. In the case of Príncipe island, data collection was expanded into four additional mixed farming-fishing communities in October 2020, but data obtained from these was not included in this analysis. On São Tomé, purse seine vessels from the Northern communities travel daily to fish in the South[18] and we do not have an accurate estimate for the total number of fishing vessels currently operating in the area. In fact, the target communities in southern São Tomé only represent 12% of the total fisher population of the island (see Annex II and Santos et al., 2017[18]). Assuming that the northern half of São Tomé follows the same fishing patterns as the South, the total effort for the island would be at least 30 times higher than on Príncipe (with 275 trips per day). Most of São Tomé's fishing effort is exerted over a much smaller insular shelf than that of Príncipe (500 km^2 compared to 1100 km^2 respectively), which is probably contributing towards the decline of demersal fish populations in the area (see section 4.4).

4.4. Differences on catch composition and CPUE of fishing techniques between islands

The CPUE for demersal gears was found to be lower on São Tomé than on Principe, which may be related to a higher fishing pressure on São Tomé exerted over a smaller insular shelf area in comparison to Príncipe. CPUE for gears targeting demersal species (such as Subtype 1 jigging handlines and set demersal lines) were significantly lower on São Tomé when compared to Príncipe. Subtype 1 jigging handlines showed differences regarding fishing times and hook size, independently of bait type, making the data less comparable between the islands and these fishing categories weaker indicators for CPUE. However, these comparability issues do not exist in the case of <u>set bottom longlines</u> (with bait type, fishing times and techniques similar across both islands), making it a more robust indicator for CPUE comparisons to be made between São Tomé and Príncipe.

CPUE for epipelagic gears does not show significant differences between the islands, indicating that the pelagic fish populations on STP are probably less affected by the pressure exerted by the current level of artisanal fishing effort. CPUE of the <u>surface gillnet</u>, targeting flying fish (family Exocoetidae), does not show significant differences between islands. The fishing times, techniques and gears used show little variation across São Tomé and Príncipe, making this type of fishing a strong indicator for CPUE across both islands. The CPUE of <u>Subtype 2 of surface troll</u> did also not show significant differences between islands, although this type of fishing does present differences in hook size and fishing times across both islands, thus making it a weaker indicator. Note that the catch of both surface troll and surface gillnet is largely composed of oceanic species.

Major differences in catch composition were found between São Tomé and Príncipe. For example, on Príncipe, the main species caught with Subtype 2 of surface trolls (large hooks) are Atlantic sailfishes (*Istiophorus albicans*), while on São Tomé, the main species is blue marlin (*Makaira nigricans*). These differences are probably related to differences in species biogeographical distribution ranges, since these are highly migratory species[25], which also explains the seasonal variation of their landings. Other differences, however, might be related to a higher fishing pressure being exerted on São Tomé. On Príncipe, the catch of certain demersal gears is dominated by small pelagic carangids such as *Caranx crysos* or *Selar*

---

[25] **Richardson**, D. E. et al. (2009) 'Importance of the Straits of Florida spawning ground to Atlantic sailfish (*Istiophorus platypterus*) and blue marlin (*Makaira nigricans*)', *Fisheries Oceanography*, 18(6), pp. 402–418. doi: 10.1111/j.1365-2419.2009.00520.x.

crumenophtalmus, which are strongly associated to reef and coastal zones (FishBase). However, on São Tomé, these gears show a significantly lower CPUE, with a higher proportion of smaller reef fish in the catch. Likewise, the proportion of the large snapper species of the genus *Lutjanus* (mainly *L. endecacanthus* and *L. agennes*) is much lower for the catch of all demersal gears on São Tomé when compared to Príncipe.

The differences in abundance of certain species between islands may either be related to variations in fishing pressure or biogeographical preferences. For example, the large carangid *Seriola rivoliana* is a ubiquitous species present in the catch of many gear types on Príncipe (especially demersal ones), but largely absent in the catch on São Tomé. Based on the data that we currently have; it is not possible to determine whether this is indeed due to differences in fishing pressure or biogeographical preferences of this oceanic species[26].

Another significant difference found between São Tomé and Príncipe is the higher abundance of smooth pufferfish (*Lagocephalus laevigatus*) in fish landings on São Tomé. On São Tomé, fishers explained that the population of adult puffers explodes seasonally from June to September (a trend that has also been observed using Baited Remote Underwater Video surveys)[27]. *Lagocephalus* pufferfishes are aggressive predatory species that display invasive traits[28] and the higher abundance around São Tomé has been hypothesized to be related to a perceived decrease in shark abundance over time[18]. However, the seasonal booms of *L. laevigatus* on São Tomé were reported by fishers as also being common 20 years ago during informal interviews and other puffer species also show seasonal patterns, using coastal regions to reproduce and then migrating to the open ocean for the rest of the year[29]. Although it remains unclear whether the puffer population around São Tomé has indeed increased throughout the years, the use of this species in fishing communities seems to have shifted in the last decades. In the past, the species was discarded when caught because of the toxicity of their innards. However, nowadays it is intentionally targeted by fishers on São Tomé, eviscerated quickly at the landing site, salted and dried, and sold across the island. This contrasts with Príncipe, where it is rarely caught and never targeted intentionally.

4.5. Fishing systems on São Tomé and Príncipe

The concept of "productive systems" has been extensively used in farming and agricultural systems, but it is rarely used in the context of artisanal fishing systems. A fishing system could be defined as the fishers' choices regarding the use of natural resources. These choices will affect and will be affected by the surrounding natural, socio-political, and economic environment. Thus, understanding socio-ecological systems as a whole is essential to improve fisheries management and to increase the resilience of socio-ecological fishing systems. The data collection and analysis protocols presented here allow for a preliminary characterisation of these fishing systems, that can serve as a basis for future research.

Fishers in São Tomé and Príncipe show a highly diverse range of fishing techniques and financial strategies that contribute to different patterns of resource use. Not only do different fishing techniques allow fishers to exploit specific sub-systems of their marine ecosystem, but also, the choice to intensify their fishing activities to increase profit from a single fishing trip. This intensification can either be done by increasing the duration of the fishing trips, using motorised vessels or increasing the length of nets and fishing lines. These

---

[26] **Mendoza-Portillo**, V. *et al.* (2020) 'Genetic diversity and structure of circumtropical almaco jack, Seriola rivoliana: tool for conservation and management', *Journal of Fish Biology*, 97(3), pp. 882–894. doi: 10.1111/jfb.14450.

[27] **Fauna and Flora International**, **MARAPA**, **Oikos**, **Fundação Príncipe**. BRUV surveys, funded by Blue Action Fund (unpublished).

[28] **Filiz**, H., **Yapici**, S. and **Bilge**, G. (2017) 'The Factors Increasing of Invasiveness Potential of Five Pufferfishes in the Eastern Mediterranean, Turkey', *Natural and Engineering Sciences*, 19(3), pp. 85–94.

[29] **Peniche-Pérez**, J. C. *et al.* (2019) 'Reproductive biology of the southern pufferfish, sphoeroides nephelus (Actinopterygii: Tetraodontiformes: Tetraodontidae), in the northern coast off the Yucatan Peninsula, Mexico', *Acta Ichthyologica et Piscatoria*, 49(2), pp. 133–146. doi: 10.3750/AIEP/02516.

choices in turn define the different fishing systems used. The preliminary analyses presented here aim to characterise the socio-ecological structure and dynamics of these fishing systems.

Seine vessels and surface gillnet vessels are always motorised, due to the inherent requirements of the associated fishing techniques and the weight and size of the canoes and nets needed. **Surface gillnet** fishing techniques and trip durations are similar on both islands and boat owners are present on more than half of the surface gillnet fishing trips. This indicates that this type of gear is most often owned by fishers themselves and that the revenue of renting fishing material out is directly injected into the fishers' households. However, the opposite pattern is observed with **seine nets**, in which 90% of fishing trips are conducted on rented vessels and boat owners are present on a minority of trips (2.5% on São Tomé and 10% on Príncipe, respectively). Further insight into the ownership of fishing nets is important to better understand the value chain and the socio-economic dynamics of this type of fishing. Moreover, seine net fishing shows major differences between São Tomé and Príncipe, with the nets used on São Tomé being much larger and presenting a higher CPUE (see Table 13). Fishing trips for this gear type are also on average longer on São Tomé, indicating that this type of fishing is more intensive on São Tomé than on Príncipe.

Different trends can also be observed regarding **line fishing** between the two islands. On Príncipe, hook and line fishing is an income-oriented activity, with 85% of the total catch being sold fresh at the landing site or salt-dried for exportation to São Tomé. This seems to correlate to a higher intensification of hook and line fishing activity, with these trips being amongst the longest on Príncipe and over 70% of the fishing trips using motorised vessels. Nonetheless, almost 50% of the fishing trips are conducted on rented vessels. Boat owners are present on approximately half of the trips, indicating that most motorised fishing vessels used for hook and line fishing are owned by fishers themselves and that the revenue obtained is directly injected into the fishers' households. In addition, hook and line fishing is the most practised type of fishing (representing approximately 60% of all fishing trips) and one of the main contributors to the islands' economy (66% of the total fish landings). Fish caught using hook and line techniques comprises 60% of the fish that is salt-dried by fishers and 71% of the fish that is sold fresh on Príncipe (corresponding to 70% of the gross revenue obtained from fresh fish sales on the island). On the other hand, on São Tomé, line fishing seems to be a more subsistence-oriented activity, with 40% of the catch kept for consumption or given away. This in turn corresponds to a lower prevalence of motorised vessels used for this type of fishing and shorter fishing trips, most of which are conducted on small rowing or sailing canoes owned by the fishers themselves. Therefore, although line fishing is also the most practised type of fishing on São Tomé (50% of the fishing trips), it only contributes to 30% of the total catch in target communities and 20% of the revenue from fresh fish sales on the island. This contrasts with the catch and effort of surface gillnet fishing on São Tomé, which only comprises 25% of the fishing trips, but accounts for 40% of the catch and 45% of the revenue from fresh fish sales across target communities in the South.

The contribution of spear fishing also shows very different patterns across target communities on São Tomé and Príncipe. In the South of São Tomé, particularly in the communities of Malanza, Porto Alegre, and Ilhéu das Rolas, spear fishing is an essential subsistence and income-generating activity, responsible of almost 12% of the landings and 20% of the gross revenue from fresh fish sales. Indeed, octopus which is exclusively caught by spear fishers is the second most landed species in the South of São Tomé. However, this does not translate to a higher prevalence of motorised vessels or longer fishing trips for spear fishers on São Tomé. In fact, most trips are conducted directly from the cost without the use of any vessel. Since both CPUE and trip duration is similar on both islands, this higher contribution of this type of fishing on São Tomé is likely due to a higher number of spear fishers in the region. On Príncipe, spear fishing only contributes to 2% of the total landings in target communities and most trips are conducted on rented, motorised vessels. These differences might be related to the different geomorphological conditions of the coast on both islands and the high number of

spear fishers in southern São Tomé might be related to the higher availability and accessibility of fishing grounds suitable for spear fishing.

A major difference between both islands is the percentage of the catch that is salt dried by the fishers, with Príncipe Island showing markedly higher proportions of fish with this end use when compared to São Tomé (see Figure 51). These results confirm previous findings by Porriños (2020)[15] which indicate that fishers (men) on São Tomé do not engage in salt-drying fish, an activity that is exclusively practised by palaiês (women). However, due to the income opportunities generated by exporting dried fish to São Tomé, fishers on Príncipe keep 11% of the catch from surface gillnets and line fishing for salt-drying.

A better understanding of the factors which control and contribute to fishers' choices and strategies is necessary to effectively manage the fishery. Market availability seems to be an important factor leading fishers on Príncipe to engage in salt-drying fish. Likewise, the geomorphological conditions of the South of São Tomé might be the reason why many fishers from the region opt for spear fishing, although other conditioning factors should also be explored, such as market or gear availability. In the case of line fishing, the comparatively low intensification of and investment in this activity on São Tomé could be a direct consequence of the possible decline in demersal fish populations and resulting lower CPUE for demersal gear types, as this would risk the catch not being enough to cover the costs of the trip. Nevertheless, other causes might also be contributing, such as socio-economic factors (low income and no capital for investment), cultural factors (traditional knowledge of fishing in the region) or environmental factors (for example, harsher weather conditions on Príncipe that force the use on engines).

4.6. Total catch

On both islands, small pelagic fish of the family Exocoetidae (flying fish), and the species *Caranx crysos*, *Euthynnus alleteratus* and *Auxis thazard* (*fulu fulu* tunas), *Hemirhapmhus balao*, and *Selar crumenophtalmus* constitute the majority of the landings, comprising 66% of the catch on Príncipe and 52% of the catch on São Tomé. Demersal fishing contributes to a small proportion of the catch on both islands, and the five most landed demersal finfish species on each island only contribute to 10% of the total catch.

The differences in the gear choices and fishing strategies used by fishers in target communities on Príncipe and São Tomé have direct consequences on the catch composition for each island. On Príncipe, *Caranx crysos* caught with hook and line fishing techniques is the most landed species (36%), followed by flying fish from surface gillnets (21%). However, on São Tomé, flying fish is the most landed species (37%), while *Caranx crysos* caught with line fishing techniques only comprises 5% of the total catch. In addition, the abundance of octopus in the total catch in southern São Tomé (9%) reveals the economic importance of the spear fishing activity for the communities in this region.

ANNEXES

Annex I: fishing communities in Príncipe island

The following list contains the landing sites and fishing communities of Príncipe island. Communities or landing sites marked with an asterisk (*) have not been included in the landing surveys.

List of communities and landing sites of the autonomous regions of Príncipe	
Abade	**Permanent community and landing site**. Fishing community divided in "*Abade Roça*" (the former farm) and "*Abade Praia*". It is also the landing site of fishers from *Nova Estrela* and *Santo Cristo*.
*Praia Abelha (or Praia Bumbú)	**Landing site**. Fishers from Terreiro Velho have been observed to land here, but no vessels are kept in this beach (personal observation). Fish landing data collected here since October 2020, but not included in analysis.
*Praia Ponta Mina (landing site of *Hospital Velho*)	**Permanent landing site. Not included in the landing surveys**. Only one fisher is known to land here.
São João (neighbourhood of *Hospital Velho*)	**Permanent community**. Its landing site is *São João* beach, which is shared with Unitel.
Unitel (neighbourhood of *Hospital Velho*)	**Permanent community**. Its population was relocated from the former community of *Praia Sundy* (Sundy beach) when a resort was built. Its landing site is *São João* beach, and the fishers keep on using their former fishing grounds, which are closer to Sundy beach.
Concom (neighbourhood of *Hospital Velho*)	**Permanent community and landing site**.
Àgua Namoro (neighbourhood of *Hospital Velho*)	**Permanent community and landing site**.
*Praia Capitania (landing site of *Santo António*)	**Permanent landing site. Not included in the surveys**. Beach located below the Captaincy, that hosts 15 to 20 vessels from Bairro Chimalô and other neighbourhoods around the city.
*Bairro Chimalô (neighbourhood of *Santo António*)	**Permanent community. Not included in the surveys**. Its main landing site is Capitania.
Santo António (neighbourhood of *Santo António*)	**Permanent community**. Fishers from this community use two nearby landing sites: hestaleiro (only one fisher) and the beach of Santo António. Both sites are covered by Santo António's extension worker.
Burras	**Permanent community and landing site**.
Campanha	**Permanent community and landing site**.
Ribeira Izé	**Permanent landing site**. Hosts the vessels of fishers from Sundy Roça, who will soon be relocated to the newly constructed community of "*Terra prometida*". This might affect the continuity of the site (José Gomes, personal communication).
*Praia Caixão	**Permanent landing site. Not included in the landing surveys**. Landing site of fishers of the inland community of São Joaquim.
Praia Lapa	**Permanent community**. It is also the landing site of fishers from the inland community of São Joaquim.
Praia Novo	**Temporary community**. Temporary community of the fishers of Ribeira Izé, who migrate from November to March approximately to be closer to the southern fishing grounds.
Praia Seca	**Temporary community**. Principe's biggest temporary settlement. It hosts fishers from all the neighbourhoods of *Hospital Velho*, as well as the inland communities of *Nova Estrela* and *Santo Cristo*.
*Praia Cabinda	**Temporary community. Disappeared in a landslide.** Former temporary settlement used by the fishers of Abade.

Annex II: fishing communities in São Tomé

From Santos *et al.* (2017)

Name	Number of fishers
NORTH	
Praias Cruz, Gamboa, Loxinga	635
Morro Peixe	176
Micoló	150
Pantufo	130
Ponte Bistp	100
Messias Alves	66
Cova Água	57
Ribeira Afonso	47
Plano Água Izé	41
SOUTH	
Porto Alegre	114
Angolares	106
Malanza	55
Praia Pesqueira	28
Ribeira Peixe	23
Angra Toldo	22
Monte Mário	17
Iô Grande	15
Ilhéu Das Rolas	

Annex III: Species' list

Species marked with an asterisk (*) are indicator species

Species name	English name	Code (Principe)	Code (São Tomé)
Acanthuridae (Surgeonfishes, tangs, unicornfishes)			
Acanthurus monroviae	Monrovia doctorfish	ASNO-LACETA	ASNO-LAMINA
Prionurus biafraensis	Biafra doctorfish	ASNO-COTA	ASNO-COTA
Albulidae (bonefishes)			
Albula vulpes	Bonefish	COLUMPIAM-BALABO	COLUMPIAM-BALABO
Anguiliformes, Muraenidae (moray eels)			
Channomuraena vittata	Broadbanded moray	MOREIA-TROPA	MOREIA-TROPA
Enchelycore nigricans	Viper moray	MOREIA-CAO	MOREIA-CAO
Gymnothorax vicinus	Purplemouth moray	MOREIA-FULA	MOREIA-DE-TERRA
Muraena melanotis	Honeicomb moray	MOREIA-PINTADA	MOREIA-MAPINTA
Muraena robusta	Stout moray	MOREIA-RONCA	MOREIA-CARRONCA
Anguiliformes, Ophichthidae (Snake eels)			
Myrichthys pardalis	Leopard eel	COBRA-MARINHA	COBRA-MARINHA
Ophichthus rufus	Rufus snake-eel	MOREIA-FUNDO	MOREIA-CONCOM
Beloniformes, Belonidae (needlefishes)			
Ablennes hians	Flat needlefish	AGULHA-ESPADA	AGULHA-ESPADA
Tylosurus sp.	Hound needlefish	AGULHA-QUIO	AGULHA-QUIO
Beloniformes, Hemiramphidae (Halfbeaks)			
Hemirramphus balao	Balao halfbeak	MAXIPOMBO	MAXIPOMBO
Berycidae (Alfonsinos)			
Beryx decadactylus	Alfonsino	OLHO-BRILHANTE	UE-NGUENE-NGUENE
Bythitidae (Viviparous brotulas)			
Grammonus longhursti		BLONZE	BLONZE
Carangidae (jacks and pompanos)			
Alectis alexandrina	Alexandria pompano	PEIXE-PRATA	PAMPULE
Carangoides bartholomaei	Yellow jack	CHEREU	SELE
Caranx crysos	Blue runner	BONITO	BONITO
Caranx hippos	Crevalle jack	COCOVADO	COCOVADO
Caranx latus	Horse-eyed jack	OLHO-GROSSO	OLHO-GROSSO
Caranx lugubris	Black jack	OSSO-MOLE-FUNDO	COCOVADO-DE-FUNDO
Decapterus sp	Mackerel scad	CAVALA	CAVALA
Elagatis bipinnulata	Rainbow runner	ALADA	ALADA
Selar crumenophthalmus	Big-eyed scad	CARAPAU	CARAPAU
Seriola rivoliana	Longfin yellowtail or Almaco jack	PEIXE-AZEITE	PEIXE-AZEITE
Trachinotus goreensis	Longfin pompano	PATA-PATA2	PATA-PATA2
Trachinotus ovatus	Pompano	PATA-PATA	PATA-PATA
Uraspis secunda	Cottonmouth jack	OSSO-MOLE	OSSO-MOLE

ANNEXES

Cirrhitidae (Hawkfishes)			
Cirrhitus atlanticus	West African hawkfish	CAPATAZ	CAZE-BUDU
Clupeidae (Herrings, shads, sardines, menhadens)			
Sardinella sp.	Sardinella	SARDINHA	SARDINHA
Coryphaenidae (Dolphinfishes)			
Coryphaena equiselis	Pompano dolphinfish	COLOMBETA-CAVEDE	COLOMBETA-CAVEDE
Coryphaena hippurus	Common dolphifish, mahi-mahi	COLOMBETA	COLOMBETA
Drepaneidae (Sicklefishes)			
Drepane africana	African sicklefish	COZINHEIRO	COZINHEIRO
Ephippidae (Spadefishes, batfishes and scats)			
Ephippus goreensis	East Atlantic African spadefish	COZINHEIRO-DE-RIO	COZINHEIRO-DE-RIO
Flying fish			
Exocetidae		PEIXE-VOADOR	VOADOR-PANHA
Haemulidae (Grunts)			
Plectorhinchus macrolepis	Biglip grunt	PEIXE-PORCO	PEIXE-PORCO
Pomadasys rogeri	Pigsnout grunt	RONCADOR	RONCADOR
Holocentridae (Squirrelfishes, soldierfishes)			
Holocentrus adscensionis	Squirrelfish	CAQUI	CAQUI
Myripristis jacobus	Blackbar soldierfish	MAE-DE-CAQUI	MAE-CAQUI
Sargocentron hastatus	Red squirrelfish	CAQUI-DE-FUNDO	CAQUI-DE-PEDRA
Istiophoridae (Billfishes)			
Istiophorus albicans	Atlantic sailfish	PEIXE-ANDALA	PEIXE-ANDALA
Makaira nigricans	Blue marlin	ESTROMBA	ESTROMBA
Kyphosidae (Sea chubs)			
Kiphosus sp	Seachub	SOPA	SOPA
Labridae (Wrasses)			
Bodianus speciosus	Blackbar hogfish	BULHAO	BULHAO-BICA
Coris atlantica		RAINHA1	RAINHA1
Thalassoma newtoni		RAINHA2	RAINHA2
Xyrichthys novacula	Pearly razorfish	LAINHA	LAINHA
Lethrinidae (Emperors or scavengers)			
Lethrinus atlanticus	Atlantic emperor	BICA	BICA
Lobsters			
	Lobster	LAGOSTA	LAGOSTA
	Slipper lobster	CAVACO	CAVACO
Lutjanidae (snappers)			
Apsilus fuscus	African forktail snapper	PEIXE-NOVO	PEIXE-NOVO
Lutjanus agennes	Red african snapper	CORVINA-PRETA	CORVINA-PRETA
Lutjanus dentatus	African brown snapper	CORVINA-DE-RIO	CORVINA-DE-RIO
Lutjanus fulgens	Golden African snapper	VERMELHO-TERRA	VERMELHO-TERRA

Lutjanus goreensis	Gorean snapper	CORVINA-VERMELHA	CORVINA-VERMELHA
Malacanthidae (Tilefishes)			
Branchiostegus semifasciatus	Zebra tilefish	PEIXE-CABRA	PEIXE-CABRA
Mobulidae			
Mobula sp	Devil ray	MARFIM	UZUA-MANTA
Molluscs			
	Octopus	POLVO	POLVO
	Sea snail	BUZIO-DO-MAR	BUZIO-DO-MAR
	Cuttlefish	CHOCO	CHOCO
Mullidae (goatfishes)			
Mulloidichthys martinicus	Yellow goatfish	SABONETE	SABONETE
Mullus surmuletus	Surmullet	SABONETE-VERMELHO2	SABONETE-VERMELHO2
Pseudupeneus prayensis	West African goatfish	SABONETE-VERMELHO	SABONETE-VERMELHO
Myliobatiformes (stingrays)			
Dasyatis pastinaca	Common stingray	RAIA2	RAIA2
Taenuria grabata	Round stingray	RAIA	RAIA
Pleuronectiformes (flatfishes)			
Pleuronectiformes	Flatfish	LINGUALE	LINGUADO
Polynemidae (Threadfins)			
Galeoides decadactylus	Lesser African threadfin	BARBUDO	BARBUDO
Polyprionidae (Wreckfishes)			
Polyprion americanus	Wreckfish	CHERNE	CHERNE
Priacanthidae (Bigeyes or catalufas)			
Heteropriacanthus cruentatus	Glasseye	VERMELHO-SOL	VERMELHO-SOL
Priacanthus arenatus	Atlantic bigeye	VERMELHO-SOL-DE-FUNDO	VERMELHO-SOL-DE-FUNDO
Scaridae (Parrotfishes)			
Scarus hoefleri	Guinean parrotfish	BULHAO-PAPAGAIO	BULHAO-PAPAGAIO
Sparisoma sp	Parrotfishes	BULHAO-PAPAGAIO2	BULHAO-PAPAGAIO2
Sciaenidae (Drums or croakers)			
Pseudotolithus brachygnathus	Croaker	RONCADOR-DE-FUNDO	RONCADOR-DE-FUNDO
Pseudotolithus senegalensis	Croaker	RONCADOR-DE-FUNDO	RONCADOR-DE-FUNDO
Umbrina cirrosa	Shi drum	BARBUDO-FUNDO	BARBUDO-FUNDO
Scombridae (mackerels, tunas, bonitos)			
Acanthocybium solandri	Wahoo	PEIXE-FUMO	PEIXE-FUMO
Auxis thazard	Frigate tuna	FULU-FULU-REBOLA	FULU-FULU-REBOLA
Auxis thazard + Euthynnus alletteratus	Little tunny and frigate tuna	FULU-FULU	FULU-FULU

Euthynnus alletteratus	Little tunny	FULU-FULU-BATIDO	FULU-FULU-BATIDO
Katsuwonus pelamis	Skipjack tuna	SINTRA	SINTRA
Scomberomorus tritor	West African Spanish mackerel	PEIXE-SERRA	PEIXE-SERRA
Thunnus albacares	Yellowfin tuna	ATUM-OLEDE	ATUM-OLEDE
Thunnus obesus	Bigeye tuna	ATUM-FOGO	ATUM
Scorpaeniformes, Dactylopteridae (Flying gurnards)			
Dactylopterus volitans	Flying gurnard	CONCOM	CONCOM
Scorpaeniformes, Scorpaenidae (Scorpionfishes or rockfishes)			
Pontinus kuhlii	Offshore rockfish	CANGA	CANGA
Scorpaenodes africanus		COME-MOLE	COME-MOLE
Serranidae (sea basses: groupers and fairy basslets)			
Anthias anthias	Swallowtail seaperch	CAPITAO	CAPITAO
Paranthias furcifer	Creole fish	MULATO	MULATO
Rypticus saponaceus	Greater soapfish	FUNHE	FUNHE
Serranidae, Epiniphelinae (groupers)			
Cephalopholis nigri	Niger hind	GAROPA-PRETA	COLOBO
Cephalopholis taeniops	Bluespotted seabass	BOBO-QUEMA	BOBO-QUEMA
Epinephelus adscensionis	Rock hind	GLOPIM	GLOPIM
Epinephelus aeneus	White grouper	BACALHAU	BACALHAU
Epinephelus goreensis	Dungat grouper	BADEJO	BADEJO
Epinephelus marginatus	Dusky grouper	MERO1	MERO
Epinephelus morio	Red grouper	MERO3	MERO3
Erythrocles monodi	Atlantic rubyfish	VERMELHO-SANGUE	VERMELHO-SANGUE
Mycteroperca rubra	Mottled grouper	MERO2	MERO2
Sharks			
Carcharias or *carcharinus*		TUBARAO-BRANCO	TUBARAO-BRANCO
Ginglymostoma cirratum	Nurse shark	TUBARAO-AREIA	TUBARAO-AREIA
Prionace sp.	Blue shark	TUBARAO-LAGAIA	TUBARAO-LAGAIA
Rhizoprionodon	Requiem shark	TUBARAO-PEIXE	TUBARAO-PEIXE
Sphyrna sp.	Hammerhead	TUBARAO-MARTELO	TUBARAO-MARTELO
Sparidae (porgies)			
Boops boops	Bogue	BONGA	BONGA
Dentex congoensis	Congo dentex	BESUGO	VERMELHO-DENTE
Dentex macrophtalmus	Large-eyed dentex	VERMELHO-FUNDO	VERMELHO-FUNDO
Pagellus bellottii	Red pandory	MALAGUETA	MALAGUETA
Pagrus caerulostictus	Bluespotted seabream	PARGO	PARGO
Pagrus pagrus	Red porgy	PARGO	PARGO
Sphyraenidae (Barracudas)			
Sphyraena barracuda	Great barracuda	BARRACUDA	BARRACUDA
Sphyraena sphyraena	European barracuda	PESCADA	ALICHOTE
Syngnathiformes, Fistulariidae (Cornetfishes)			

Fistularia tabacaria	Cornetfish	AGULHA-BUZINA	AGULHA-BUZINA
Tetraodontiformes, Balistidae (triggerfishes)			
Balistes capriscus (=Balistes carolinensis)	Grey triggerfish	ASNO-FUNDO	ASNO-FUNDO
Balistes punctatus	Blue-spotted triggerfish	ASNO-GALINHA	ASNO-TERRA
Canthidermis sufflamen	Ocean triggerfish	ASNO-OCEANICO	ASNO-MAMBO
Melichthys niger	Black triggerfish	ASNO-PRETO	ASNO-PRETO
Tetraodontiformes, Monacanthidae (filefishes)			
Aluterus scriptus	Scribbled leatherjacket filefish	ASNO-PERGUICOSA	ASNO-LEMBE-LEMBE
Tetraodontiformes, Tetraodontidae (puffers)			
Lagocephalus laevigatus	Smooth puffer	COELHO	COELHO
Others			
NA	NA	DOBRADA	MAZEBE
Species not included in the list	NA	OUTRO-PEIXE	OUTRO-PEIXE

Annex IV: Assessment of the work of extension workers – training phase (Jul. – Sep. 2019)

The following tables describe the criteria used to assess the work of the extension workers during the training phase in São Tomé (Jul – Sep 2019). Scores on each parameter were assigned based on the subjective criteria of the trainer, Guillermo Porriños.

	№ training sessions	Using ODK and the smartphone		Understanding the questionnaire		Interview		Total		Final assessment	Engaging the fishers
		Beg.	End	Beg.	End	Beg.	End	Beg.	End		
Community 1	5/5	0	1.5	1	2	1	2	0.7	1.8	Not able to conduct the work	2
Community 2	5/5	1	2	1	2	1	2	1.0	2.0	Able to conduct the work, but needs support	3
Community 3	6/6	3	3	3	3	3	3	3.0	3.0	Able to work independently	3
Community 4	4/4	3	3	3	3	3	3	3.0	3.0	Able to work independently	2
Community 5	5/5	0	2.5	0.5	3	1	2.5	0.5	2.7	Able to work independently	1
Community 6	3/5	0	1.5	1	1.5	0	1.5	0.3	1.5	Not able to conduct the work	3
Community 7	3/4	2.5	2.5	2	3	2	3	2.2	2.8	Able to work independently	3
Community 8	6/6	1.5	2	2	2.5	2	2.5	1.8	2.3	Able to conduct the work, but needs support	3
Community 9	3/3	3	3	3	3	3	3	3.0	3.0	Able to work independently	2
Community 10	4/4	3	3	3	3	3	3	3.0	3.0	Able to work independently	3

Assessment criteria
Using ODK and the smartphone: Using a smartphone android independently, including navigating the different applications, writing using a touchscreen keyboard, etc.
Understanding the questionnaire: Understanding the questions, the type of information and its meaning.
Interview and data collection: Conduct the interview independently and develops strategies to collect the information (weighing, counting…), considering the complex dynamics of the landings.
Engaging the fishers in the activity: Explaining the fishers the activity, how and when it will happen, why it is done and its importance.

Scores
0 → Does not manage to perform the task, even when explained.
1 → Does not manage to perform the task but manages when explained.
2 → Manages to perform the task, but needs support
3 → Manages to perform the task independently.

4.7. Annex V: Criteria for the assessment of data quality

The following table describe the criteria used to assess the work of the extension workers during the training phase in São Tomé.

Data frame	Weight	Description
Number of interviews and daily number of boats	1	Filled the form on the number of daily trips every day.
	3	Filled all the information on the daily number of canoes.
	7	The number of interviews conducted corresponds to the expected number of canoes departing from that community (at least 6 interviews per working day for big communities).
General information of the fishing trip	1	Landing and departing times are correct.
	1	Recorded the names of all the fishers.
	1	Recorded the correct type of vessel, as well as the amount of fuel and the price, if relevant.
	1	Recorded the fishing ground.
	1	Recorded the number of fish that the fisher kept for consumption, as well as the number of fish given as a tip (São Pedro).
	1	Recorded whether the fisher had any problems while fishing.
Fishing effort	2	Recorded all the fishing gears used by the fisher.
	2	Recorded the correct fishing gears.
	5	Recorded the type of fish caught with each gear.
	2	Recorded the times when the fisher was fishing with each gear.
	1	Recorded the number of times that the fishing gear was deployed (if relevant).
	1	Recorded the size of the hook or mesh, bait type and whether night lights were used (if relevant).
	5	Recorded length and depth of the net and the number of hooks and lines.
	5	Recorded all the species caught.
Catch	1	Recorded the correct species.
	3	Counted and weighed all the fish.
	2	Recorded the use given to the fish (consumption, salted, sold…)
	2	Recorded the correct prices
	2	Recorded the units used to sell the fish (kg? *n* fishes?)
Indicator species	1	Took a picture of the indicator species asked by the form.
	2	Took a picture of at least 10 fish.
	2	Took the picture from above and using the reference for size.

4.8. Annex VI: Assessment of Principe's data quality

Percentage of data properly collected in Príncipe during August and September, using the criteria described in Annex V.

Criterium	Community 1		Community 2		Community 3		Community 4		Community 5	
	Aug-19	Sep-19	Aug-19	Sep-19	Aug-19	Sep-19	Aug-19	Sep-19	Aug-19	Sep-19
Recording number of daily fishing trips and canoes and number of interviews conducted	100%	100%	100%	100%	100%	100%	80%	100%	100%	100%
General information of the trip	98%	100%	96%	99%	91%	96%	95%	100%	98%	100%
Fishing effort	100%	100%	85%	99%	66%	71%	89%	76%	71%	99%
Catch	99%	73%	93%	89%	94%	100%	100%	100%	86%	100%
Picture of the indicator species	27%	36%	55%	75%	22%	100%	68%	60%	20%	100%
TOTAL	92%	86%	87%	94%	76%	88%	90%	87%	76%	100%

Criterium	Community 6		Community 7		Community 8		Community 9		Community 10	
	Aug-19	Sep-19	Aug-19	Sep-19	Aug-19	Sep-19	Aug-19	Sep-19	Aug-19	Sep-19
Recording number of daily fishing trips and canoes and number of interviews conducted	100%	100%	100%	100%	20%	50%	100%	100%	100%	100%
General information on the trip	100%	100%	100%	100%	96%	100%	99%	99%	94%	99%
Fishing effort	98%	100%	63%	77%	75%	79%	82%	87%	67%	65%
Catch	92%	100%	83%	83%	50%	50%	97%	99%	84%	92%
Picture of the indicator species	33%	84%	60%	60%	80%	80%	72%	100%	0%	60%
TOTAL	90%	98%	77%	82%	66%	71%	89%	95%	72%	80%

4.9. Annex VII: Assessment of São Tome's data quality

Percentage of data properly collected in São Tomé in October 2019, using the criteria described in Annex V.

CRITERIUM	Com. 1	Com. 2	Com. 3	Com. 4	Com. 5	Com. 6	Com. 7	Com. 8	Com. 9	Com. 10
	Oct. 19	Oct. 19	Oct. 19	Oct. 19	Oct. 19	Oct. 19	Oct. 19	Oct. 19	Oct. 19	Oct. 19
Recording number of daily fishing trips and canoes and number of interviews conducted	8%	69%	7%	92%	76%	49%	75%	21%	1%	109%
General information of the trip	80%	97%	92%	100%	98%	95%	95%	54%	NO RECORDS	95%
Effort	87%	95%	92%	85%	97%	94%	100%	60%	NO RECORDS	100%
Catches	24%	95%	88%	99%	86%	88%	77%	0%	NO RECORDS	90%
Picture of indicator species	0%	76%	27%	80%	80%	78%	72%	0%	NO RECORDS	84%
TOTAL	52%	90%	71%	92%	89%	84%	86%	30%	1%	96%