

# Perceived Social Benefits and Drawbacks of Sea Turtle Conservation Efforts in a Globally Important Sea Turtle Rookery

Sara Vieira (✉ [a28980@ualg.pt](mailto:a28980@ualg.pt))

Universidade do Algarve

Victor Jiménez

Associação Programa Tatô

Betânia Ferreira-Airaud

Universidade do Algarve

Antunes Pina

Universidade de São Tomé e Príncipe

Venceslau Soares

Universidade de São Tomé e Príncipe

Manjula Tiwari

Research Affiliate of NOAA Southwest Fisheries Science Center

Maria A. Teodósio

Universidade do Algarve

Rita Castilho

Universidade do Algarve

Ana Nuno

NOVA University Lisbon

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## Research Article

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# Abstract

Conservation interventions have wide-ranging social impacts - both positive and negative. Yet a limited understanding of how conservation initiatives affect people's livelihoods often hinders our ability to learn from past efforts and design more effective and equitable conservation measures. This is particularly needed when there is a high degree of overlap between critical habitats and human activities or a high cultural and economic demand for products derived from the conservation target. Here, we explore the social impacts of sea turtle conservation initiatives implemented on São Tomé Island (Gulf of Guinea) as a case study and consider how these might enhance or hinder future efforts. Semi-structured interviews were conducted with key actors involved in the sea turtle trade in December 2014-February 2015 (prior to the implementation of key initiatives) and February-April 2022. Our findings suggest a clear reduction in the scale of the sea turtle trade and the number of main actors involved. However, most of the interviewees previously involved in the trade had experienced economic displacement and several associated social impacts, such as the reduced ability to support family and friends and food insecurity, due to trade restrictions. Financial capital was the main barrier to transitioning to alternative livelihoods, followed by the lack of skills and peer pressure. Finally, this study highlights the importance of considering human dimensions during the planning and implementation phase of conservation actions and the need for more investment focused on the well-being of communities to ensure the long-term survival of endangered species.

## Introduction

Research on the human dimensions of natural resource management and biodiversity conservation is increasingly recognised as an essential means of producing robust and effective policies, actions and outcomes (Bennett et al. 2017). Social considerations are crucial to the fairness and success of conservation strategies that do not negatively impact people (particularly the most vulnerable) and, ideally, generate tangible benefits for local communities and aim to improve human health and wellbeing (Chaigneau et al. 2019). Increasingly, conservation agencies, civil society organisations, donors, and academics are recognizing that conservation interventions have wide-ranging social impacts - both positive and negative - and that these should be robustly assessed (De Lange et al. 2016; Holmes and Cavanagh 2016).

Robust consideration of human dimensions has often been highlighted as a critical element for the success of sea turtle conservation due to the high degree of overlap between critical sea turtle habitats and human activities (Davenport and Davenport 2006), as well as the cultural and economic importance of sea turtle by-products (Liles et al. 2015, Rojas-Canizales et al. 2022). Sea turtle harvesting for human consumption is still considered a primary threat in many regions of the world (Senko et al. 2022), and illegal supply of sea turtle by-products is still a reality in local, regional and international markets (CITES 2019, Lopes et al. 2022). Despite the limited incorporation of social sciences in sea turtle conservation to understand threats and adopt sound management practices co-developed with relevant stakeholders (Godley et al. 2020), progress is being made, and increasing attention to interdisciplinary applications in

sea turtle conservation is delivering insightful results (e.g. Hancock et al. 2017, Delisle et al. 2018, Pakiding et al. 2020).

Worldwide, social interventions focused on local resource users' compensation, poverty alleviation and/or livelihood diversification have been implemented in an attempt to curb the illegal sea turtle trade (Ferraro and Gjertsen 2009, Marcovaldi and Marcovaldi 1999, Sardeshpande and MacMillan 2019). Some of the most widely used interventions include alternative livelihoods programmes, incentive-based approaches to influence sea turtle users' behaviour and community-based ecotourism initiatives (Sardeshpande and MacMillan, 2019). Despite their potential role in promoting behavioural change and long-term solutions to unsustainable sea turtle trade, challenges to their successful implementation generally abound. For example, several projects face multiple barriers, including incompatible alternative livelihoods, inequitable benefit distribution, and economic displacement (i.e., loss of assets or access to assets that leads to loss of income sources or livelihoods) as a result of resource access restrictions and potentially associated factors, highlighting the need for robust assessment of the social impacts of these interventions (Aguilar-González et al. 2014, Campbell 2007, Meletis and Campbell 2009).

In this case study, we focused on conservation efforts to reduce the trade in sea turtle by-products on the island of São Tomé (São Tomé and Príncipe). The country hosts important breeding and feeding grounds for five of the seven species of sea turtles currently found over the world, all of them listed on the IUCN Red List of Threatened Species (Castroviejo et al. 1994, IUCN 2022). However, the unsustainable harvest of sea turtles has been identified as a major national threat to their conservation (Ferreira-Airaud et al. 2022). Intentional capture of sea turtles on the island appears to have declined recently due to a mix of top-down governance instruments and bottom-up conservation strategies focused on the social and economic well-being of some of the sea turtle trade's main actors (Ferreira-Airaud et al. 2022). Yet, similar to many sea turtle conservation initiatives worldwide (Godley et al. 2020), the range and magnitude of social impacts related to sea turtle conservation remain poorly assessed. This study thus aimed to explore the social impacts of sea turtle conservation on the island and consider how these might enhance or hinder future efforts. We began by characterising the sea turtle exploitation and trade on the island at the start of these interventions (i.e. 2014), and assessed how this had changed in the subsequent eight years, including potential socioeconomic differences among those involved in the trade. We then identified barriers to transitioning to alternative livelihoods and factors potentially associated with promoting or hindering conservation impacts, such as awareness and involvement in decision-making. In light of recent efforts to improve marine conservation in this under-studied region, these data are essential for the development and implementation of conservation strategies to protect threatened marine species.

## Methods

### Study area

The Democratic Republic of São Tomé and Príncipe (STP) is an archipelago composed of two islands, São Tomé and Príncipe, located in the Gulf of Guinea, West Africa (between 0° 15' and 1° 36' N and 6° 36' and 7° 23' E; Fig. 1). This Small Island Developing State (SIDS) has a population of approximately 210,000 people, mostly living on the main island of São Tomé (INE 2020). As the second smallest economy in Africa based on an agrarian economy, STP relies on subsistence farming and fisheries, with two-thirds of the population living in poverty and nearly one-half (47%) of the population living in extreme poverty (INE 2020). Artisanal fishing employs 10% of the working population, and fish consumption rates are among the highest in the world (57.8 kg capita<sup>-1</sup> year<sup>-1</sup>; Belhabib et al. 2015). Limited fisheries monitoring and enforcement, high levels of poverty, gradual decline in fish abundance and growing demand for animal protein linked to a rapid human population growth (1.92% per year; INE 2020) have contributed to the use of less selective and more destructive fishing practices by the local communities as well as the harvest of endangered species, leading to the progressive degradation of marine ecosystems (Maia et al. 2018, Nuno et al. 2021, Zacarias et al. 2022).

## Key social efforts for sea turtle conservation in São Tomé

STP is regionally and globally important for sea turtles, particularly for the green (*Chelonia mydas*) and the critically endangered hawksbill (*Eretmochelys imbricata*) sea turtles. In particular, the archipelago is home to the last significant hawksbill rookery in the Eastern Atlantic, being among the top 11 sea turtle conservation priorities worldwide (Wallace et al. 2011). Sea turtles have been traditionally exploited for commercial, cultural and subsistence reasons, and their exploitation and trade represented a significant source of income for local communities (Fretey 2001, Kingshott 1995). Currently, there is still a high demand for sea turtle meat and eggs in both rural and urban communities of the main island of São Tomé (Veríssimo et al. 2020).

Sea turtle conservation efforts in São Tomé started in the 90s (Graff 1996). In 1998, ECOFAC, the European Commission Program for the Conservation and Sustainable Use of Forest Ecosystems in Central, established “Programa Tatô”, handing its coordination over to the national NGO MARAPA (Mar, Ambiente e Pesca Artesanal) in 2002 – an initiative to monitor sea turtle populations, develop conservation and research actions and lobby the government to implement a sea turtle protection law (Formia et al. 2003; “Programa Tatô” became an independent NGO in 2018, Ferreira-Airaud et al. 2022). In the early 2000s, several sea turtle conservation initiatives were implemented to promote behavioural change through financial compensation and alternative livelihood opportunities. Specific measures included: an incentive payment per live turtle harvested on nesting beaches or at sea, mainly focused on fishers and traders; professional reconversion especially targeting tortoiseshell crafters; access to loans for complementary sources of income; and the acquisition of all stocks of scales and manufactured objects as compensation for professional reconversion (Fretey and Dontaine 2001). None of those approaches succeeded due to financial constraints, inequitable loan distribution, lack of effective professional reconversion follow-up and the absence of a sea turtle protection legal framework (Ferreira 2015, Ferreira-Airaud et al. 2022). The Santomean government approved national legislation in 2014

(Decreto-Lei n. 8/2014, of 28 April), criminalising sea turtles' possession, trade and transportation. However, enforcing environmental laws also brought significant challenges, with competent institutions often lacking the technical capability and means to apply legislation effectively (Vieira et al. 2016).

Since 2014, Programa Tatô has made substantial efforts to understand the drivers of sea turtle trade and consumption in São Tomé (Veríssimo et al. 2020), including an ongoing conservation marketing campaign aimed at reducing the consumption of sea turtle meat and eggs (Thomas-Walters et al. 2020); identified and promoted viable alternative livelihoods for the main actors of sea turtle trade, including sea turtle data collection (e.g. the conversion of harvesters into beach patrollers and in-water monitors) and handmade crafts production (e.g. association of former women sea turtle traders trained on the production of souvenirs); and led initiatives to improve law enforcement strategies (Ferreira-Airaud et al. 2022, Vieira et al. 2017).

## Data collection

Face-to-face semi-structured interviews were conducted with key actors involved in the sea turtle trade on São Tomé Island. An initial data collection phase occurred between December 2014 and February 2015 to gather information on the temporal and spatial trade of sea turtle by-products. Although the sea turtle protection legal framework was approved in April 2014, systematic enforcement only began in 2017 (Thomas-Walters et al. 2020). A follow-up study was conducted between February and April 2022 to explore how conservation efforts had affected the trade of sea turtle products and these same groups of actors over the past eight years, including potential changes in socioeconomic status and perceptions about sea turtle conservation initiatives. The first survey was divided into two sections: sociodemographic characteristics of the respondents (i.e., age, gender, education level, household size, place of residence, monthly revenue – which may represent different economic activities besides sea turtle trade, and main occupation); and individual involvement in sea turtle trade and description of temporal and spatial trade and sale patterns of sea turtle by-products (Appendix 1 - Interviews and survey scripts). The price for an entire turtle usually refers to the amount customers pay on the beach. The by-products are sold directly on the beach, in coastal communities and in the main market. The second survey was composed of five sections: sociodemographic information; awareness and perceptions about sea turtle conservation efforts; individual involvement in sea turtle trade and description of temporal and spatial trade of sea turtle by-products in the past (approximately ten years ago) and in the present; opportunities of the transition to alternative livelihoods; and perceived economic impacts of sea turtle conservation efforts, including changes in monthly income and main occupation, and potentially associated factors, such as interpersonal relationships with family and neighbours (Appendix 1 - Interviews and survey scripts). The first survey took place in 12 coastal communities and in the main market of São Tomé City, where sea turtles are more regularly available for purchase (Fig. 1). These communities were selected because they are adjacent to important turtle nesting beaches and aggregations in coastal waters where sea turtle harvesting is known to happen (Programa Tatô 2021). The second survey took place at similar locations.

Six main types of suppliers of sea turtle by-products in São Tomé were approached for participation in our study (for a study on the consumer side of this trade, see Veríssimo et al. 2020). Snowball sampling (Goodman 1961) was used to ensure adequate representation of informants from each key stakeholder group: non-intentional fishers, including randomly selected fishers; intentional turtle fishers, including fishers employing a specific technique to catch sea turtles using a large hook, lashed onto a long pole (described by Graff 1996) and spearfishers considering sea turtles as their main target species; beach harvesters; beach traders; market traders; and tortoiseshell crafters. This was done by pre-selecting key informants from the personal and professional networks of the NGOs Programa Tatô and MARAPA team and asking those contacts, as well as other subsequent participants, to recommend additional participants with relevant knowledge and experience (Bottrill and Pressey 2012). When a point of data saturation was reached (i.e. when additional interviews provided no new substantive information), the sampling was ceased (Guest et al. 2006). On average, interviews lasted 35 minutes. Only respondents over 18 years old were eligible for participation in this study.

During the second survey phase, a similar sampling approach was employed. In addition to people currently involved in the sea turtle trade, we also aimed to interview people who were no longer involved; the following groups were thus considered: non-intentional fishers, including randomly selected fishers; former intentional turtle fishers, including fishers that were employing a specific technique to catch sea turtles and former spear fishers considering sea turtles as their main target species in the past; former and actual beach harvesters; former and actual beach traders; former and actual market traders; and former tortoise shell crafters.

For both study phases, the survey was conducted within participants' homes, in a mixture of Portuguese and *Forró* creole by one researcher affiliated with Programa Tatô and one local Santomean student affiliated with the University of STP; one acted as a facilitator while another took notes, aided in communication and was responsible for recording to allow transcription. While the direct involvement of a Programa Tatô representative in the interviews can be seen as a potential source of bias (particularly during the follow-up study), access to these particular and relatively small groups of people required previous relationships and a sense of trust; relying on a neutral but external person was deemed not viable (see Discussion for further considerations). Five pilot interviews in each study phase were performed in the city of São Tomé, based on which minor adjustments to the format of several questions were made prior to both stages. This pilot data was not included in any further analysis.

No identifying information was collected from respondents, so we could not link answers between the two different stages of the study to specific individuals. Before beginning each interview, participants were verbally informed of the anonymity of their responses. The study's purpose was explained to the participants, confidentiality was ensured, and consent was recorded during the interviews. All the interviews were recorded and subsequently transcribed by hand. This research was approved by the STP's National Statistics Institute (027/INE/MPFEA/2022) and the Ethics Committee at the University of Algarve, Portugal (reference CEUAlg Pn°8a/2022).

## **Data analysis**

Responses to closed questions were analysed as frequencies. To investigate the main sea turtle trade paths for sea turtle products in São Tomé Island in 2014 and 2022, we built comparative transaction flow diagrams between main actors based on how frequently different transactions were reported for each study phase. The thickness of the arrows corresponds to the relative magnitude of each trade path between the main actors (Tagg et al. 2018).

Consumer price index (CPI), one of the most widely used price measures to adjust wage/payment rates for the effects of inflation over a certain period (Bryan and Cecchetti 1993), was used to adjust economic data collected in 2014 (i.e., monthly revenues and prices of sea turtle by-products). Before running statistical models, we used Generalised Variance Inflation Factors (GVIFs) to check for multicollinearity between explanatory variables. All variables (Table S1 - Summary of the main characteristics of study participants in 2014 (n = 302) and 2022 (n = 86) per key actor of sea turtle trade type (GVIFs < 3) were within acceptable norms (i.e., GVIFs < 3) (Thomas et al. 2013). We used a generalised linear model (GLM) with a gamma error distribution to compare the monthly revenues of sea turtle main actor types in 2014 (adjusted for inflation) and 2022. All statistical analyses were done in R 4.1.2 (R Core Team 2021).

Responses to open questions (i.e., perception of sea turtle conservation efforts carried out in the country, impacts on interviewees' livelihood and main barriers to transit to alternative livelihoods) were categorised using an inductive approach in which summary themes were created by examining the data (Elo and Kyngäs 2008) and then analysed as frequencies.

## Results

### Characteristics of study participants

We conducted 388 interviews: 302 respondents took part during the first stage in 2014–2015 and 86 during the follow-up stage in early 2022. Sample sizes vary per stakeholder group and study phase: non-intentional fishers ( $n_{2014} = 202$ ,  $n_{2022} = 28$ ); intentional turtle fishers ( $n_{2014} = 24$ ,  $n_{2022} = 8$ ); beach harvesters ( $n_{2014} = 20$ ,  $n_{2022} = 9$ ); beach traders ( $n_{2014} = 21$ ,  $n_{2022} = 10$ ); market traders ( $n_{2014} = 20$ ,  $n_{2022} = 23$ ); and tortoiseshell crafters ( $n_{2014} = 15$ ,  $n_{2022} = 8$ ).

Based on interviews during the first survey phase, harvesting of sea turtles in São Tomé was generally carried out by fishers, and the sale of sea turtle by-products was mostly by fishmongers, locally known as “palaiês” (a job predominantly carried out by women). In our 2014–2015 interviews, all respondents were involved in the sea turtle trade, except eight fishers who mentioned releasing sea turtles alive into the water when incidentally caught in their gear. In contrast, only 20 respondents interviewed in 2022 reported current involvement in the sea turtle trade (namely, eight beach harvesters, two fishers, five beach traders and five market traders). Thirty-five of the recent 86 respondents reported having access to alternative livelihoods unrelated to fishing (e.g. tourism and sea turtle conservation), and 32 reported fishing as their primary occupation. A summary of key sociodemographic characteristics of participants is provided in table S1.



# Harvesting and trade of sea turtles on São Tomé Island

Based on our initial interviews, sea turtles were caught by beach harvesters during the nesting season, and by fishers all year round. Intentional capture of sea turtles was performed mainly by intentional turtle fishers and spearfishers around the island. However, most of the interviewed fishers reported unintentional or opportunistic captures while individuals were mating or resting on the surface and were mostly captured by drifting gillnet and purse seine fisheries. Most of the harvested turtles (which almost every fisher reported selling instead of using for direct consumption) were sold to beach traders (usually women living in the fisher's community), who would then sell them to market traders or a lesser extent, to their neighbours (Fig. 2a). Market traders were the main suppliers of sea turtle by-products, mainly meat and eggs, to the general consumers and other market traders. Specifically for hawksbill turtles, tortoiseshell crafters would buy sea turtle shells, mainly from the market traders. Although these crafts were mostly destined for tourists, a considerable amount was sold to local consumers and Santomeans living abroad. In addition, sea turtle bones were also reported to be bought by traditional doctors to produce traditional remedies (Table S2 - Interviewees' main livelihoods in 2014 and 2022).

**Figure 2.** Main actors and trade paths for sea turtle products in São Tomé Island in 2014 (a) and 2022 (b). Comparative transaction flow diagrams between the main actors of sea turtle trade in São Tomé were built based on how frequently different transactions were reported. The thickness of the arrows corresponded to the relative magnitude of each trade path between the main actors: thicker lines indicate the main trade flow and thinner lines indicate secondary flows.

In 2014, most fishers (hereby referring to both non-intentional and intentional turtle fishers) self-reported relatively high annual capture rates (20 turtles or more per year reported by 156 fishers; 71% of those interviewed), with 42 (19%) reporting medium (10–20 turtles per year) and 23 fishers (10%) reporting low annual off-take (1–10 turtles per year). Based on the capture rates reported by all fishers and beach harvesters, we estimate an annual harvest between 3 and 160 sea turtles per person (Fig. S3 - Number of sea turtles traded per year reported by each main actor type in 2014. The bars represent the interquartile range (IQR) and the horizontal bar the median values). According to these respondents, turtles were generally harvested opportunistically (197 of all 226 fishers surveyed), mainly to cover extra expenses related to boat fuel or when fish catch or associated income was low. Typical products traded included: whole turtles, turtle meat, eggs, bones and scutes. According to all main actors groups interviewed, prices were generally determined by species and turtle size rather than seasonal availability (Table S4 - Prices for sea turtles and their by-products in 2014. The price for an entire turtle usually refers to the amount customers pay on the beach. The by-products are sold directly on the beach, in coastal communities and in the main market). Although turtle harvesting was not considered a primary source of income for most beach harvesters and fishers, 23 traders (56%) and 14 crafters (93%) reported the sale of sea turtle by-products as their primary livelihood.

Based on 20 interviewees reporting present involvement in sea turtle trade, sea turtle trade is currently done clandestinely. Beach harvesters and unintentional fishers captured sea turtles and generally sold

them to traders living in their community (Fig. 2b). Sea turtles caught by fishers are killed at sea; the meat is transported in black plastic bags and sold to traders. Whereas sea turtles captured by beach harvesters are sold alive to beach or market traders and then killed. Turtle meat is sold to their neighbours or on the streets of small rural communities; however, four traders reported that they directly contact clients by phone to arrange a pick-up time and place, which can be at their home or at the main market. Those clients may be local consumers or other trusted market traders. Finally, the sale of typical meals cooked with sea turtle meat and eggs at home was reported by one beach trader. In contrast to what was reported by the main actors interviewed in 2014, the only traded product mentioned in 2022 was sea turtle meat. Apparently, the price is no longer determined by species or turtle size. Based on the information provided by 20 respondents, the current price of a sea turtle flipper varies between 250 and 300 STN (€10 and €12, respectively).

## Perceived economic and other social impacts

All respondents surveyed in 2022 were aware of at least some sea turtle conservation efforts in São Tomé during the last decades (see results below). When asked about potential changes in their income since the conservation efforts started, 52 respondents (60%) stated that their income had decreased, 27 (31%) said they did not experience any change, and 7 (8%) said they had seen an increase. In addition, when comparing self-reported income obtained from data collected in 2014 (after adjusting for inflation) and 2022, crafters earned the highest monthly income compared to the other main actor types in 2014 (Fig. 3) and experienced the most negative economic changes since then (their monthly income decreased 94% since conservation efforts started;  $p < 0.01$ ). These changes were followed by market and beach traders, who reported decreases of 36% and 34%, respectively, and unintentional and intentional turtle fishers reporting decreases of 31%, and 27%, respectively (all  $p$ -values  $< 0.01$ ). Only beach harvesters experienced a non-significant increase in monthly revenue (16% increase;  $p = 0.46$ ).

Other types of self-reported social impacts described by study participants in 2022 included, for example, an increase in their knowledge of marine biodiversity and the ecological importance of sea turtles for the sustainability of marine ecosystems (reported by 56 out of 86 interviewees) and economic displacement: 27 respondents mentioned completely changing their professional activity, and 19 reported having invested in complementary sources of income as a compensation strategy, such as agriculture, pig farming or handcrafts production. According to most of the fishers interviewed, they did not have to change their main occupation. They simply had to stop trading in sea turtles, focusing their fishing efforts on other marine species and releasing any sea turtle accidentally caught on their fishing gear. Similarly, most sea turtle traders invested in selling only fish, particularly salted or smoked. Nevertheless, this relatively easier transition also brought some challenges. For example, according to one of the interviewees who traded in sea turtles on the main market of São Tomé for more than 25 years and reported having abandoned this activity in 2016, selling fish was considerably more difficult than sea turtle meat due to intense competition among traders, and aggravated by the lack of training and limited professional opportunities in coastal communities. Reduced income and economic displacement brought several associated social impacts, such as food insecurity, reduced ability to support family and friends,

and reduced assets; Table 1 summarises specific impacts (labelled as positive or negative, when relevant, except for economic displacement as it can cause some degree of expansion or reduction in a certain economic activity) and provides illustrative quotes.

Table 1

Main types of changes associated with social impacts experienced by interviewees since conservation efforts started, with illustrative quotes.

Type of experienced social impact		Frequency (out of 86)	Illustrative Quotes
Knowledge and Education	+	56	<p><i>"Today I know sea turtles are not a normal fish. They ensure the health and the balance of our oceans"</i> (Fisher)</p> <p><i>"My son learned at school that we shouldn't eat sea turtles, because they ensure the productivity of our seas and it is forbidden by law"</i> (Market trader)</p>
	-	38	<p><i>"Today I have less financial ability to help my family and friends"</i> (Market trader)</p>
Ability to assist family and friends	+	7	<p><i>"Today I think I have more means to help my family and also Programa Tatô gave me knowledge on how to manage my money and to take care of my family"</i> (Turtle Intentional Fisher)</p>
	-	37	<p><i>"All the money that I got from the selling of sea turtle by-products was invested in my house and to raise my kids. Today I don't earn enough money to invest in my house or in myself. All the money I get nowadays is to buy food and to pay daily expenses"</i> (Market trader)</p> <p><i>"All the money I get from selling fish and working in Programa Tatô is to buy food and to pay daily expenses. I have to ask for "fiado" [to buy on credit] to ensure my family's daily expenses. In the past, I would never have to ask for "fiado"</i> (Market trader)</p> <p><i>"I have less things now. I started to earn less money when I started to give training to other crafters to learn how to work cow horn, instead of producing tortoiseshell handcrafts, a project of Santa Casa da Misericórdia in partnership with the Embassy of Brazil"</i> (Tortoiseshell crafter)</p>
Income and assets	+	15	<p><i>"For the first time in my life, I have a monthly salary that allows me to invest in my house and think about the future. In the past, I was going to fish or harvest sea turtles daily to ensure the dinner of each day"</i> (Beach harvester)</p>
	-	28	<p><i>"During the first months after I stopped selling sea turtles, my family and I had a hard time. I was not making sufficient money to put food on the table like I used to and we always had sea turtles to eat at home. It were really difficult times for me and for my family"</i> (Market trader)</p> <p><i>"Today I have to ask for help or "fiado" [to buy on credit] to ensure food in the table every day"</i> (Market trader)</p> <p><i>"Well, we have to buy cheaper fish to put at home... We weren't hungry but things changed a lot for me and my family"</i> (Beach harvester)</p> <p><i>"Now I cannot buy meat every week"</i> (Tortoiseshell crafter)</p>
Food Security	-	28	<p><i>"During the first months after I stopped selling sea turtles, my family and I had a hard time. I was not making sufficient money to put food on the table like I used to and we always had sea turtles to eat at home. It were really difficult times for me and for my family"</i> (Market trader)</p> <p><i>"Today I have to ask for help or "fiado" [to buy on credit] to ensure food in the table every day"</i> (Market trader)</p> <p><i>"Well, we have to buy cheaper fish to put at home... We weren't hungry but things changed a lot for me and my family"</i> (Beach harvester)</p> <p><i>"Now I cannot buy meat every week"</i> (Tortoiseshell crafter)</p>

Type of experienced social impact	Frequency (out of 86)	Illustrative Quotes
	+ 9	<i>"Today I have more means to ensure food on the table to my family, not only because I have several sources of income, but also because I have a monthly salary as a sea turtle ranger and as a crafter in the Productive Group of Programa Tatô"</i> (Beach harvester)
Economic displacement	27	<p><i>"I stopped selling sea turtle by-products and started to sell fresh and salt fish and nowadays I sell clothes and work for Programa Tatô"</i> (Market trader)</p> <p><i>"I stopped selling sea turtles and started to work as a sea turtle ranger, in the Productive Group, selling fish, investing in agriculture and selling "cacharamba" [local sugar cane brandy]"</i> (Beach harvester)</p> <p><i>"Now besides being a fisherman, I am also a beach ranger. In the past I would bring every sea turtle that I would see resting on the surface, but today I protect them"</i> (Fisher)</p> <p><i>"I had to stop to produce tortoiseshell products and to fully dedicate my time to agriculture"</i> (Tortoiseshell crafter)</p>

## Access to alternative livelihoods

Sixty-six out of 86 interviewees in 2022 reported abandoning activities associated with the sea turtle trade as their main livelihood. While 35 interviewees reported now having access to livelihoods not related to fishing, such as tourism and sea turtle conservation, 51 mentioned that financial capital was the main obstacle for transitioning to alternative livelihoods, followed by the lack of skills, pressure from others and the lack of tools (Table 2). For example, according to one of the interviewees who worked as a tortoiseshell crafter for more than 20 years, all the 45 members of the Association of the Tortoiseshell Crafters had been trained to replace the tortoiseshell with cow horn as raw material. Nevertheless, less than ten crafters had the means to import cow horns and the necessary tools to work this material. Some respondents were more optimistic about this transition. For example, one former intentional turtle fisher stated that there were "lots of options" for livelihoods, such as souvenir trading, tour guiding and driving tourists with their boats. Another interviewee who worked as a sea turtle beach ranger said: "It was not easy in the beginning because I needed time and patience to learn how to collect scientific data and fill datasheets on sea turtle ecology and biology, but nowadays I am actively involved in sea turtle conservation, and I am economically better off because of that" (former beach harvester, 2022).

Several interviewees who had abandoned the sea turtle trade as their main livelihood reported peer pressure as an important barrier. Twenty-four per cent of the interviewees who had abandoned the sea turtle trade (n = 66) reported they had felt social pressure from their neighbours to not stop trading in sea turtles. Additionally, interviewees who had abandoned the sea turtle trade between 2016 and 2018 and got involved in sea turtle conservation actions (n = 23) commonly expressed how difficult it was to handle interpersonal relationships, as summarised by one former beach harvester who said: "In the beginning,

my family didn't agree with my involvement in the sea turtle conservation project as a beach ranger since you get many enemies in your community". Nevertheless, 20 interviewees who continued to be involved in the sea turtle trade also had experienced interpersonal consequences, mainly with their families, as summarised by a beach trader who said: "I have been having conflicts with my family during the past two years because they are afraid I might be arrested".

Table 2

The main types of barriers to alternativelivelihoods identified by the interviewees, with illustrative quotes.

Barriers	Frequency (out of 86)	Illustrative Quotes
Monetary	51	<i>"It was really difficult to learn how to sew and do handcrafts. Also, we were working a lot of hours per day and I didn't get money every day as I used to get when I was selling sea turtles. We just get money on the end of the month"</i> (Market Trader)
Lack of skills / Low Literacy	33	<i>"The main obstacle to start working as a beach ranger was learning how to collect data and fill the datasheets"</i> (Fisher)  <i>"The main obstacle to start working as a marine technician was learning how to catch a sea turtle without any fishing gear"</i> (Turtle Intentional Fisher)  <i>"It was not easy in the beginning because I didn' know how to do other activity besides selling sea turtles. I tried to sell fish first but I didn't have buyers. I also had to struggle a lot to learn how to produce crafts in Programa Tatô, because it was the first time that I was doing something similar, but with time and patience I learned and now I am really happy to do this work"</i> (Market Trader)
Pressure from others	23	<i>I suffered a lot of pressure from my family to not stop selling sea turtles. Also the people from my community were making fun of me when I started to sell fresh fish and clothes"</i> (Beach Trader)  <i>"It was not easy in the beginning because I needed to learn things that I had never done before and I also started to earn much less money. I suffered a lot of pressure from other traders and from the tortoiseshell crafters. They were my best clients"</i> (MarketTrader)
Lack of tools	6	<i>"The main obstacles to develop an alternative livelihood were the lack of tools to work the cow horn and difficulties to import it"</i> (Tortoiseshell crafter)

## Potential factors associated with sea turtle conservation impacts

Regarding awareness about specific sea turtle conservation efforts on the island, the approval of a sea turtle protection law (n = 84), the development of the social marketing campaign Tataluga Mém Di Omali (n = 61) and the involvement of local communities (n = 42) were the most commonly cited among respondents in 2022. In addition, when asked about sea turtle abundance at sea, 94% reported an

increase over the last ten years, with 5% reporting it had decreased and 1% reporting no change. Furthermore, all participants stated that the levels of sea turtle harvesting had decreased during the last ten years. The implementation of legislation was perceived as the main deterrent measure to restricting sea turtle trade, being reported as the main reason for stopping trading in sea turtles by 58 interviewees (67% of all actors surveyed in 2022); this was followed by eight reporting the increased knowledge on the importance of sea turtle conservation to ensure the long-term sustainability of marine resources. For example, when considering why conservation efforts were being implemented in São Tomé, 77% of the respondents mentioned that too many sea turtles were being harvested, so the governmental institutions had to implement a law to protect them; otherwise, these species would disappear.

When asked about their involvement in the sea turtle protection legislative process, 77% of the respondents mentioned they did not feel involved, and 85% stated their interests and concerns had not been considered, as summarised by a tortoiseshell crafter who said: “I have been dedicated to the tortoiseshell crafter since I was 14 years old and my grandfather was one of the best artists of São Tomé and Príncipe. Now, we will not be able to continue our legacy. I cannot believe that our government could not start a dialogue with us before the approval of the national sea turtle protection law. This is not the correct way of doing things when hundreds of families depend on this resource as a main source of income”. Furthermore, other factors potentially undermining support for sea turtle conservation efforts include a perceived lack of conservation benefits to themselves (44 out of 86 interviewees, as summarised by a market trader who said: “I felt sad and angry because sea turtle was my main business! I was an expert on sea turtle trade, one of the main sea turtle traders in the country”); and loss of cultural heritage (8 interviewees; as summarised by a tortoiseshell crafter: “I felt angry and frustrated, and I am still angry because that had been my work since ever and this art has been in my family for three generations”).

## Discussion

Despite two decades of targeted interventions to improve the conservation status of sea turtle populations in São Tomé and Príncipe, this study provides the first comprehensive assessment of socioeconomic impacts related to sea turtle conservation efforts in the country. Our findings suggest that, since the implementation of the sea turtle protection legal framework in 2014 and the ongoing conservation efforts, the scale of sea turtle trade and the number of key actors involved has clearly decreased. Moreover, most of the interviewees previously involved in the trade had experienced economic displacement and several associated social impacts, such as the reduced ability to support family and friends and food insecurity, due to trade restrictions. Nowadays, the island's most traded sea turtle by-products originate from bycatch in fishing gear. However, some participants reported targeted takes when the animals are mating or resting at the surface. As in many developing countries, the lack of adequate law enforcement and surveillance at sea and at landing sites makes trade in sea turtles generally unnoticed and difficult to assess. Further research is essential to assess the ecological impact of this illegal harvesting and trade linked with the impact of incidental captures at sea.

One of the bottom-up conservation strategies implemented on the island was focused on the social and economic well-being of some of the main actors in the sea turtle trade, mainly traders, former beach harvesters and intentional turtle fishers. This study found that most of those interviewed perceived a reduction in their income as a result of the implementation of sea turtle conservation measures, particularly tortoiseshell crafters. This activity, developed by highly specialised crafters using skills passed down from generation to generation, used to generate higher income returns than any other sea turtle trade activity. Meanwhile, most of the traders and fishers interviewed argued that they could catch or trade in other marine species besides sea turtles and most of the harvesters are currently working with the sea turtle conservation project. This highlights an unequal burden of conservation impacts on different groups of people, with conservation initiatives failing to minimise negative social impacts across all involved. Inequalities are often neglected in conservation but inequalities originating from conservation actions may be a continuation of underlying structural inequalities already present in the community (e.g. related to differential access to education and wealth levels or occupations; Peterson 2015). It is essential that these are increasingly assessed and addressed. This requires, for example, understanding how certain initiatives make some groups disproportionately vulnerable to changes in policy, environment or social context, and directly addressing the underlying structural inequalities that cause them (Peterson 2015).

Despite the economic displacement and associated social impacts reported by the study participants, many perceived conservation efforts positively. This may be linked to improvements in their knowledge of the importance of sea turtle conservation, following the launch of a national social marketing campaign aimed at influencing consumer behaviour and reducing the demand for sea turtle by-products (Thomas-Walters et al. 2020). Despite encouraging conservation outputs in terms of reduced sea turtle harvest in recent years (Programa Tatô 2022), the process of transitioning to alternative livelihoods appeared to be perceived as hard and challenging by local communities. Similar to interventions in developing countries around the world (e.g. Aguilar-González et al. 2014, Campbell 2007), financial capital was the main barrier to transitioning to alternative livelihoods, followed by a lack of skills, pressure from others and a lack of tools. Furthermore, while many expressed an understanding of the motivation behind the conservation efforts, the perceived lack of benefits or compensation was one of the main drivers of negative perceptions and unfairness of conservation efforts. In addition, perceptions related to cultural heritage appeared to potentially undermine support for sea turtle conservation efforts among former tortoiseshell crafters. This finding reflects the risk of neglecting a wide range of social and cultural values important to communities, in addition to those associated with income, which may influence the users' perceptions and compliance (Delisle et al. 2018). This study highlights the usefulness of an in-depth analysis of perceptions to determine potential causes of lack of support and to identify appropriate interventions to ensure long-term support and subsequent success of conservation efforts (Bennet 2016). Nevertheless, we acknowledge that some bias may have been introduced into this study as one of the interviewers who conducted both phases of data collection was a researcher affiliated with Programa Tatô. While being aware of potential social desirability biases affecting the information being reported by respondents, access to these small groups of people involved in the sea turtle trade required



interpersonal trust between the researcher and the participants to ensure people's willingness to answer our questions. Building rapport and trust with key individuals over time was essential, and the lead author's understanding of the local context, based on years of work experience in the area, was considered crucial to overcoming potential challenges in data collection. Potential concerns could be addressed by using multiple data sources to validate our findings and specialised questioning techniques, reducing the risk of bias (Nuno and John 2015). For example, the reduction in sea turtle harvest reported in this study was also noticeable from other types of evidence, including nesting beaches monitoring and self-reporting by-catch data (Programa Tatô 2022).

Notwithstanding the social impacts identified in this study, some of these were positive (e.g. widespread improvements in knowledge as well as access to livelihood opportunities and income for some individuals). Nevertheless, the encouraging conservation results recorded in recent years in terms of reduced sea turtle harvest appear to have been achieved through a combination of factors not necessarily related to the social and economic well-being of the former main actors in the sea turtle trade. These are likely to include improved law enforcement, the implementation of a social marketing campaign, the involvement and capacity building of former key actors in sea turtle conservation activities, and strengthened biological monitoring efforts (Ferreira-Airaud et al. 2022, Thomas-Walters et al. 2020). The long-term survival of these endangered species in the study area requires further work to develop comprehensive and innovative educational and socioeconomic activities aimed at improving the social and economic well-being of local communities while achieving sea turtle conservation goals.

Combining social progress with environmental protection is one of the great challenges of our time, especially in remote areas that face many more development challenges (Fischer et al. 2021). Given the challenges faced by coastal communities of São Tomé and other SIDS around the world, including socioeconomic vulnerability, lack of job opportunities, low levels of education and gender inequality (Ferreira-Airaud et al. 2022), sustainable sea turtle conservation strategies need to be designed as part of an integrated development plan for the country. Stakeholder engagement and collaborative networks that bring together representatives from local communities, government, private sector and NGOs are essential, following the basic principles of sustainable development (Kapurusinghe 2021). Globally, we must promote inclusive approaches to sea turtle conservation that effectively contribute to the ecological integrity and resilience of marine ecosystems and associated coastal communities. This will be benefit from an integrated consideration of sociocultural, economic and natural assets, as well as more robust evaluations of past interventions. Only by learning and sharing what works and what does not work in conservation, will we be able to make informed decisions for improved social and environmental outcomes (Catalano et al 2018).

## **Declarations**

### **STATEMENTS AND DECLARATIONS**

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### **Conflicts of interest**

S.V. and B.F-A are pro-bono members of the Board of Directors of Associação Programa Tatô, and V.J. is an employee of Associação Programa Tatô. There are no other conflicts of interest to declare.

### **Author Contributions**

A.N., B.F-A, S.V. and V.J. conceived the intervention and designed methodology; S.V., V.J., A.P. and V.S. collected the data; S.V. analysed the data; S.V. and A.N. conceptualised the manuscript framing; A.N. and S.V. led the writing of the manuscript; R.C., M.T. and M.A.T reviewed the manuscript. All authors contributed critically to the drafts and gave final approval for publication.

### **Ethical standards**

This research was approved by the STP's National Statistics Institute (027/INE/MPFEA/2022) and the Ethics Committee.

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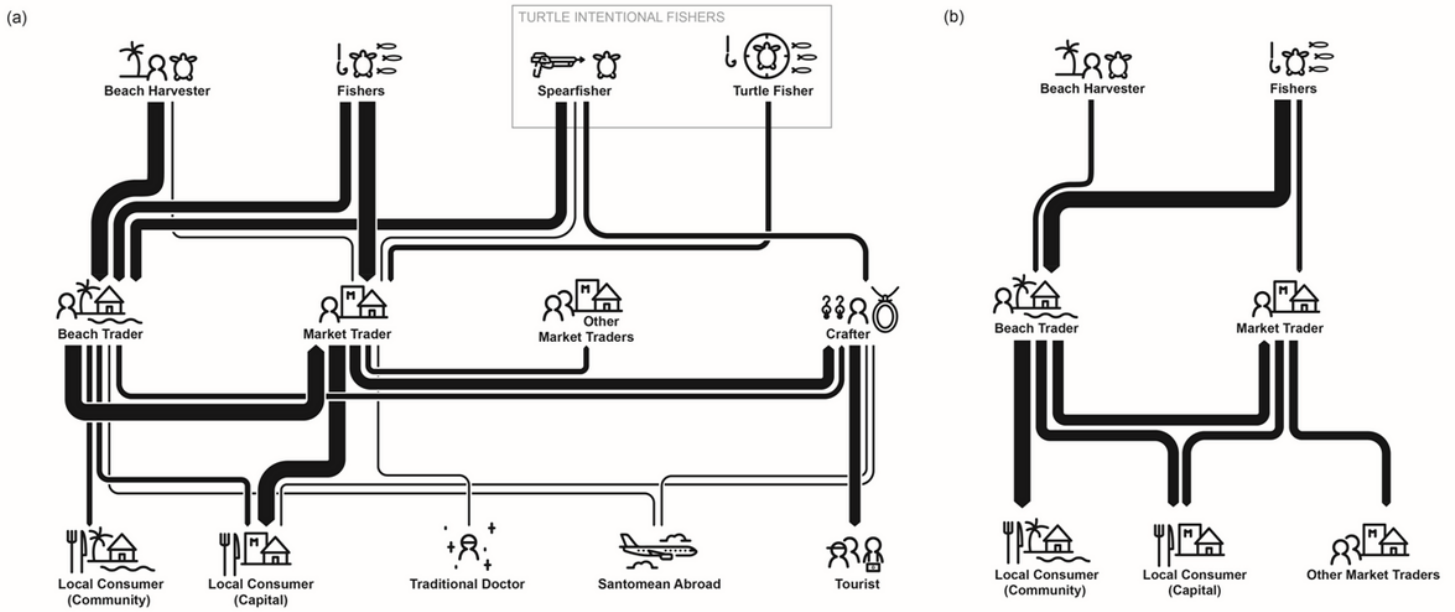
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## Figures



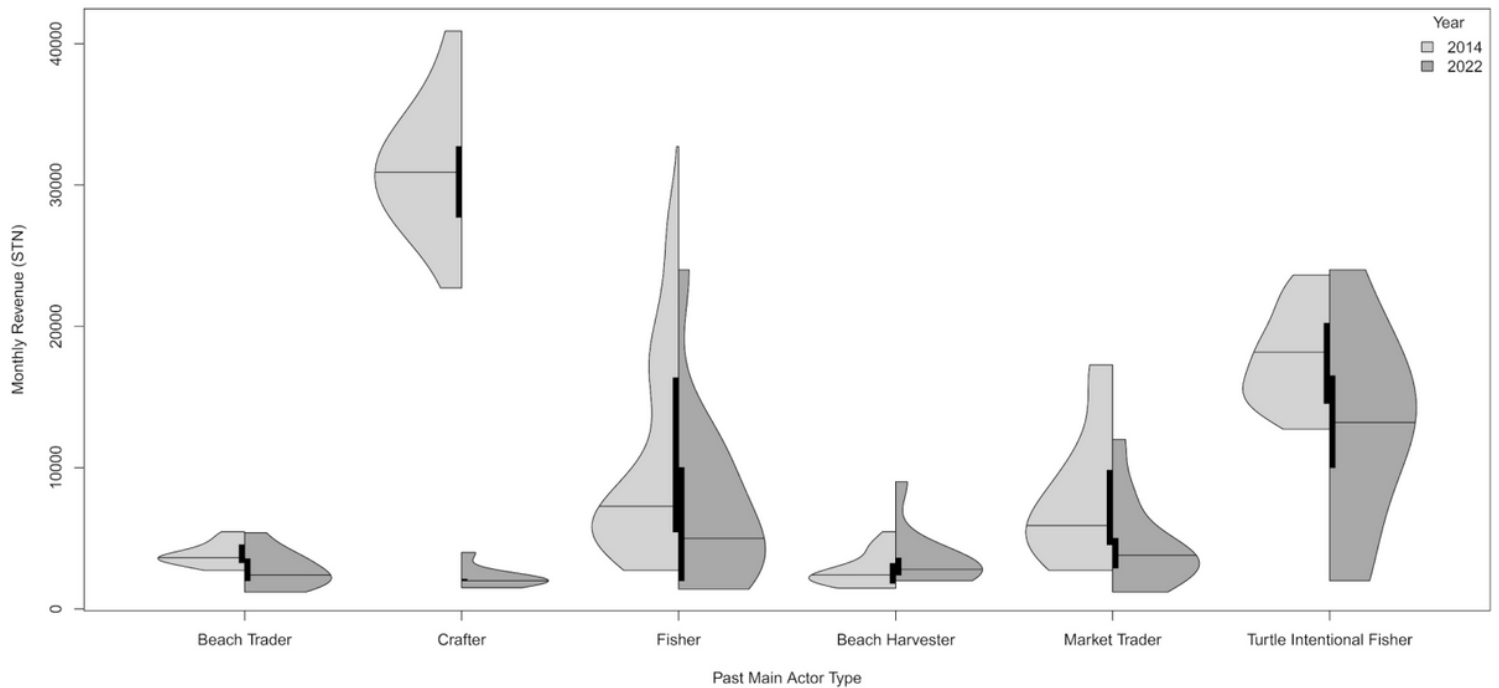
**Figure 1**

(a) Location of São Tomé and Príncipe in the Gulf of Guinea and surveyed coastal communities (n = 12; note that community names are not reported to preserve respondents' anonymity). Main actors of sea turtle trade: (b) beach harvesters, (c) intentional turtle fishers, (d) non-intentional turtle fishers, (e) beach trader, (f) market traders and (g) tortoiseshell crafter. Photo credits: A. Besugo, J.C.B. Costa, J. Fretey, J. Hancock, V. Jiménez.



**Figure 2**

Main actors and trade paths for sea turtle products in São Tomé Island in 2014 (a) and 2022 (b). Comparative transaction flow diagrams between the main actors of sea turtle trade in São Tomé were built based on how frequently different transactions were reported. The thickness of the arrows corresponded to the relative magnitude of each trade path between the main actors: thicker lines indicate the main trade flow and thinner lines indicate secondary flows.



**Figure 3**



Monthly income reported per main actor type in 2014 and 2022, which may include different economic activities in addition to that related to sea turtle trade. Data collected in 2014 were inflation-adjusted to 2022 for improved comparability. Data shown as a violin plot; maximal and minimal monthly income values for each main actor type based on the main activity developed in 2014 are indicated by each violin symbol's upper and lower limits. In contrast, the width of the violin symbols shows the kernel density distribution of observations at that value. Horizontal lines mark median values, and the interquartile range (IQR) by thicker vertical lines.

## Supplementary Files

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