ORIGINAL RESEARCH

Perceived social benefits and drawbacks of sea turtle conservation efforts in a globally important sea turtle rookery

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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 respondents 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.

Keywords Conservation trade-offs · Gulf of Guinea · Human dimensions of conservation · Marine turtles · Small island developing states · Wildlife trade

Communicated by Matthew Godfrey.

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Introduction

Research on the human dimensions of natural resource management and biodiversity conservation is increasingly recognised as a vital means of generating 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 spatial overlap between critical sea turtle habitats and human activities (Davenport and Davenport 2006), as well as the cultural and economic importance of sea turtle products (Liles et al. 2015, Rojas-Canizales et al. 2022). The take of sea turtles for human consumption is still considered a primary threat in many regions of the world (Humber et al. 2014; Senko et al. 2022), and the illegal supply of sea turtle 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), 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 compensating local resource users, alleviating poverty and/or diversifying livelihoods 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, there are generally many challenges to their successful implementation. For example, several projects face multiple barriers, including incompatible alternative livelihoods, inequitable distribution of benefits, and economic displacement (i.e., loss of assets or access to assets leading 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 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 which are listed on the IUCN Red List of Threatened Species (Castroviejo et al. 1994; IUCN 2022).However, the unsustainable take of sea turtles has been identified as a major national threat to their conservation (Ferreira-Airaud et al. 2022). Intentional take 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 key actors in the sea turtle trade (Ferreira-Airaud et al.

2022). Yet, similarly 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 activities on the island and consider how these might enhance or hinder future efforts. In particular, we: (1) characterised 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; (2) assessed perceived socioeconomic impacts of change among those involved in the trade; (3) identified barriers to transitioning to alternative livelihoods; and (4) explored factors potentially associated with promoting or hindering conservation impacts, such as awareness and involvement in decision-making. Given recent efforts to improve marine conservation in this under-studied region (de Lima et al. 2022), a better understanding of the human dimensions of conservation will be critical to promote the development and implementation of more effective and sustainable conservation strategies to protect threatened marine species, while safeguarding the livelihoods of resource users (Bennett et al. 2017; Nuno et al. 2021).

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 0º 15' and 1º 36' N and 6º 36' and 7º 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^{-1} year^{-1}; 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 take 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 and is one of the top 11 priorities for sea turtle conservation worldwide (Wallace et al. 2011). Sea turtles have traditionally been exploited for commercial, cultural and subsistence purposes,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
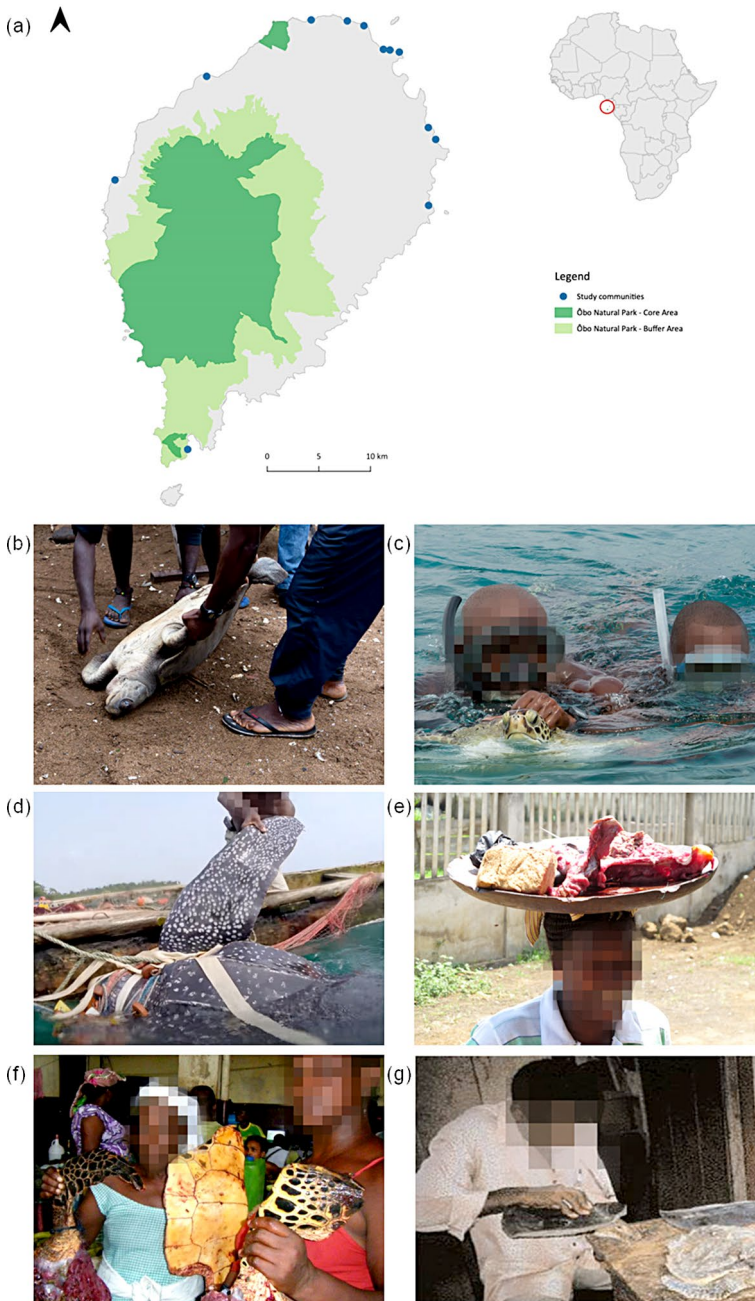
Fig. 1 **a** Location of São Tomé and Príncipe in the Gulf of Guinea and surveyed coastal communities ($n=12$; note that community names are not reported to preserve respondents' anonymity). Main actors of sea turtle trade: **b** beach harvesters, **c** intentional turtle fishers, **d** non-intentional 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

for sea turtle meat and eggs in both rural and urban communities on the main island of São Tomé (Veríssimo et al. 2020).

Sea turtle conservation efforts in São Tomé began in the 1990s (Graff 1996).In 1998, ECOFAC, the European Commission's 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 activities 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 taken on nesting beaches or at sea, mainly focused on fishers and traders; professional reconversion,mainly targeting tortoise-shell crafters; access to loans for complementary sources of income; and the purchase of all stocks of scales and manufactured items as compensation for professional reconversion (Fretey and Dontaine 2001). None of these approaches were successful due to financial constraints, inequitable loan distribution, lack of effective follow-up of professional reconversion and the absence of a legal framework for the protection of sea turtles (Ferreira 2015; Ferreira-Airaud et al. 2022). The Santomean government approved national legislation in 2014 (Decreto-Lei n. 8/2014, of 28 April) that criminalises the possession, trade and transportation of sea turtles. However, enforcement of environmental legislation has also posed significant challenges, with the relevant institutions often lacking the technical capacity and means to effectively apply legislation (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). For example, a study conducted in 2016 focused on characterising consumers of sea turtle products in São Tomé, including their motivations, prevalence of consumption and potential drivers (e.g. culture and food security; Veríssimo et al. 2020). Ongoing activities include identifying and promoting viable alternative livelihoods for the main actors of sea turtle trade, including sea turtle data collection (e.g. converting people illegally taking sea turtles from the beach into beach patrollers and in-water monitors) and handicraft production (e.g. association of former women sea turtle traders trained in souvenir production). Moreover, the association has 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 was conducted between December 2014 and February 2015 to gather information on the temporal and spatial trade of sea turtle products (e.g. eggs, meat, shell and bones). Although the legal framework for sea turtle protection was approved in April 2014, systematic enforcement did not begin until 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 of sea turtle conservation initiatives. The first survey was divided into two sections: (1) 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 (2) individual involvement in sea turtle trade and description of temporal and spatial trade and sale patterns of sea turtle products (interview templates available from Appendix 1). The second survey was composed of five sections:1) sociodemographic information; 2) awareness and perceptions about sea turtle conservation efforts; (3) individual involvement in sea turtle trade and description of temporal and spatial trade of sea turtle products in the past (approximately ten years ago) and in the present; (4) opportunities of the transition to alternative livelihoods; and (5) 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). The surveys took place in the main market of São Tomé City, where sea turtles are more regularly available for purchase, and 12 coastal communities (Fig. 1). These communities were selected because they are adjacent to important turtle nesting beaches and/or foraging aggregations in coastal waters where the take of sea turtles is known to happen (Programa Tatô 2021).

Six main types of suppliers of sea turtle products in São Tomé were approached for participation in our study: 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; people illegally taking sea turtles from the beach (hereby designated as "beach harvesters"); beach traders; market traders; and tortoiseshell crafters (for a complementary study surveying sea turtle consumers in São Tomé, see Veríssimo et al. 2020). Snowball sampling (Goodman 1961) was used to ensure adequate representation of informants from each key stakeholder group. 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). During the second survey phase, a similar sampling approach was employed, targeting the suppliers listed above, but we also aimed to interview people who ceased being involved in sea turtle trade. When a point of data saturation was reached (i.e. when additional interviews provided no new substantive information), the sampling on the second survey phase was ceased (Guest et al. 2006). Only respondents over 18 years old were eligible for participation.

For both study phases, the survey was conducted within participants' homes, in a mixture of Portuguese and *Forrô* 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 and might have led to less reliable data given that interviewees were asked for potentially incriminating information (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 Pnº8a/2022).

Data analysis

Responses to closed-ended 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 products). Before running statistical models, we used Generalised Variance Inflation Factors (GVIFs) to check for multicollinearity between explanatory variables. All variables (Table S1) 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-ended questions (i.e. perceptions of sea turtle conservation efforts in the country, impacts on respondents' livelihood and main barriers to transition 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, take of sea turtles in São Tomé was generally carried out by fishers, and the sale of sea turtle products was mostly by fish-

mongers, 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 respondents reported fishing as their primary occupation. A summary of key sociodemographic characteristics of participants is provided in Table S1.

Take and trade of sea turtles on São Tomé Island

Our initial interviews revealed that sea turtles were taken by beach harvesters during the nesting season, and by fishers all year round. Intentional take of sea turtles at sea was primarily done by intentional turtle fishers and spearfishers around the island. However, most of the interviewed fishers reported unintentional or opportunistic take of sea turtles while individuals were mating or resting on the surface. Drifting gillnets and purse seine fisheries were the main gears used to take sea turtles.

Most of the turtles taken were sold to beach traders, usually women living in the fisher's community. The beach traders would then sell them to market traders or, to a lesser extent, to their neighbours (Fig. 2a). Market traders were the main suppliers of meat and eggs to the general consumers, and tortoiseshell to handcrafters. Tortoiseshell, extracted exclusively from hawksbill sea turtles, was used to produce crafts that were sold to both local consumers, santomeans living abroad and international tourists. In addition, sea turtle bones were also reported to be bought by traditional doctors to produce traditional remedies (Table S2).

In 2014, most fishers self-reported relatively high annual take of sea turtles; 20 turtles or more per year were reported by 156 fishers (71% of those interviewed). In addition, 42 fishers (19%) reported medium rates (10–20 turtles per year) and 23 fishers (10%) reported low annual off-take (1–10 turtles per year). Based on the take of sea turtles reported by all
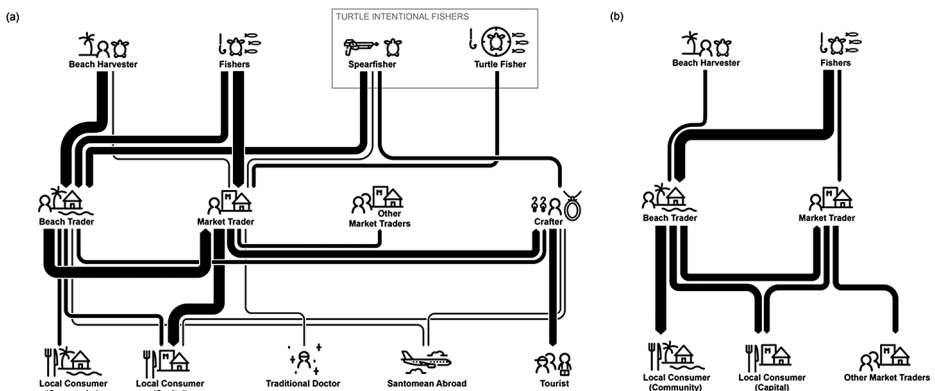

Fig. 2 Main actors and trade paths for sea turtle products in São Tomé Island in 2014 **a** and 2022 **b**. Comparative transaction flow diagrams between the main actors of sea turtle trade in São Tomé were built based on how frequently different transactions were reported. The thickness of the arrows 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

fishers and beach harvesters, we estimate an annual take between 3 and 160 sea turtles per person (Fig. S3).According to these respondents, turtles were generally taken 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). Although the take of sea turtles 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 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 took sea turtles and generally sold them to traders living in their community (Fig. 2b). Sea turtles taken by fishers are killed at sea; the meat is transported in black plastic bags and sold to traders, whereas sea turtles taken 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 home-made typical meals cooked with sea turtle meat and eggs 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; $p = 0.46$).

In contrast, 7 of the 20 respondents who continued to be involved in the sea turtle trade did not experience any economic changes since the conservation efforts started. In addition,9 have reported a decreased on their income, apparently associated with a decrease in the demand of sea turtle products, as summarised by a fisher who said: "Now that we have more sea turtles in the sea, the traders don't want to buy it anymore, because they say it's forbidden. Sometimes I can take more than 3 sea turtles per day, but I let them in the sea, because nowadays it is difficult to find a trader who is willing to buy it and I don't have the
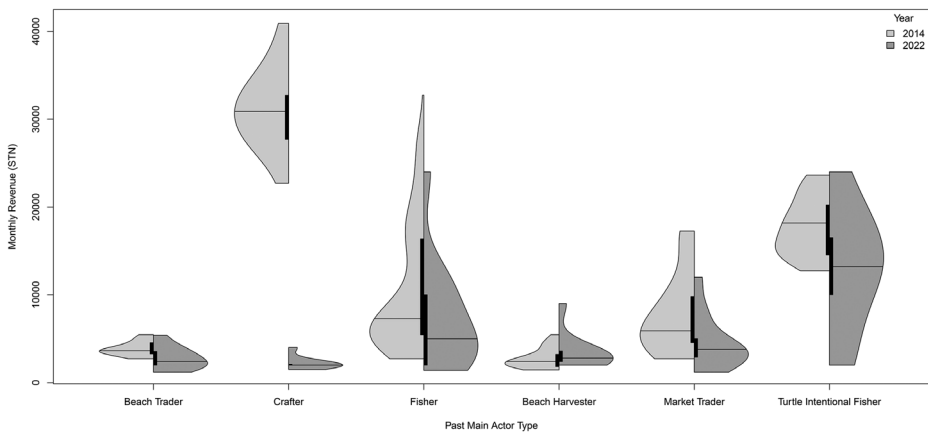
Fig. 3 Monthly income reported per main actor type in 2014 and 2022, which may include different economic activities in addition to that related to sea turtle trade. Data collected in 2014 were inflation-adjusted to 2022 for improved comparability. Data shown as a violin plot; maximal and minimal monthly 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

courage to kill them". Only 4 beach traders have reported an improvement on their economic situation since the conservation efforts started as summarised by a beach trader who said: "I feel I can make more money now with sea turtle products then 10 ago. Now there are less people selling it because it's forbidden, so I can sell it for a higher price".

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). Economic displacement was reported by 27 respondents, who mentioned completely changing their professional activity,while 19 reported having invested in complementary sources of income as a compensation strategy (e.g. agriculture, pig farming or handicrafts production). Most fishers interviewed said they did not need to change their main occupation; they simply stopped trading sea turtles and focused on other marine species, also releasing any sea turtles accidentally caught in 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, one of the interviewees, who had traded sea turtles on the main market of São Tomé for more than 25 years, abandoned this activity in 2016. She reported that selling fish was considerably more difficult than sea turtle meat due to intense competition among traders, 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	*"Today I know sea turtles are not a normal fish. They ensure the health and the balance of our oceans"* (Fisher) *"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"* (Market trader)
Ability to assist family and friends	-	38	*"Today I have less financial ability to help my family and friends"* (Market trader)
	+	7	*"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"* (Turtle Intentional Fisher)
Income and assets	-	37	*"All the money that I got from the selling of sea turtle 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"* (Market trader) *"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"* (Market trader) *"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"* (Tortoiseshell crafter)
	+	15	*"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 to take sea turtles daily to ensure the dinner of each day"* (Beach harvester)
Food Security	-	28	*"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"* (Market trader) *"Today I have to ask for help or"fiado"* [to buy on credit] *to ensure food in the table every day"* (Market trader) *"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"* (Beach harvester) *"Now I cannot buy meat every week"* (Tortoiseshell crafter)
	+	9	*"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"* (Beach harvester)
Economic displacement		27	*"I stopped selling sea turtle products and started to sell fresh and salt fish and nowadays I sell clothes and work for Programa Tatô"* (Market trader) *"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] (Beach harvester) *"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"* (Fisher) *"I had to stop to produce tortoiseshell products and to fully dedicate my time to agriculture"* (Tortoiseshell crafter)

In parallel, the 20 respondents who continued to be involved in the sea turtle trade reported an increase in their knowledge of marine biodiversity and the importance of sea turtle conservation due to the social marketing campaign *Tataluga Mém Di Omali.* The nine respondents that reported a decreased on their income also reported other associated social impacts such as food insecurity and reduced ability to support family and friends, and reduced assets. Although four traders had experienced an improvement on their income, two of them have reported a reduction of their assets and economic displacement, as summarised as summarised by a beach trader who said: "I was used to buying sea turtles in my community. Since the conservation efforts started, I have to buy sea turtles in other communities that are quite distant.

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. Other barriers included 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.

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 continue trading 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.

In contrast, among the 20 respondents that were still involved in the sea turtle trade when asked about the main barrier to developing an alternative livelihood, all mentioned the lack of financial capital, while 6 the 11 traders interviewed additionally mentioned the lack of skills, as summarised by one of them who said: "My mother had learned to kill sea turtles and sell its products with my grandmother and I have learned it with my mother. I am 62 years old and I don't know how to write, how to read it nor to sell fish as the other traders. How am I supposed to be able to change my main source of income at this age?"

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

Table 2 The main types of barriers to alternative livelihoods identified by the interviewees, with illustrative quotes

Barriers	Frequency (out of 86)	Illustrative Quotes
Monetary	51	*"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"* (Market Trader)
Lack of skills / Low Literacy	33	*"The main obstacle to start working as a beach ranger was learning how to collect data and fill the datasheets"* (Fisher) *"The main obstacle to start working as a marine technician was learning how to catch a sea turtle without any fishing gear"* (Turtle Intentional Fisher) *"It was not easy in the beginning because I didn't 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"* (Market Trader)
Pressure from others	23	*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"* (Beach Trader) *"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"* (Market trader)
Lack of tools	6	*"The main obstacles to develop an alternative livelihood were the lack of tools to work the cow horn and difficulties to import it"* (Tortoiseshell crafter)

levels of the take of sea turtles 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 taken, 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 the of 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").

Nevertheless, among the 20 respondents that were still involved in the sea turtle trade, when asked about the reason for non-compliance, all stated economic reasons and the lack of their involvement in the sea turtle protection legislative process. All of them 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". When considering the actual legal status of sea turtles, 18 out of 20 said they will only abandon this activity when the governmental authorities give them a viable livelihood alternative or compensation. Furthermore, a generalised perceived lack of individual conservation benefits and a belief that the implemented measures just benefit part of the population seemed to undermine support for sea turtle conservation efforts among this group.

Discussion

Despite two decades of targeted interventions to improve the conservation status of sea turtle populations in São Tomé and Príncipe, this study is the first to comprehensively assess the socioeconomic impacts of sea turtle conservation efforts in the country. Our findings suggest that, since the implementation of the legal framework for sea turtle protection in 2014 and the ongoing conservation efforts, the scale of sea turtle trade and the number of key actors involved have clearly decreased. Moreover, most of the respondents who had previously been involved in the trade experienced economic displacement and several related social impacts, such as the reduced ability to support family and friends and food insecurity, due to trade restrictions. Nowadays, the most traded sea turtle products on the island originate from bycatch in fishing gear. However, some participants reported targeted takes when the animals are mating or resting on 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. This study complements previous research in São Tomé on consumers of sea turtle products, characterising their profile and motivations (Veríssimo et al. 2020). Further research is necessary to assess the ecological impact of this illegal take and trade linked with the impact of incidental take 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 (Ferreira-Airaud et al. 2022).

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 former beach 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). These should be assessed and addressed to produce more effective, equitable, integrative and lasting successful conservation policies and practices (Ruano-Chamorro et al. 2022; Lenzi et al. 2023). 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 sea turtle 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 products (Thomas-Walters et al. 2020). Despite encouraging conservation outputs in terms of reduced take of sea turtles in recent years (Programa 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), the main barriers to transitioning to alternative livelihoods were financial capital, followed by a lack of skills, pressure from others and a lack of tools. Furthermore, while many expressed an understanding of the motivations 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. Similarly, although the primary importance of sea turtles to resource users in El Salvador was their economic value, a deeper cultural connection was also evident (Liles et al. 2015). Changes in knowledge and education, ability to help family and friends, income and assets, food security and economic displacement were identified as the main types of social impacts experienced. However, these are likely to be interlinked and their implications for wellbeing, including health (Woodhouse et al. 2015), highlight the need to go beyond income metrics and better understand the multifaceted impacts of conservation on aspects of people's lives that they value. These findings reflect the risk of neglecting a wide range of social and cultural values important to communities which may influence the users' perceptions and compliance and jeopardize conservation efforts (Delisle et al. 2018; Liles et al. 2015). 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 (Bennett 2016).

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. This may have led to less reliable data, as interviewees were asked for potentially incriminating information (particularly during the follow-up study). While we are aware of potential social desirability or non-response biases in respondents' answers (e.g. to hide their true behaviours), access to these small groups of people involved in the sea turtle trade required interpersonal trust between researchers and participants to ensure their willingness to answer our questions. For example, out of 94 people approached for an interview in the follow-up study, only eight declined to participate (refusal rate=8.5%), including five handcrafters, two fish traders and one beach harvester (these three were believed to still be active in the trade). Building rapport and trust with key individuals over time was critical and the lead author's understanding of the local context, based on years of working in the area, was considered crucial to overcoming potential challenges in data collection. Nevertheless, some actors in the sea turtle trade remained inaccessible to our team, with potential implications for our understanding about this trade and associated assessment of potential conservation impacts. 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 take reported in this study was also evident from other types of evidence, including nesting beach monitoring and self-reporting bycatch data (Programa 2022).

Notwithstanding the adverse social impacts identified in this study, some important positive impacts have been identified found (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 take of sea turtles 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. Different socioeconomic backgrounds of the people or groups involved in sea turtle trade, conservation and decision-making around the world are often linked to increasing conflicts among and between local, national, regional and international stakeholders (Barrios-Garrido et al. 2019). Potential solutions to these conflicts include the need to increase the involvement and participation of local community members at all stages of sea turtle conservation (Barrios-Garrido et al. 2019). For example, work with fishers and other stakeholders in the Turks and Caicos Islands has been set up to integrate fishing

community concerns and opinion in the design and proposed implementation of recommended turtle fishery management measures (Stringell et al. 2013); through this stakeholder engagement process, fishers provided extensive input into legislative measures, contributing towards the implementation of one of the most regulated turtle fisheries in the world (Stringell et al. 2015). Overall, stakeholder engagement and collaborative networks for sea turtle conservation that bring together representatives from local communities, government, private sector, researchers and NGOs should consider basic principles of sustainable development for effective management of these resources (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, in conservation, can informed decisions be made to improve social and environmental outcomes (Catalano et al. 2018).

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.

Declarations

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

Conflict 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.

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