

# Aquatic wild meat consumption of cetaceans in São Tomé and Príncipe (Gulf of Guinea)

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## Abstract

*Aquatic wild meat consumption of cetaceans in São Tomé and Príncipe (Gulf of Guinea).* Relatively little is known about cetaceans in São Tomé and Príncipe and in recent years, some episodes of cetacean bycatch and human consumption have been described. Aiming to provide insight into the reliance upon cetaceans as a source of meat, we present findings from complementary studies conducted in the islands of São Tomé and Príncipe from 2012 to 2021. Based on interviews with local residents, we assessed the prevalence of human consumption of cetaceans and identified potential sociodemographic drivers. This study provides the first comprehensive assessment of harvest (direct remove or incidental take) and consumption of cetaceans (mainly the family Delphinidae) in the country. These findings will be useful in the development of regional conservation measures and contribute to our understanding of anthropogenic activities affecting cetacean populations in the Gulf of Guinea.

Key words: Africa, Atlantic Ocean, Conservation, Direct capture, Fisheries, Incidental catches

## Resumen

*Consumo de carne de cetáceos silvestres en Santo Tomé y Príncipe (Golfo de Guinea).* Se sabe relativamente poco sobre los cetáceos de Santo Tomé y Príncipe y, en los últimos años, se han descrito algunos episodios de captura incidental y consumo humano de cetáceos. Con objeto de aportar conocimientos sobre la dependencia de los cetáceos como fuente de carne, presentamos los resultados de los estudios complementarios que se realizaron en las islas de Santo Tomé y Príncipe entre 2012 y 2021. A partir de las entrevistas realizadas a los residentes locales, evaluamos la prevalencia del consumo humano de cetáceos y determinamos los posibles factores sociodemográficos que intervienen en este consumo. En el presente estudio se proporciona la primera evaluación exhaustiva de la captura (directa o incidental) y el consumo de cetáceos (principalmente de la familia Delphinidae) en el país. Estos resultados deberían servir para fundamentar las medidas de conservación y contribuir a que se comprendan las actividades antropogénicas que afectan a las poblaciones de cetáceos en el Golfo de Guinea.

Palabras clave: África, Océano Atlántico, Conservación, Captura directa, Pesca, Capturas incidentales

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## Introduction

Aquatic mammal use as bushmeat is common in many countries and has been increasing in recent decades (Cosentino and Fisher, 2016; Ingram et al., 2022; Robards and Reeves, 2011; Weir and Pierce, 2013). However, in comparison with terrestrial bushmeat, there is a large knowledge gap in terms of the extent and source of aquatic bushmeat (Aquatic Mammals Working Group, 2017; Cosentino and Fisher, 2016). This lack of information regarding aquatic systems is concerning given the importance of coastal and marine areas to food safety, poverty alleviation, wellbeing and health, in addition to a crucial contribution to sustainable use of natural resources and conservation of biodiversity.

The Gulf of Guinea is considered as one of the 18 global richest centres of marine endemism (Roberts et al., 2002) and one of three areas with the highest marine species biodiversity in the Eastern Central Atlantic (Polidoro et al., 2017). At least 28 species of cetaceans occur in the waters of the Gulf of Guinea (Jefferson et al., 1997; Weir, 2010). Despite recent research efforts (e.g., data from strandings, landings, and other sources providing updated lists of cetaceans species and their interactions with fishing communities in Ghana and Côte d'Ivoire; de Boer et al., 2016; Perrin and van Waerebeek, 2007; van Waerebeek et al., 2009), information relating to their abundance and distribution, threats, and conservation status is limited (Weir, 2010). Within the Gulf of Guinea, the waters of São Tomé and Príncipe are an important area for some species of cetaceans (Carvalho et al., 2011; Pereira et al., 2013; Picanço et al., 2009; Sesani et al., 2020; Weir, 2010). This archipelago has attracted relatively limited research on cetaceans (mostly in coastal waters of São Tomé Island and focusing on species occurrence; Carvalho et al., 2022) and, in recent years, some episodes of cetacean bycatch and human consumption have been described (Collins et al., 2019).

Aiming to provide insight into the reliance upon cetaceans as a source of wild meat, we present findings from complementary studies conducted in the islands of São Tomé and Príncipe from 2012 to 2021 in order to assess human consumption of these animals and identify potential sociodemographic drivers. Our findings provide useful information for regional conservation measures and contribute to the understanding of anthropogenic activities affecting cetacean populations in the Gulf of Guinea.

## Material and methods

### Study area

The Democratic Republic of São Tomé and Príncipe (STP; fig. 1) consists of two small oceanic islands in the Gulf of Guinea, located 220 km off the coast of Central Africa. The country has a large exclusive economic zone (EEZ; almost 165,000 km<sup>2</sup>) and, as a consequence of their volcanic origin, the islands

display high relief. The surrounding littoral fringe is very narrow, with bathymetries of around 200 m depth close to the shore (Afonso et al., 1999). STP has ca. 210,000 inhabitants (INE, 2017) with a population density unevenly split between islands (Príncipe, with an area of only 142 km<sup>2</sup>, has around 8,300 inhabitants, while São Tomé hosts > 95% of the population in an area of around 850 km<sup>2</sup>). As the second smallest economy in Africa and with an agrarian-based economy, STP relies heavily 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).

To date, the presence of 13 cetacean species has been confirmed in STP (Carvalho et al., 2022; Pierpoint et al., 2021): pygmy killer whale (*Feresa attenuata*); short-finned pilot whale (*Globicephala macrorhynchus*); Risso's dolphin (*Grampus griseus*); dwarf sperm whale (*Kogia sima*); humpback whale (*Megaptera novaeangliae*); killer whale (*Orcinus orca*); sperm whale (*Physeter macrocephalus*); false killer whale (*Pseudorca crassidens*); Pantropical spotted dolphin (*Stenella attenuata*); striped dolphin (*Stenella coeruleoalba*); rough-toothed dolphin (*Steno bredanensis*); common bottlenose dolphin (*Tursiops truncatus*); and Cuvier's beaked whale (*Ziphius cavirostris*). Of these, the IUCN classifies the sperm whale as 'Vulnerable', the false killer whale as 'Near Threatened', the killer whale as 'Data Deficient' and all the others have 'Least Concern' conservation status (IUCN, 2022). With the exception of humpback whale and bottlenose dolphins, information on cetaceans in the archipelago is very limited (Carvalho et al., 2022).

STP has signed several international conventions that protect cetaceans, such as the Convention on the Conservation of Migratory Species of Wild Animals (CMS), Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), and the International Whaling Commission (IWC). However, cetaceans in the waters of STP have no specific legal protection, although the most recent fisheries law at the time of publication (Decree-law N° 22/XI/5ª/2021) mentions the possibility of creating protected areas in locations important for migration and/or feeding of cetaceans. Although there are presently no marine protected areas (MPAs) in the country, since 2016 there has been a noticeable investment in coastal and marine conservation in STP, focusing on sustainable fisheries through engagement with coastal fishing communities (de Lima et al., 2022). Building on these efforts, a network of MPAs is currently being designed and expected to be established in the near future.

### Survey design and administration

Data on consumption of cetaceans was collected using questionnaires. Firstly, fishers were opportunistically approached in five communities on the island of São Tomé in 2012 and in 2016 as part of a project on whale

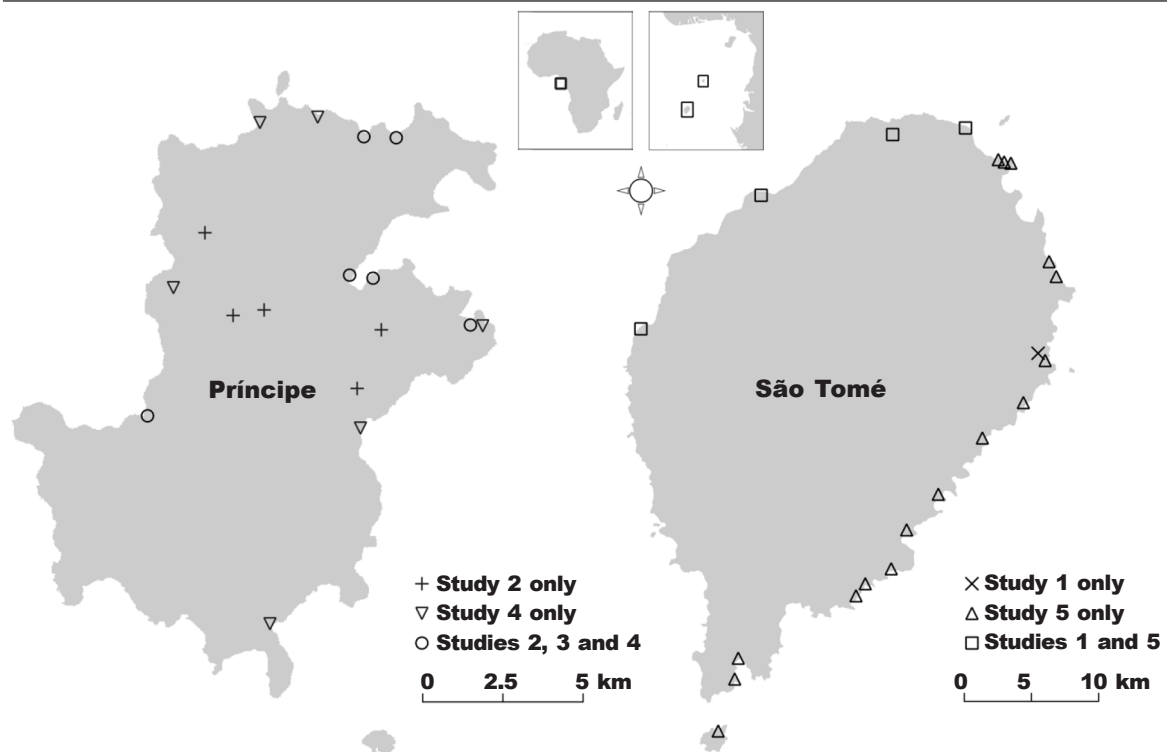


Fig. 1. Location of São Tomé and Príncipe in the Gulf of Guinea, with both inhabited islands illustrated, showing surveyed communities per study. Community names are not reported and approximate locations are used to preserve respondents' anonymity.

*Fig. 1. Mapa de Santo Tomé y Príncipe en el Golfo de Guinea, con las dos islas habitadas, donde se muestran las comunidades a las que se entrevistó en cada estudio. No se indican los nombres de las comunidades y se muestran las ubicaciones aproximadas para mantener el anonimato de los entrevistados.*

watching and cetacean conservation (study 1, table 1). These interviews were carried out at five landing sites in February 2012 and January–April 2016, and included questions about harvest and use of cetaceans. As part of a project on small-scale fisheries and marine conservation in the island of Príncipe, household questionnaires were then conducted in 11, 6 and 15 communities in February–March 2017 (study 2), January–February 2019 (study 3) and September–October 2021 (study 4), respectively. The questionnaire included questions about the use of natural resources of conservation interest (both marine and terrestrial, such as dolphins, rays and introduced monkeys); here we only report on findings related to consumption of dolphins. Finally, similar household questionnaires were conducted in 21 fishing communities in São Tomé in July–August 2019 and September–October 2021 (study 5). For studies 2–5, survey respondents were first asked if they knew what dolphins were and, if so, they were asked if they had eaten dolphin in the last 12 months, with options being: yes/no/don't know/don't want to answer. Given the diverse nature of the sampling approaches and questions used to obtain this information, we present a detailed comparison in table 1.

Sociodemographic information collected in the most recent surveys (data collected in 2021 from studies 4 and 5) was used to explore potential predictors of dolphin consumption. This included: gender, age, education level, main occupation, region of residence, household size and ownership of specific household assets as wealth indicators (type of house walls, mobile phone, motorbike).

All interviews were conducted in Portuguese and, if required, creole explanations were used. Participants' anonymity was protected and the names of specific communities are not presented in this publication so as to fully protect respondents from any potential consequences (St John et al., 2016) given potentially sensitive nature of cetacean harvest and consumption. Studies 2–5 (table 1) and their methodologies were approved by the College of Life and Environmental Sciences (Penryn) Ethics Committee at the University of Exeter (UK, Ref. 2017/1565). All studies adhered to the guidelines by the British Psychology Society. Studies 4–5 were also approved by the National Statistics Institute in STP.

Table 1. Comparison of sampling approaches used to obtain information of human consumption of cetaceans in São Tomé and Príncipe. Study 1 focused on cetaceans while studies 2–5 asked specifically about dolphins: <sup>a</sup> only residents (defined as living in that community at least six months per year; INE, 2016) and people aged 18 or older were eligible for participation.

*Tabla 1. Comparación de los métodos de muestreo utilizados para obtener información acerca del consumo humano de cetáceos en Santo Tomé y Príncipe. El estudio 1 se centró en los cetáceos, mientras que en los estudios 2 a 5 se preguntó específicamente por los delfines: <sup>a</sup> solo participaron los residentes (definidos como las personas que viven en dicha comunidad al menos seis meses al año; INE, 2016) y las personas de 18 años o más.*

	Study 1	Study 2 <sup>a</sup>	Study 3 <sup>a</sup>	Study 4 <sup>a</sup>	Study 5 <sup>a</sup>
Location	Landing sites of five fishing communities, island of São Tomé	Six main permanent coastal communities (i.e., temporary communities or landing sites were excluded) and five randomly-selected non-coastal communities, island of Príncipe	Six main permanent coastal communities (i.e., temporary communities or landing sites were excluded), island of Príncipe	15 fishing communities, island of Príncipe	21 fishing communities island of São Tomé
Dates	9–11th Feb 2012 and Jan–April 2016	Between 6th of February and 21st of March 2017	Between 11th January and 8th February 2019	Between 9th September and 13th October 2021	1st phase: between 23rd of July and 19th August 2019 2nd phase: between 9th September and 13th October 2021
Sampling approach	Opportunistic interviews with fishers at landing sites	Surveys were administrated to all households, targeting household head and respective partner separately, if available	Surveys were administrated to all households, targeting household head and respective partner separately, if available	Systematic household selection was used, approaching every 5th house. Interviews were stratified in order to interview approximately 12 fishers, 12 fish traders and 12 people with other occupations within each community	Systematic household selection was used, approaching every 5th house. Interviews were stratified in order to interview approximately 12 fishers, 12 fish traders and 12 people with other occupations within each community.
Information collected	Individual harvest of cetaceans, targeted or accidental nature of capture, and how captured animal was dealt with (consumed or released)	Individual consumption of dolphins in last 12 months prior study and potential sociodemographic predictors + source of wildlife product (caught/bought/gift)	Individual consumption of dolphins in last 12 months prior study and potential sociodemographic predictors + source of wildlife product (caught/bought/gift)	Individual consumption of dolphins in last 12 months prior study and potential sociodemographic predictors	Individual consumption of dolphins in last 12 months prior study and potential sociodemographic predictors
Sample size (number of individuals interviewed)	92	869	516	531	1st phase: 882 2nd phase: 1847

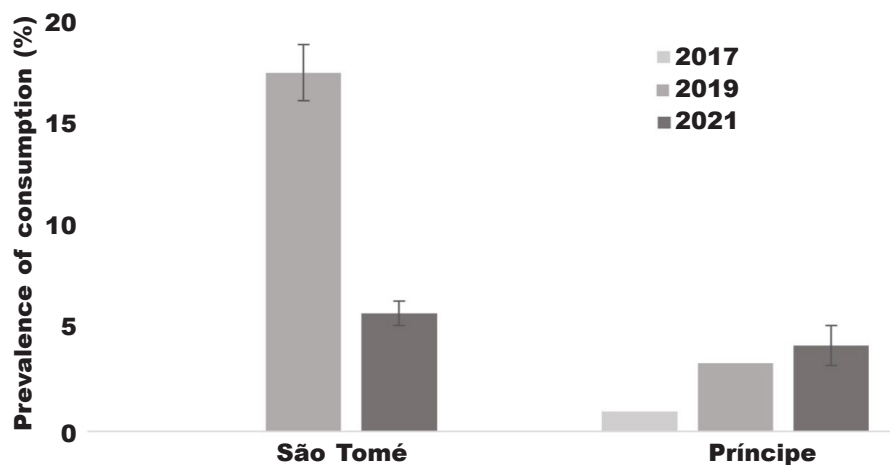


Fig. 2. Prevalence of consumption of aquatic wild meat from dolphins in São Tomé and Príncipe (2017–2021). Sampling approaches and sample sizes described in table 1. Error bars not available for Príncipe 2017 and 2019 (study 2 and 3) because a census approach was used then.

*Fig. 2. Prevalencia del consumo de carne de delfines silvestres en Santo Tomé y Príncipe (2017–2021). En la tabla 1 se describen los métodos de muestreo y el tamaño de las muestras. No se dispone de las barras de error para Príncipe en 2017 y 2019 (estudios 2 y 3) porque en aquel momento se utilizó un censo.*

#### Data analysis

Prevalence rates of target behaviours are presented as percentages out of surveyed sample; specific sample sizes are described throughout all sections.

To measure household wealth, we produced a socio-economic index based on ownership of 17 assets; these were locally defined and based on similar indicators adopted in national census assessments (INE, 2016). A wealth index was thus produced using a Principal Component Analysis (PCA); factor loadings for the first principal component were reduced to a single index of material style of life (Vyas and Kumaranayake, 2006).

Sociodemographic information used to explore potential predictors of consumption included: gender, age, education level, fisheries dependence (whether fishing or fish trading was the primary occupation), region of residence (Northern São Tomé, Southern São Tomé or Príncipe), household size and wealth ranking. To investigate effects on binary variables (dolphin consumption or not), we fitted generalized linear models with binomial error distribution and a logit link. The Akaike information criterion (AIC) was used to select the most parsimonious models and to rank models according to their log-likelihood penalised for the number of parameters (Burnham and Anderson, 2002). We averaged parameter estimates across models with  $\Delta AIC < 4$  using the MuMIn Package v.1.42.1 (Bartoń, 2018), and 85% unconditional confidence intervals are presented to make confidence intervals AIC compatible as recommended by Arnold (2010). The relative importance of predictor variables (RVI) is expressed as the sum of the Akaike

weights for the variables included in the averaged models. Statistical analyses were conducted in R version 4.0.3 (R Core Team, 2020).

#### Results

##### Prevalence rates

From among 92 fishers opportunistically interviewed in five communities in São Tomé in 2012 and 2016 (study 1), 30.4% ( $n = 28$ ) reported having caught a cetacean (the question grouped dolphins and whales, although they mentioned only dolphins) at least once before our study. Six of these fishers reported having targeted those cetaceans for capture, while the remaining 22 reported having caught them as bycatch. Among the 28 fishers who reported having captured cetaceans, five stated they generally released the animals live, while all the others mentioned meat consumption (for themselves, for selling, or for sharing within communities). Although participants were not explicitly asked about fishing gear, some occasionally reported capturing these animals using harpoons ('zagaia') or finding them accidentally caught in their fishing nets. In addition, 43.5% reported having seen stranded cetaceans at the beach, with seven also mentioning consumption of these stranded animals (only dolphins were mentioned).

Among the people surveyed in studies 2–5 (ranging from 516 to 1,847 individuals per study), consumption of dolphins varied between 1.1% and 17.9% of those interviewed (see figure 2 for all estimates and error bars). Prevalence of consumption was considerably

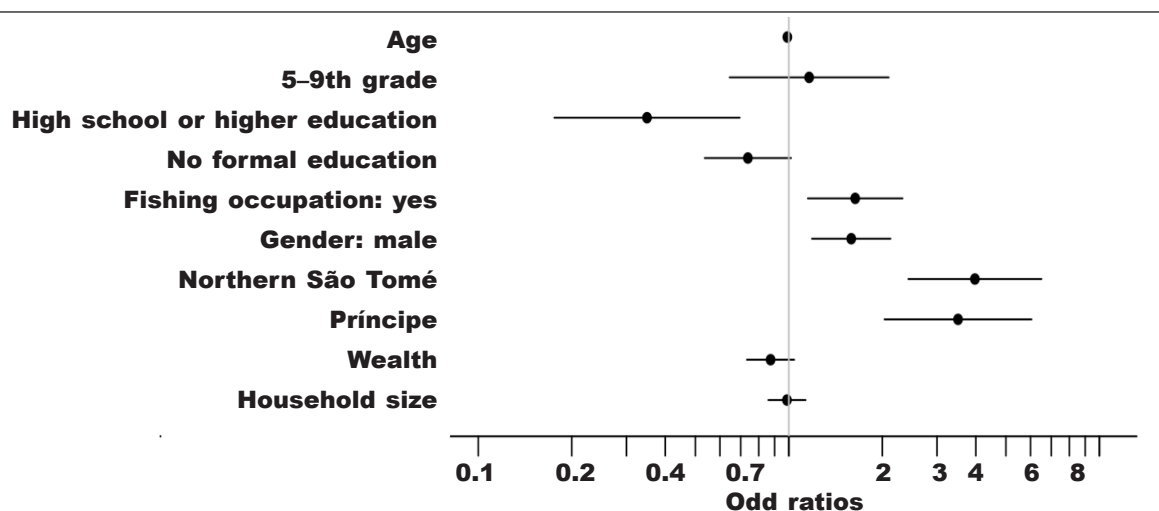


Fig. 3. Odds ratios (with 85% confidence intervals) of prevalence of dolphin consumption in function of multiple sociodemographic variables. Each level shown is compared with reference categories: primary school; no fishing occupation; female; Southern São Tomé. Grey line represents odd ratio = 1 (with odd ratios > 1 representing increases in the odds of the prevalence of dolphin consumption).

*Fig. 3. Oportunidades relativas (con intervalos de confianza del 85%) de la prevalencia del consumo de delfines en función de múltiples variables sociodemográficas. Cada nivel mostrado se compara con las categorías de referencia: educación primaria, trabajo en el sector pesquero, mujer, Santo Tomé meridional. La línea gris representa la oportunidad relativa = 1 (las oportunidades relativas > 1 representan un aumento de la oportunidad de la prevalencia del consumo de delfines).*

higher in São Tomé in the 2019 studies. However, a significant decline ( $t$ -value = 244.1,  $df$  = 1253,  $p$  < 0.001) in consumption rate in São Tomé was recorded in the 2021 studies, resulting in no significant differences between islands ( $t$ -value = -0.65,  $df$  = 2188,  $p$  > 0.51). In addition, when comparing consumption among coastal and non-coastal communities in 2017 in Príncipe (study 2 was the only surveying non-coastal communities as well), no significant differences were found ( $t$ -value = 0.01,  $df$  = 860,  $p$  > 0.99).

Participants in Príncipe who reported having eaten dolphin were also asked about the origin of that wildlife product in studies 2–3. Receiving it as a gift was the most frequent answer (56% of consumers in 2017 and 44% of consumers in 2019), followed by harvesting through direct take or incidental bycatch (22–25% of consumers) and buying (11% in 2017 and 19% in 2019).

#### Potential socio-demographic predictors of dolphin consumption

Based on the most recent information (data collected in 2021), consumption of dolphins was less likely in Southern São Tomé than in the Northern area or Príncipe. Women were less likely than men to eat dolphin, as were participants who had attended high school or had higher education, and those whose main occupation was not fishing—re-

lated despite living in coastal communities (fig. 3). The odd ratios of estimated effects are presented in figure 3 and their 85% confidence intervals did not overlap, except for other education levels, decreasing our confidence in the direction of this effect. Other variables included in the top models, although with less support ( $RVI$  < 0.5), were age, wealth and household size.

#### Discussion

This study provides the first comprehensive assessment of harvest (direct take or incidental) and consumption of cetaceans (mainly dolphins) in São Tomé and Príncipe. While much remains unknown about these incredibly rich waters, and further scientific research is certain to bring important insights into these ecosystems, there is an urgent need for effective management to maintain ecosystem function, protect cetaceans and support livelihoods. Despite not being species specific (so more detailed information is essential for linking potential threat to specific species as well as its role for food security in STP; Carvalho et al., 2015), our findings suggest a minority of households consume dolphins as a source of aquatic wild meat. In addition, in some cases, this wildlife product originated from bycatch in fishing gear or stranded animals, although some participants reported targeted takes (see Collins et

al., 2019 for photographic evidence of strandings and captures in STP). We also provide insight into potential target audiences for efforts aiming to reduce consumption of this wildlife product (via social marketing and environmental awareness activities). Although cetaceans in STP have no specific legal protection, respondents could nevertheless consider this a sensitive topic (if against social norms or contrary to ongoing conservation efforts) and thus have hidden their true behaviour during our interviews. Our estimates should be seen as conservative and, in addition to complementary sources of information (e.g. landing surveys and direct observation), specialised questioning techniques could be used in future assessments to encourage honest answering through further protecting respondent's privacy (Nuno and St John, 2015).

The harvest of migratory small cetaceans for aquatic wild meat in the Gulf of Guinea is assumed to be threatening these populations despite relatively limited information on harvest levels, population size and distribution (Collins et al., 2019; de Boer et al., 2016). CMS has taken an early step, agreeing to progress the development of a sub-regional Aquatic Wild Meat Action Plan for the Gulf of Guinea for consideration by CMS COP14 (Decision 13.64, COP13, CMS 2020). In STP, information relating to these issues is much needed. In the last decades, the number of artisanal fishers in STP has increased considerably (Maia et al., 2018), as have the numbers in catches through national semi-industrial fishing and foreign industrial fishing (Carneiro, 2011; EU, 2019), with small-scale fishers reporting decreased catches over time (Nuno et al., 2021). The opportunistic use of bycatch as aquatic bushmeat may be the result of local demand for alternative food sources due to the decline in traditional fish stocks (Leeney et al., 2015; Van Waerebeek et al., 2017). Increased monitoring of the extent of aquatic wild meat use in local contexts is therefore advised (Ingram et al., 2022).

In the absence of bycatch monitoring or reporting and when the conservation status of cetacean populations is mostly unknown, population declines are likely to go undetected and undocumented. Additionally, by exploring not only potential ecological impacts but also reliance upon these wildlife products, we can consider the context in which interventions to reduce demand for wild meat can be implemented. This is key to ensure not only that such interventions have the highest likelihood of success but also that no undue burdens are placed on the target audience (if a group of people using wild meat for either livelihood or subsistence purposes were targeted without considering that there could be no other viable alternatives to them). Working in close partnership with small-scale and artisanal fishers is thus an essential approach to assess potential impacts of bycatch and directed take on cetacean populations, contributing towards developing informed interventions for cetacean conservation and public health (e.g. transmission of zoonotic diseases related to consumption of aquatic bushmeat; Reeve–Arnold et al., 2021).

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