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Research article

Illegal take of nesting sea turtles in Tortuguero, Costa Rica: Conservation, trade, or tradition?

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ABSTRACT

Tortuguero, Costa Rica is considered the second largest green turtle (*Chelonia mydas*) rookery in the world. By 1950, Tortuguero was one of the sites with the greatest take of green turtles in the Caribbean. Currently, Tortuguero is a worldwide example for ecotourism-based on sea turtle conservation. However, illegal take of nesting turtles still occurs. We aimed to describe the illegal take at Tortuguero, estimating the minimum number of sea turtles taken using data collected during daily and weekly track surveys from 2005 to 2021. Additionally, we conducted 12 semi-structured interviews with key informants to obtain a better understanding of this activity. We documented 735 nesting turtles illegally taken at Tortuguero, being the green turtle the most affected species; these findings were also supported by our interviewees. Respondents stated that in Tortuguero the take of sea turtles has always occurred and traditions regarding sea turtle meat consumption are still present, even though it is considered shameful in the village. However, our interviewees affirmed that most of the sea turtles taken are traded to other locations away from Tortuguero. Our findings represent the minimum of illegal take (documented only at the beach), as not all the sea turtles taken were observed. Finally, despite long-standing conservation efforts carried out in Tortuguero, further changes in the National Park's management plans are needed, including more personnel and increased law enforcement. This may be necessary to reduce the impact on the Tortuguero green turtle nesting population in the near future.

1. Introduction

Understanding the complexity of the underlying socio-economic and cultural context of threatened species trade, such as sea turtles, is challenging (Hamann et al., 2010; Bennett et al., 2017). The cultural context is especially challenging because information regarding these activities is difficult to obtain due to the protection status of these species in most places in the planet (Humber et al., 2014; Nuno et al., 2015; Lopes et al., 2022), and aspects such as the level of take, the status of the target populations, and socio-economic factors are unknown in most cases (Barrios-Garrido et al., 2020a). Therefore, one of the research priorities for sea turtle conservation is to understand if the change in the local economy dynamics with and without consumptive use of sea turtles is sustainable (Hamann et al., 2010).

Historically, sea turtles have been one of the most heavily impacted species by human consumption (Campbell, 2010; Lopes et al., 2022), from small-scale subsistence and/or cultural use to large-scale systematic commercial take (Early-Capistrán et al., 2018; Senko et al., 2022). Sea turtles are traditionally used for medicinal purposes, as well as cultural symbols, religion, ornaments and especially as a food source, playing a major role in the subsistence of many Caribbean coastal communities (Rueda-Almonacid et al., 1992; Lagueux et al., 2017;

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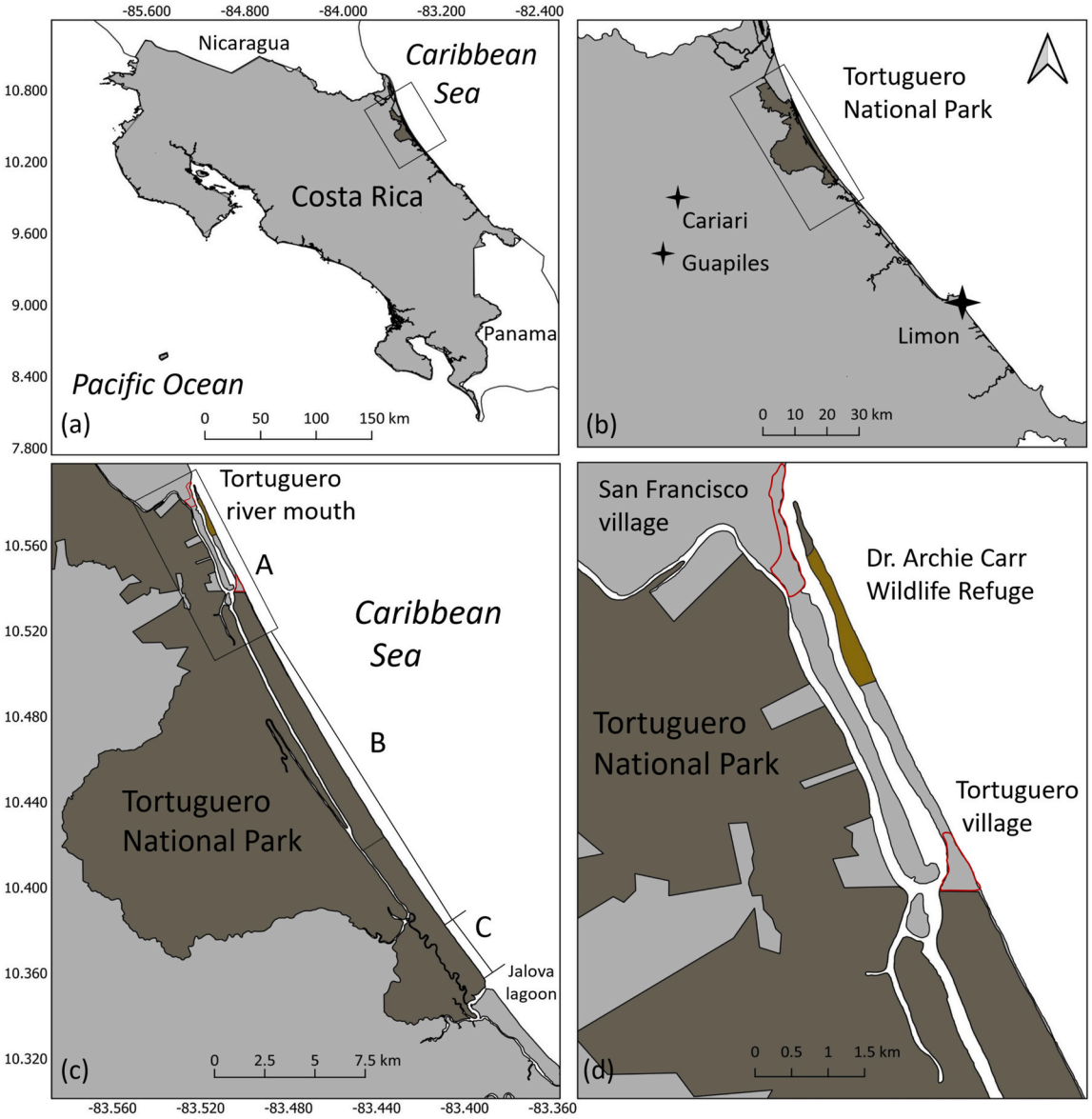

Fig. 1. Geographic location of the study area. (a) Showing its relative position in Costa Rica (marked in a rectangle). (b) Detail of TNP and three of the nearest main towns in the province of Limon: Cariari, Guapiles and the city of Limon. (c) Location of TNP and the three main monitoring areas: A (marked in a rectangle), B, and C. (d) Detail of area A, monitored daily, which includes ACWR (north yellow polygon), Tortuguero village (southernmost red polygon), and 2.5 km of TNP. It also shows the relative position of San Francisco village (northernmost red polygon). (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

Barrios-Garrido et al., 2018).

Tortuguero, Costa Rica, is known as the second largest rookery in the world for the endangered green sea turtle *(Chelonia mydas)* (Seminoff, 2004), and the most important rookery in the Atlantic with over 70,000 nests per year (Restrepo et al., 2023a). The critically endangered hawksbill turtle *(Eretmochelys imbricata)* (Troëng et al., 2005), the regionally endangered leatherback turtle (*Dermochelys coriacea*) (IUCN, 2019), and the rarely reported vulnerable loggerhead turtle *(Caretta caretta)* (Restrepo et al., 2022b) also nest at Tortuguero, in lower numbers.

For decades, sea turtles were exploited on a large scale by the community at Tortuguero (Jacobson and Robles, 1992; Gutiérrez-Lince et al., 2021; Mejías-Balsalobre et al., 2021). In 1950 when Dr. Archie Carr first arrived in Tortuguero, nearly every nesting green turtle was taken, used for subsistence, and traded with nearby communities (Bjorndal et al., 1999; Campbell and Lagueux, 2005). However, over the years the take of sea turtles at this rookery has been reduced by diverse conservation and management efforts conducted in the area. The monitoring program implemented by the Sea Turtle Conservancy (STC) since 1959, the establishment of the Tortuguero National Park (TNP) in 1970 (La Gaceta 213, 1970), the listing of sea turtles in 1978 in the U.S Endangered Species Act and in the and the Convention on International Trade in Endangered Species of Wild Fauna and Flora of 1973 (Valverde and Holzwart, 2017), the ecotourism based on sea turtle conservation developed by the community since mid-1980 (Meletis and Harrison, 2010) and the ban of sea turtle take in 2002 (La Gaceta 230, 2002), along with the support from members of the local community were crucial to reduce the take of sea turtles at Tortuguero (Troëng and Rankin, 2005; Gutiérrez-Lince et al., 2021). Nevertheless, despite these long-term conservation efforts and the revenue obtained by community members from sea turtle conservation-based ecotourism, sea turtle take is still occurring at Tortuguero (Mejías-Balsalobre et al., 2021).

Recently, Pheasey et al. (2021) quantified the magnitude of sea turtle take in the northernmost 8 km of Tortuguero finding that 373 sea turtles

were taken between 2006 and 2019 in the rookery. This study aims to expand on those results by describing the illegal take of nesting sea turtles in Tortuguero implementing interdisciplinary research, combining field data collected from 2005 to 2021 in the 29.6 km of TNP, with semi-structured in-depth interviews with key informants to improve our understanding of sea turtle take in the entire Tortuguero rookery.

2. Methods

2.1. Study area

Tortuguero is located on the Eastern Caribbean coast of Costa Rica (Fig. 1a) in the Limon province (Fig. 1b). This rookery spans over 29.6 km of coastline, encompassing the Tortuguero river mouth (RM), the Dr. Archie Carr Wildlife Refuge (ACWR), Tortuguero village, and the TNP limited at the south end by the Jalova lagoon (Fig. 1c and d) (Bjorndal et al., 1999; Bruno et al., 2020).

The Tortuguero village is a small (1.2 km length), isolated settlement accessible only by boat or small airplanes and is separated from the mainland by the Tortuguero River (Fig. 1d). This settlement hosts a population of around 1500–2000 inhabitants (Mejías-Balsalobre et al., 2021). The village belongs to a region with low social and economic development comprised of Hispanic, Afro-Caribbean, and West Indian descent people (Jacobson and Robles, 1992).

To aid monitoring efforts we divided the beach every kilometer by markers (Restrepo et al., 2023a). For this study, we divided the rookery in three main monitoring sections (Fig. 1c): section A, is the northernmost section; it includes areas with different management categories (e.g., Wildlife Refuge, Public beach, and TNP) (Fig. 1d) (Dudley, 2008), and it goes from Tortuguero's RM at the ACWR to the 8 km marker inside TNP. We monitored this section daily through morning track surveys. Section B encompasses the area from the 8 km to marker 24 km in TNP; we monitored this section weekly. Section C constitutes the area from the 24 km maker to the Jalova Lagoon (29.6 km), the most inaccessible southward section of the beach (Troëng and Rankin Gonzalez, 2000), which we have monitored daily during the nesting season since 2010 (Fig. 1c).

2.2. Survey sampling

For this study, we used the data on illegal take of sea turtles for the northernmost 8 km at TNP reported by Pheasey et al. (2021) for the period 2006–2019, complementing these with data collected during daily and weekly track surveys in the three main monitored areas (29.6 km) between 2005 and 2021. We conducted surveys by foot early in the morning to record the nesting activity of egg laying females from the previous night, as well as any signs of turtles illegally taken at the beach (Bjorndal et al., 1999; Bruno et al., 2020). We conducted track surveys daily from June to October in sections A and C, (with the exception of 2020 when due to COVID-19 restrictions section C was not monitored), while weekly surveys spanned over the entire year and included the three sections (A, B and C) (Troëng and Rankin, 2005).

We determined that a sea turtle had been taken when (1) there were no down tracks of the turtles returning to the sea and there were dragging marks accompanied by footprints nearby where the turtle tracks were found (Marco et al., 2012; Pheasey et al., 2021), (2) when the turtles were found butchered on the beach or the carcasses were abandoned nearby (Marco et al., 2012) and/or (3) when the sea turtles were found stranded tied and dead, or with fresh harpoon injuries (Meylan et al., 2013). For each encounter we recorded the species, date, and sector marker. We took pictures when possible. Additionally, we recorded observations regarding the take event such as: abandoned carcasses, found tied up to the vegetation, loaded onto a boat, among others (Marco et al., 2012, 2021). All the live turtles found tied up to the vegetation or flipped over during the 2021 nesting season were released and included in the results as they provided valuable information about the sea turtle take techniques. We compared the nesting turtles taken per kilometer and estimated the minimum number of sea turtles taken per year, in each of the three main sections of the rookery.

Table 1
Common themes mentioned by interviewees, number of respondents, values attributed to each theme, and illustrated examples.

Theme (No. of respondents)	Value type	Illustrated example
Sea turtles taken in Tortuguero (n = 12)	Take	*"We are aware that people take turtles every night at the National Park"* *"Sea turtles taken from Tortuguero end up in Limon or even Guápiles"* *"Sea turtles from Tortuguero are taken to San Francisco"* *"It is difficult to know how many sea turtles are taken by poachers"*
People in Tortuguero village eating sea turtle meat (n = 10)	Consumption	*"In the village no one sells sea turtle meat"* *"The whole sea turtle is consumed, not only the meat"* *"If you want sea turtle meat people with drug issues deliver it to you"*
Sea turtle conservation is important in Tortuguero (n = 9)	Conservation	*"Life is harder without sea turtles"* *"As Archie Carr said if we don't take care of the turtles our children will not see them"* *"Sea turtle take stopped thanks to the creation of the National Park and Archie Carr"*
Tortuguero's economy is based on sea turtles (n = 8)	Economic	*"Most of the tourists come to Tortuguero due to the sea turtles"* *"In Tortuguero, sea turtles are more valuable alive than dead"* *"Tortuguero is a commercial brand and sea turtles are the image"* *"Sea turtles are like the goose with the golden eggs"*
Sea turtle consumption is linked to Tortuguero inhabitants (n = 7)	Tradition	*"I grew up eating sea turtle meat"* *"When I was a kid, my mom cooked sea turtle soup"* *"In Tortuguero is a tradition among Tortuguero people to eat sea turtle meat or eggs at least once a year"* *"When I was a kid sea turtles were shared among the families"* *"Eating sea turtle meat was not forbidden in the past, it was our resource"* *"It is difficult to stop eating something that you have consumed your whole life"*

In addition, to better understand the take of sea turtles at Tortuguero, we conducted 12 semi-structured in-depth interviews (open-ended) with key informants (Barrios-Garrido et al., 2017, 2018) between April and October 2021. The interviews were conducted individually in Spanish, with previous oral consent and guaranteeing anonymity regarding personal information (Barrios-Garrido et al., 2017, 2020a, 2020b; Álvarez-Varas et al., 2020). Informants were from different backgrounds related to sea turtles in the Tortuguero village to increase diversity of opinions in the study. Specifically, they were members of native families (n = 3), international NGOs (n = 2), poachers (n = 1), local authorities (n = 3), or people who benefited directly from turtle tourism (n = 3) (Meletis and Harrison, 2010; Bennett et al., 2017). Interviewees were selected by convenience sampling, based on the interviewees' expertise on specific topics (Lewis-Beck et al., 2004), and "snowball" sampling selecting the next participant based on the recommendation of an interviewee (Newing, 2010). All participants were informed in advance of the purpose of the study.

We focused our interviews on three main subjects: (a) traditional use (non-commercial use of sea turtle products), (b) trade and consumption

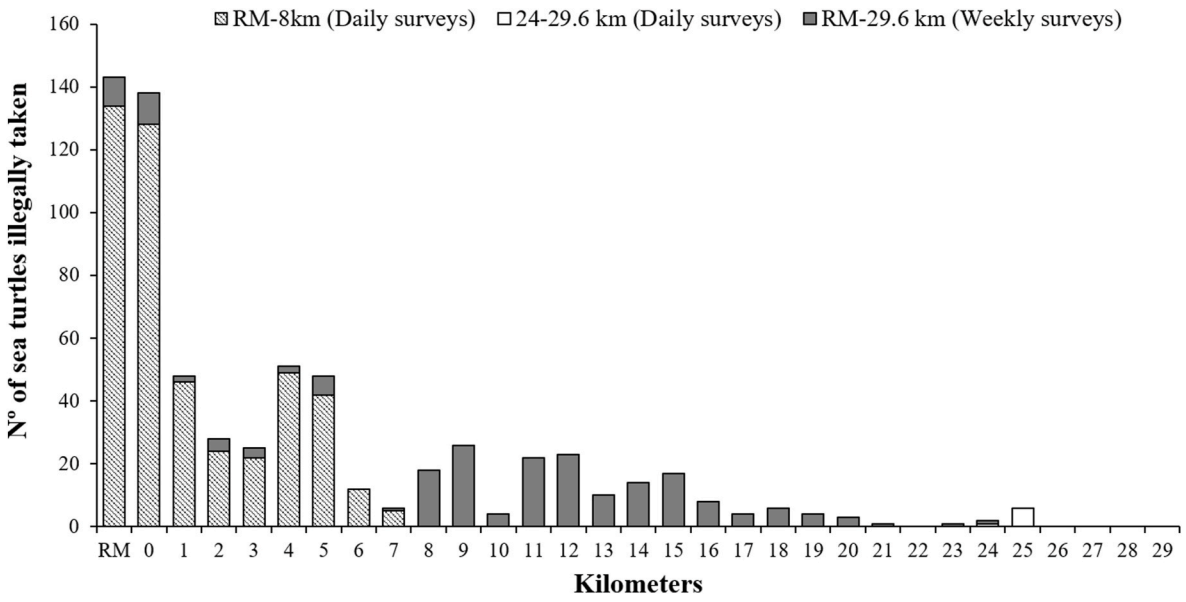

Fig. 2. Nesting turtles illegally taken between 2005 and 2021 in Tortuguero, presented by kilometer in three different surveyed areas, n = 735. RM stands for river mouth.

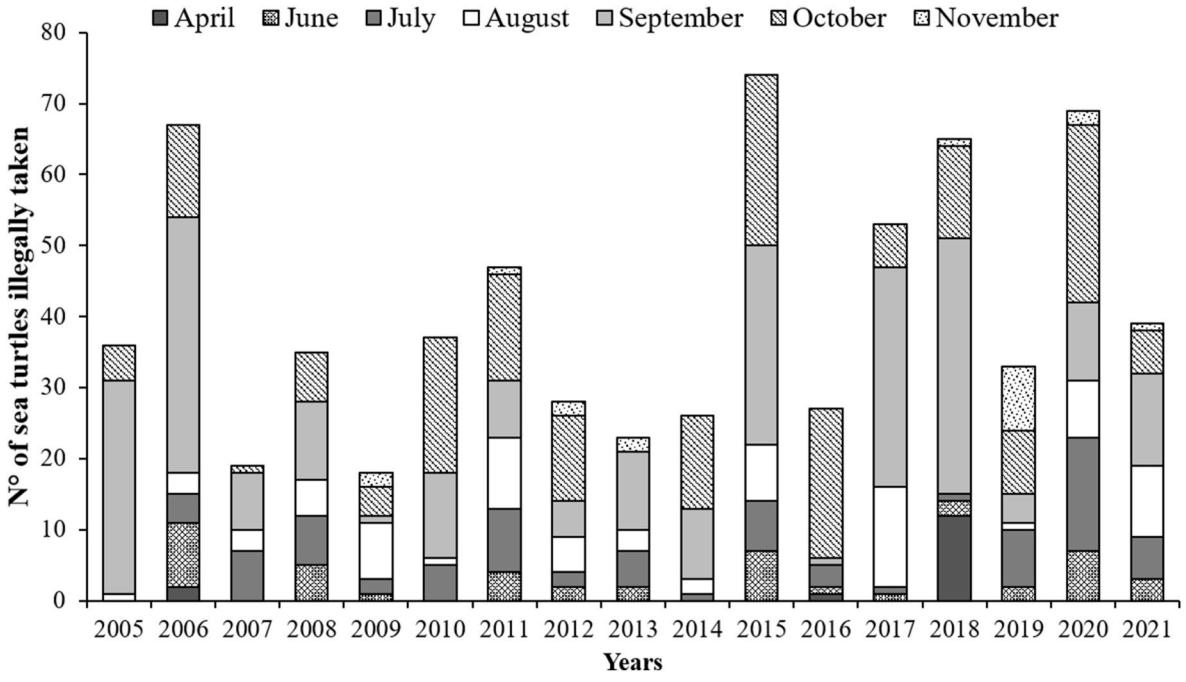

Fig. 3. Nesting sea turtles illegally taken per year and month from March to November for the 29.6 km at Tortuguero for the period 2005–2021; n = 687.

(level of take, trade routes, and price of sea turtle products) and (c) anecdotal information about sea turtle take (Tambiah, 1999; Barrios--Garrido et al., 2017; Mejías-Balsalobre et al., 2021). Finally, according to the obtained responses, we described and classified the sea turtle take techniques employed in the three main monitored sections at Tortuguero. We analyzed the data obtained from informants by classifying the responses about sea turtle take into categories according to the frequency of response. Based on that classification, we extracted common themes mentioned during the interviews, such as "take", "consumption", "conservation", "tradition" (See Table 1) (Barrios-Garrido et al., 2017; Álvarez-Varas et al., 2020). Finally, prices of sea turtle products were calculated at an exchange rate of US$1 per ₡622.50 Costa Rican currency (October 19th, 2021).

3. Results

3.1. Sea turtles illegally taken

From 2005 to 2021, we recorded 735 nesting turtles taken in the entire beach (29.6 km) at Tortuguero (Fig. 2). Mean annual take rate was 43.2 ± 18.4 per year. Most of the individuals taken were green turtles (n = 708, 96.3%), followed by hawksbills (n = 27, 3.7%). No taken leatherback or loggerhead turtles were recorded during the study period. Sea turtle take events were recorded every year, with the highest number registered in 2015 (n = 80, 10.9%) and the lowest in 2009 (n = 18, 2.5%) (Fig. 3). Most of the poaching activity occurred during the month of September (n = 256, 35.4%), followed by October (n = 193,

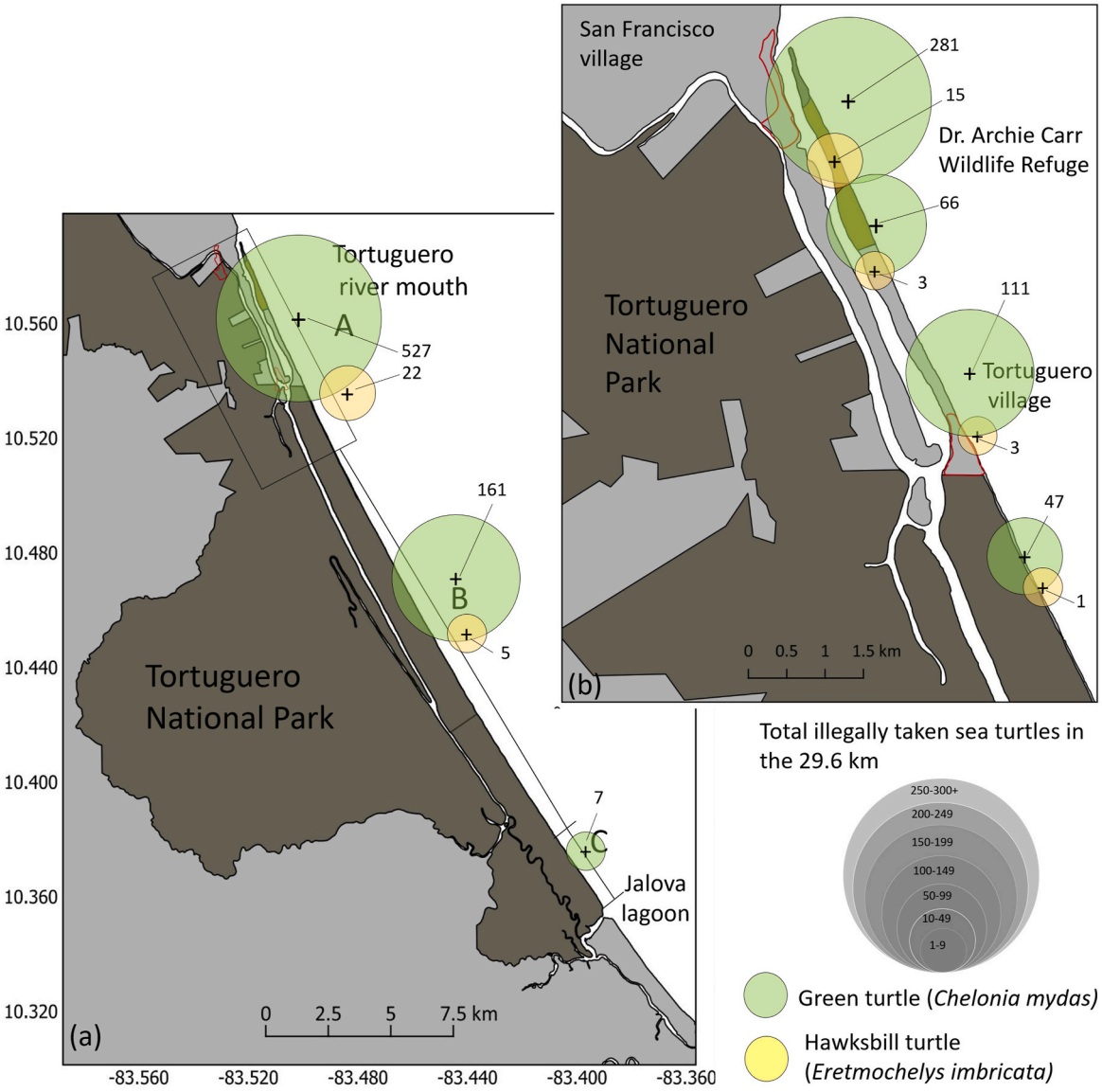

Fig. 4. (a) Spatial distribution of the sea turtle species illegally taken during period 2005–2021. (b) Detail of sea turtle take in area A (8 km), n = 700.

26.7%), while the lowest occurrences were registered in April (n = 15, 2.1%) (Fig. 3). Since the data collected during 2014, 2015, and 2016 did not include the date (month), not every encounter was included in Fig. 3. However, data from those years were included in the number of nesting turtles taken per year.

The vast majority of the turtles taken were recorded in section A (n = 527, 75.3%), followed by B (n = 166, 23.7%) and lastly section C (n = 7, 1.0%) (Fig. 4a). Most of the sea turtles taken in section A were recorded at Tortuguero RM (n = 296, 42.3%) and at the Tortuguero village (n = 114, 16.3%) (Fig. 4b). Additionally, during the study period we documented multiple sea turtles (dead and alive), with evidence of anthropogenic attacks at the northernmost 8 km (Fig. 5) and within TNP (Fig. 6).

3.2. Semi-structured in-depth interviews

We obtained a 100% response rate (n = 12) from the semi-structured in-depth interviews. However, some respondents preferred not to answer specific questions. All the interviewees reported that in Tortuguero the sea turtle take has always occurred, and 83.3% of them had witnessed it. According to them, the green turtle is the species most taken (100%) and the take activity is focused on the nesting (June–October) and mating seasons (April–August). The interviewees stated that hawksbill turtles are also taken as they are economically more valuable (33.3%), while leatherback turtles are not taken due to their size and unpleasing taste (33.3%).

All the interviewees knew about common and traditional techniques employed to take sea turtles from the beach and at sea. They identified 11 take techniques used at Tortuguero (Table 2). According to the respondents, sea turtle take occurs in the three main monitored sections. They mentioned that turtle poachers have improved their take techniques over time to pass undetected (33.3%); however, dragging the turtles off the beach into the vegetation is still the primary and most employed technique (83.3%). Our respondents also confirmed that harpoons have always been used in Tortuguero waters (91.7%) near to TNP (58.3%) and harpoon hunters come from the city of Limon (50.0%) located 87 km south of Tortuguero (Fig. 1b). Interviewees stated that poachers from Limon could take between 10 and 30 sea turtles on a given night at TNP during the peak of the nesting season (41.7%), even though the ACWR was pointed out as the area with greatest take in

Fig. 5. Green turtle illegal hunting activity at TNP. (a) Green turtle taken and butchered in front of Tortuguero village, 2020. (b) Live green turtle with major cut injuries abandoned by poachers in front of Tortuguero village, 2020. (c) Green turtle found stranded after being tied up by the flippers to be taken in TNP, 2021. (d) Green turtle found butchered in front of Tortuguero village, 2021. (e) Green turtles found flipped over at ACWR before being taken, 2014. (f) Green turtle meat left by a fleeing poacher in front of Tortuguero village, 2021. Photographers: Jaime Restrepo, Jimena Gutiérrez-Lince, Ben Luke and Gloria Guerrero. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

Tortuguero (91.7%). In addition, it was mentioned that green turtles are usually dragged and taken off the beach alive, while hawksbill turtles could be lifted and taken readily (16.7%). Finally, they mentioned that the take techniques depend on the beach location, timing (day or night), month, and presence/absence of scientific patrollers or rangers.

In Tortuguero village, sea turtles are still consumed due to tradition (33.3%). However, some respondents mentioned that it is difficult to find sea turtle meat in the village and the only way to obtain it is by previous order, as the meat is sold in advance by local people suffering from substance abuse problems (41.7%). On the other hand, the city of Limon (Fig. 1b) was identified by 83.3% of the interviewees as the major regional destination of sea turtles taken from TNP, followed by the San Francisco community (16.7%) (Fig. 1d). The intermediate towns of Guápiles (62 km) and Cariari (40 km) were also identified as final destinations (Fig. 1b). Furthermore, respondents affirmed that in the city of Limon there is a special festivity occurring in October where the tradition of eating sea turtle meat still remains (25.0%). Our interviewees affirmed that the prices for sea turtle products depended on the timing within the season and their final destination. The price of an entire sea turtle ranges from US$177 up to US$563, if it includes the mating pair (female and male together). Meat was reported to be cheaper in Tortuguero (US$3 to US$4 per kg) and more expensive in Limon, with a value of US$8 to US$13 per kg. Hawksbill meat has the same price as green turtle meat. According to our respondents (66.7%), the whole sea turtle is consumed, except the carapace and the plastron.

Most of the interviewees (75.0%) believed that sea turtle take has decreased in Tortuguero over time since the creation of TNP and the monitoring program. Nevertheless, according to our respondents (41.7%), it is necessary to have more vigilance by TNP rangers to prevent the take of sea turtles, even when most of the interviewees were aware that the extent of the area and lack of personnel were great impediments to do so.

4. Discussion

4.1. Sea turtle take in Tortuguero

The legal and illegal take of sea turtles have been documented for generations at Tortuguero (Carr, 1954; Troëng and Rankin Gonzalez, 2000; Pheasey et al., 2021). By the beginning of the 20th century, Tortuguero hosted a legal large-scale export operation by 18-ton ships taking sea turtles regularly from the nesting beach (Gutiérrez-Lince et al., 2021). However, since 2002, sea turtle take, trade and use of sub-products became illegal in the entire country (La Gaceta 230, 2002), with the exception of Ostional nesting beach where the egg harvest is still legal (Valverde et al., 2012; Rojas-Cañizales et al., 2022).

According to our findings, green sea turtles are still the most poached species in Tortuguero. We found that a minimum of 43.2 sea turtles are taken per year, on average, at this rookery. Pheasey et al. (2021) found through daily monitoring within the northernmost 8 km (Section A) that

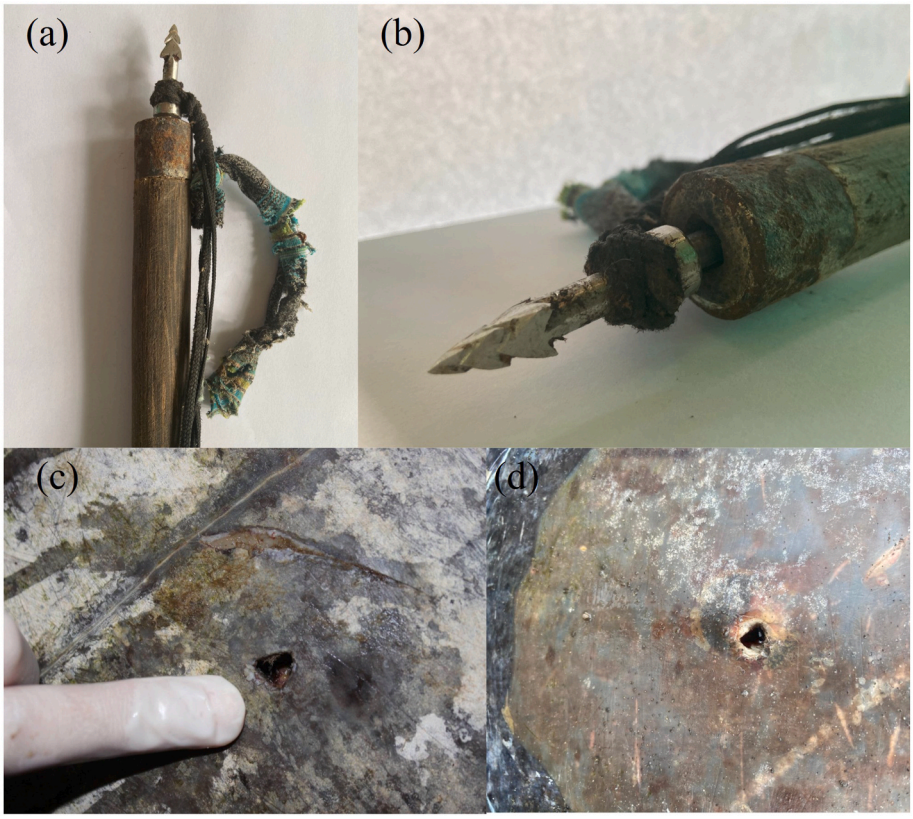

Fig. 6. Evidence of illegal activity at TNP. (a) and (b) Harpoon found at the beach in TNP, 2018. (c) Green turtle injured by a harpoon in TNP, 2015. (d) Green turtle injured by a harpoon and found stranded in TNP, 2021. Photographers: Daniela Rojas-Cañizales, Raúl García and Ben Luke. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

373 green turtles were taken between 2006 and 2019, indicating also that the take gradually decreased over that time. However, we found that 735 sea turtles were taken during the period 2005–2021, showing that the number was actually higher when including TNP's entire extension (29.6 km). So far, the documented sea turtle take in Tortuguero is considerably lower if we compare with Nicaragua, the second-largest legal fishery of green turtles in the world at 8000 turtles per year (Lagueux et al., 2014), or other locations in the Caribbean such as the Colombia Guajira Peninsula (5000 turtles per year) (Rueda-Almonacid et al., 1992; Vásquez-Carrillo and Peláez-Ossa, 2021) and the Venezuela Guajira Peninsula (3556 green turtles per year) (Barrios-Garrido et al., 2020b; Rojas-Cañizales et al., 2020). These three locations are exposed to larger rates of sea turtle take in the Caribbean Sea and they serve as foraging grounds for the Tortuguero green sea turtles (Lagueux et al., 2014; Barrios-Garrido et al., 2020c).

We acknowledge that our findings represent a minimum take, which is likely an underestimation as it does not account for the number of turtles taken in remote areas of TNP, transported elsewhere, captured at sea, and/or taken alive with undetected tracks/signs. Moreover, according to our local interviewees, up to 30 turtles could be taken in TNP on a given night during the peak of the nesting season. This suggests that the number of taken animals may have been significantly higher than our record shows. However, it is important to mention that we do not know how accurate this suggested estimate is. If accurate, it would represent thousands of sea turtles taken over nearly two decades. Current data indicate that the green turtle nesting population has been undergoing a gradual decline since about 2008 (Restrepo et al., 2023a). The reason for this decline is currently unknown, but it may be due to the legal and illegal take that this population has sustained for many decades across its entire range in the Greater Caribbean (Stringell et al., 2013; Lagueux et al., 2014, 2017; Barrios-Garrido et al., 2020a; Rojas-Cañizales et al., 2020; Senko et al., 2022; Restrepo et al., 2023a).

The second most taken species in Tortuguero is the hawksbill sea turtle (3.7%), which nests in low numbers at this rookery. The hawksbill nesting population has suffered a sharp decline (Meylan, 1999; Troëng et al., 2005), with an estimated number of <25 nests/year between 1955 and 1993 (Bjorndal et al. 1993). The historical levels of direct and incidental take of hawksbill turtles in the Caribbean Sea have been documented as one of the major reasons for the decline of this population (Troëng et al., 2005; Pheasey et al., 2021). According to our findings, there is still illegal take of hawksbill turtles at Tortuguero. Nevertheless, not all the turtles taken were recorded. Interviewees mentioned that since hawksbills are smaller than greens, poachers lift and take them with ease, which makes it difficult to properly quantify their take during surveys. An assessment of the current status of the nesting hawksbill population at Tortuguero is needed to evaluate the extent to which this species is affected by poaching of adults in the area and to develop strategies to avoid further negative impacts on this declining population.

4.2. *Sea turtle take: spatial-temporal distribution*

We found that sea turtle poaching fluctuated over time and did not occur all year round. Instead, the majority of the take occurred during the peak of the green turtle nesting season in September (35.4%) (Bruno et al., 2020; Restrepo et al., 2023a), although the take of hawksbill turtles was mainly reported before and after the green turtle nesting season, when there were only a few green turtles nesting on the beach. This pattern is consistent with sea turtle take in other locations where the take is related to the availability of the species throughout the year (Koch et al., 2006; Mancini and Koch, 2009; Barrios-Garrido et al., 2020b). According to track survey data, Tortuguero has two hotspots for

Table 2
Techniques employed for the illegal take of sea turtles in Tortuguero rookery.

Main nesting area	Location	Sea turtle take technique description
Area A	Tortuguero RM ACWR	At the beach, sea turtles are tied to a buoy and released into the water where poachers on boats collect them. Sea turtles are tied up with a rope and then once in the water while swimming the turtle is dragged to the river and carry onto a boat Sea turtles are flipped over and left on the beach to be carried onto a boat on the shore. Sea turtles are tied up to trees using a long rope, allowing them to return to the sea, then a boat take them off the water. Sea turtles are flipped over and dragged into the vegetation until an open access into the river is reached, there they can be taken by boat.
	Tortuguero Village	Sea turtles are dragged off the beach into the vegetation to be butchered. Sea turtles are tied up with a rope by one of their flippers and then dragged into the vegetation. Sea turtles are lifted by two or more people and carried to a local house. Sea turtles are scared and forced to return to the sea, once off the shore, the turtle is lifted and taken without any signs of poaching.
Area B	TNP (8 km–24 km)	Many sea turtles are flipped over at the same time by poachers and left at the beach to be taken by a boat when the tides allow boats to get close to the shore. Sea turtles are flipped over and dragged into the vegetation in TNP until reaching an open access into the river, where they are taken by boat. Sea turtles are taken out in the sea by using harpoons to pierce their carapace, this technique is specially used to capture mating turtles. Numerous sea turtles are flipped over and tied up by their flippers with a long rope at the beach and then released. The rope has a light in one end, which sends a signal to the boat that will take the turtles "emboyadas" (Fig. 7). Sea turtles are flipped over at the shore and poachers make holes in their four flippers to tie them with a rope and lift them with a long poll to carry them into the boats.

sea turtle take: the northernmost section A (42.3%), close to populated areas (Tortuguero RM, ACWR and Tortuguero village), and deep inside TNP in section B (23.7%) (Fig. 4a). Similarly, Pheasey et al. (2021) found that sea turtle take hotspots were correlated with populated areas in Tortuguero and nearby beaches, in agreement with our interviewees' opinions. The high number of sea turtles taken at the ACWR could be related to the proximity to the neighboring community of San Francisco de Tortuguero, which somewhat benefits from sea turtle-related ecotourism (Mejías-Balsalobre et al., 2021). As well, the number of sea turtles recorded taken in section A could be related to the daily monitoring in which is more feasible to detect these events. On the other hand, sea turtle take in section B may be higher than what our results suggest as this section is not monitored daily. In addition, section B supports most of the green turtle nesting activity during the nesting season (Restrepo et al., 2023a), offering a large availability of green turtle. In fact, in 1997 this section was pointed out by previous research as the area with greatest sea turtle take at Tortuguero (Troëng and Rankin Gonzalez, 2000). Lastly, the isolation of section C and the conservation efforts along with constant monitoring could be the reason for the low numbers of sea turtles taken in this section (1.0%).

4.3. Sea turtle take techniques

Different sea turtle poaching techniques have been employed and documented for generations in many coastal localities (Carr, 1954; Nietschmann, 1972; Delgado and Nichols, 2005; Marco et al., 2012; Stringell et al., 2013; Barrios-Garrido et al., 2020b). However, in Tortuguero, this is the first time that sea turtle take techniques have been identified and described. Among the identified techniques (Table 2), harpooning is one of the oldest employed at the rookery and around the Caribbean Sea (Carr, 1954; Nietschmann, 1972; Meylan et al., 2013; Barrios-Garrido et al., 2020b). In 2015, five green turtles presenting harpoon injuries were found by TNP rangers, and in 2018 two harpoons were found in TNP (Fig. 6). Additionally, flipping over and dragging sea turtles off the beach are techniques employed as well at this rookery (Carr, 1954; Troëng and Rankin Gonzalez, 2000; Marco et al., 2012). According to our respondents, harpooning occurs during the entire breeding season and is carried out by people from Limon that can be seen offshore of TNP in speed boats. Meanwhile, the flipping technique only occurs during the nesting season and was already described in Tortuguero in 1954 (Carr, 1954). Interestingly, we did not record fishing gillnets in Tortuguero, which are usually used in other locations of the

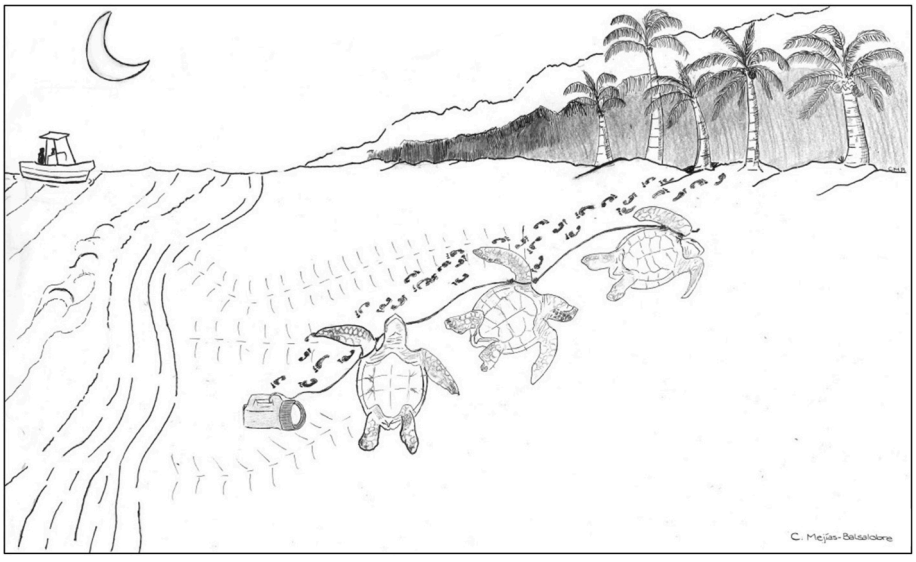

Fig. 7. "Emboyadas" technique, graphical technique description. Numerous sea turtles are flipped over and tied up by their flippers with a long rope at the beach and then released. The rope has a light in one end, which sends a signal to the boat that will take the turtles.

Caribbean Sea to take sea turtles (Meylan et al., 2013; Barrios-Garrido et al., 2020b).

According to our findings, it seems that the take techniques employed by poachers at Tortuguero have changed and improved over time. Take techniques like "las emboyadas" (Table 2; Fig. 7), have not been formally documented before. The extent of TNP and the diverse techniques that do not leave a trace are the main issues that rangers face to detect this illegal activity. Likewise, the constant adaptations and changes in the take techniques are also a challenge for determining the hotspots for the take of sea turtles inside TNP.

4.4. Attitudes toward sea turtles and sea turtle take at Tortuguero village

Interview respondents mentioned that all the initiatives carried out at Tortuguero in recent years have helped to decrease the amount of sea turtles taken by the community. It seems that interviewees were aware of the implications that sea turtle take could have on the nesting population as well as on the tourism as occurs in Rapa Nui, Chile (Álvarez-Varas et al., 2020). However, even though they considered that most sea turtles are not taken close to the village, they mentioned that some locals still consume sea turtle meat. According to the respondents, most of the consumers are aware that sea turtle take is an illicit activity and do not publicly buy or eat sea turtle products as it is considered shameful. In fact, respondents mentioned that at the village it is not possible to openly find sea turtle meat as it is usually acquired by previous order to illegal sellers, which has been documented for other turtle products in this village (Mejías-Balsalobre et al., 2021). One of our interviewees indicated that an old poacher in the village taught him how to take and butcher sea turtles. Thus, it seems that take techniques are shared and transmitted among people.

Interviewees stated that sea turtles were important to them as they grew up eating turtle meat and sharing it with their families, especially during special occasions (e.g. birthdays, carnivals). This suggests that sea turtles are also important as a traditional food resource. On the other hand, it has been documented that long-term Tortuguero residents believe that locals should have the right to eat turtle meat (Gutiérrez-Lince et al., 2021), this could be one of the reasons for consumption of sea turtle meat in the village at present. According to our findings, traditions regarding sea turtle consumption at Tortuguero are still present and linked to a sense of belonging for some long-term residents, which has been reported in other coastal communities such as Rapa Nui, Chile (Álvarez-Varas et al., 2020), Wayuú in Colombia and Venezuela (Barrios-Garrido et al., 2018), and Baja California in Mexico (Delgado and Nichols, 2005).

4.5. Sea turtle trade

We found different opinions regarding trade and consumption of sea turtles. In general, sea turtle take at Tortuguero appears to be an important alternative income for people from different locations, Limon being the most profitable. One of our respondents mentioned that the whole turtle is used and provides good profit to the poacher who sells it. Sea turtle products from Tortuguero, such as meat and eggs, can be found in local and regional black markets in the country with prices ranging between US$3 to US$13 kg^{-1} for the meat and US$117 to US $563 for a whole turtle. The prices of sea turtle products from Tortuguero are similar to the prices reported for the Venezuelan Guajira for green turtle meat (US$5 kg^{-1}) and the whole sea turtle (US$300) (Barrios-Garrido et al., 2017). Our respondents also mentioned that the value of sea turtles depends on the season and the final destination of the animal. This statement is supported by the fact that sea turtles are usually higher priced at regional markets than in coastal communities, as the price increases with the distance from the point of take (Mancini and Koch, 2009; Barrios-Garrido et al., 2017).

Barrios-Garrido et al. (2017) mentioned that the price of sea turtle products in the Guajira Peninsula (Colombia and Venezuela) usually varies among species. However, green turtle and hawksbill meat is sold at Tortuguero for the same price. According to our respondents the only product that is better paid by the consumers is the hawksbill carapace, which has been documented in other Caribbean locations as well (Barrios-Garrido et al., 2017, 2018; Nahill et al., 2020). Mancini and Koch (2009) mentioned that the main traffic routes coincided with communities where the sea turtle fishery is legal. This may be the case in Tortuguero, as the law that bans the sea turtle fishery in the country was created only in the early 2000s (La Gaceta 230, 2002), and some members of the community still believe that they are entitled to consume sea turtle products.

4.6. Conservation implications in Tortuguero management

Tortuguero is renowned worldwide for its sea turtle ecotourism and conservation efforts (Meletis and Harrison, 2010). Yet, our findings show that even when sea turtles tours offer high rewards (between US $12 to US$15 by person) to the community (Personal communication), consumption still occurs. This could have a negative impact in this green turtle nesting population, which is starting to show signs of decline (Restrepo et al., 2022a). In 2019, as a potential solution to reduce the take of sea turtles, the National System of Conservation Areas (SINAC) together with the TNP formed a Natural Resource Surveillance Committee known as COVIRENA (Pheasey et al., 2021). This program recruits volunteers from the community who support and help officials protect and reduce illegal activities in the area. The creation of COVIRENA has so far helped to reduce the sea turtle take at Tortuguero in populated areas. However, this committee is relatively new, and it is necessary to maintain it over the years to evaluate if this initiative helps to reduce sea turtle poaching at Tortuguero in coming years.

The involvement of communities such as Limon in the sea turtle take makes it challenging to assess the real magnitude of this problem, since the level of the demand and consumption of sea turtle products is unknown. This is why it is necessary to conduct research from a social science perspective in Limon, aiming to assess the local knowledge in sea turtle consumption that may be critical to better understand this complex issue. It is important to mention that this study constitutes a critical step toward elucidating the sea turtle take hot-spots at Tortuguero and provides information about take techniques that could help to better identify and detect this illicit activity. Finally, we recommend further changes in the management plans of TNP, as well as more personnel.

Credit author statement

Daniela Rojas-Cañizales: conceptualization, methodology, formal analysis, investigation, data curation, writing - original draft, visualization. **Jaime Restrepo:** conceptualization, investigation, resources, data curation, writing - review & editing, visualization. **Carmen Mejías-Balsalobre:** methodology, investigation, writing - review & editing, visualization. **Héctor Barrios-Garrido:** methodology, investigation, resources, writing - review & editing, visualization, supervision. **Roldán A. Valverde:** resources, writing - review & editing, project administration, supervision.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jenvman.2022.116408.

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