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Aquatic Wildmeat Consumption of Guiana Dolphins (*Sotalia guianensis*) in Lake Maracaibo System, Venezuela

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In many regions of the world, the use of cetaceans as bait or protein source has been reported. In most cases the individuals are from bycatch but also from intentionally killed animals. Cetaceans with coastal habits are more susceptible to negative interactions with small-scale fisheries, as in the case of the Guiana dolphin (*Sotalia guianensis*) in the Lake Maracaibo system. For decades, the use of Guiana dolphins by local communities has been reported in this region and is culturally supported by recipes for its preparation. Most of these data was outdated and some were anecdotal, so the objective of this work was to collect systematically data through surveys using the snowball method in seven artisanal fishing communities and to try to quantify the capture rate and to inquire about the potential impact of this practice on the population of Guiana dolphin. From 2017 to 2019, 95 semi-structured interviews were applied. An average bycatch of 180 individuals/year was obtained, the highest catch rate in the entire geographic distribution, an alarming situation considering that the surveys were not carried out in all the fishing ports, generating an underestimation. A total of 78% of interviewed recognized at least one bycatch event during their fishing effort. Surveys revealed a higher incidence of entanglement of offspring and juveniles (78%). 77% of the respondents deny the sale and commercialization of the species, while 5% mention some type of trade. The most frequent part exploited was the dorsal muscle, confirmed by fishermen (97%, n = 72) and the rest of the animal is discarded. During this investigation three episodes of directed capture were recorded, affecting a total of 23 individuals, two of them were pregnant females. The interviews also revealed that the majority of fishermen (93%) recognize the capture of this species as illegal. Considering the vulnerability of the Guiana dolphin in the country, the high incidence of capture and consumption and the lack of surveillance and sanctions by government entities, it is imperative to immediate actions to mitigate the negative impact on the population.

Keywords: *Sotalia guianensis*, aquatic wildmeat, consumption, bycatch, Lake Maracaibo

INTRODUCTION

Direct fisheries interaction has been recognized as the main cause of cetacean mortality throughout the world (Mitchell, 1975; Reeves et al., 2013, 2003; Brownell et al., 2019), even nearly causing the extinction of species such as the "vaquita marina" (*Phocoena sinus*) (Rojas-Bracho and Taylor, 1999; Rojas-Bracho et al., 2006). Cetacean species with coastal habits are even more vulnerable due to anthropogenic threats as the species distribution overlaps with the presence of humans and their activities (Reeves et al., 2003; Lotze et al., 2006; Hawkins et al., 2017).

Historically, the use of cetaceans around the world is diverse, i.e., as bait in shark fishing (Mintzer et al., 2018), as a protein resource (Read et al., 1988; Ávila et al., 2008) and the use of some of parts for mythical/religious purposes (Alves and Rosa, 2008), among others. Generally, these animals come from bycatch and sometimes from intentional capture, but both situations represent a threat to the population stability of many aquatic mammals (Clapham and Van Waerebeek, 2007; Robards and Reeves, 2011; García et al., 2013). Recently, the Convention on Migratory Species generated a concept for this exploitation, thus defining aquatic wild meat as all products derived from aquatic megafauna, used for food or non-food purposes (CMS, 2017).

The Guiana dolphin (*Sotalia guianensis*) (Van Bénéden, 1864), distributed from Nicaragua (Carr and Bonde, 2000) to Southern Brazil (Borobia et al., 1991; Da Silva and Best, 1996), is listed by the IUCN as "Near Threatened" (Secchi et al., 2018), a species for which frequent bycatch has been reported, which may be affecting its population stability at the local scale. In fact, in Venezuela it is classified as "Vulnerable" (Barrios-Garrido et al., 2015), as in Brazil (Instituto Chico Mendes de. (Conservação)da Biodiversidade (ICMBio), 2018) and Colombia (Trujillo et al., 2006).

The Lake Maracaibo system in western Venezuela, has important economic value because of the oil industry and the benefit it brings to large fishing communities. It is also the main area of occurrence of *S. guianensis* in Venezuela (Casinos et al., 1981). These anthropic activities generate several negative impacts on this ecosystem such as overfishing, eutrophication processes and frequent oil spills (MARN, 2000; Ferrer and Morales, 2013; Molina and Yedra, 2019).

The population of *S. guianensis* in Lake Maracaibo has been suggested as a separate management unit due to its unique genetic and morphological characteristics (Caballero et al., 2010, 2018; Cunha et al., 2010; Briceño et al., 2017). Despite its ecological relevance, its use as bait for shark fisheries and as a protein source for humans has been reported for decades and is culturally supported by recipes for its preparation (Ramírez, 2005; Pirela et al., 2006; Sánchez-Criollo et al., 2007; Sánchez and Briceño, 2017), despite the existence of laws in force that prohibit it. In the past, only bycatch dolphins were exploited, but in recent decades (since 2010), a growing interest in live capture has been registered.

Many records on the use of Guiana dolphins in the Lake Maracaibo system are anecdotal, with information derived from easily accessible locations, and those that have been compiled using some methodology are out of date. These factors limit a larger-scale analysis of the problem, as it is difficult to estimate the capture rate and its possible impact on the population. It is also difficult to gain clear knowledge about the current use of these dolphins and their value to the local people. Without this information, conservation strategies may be ineffective or insufficient.

The objective of this study was to present updated information on the consumption of the Guiana dolphin in some areas of Lake Maracaibo, to try to quantify the capture rate and to inquire about the potential impact of this practice on the population of *S. guianensis* in Lake Maracaibo.

MATERIALS AND METHODS

Study Areas

The Lake Maracaibo system is located in western Venezuela (9°48′57″N 71°33′24″W), and is considered to be a set of interconnected bodies of water. This system is composed by Gulf of Venezuela, El Estrecho with a length of 55 km, El Tablazo bay and Lake Maracaibo itself, the only one of its kind with its connection to the Caribbean Sea (Rodríguez, 2001; José, 2000). The physicochemical variables differ in these areas, as salinity decreases from the north (influenced by the salinity of the sea) to the south (influenced by the contribution of large rivers) (José, 2000). This gives rise to different habitats with diverse fish fauna, some strictly marine, marine-estuarine and freshwater species (José, 2000; Rodríguez-Olarte et al., 2011).

The lake Maracaibo system has two areas of great ecological value. In the extreme northeast, the Refuge of Wild Fauna and Fishing Reserve "Ciénaga de Los Olivitos" is a wetland with a great diversity of fauna and flora, and in the southwest is the National Park "Ciénagas de Juan Manuel," characterized by its swampy soil, where delta, flooded forests and tropical forests are also found (Medina and Barboza, 2006) with a high diversity of endemic fauna. The portion of water that the park encompasses is an important habitat for *S. guianensis,* because the shallow bays in the zone, with the presence of vegetation, which provide shelter and food for the calves (Briceño and Sánchez, 2017).

Localities Evaluated

A total of seven artisanal fishing communities located in the northern, central western and southern regions of Lake Maracaibo were visited (**Table 1**).

The boats used throughout Lake Maracaibo were similar, and were made out of fiberglass and wood with a size between 4 and 7 m, with one 40 HP outboard motor. Generally, activity takes place near the coast.

Despite the fact that in some of these regions there is intensive fishing and some economic income from tourism, all of these communities are considered low-income and the inhabitants have a low level of formal education. These localities were selected because they are the ones with the largest number of formally

registered fishermen, and from which previous data (Sánchez-Criollo et al., 2007; Ramírez, 2005) on the consumption of the Guiana dolphin were obtained (**Figure 1**).

Interviews

From 2017 to 2019, 95 semi-structured interviews that represents the 10% percent of the fishermen registered (950) in the seven communities grouped in four (4) fishing ports. Open and closed questions were applied in all fishing communities selected of Lake Maracaibo system. In the northwest (NW) a total of 33 interviews were applied (San Carlos island 15, Toas island 10, and Zapara island 8), in the northeast (NE) 12 (Los Puertos de Altagracia), Central west (CW) 10 (Barranquitas), and the Southwest (SW) region 40 (31 in Puerto La concha and nine in Ologá). The non-probabilistic snowball technique was used (Naderifar et al., 2017), which consists of identifying a subject who can provide the required information and then that subject suggests the next person to interview.

The choice of this technique does not allow to know in advance the final number of participants, but it does guarantee that the data collection is less biased and with higher quality, because allows for establishing a link and building trust between the parties involved (Biernacki and Waldorf, 1981; Zappes et al., 2013).

Closed (Yes or No) and open questions were considered to collect more extensive information and allow the fisherman to express himself freely (Huntington, 2000; Kendall, 2008; Albuquerque et al., 2014). The survey began by asking if they knew of or had seen the "tonina," as they are called locally. They were asked to describe the animal and indicate if it had any relevant characteristics and then a set of images were showed them to verify the identification of the species.

The interviewed persons met these requirements: fishing as the main economic activity, being a resident of the town and having at least 5 years of fishing experience or more, in order to guarantee data quality.

Additionally, direct observations were made in the field, and expeditions were made in search of stranded individuals with evidence of anthropic interaction. A review of the information available in scientific articles and the gray literature on this subject was performed in order to detect changes in the use of this species.

RESULTS

Along most of Venezuela's coasts the fishermen's council is led by a local fisherman. These were located to explain the activity to be carried out and invite them to participate voluntarily. A total of 95 interviews were conducted between 2017 and 2019 in seven fishing communities. The surveyed population corresponded entirely to fishermen between 24 and 70 years of age.

Knowledge of the Species

In response to the kind of animal, 9% of them identified the species as a mammal, 14% did not know and 77% (n = 73/95) simply indicated that it was a "tonina." Twenty-one fishermen (22%) denied bycatch during their fishing operations, while the rest (78% n = 74) stated that an event of this type had occurred on some occasions. A total of 34% of interviewees (n = 25) indicated that more than one dolphin was captured per month. Obtaining an average of 3–4 individuals per month, and at least 180 dolphins per year, the majority (77%) were juveniles (n = 41) and calves (n = 16) individuals, considering the length of the body (**Figure 2**).

The following measurements were considered > 1.7 m (adult), > 1 m < 1.7 (juvenile), and < 1 m (calf) (Di Beneditto and Ramos, 2004; Riquelme et al., 2011; Lima et al., 2017) to determine the ontogeny of captured individuals. This question

TABLE 1 | Localities evaluated in four regions of the Lake Maracaibo system.

Region	Locality	GPS coordinates	Type of fishing gear	Length	Fauna
North west (NW)	San Carlos Island	10°59′17.60″N, 71°36′43.94″W	• Nylon multifilament or monofilament nets with 3–5 inch openings. • Longlines	• Nets 200–500 m • Longlines 200–400 m	• Marine fish • Shrimp • Sharks • Rays
	Zapara Island	10°58′54.54″N, 71°34′03.83″W			
	Toas Island	10°58′54.54″N, 71°34′03.83″W			
North east (NE)	Los Puertos de Altagracia	10°40′26.58″N, 71°30′49.72″W	• Nylon multifilament or monofilament nets with 3–5 inch openings. • Longlines	• Nets 200–500 m • Longlines 200–400 m	• Fish • Shrimp • Blue crab (*Callinectes sapidus*)
Central west (CW)	Barranquitas	9°58′38.69″ N, 72°01′0.15″W	• Nylon multifilament or monofilament nets with 3.5–4 inch openings. • Longlines (mainly)	• Nets 200–500 m • Longlines 200–500 m	• Blue crab (mainly) • Fish
South west (SW)	Puerto Concha	9°01′32.07″N, 72°44′56.81″W			
	Ologá	9°25′33.19″N 71°49′42.87″W			

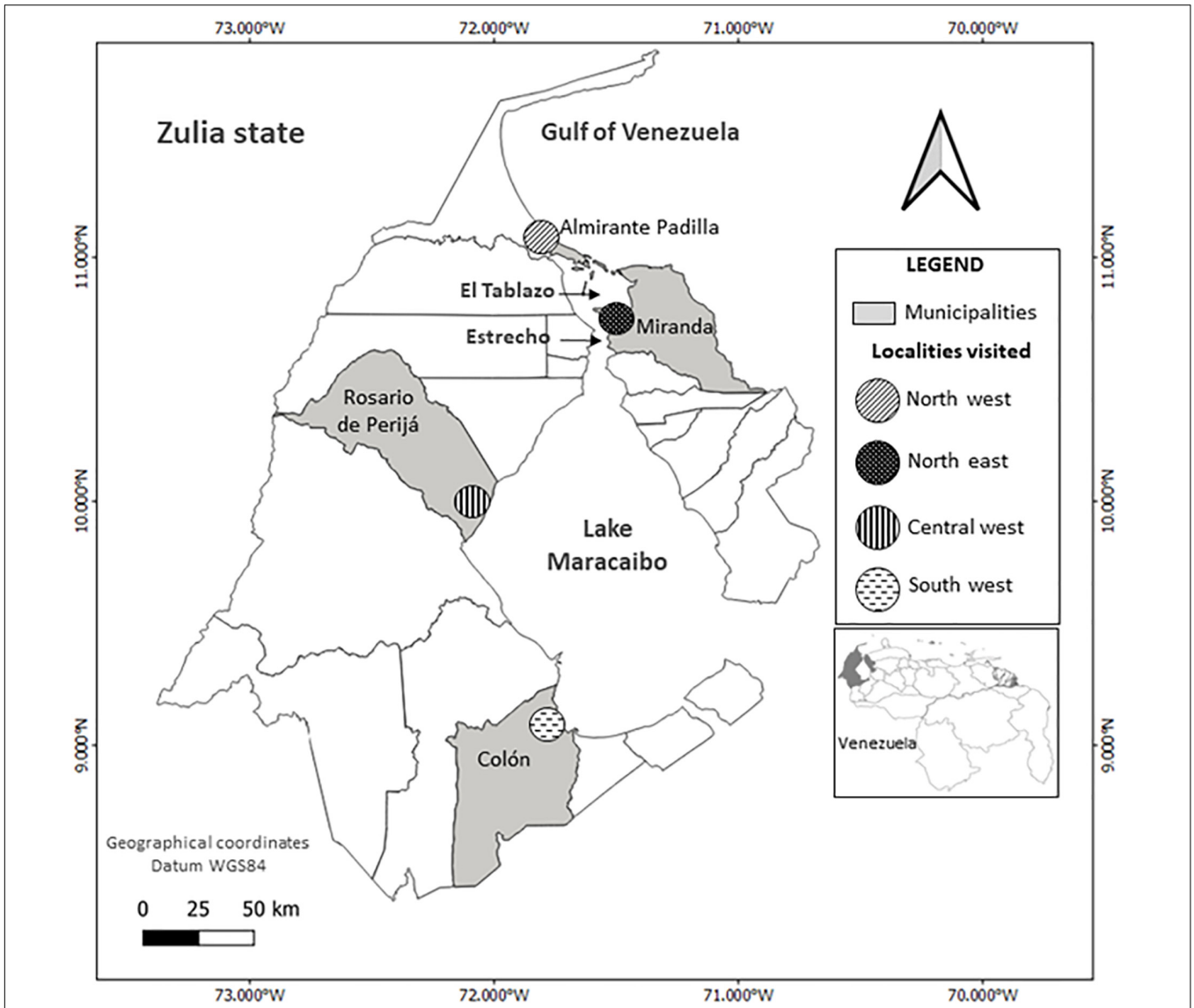

FIGURE 1 | Zulia state with the location of the fishing communities visited San Carlos, Zapara and Toas islands (northwest), Los Puertos de Altagracia (northeast), Barranquitas (central west), Puerto La Concha, and Ologá (southwest).

was applied to them with great precision, using different elements of their environment as a reference. Regarding seasonality and its possible relationship with dolphin catches, it was concluded that the events occurred indistinctly in the rainy (since April to November in the north and center regions, in the south is not delimited) or dry season (since December to March in the north and center regions, not delimited in the south) (José, 2000). Of the total respondents, 84% (n = 62) said they did not notice any difference.

Use of Guiana Dolphin

Twenty-two (26%) fishermen from the northern region confirm the use of meat as bait in shark fishing; this is the zone where the elasmobranch group is found, and 74% (n = 62) reported use as a source of protein. All the interviewees denied any use for mythical/religious purposes.

The most frequent part exploited was the dorsal muscle, confirmed by fishermen (97%, n = 72) (**Figure 3**). Only two respondents mentioned the use of the ribs and liver. The rest of the animal was discarded directly in the lake according to the data collected (96%, n = 91), while some reported not knowing what the fishermen did with the rest of the captured animal.

A high percentage claimed to have eaten Guiana dolphins at least once (80%, n = 67) and stated that it tasted good. Regarding meat preparations, in general, in all communities, the dorsal muscle is cut into pieces and salted until it is consumed, the ribs are salted in the same way and its meat is shredded, and the liver is refrigerated until the moment of its consumption. The recipes vary according to the region. In the northwest, they cook

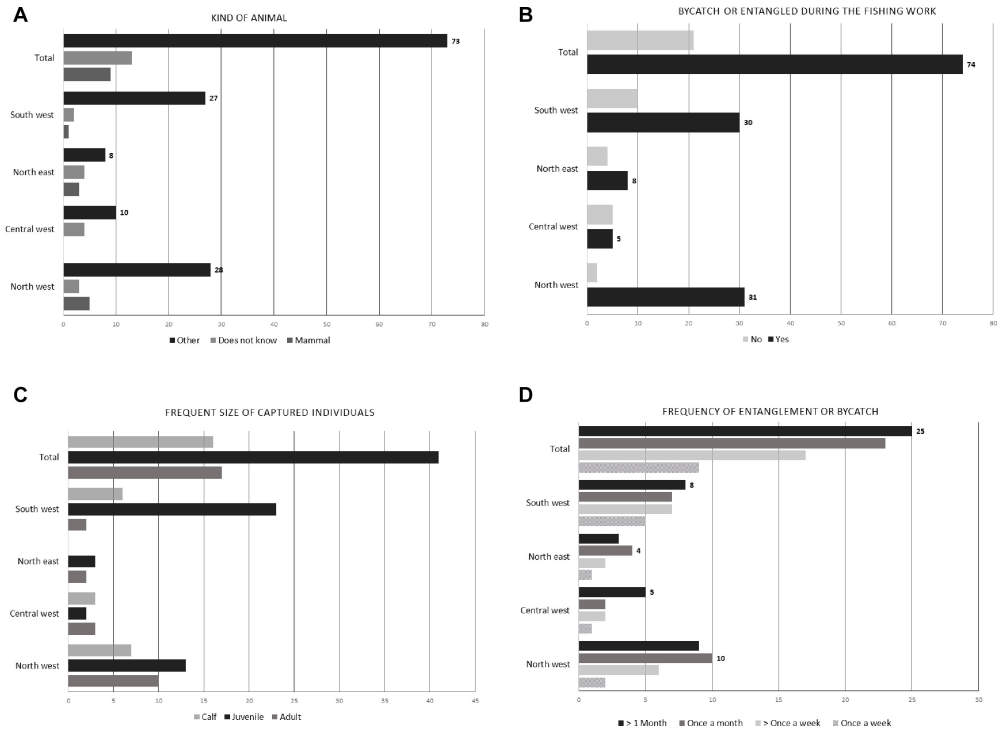

FIGURE 2 | Answers to the following questions in each locality evaluated and the total: **(A)** What kind of animal is it? **(B)** Has a tonina ever been caught in a net during your fishing operations? **(C)** How often do you think that happens in this locality? **(D)** What is the most frequent size of the tonina you caught?

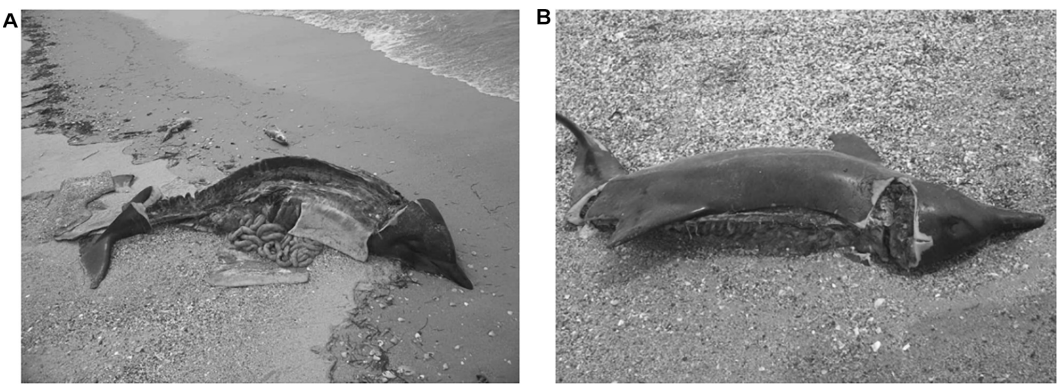

FIGURE 3 | Two individuals of *Sotalia guianensis* **(A,B)** found in northern region in 2019 with signs of anthropogenic interaction. In both cases, the dorsal muscles were removed.

it with spices and shred the meat to prepare a dish known as "pastelitos," which is a dough of wheat flour filled with dolphin meat and then fried. In the central west region, they also make a stew, and the muscle pieces along with a portion of the fat is fried and consumed as "chicharrón." In the southwest, they prepare the stewed muscle with spices and coconut cream is added.

Conflicts Associated With Exploitation

Only 5% of the fishermen reported on the commercialization of dolphin meat on some occasions, but is not a regular offer; the majority denied it (77%, $n = 73$), and the rest indicated they did not know anything about it (18%). In the southwest, all bycatch dolphins are consumed by the fisherman and his close family, and there has never been a commercial supply of this meat. A total of 48% ($n = 51$) indicated a decrease in their fishing in the last 5 years, as a consequence of constant oil spills.

Fishermen from the southwest reported two particular incidents. In July 2019, a fisherman left a net (400 m long) for a day and approximately 34 Guiana dolphins were trapped. The fishermen arriving at the site disentangled and consumed three dolphins as they were still fresh, discarding the others. The second event was in reference to entanglement with crab

fishing lines, and in that case the dolphin, despite being alive, was captured and consumed. In the northeast region, they reported that Guiana dolphins frequently bite fish on nets, specifically when there is "curvina" (*Cynoscion acoupa*), but they did not mention retaliation against dolphins.

In addition, in the course of this investigation, three cases of directed capture were reported. The first took place on the eastern shore of the lake, fishermen from a band dedicated to hunting dolphins were intercepted by members of the Bolivarian National Guard, finding an individual captured of Guiana dolphin on the boat for later sale. The next event reported in 2018 occurred in the south of the lake where a group of fishermen caught five individuals and brought them to a nearby town in the central region of the lake for sale. The last occurred in the northern region where seventeen individuals were deliberately captured, two of them were pregnant females and all the animals were distributed free within the community for their consumption.

Regarding the legal framework, the majority of fishermen (93% n = 88) know that the capture, consumption, and commercialization of this species are illegal.

DISCUSSION

Knowledge of the Species

All the fishermen in the interviewed communities are fully aware of the Guiana dolphin, despite the fact that many of them cannot place it within its taxonomic group. This may be associated with the low level of formal education and their inability to associate this species with marine dolphins because they are present in a lake, an ecosystem that they consider to be freshwater and which is an estuary.

The fishing activity along the entire coast is generally carried out within the first 15 km, and the Guiana dolphin inhabits precisely that coastal strip, intensifying bycatch.

Use of Guiana Dolphin

More than two decades ago, the exploitation of this species was reported in the northern region (Coty, 1995; Bolaños and Bermúdez, 1996; Pirela et al., 2002; Ramírez, 2005). Ramírez (2005) also documented the beginning of the commercialization of dolphin meat in the northwest, and the hunting of a group of twenty Guiana dolphins (Ramírez, 2005). Previous bycatch estimations for the northwest region indicated 3.42 dolphins/month (Ramírez et al., 2013), and current results show an increase in the same area (northwest) to 4 dolphins/month. The Lake Maracaibo system, as in many communities in the world that consume the meat of dolphins, the dorsal muscle is the most valued portion regardless of whether it is used as bait or as a protein source (Alfaro-Shigueto et al., 2010; Barbosa-Filho et al., 2018). The rest of the body is usually discarded offshore, as in most countries it is a crime to capture these marine mammals (Mangel et al., 2010; Manzan and Lopes, 2015).

Throughout the lake there are different fishing strategies with nets, but two forms of them are recurrent. The first occurs perpendicular to the coast, in which the nets, which can vary in length from 200 to 600 m, are cast and left for half an hour to an hour, then lifted to extract the fish. This procedure is reported several times during the fishing day. The second strategy is to leave the net permanently and check it at intervals of 4–8 h to remove the prey. This technique is responsible for the largest amount of bycatch of Guiana dolphins in the Lake Maracaibo system.

Juvenile individuals are more susceptible to bycatch events, possibly due to lack of experience in reacting and avoiding fishing nets, since naturally the behavior described for the Guiana dolphin has been evasion in the face of disturbances (Santos and Rosso, 2007). This is an unfavorable situation, particularly in the south of the lake, where its bays are considered breeding areas for the species (Briceño et al., 2017).

The consumption of *S. guianensis* is not exclusive to Venezuela. In Brazil, the use of the meat has been reported for the same purpose (Ferreira, 2006; Zappes et al., 2009; Meirelles et al., 2010). In each region evaluated (northeast, northwest, central west, southwest) they are experienced in removing and preparing the dorsal muscles, and it is possible to appreciate its culinary cultural value, due to the existence of recipes that have been passed on through oral tradition.

Currently, some recipes previously reported (Ramírez, 2005) in the northern region are no longer prepared, but in contrast, the meat of this dolphin seems to be acquiring a new culinary value. On the beach of San Carlos Island, tourists were offered "tonina pastries" for the first time as an exotic and exclusive dish.

Conflicts Associated With Exploitation

Certain situations could be responsible for the increase in bycatch and consumption of Guiana dolphin meat. One is the fear of fishermen to move away from the coast due to piracy. Second, the constant oil spills that affect the biota and their work tools (boat, engine, nets) limit the mobility of fishermen, and concentrate their work to the first 5 km of coastline. Furthermore, dolphins are unfortunately a good option because they are easy prey that provide a lot of protein. However, fishing for many of them is still profitable, which suggests that the consumption of Guiana dolphin meat could also be associated with a change in perception, from opportunistic use to the consideration of a new protein source.

Denial of intentional capture of Guiana dolphin is a response conditioned by the fear of being penalized, a situation reported in other locations where this topic has been investigated (Zappes et al., 2013; Barbosa-Filho et al., 2018). However, the data obtained on the three directed hunting events in different regions of the Maracaibo lake system contradicts the version of the fishermen and allows us to affirm the existence of this practice. Currently, it is undeniable that the lack of surveillance has led to the growth of this activity.

These results reflect the highest capture rate of *S. guianensis* (180 dolphins/year) currently reported in its range of distribution (East Atlantic Coast), an alarming situation considering that the surveys were not carried out in all the fishing ports, generating an underestimation of the number of Guiana dolphins captured incidentally or intentionally in the Lake Maracaibo system.

CONCLUSION

The lack of appreciation and knowledge about the ecological importance of a species, together with changes in the perception of a population about a group of fauna in particular, can condition its future.

Since 2018, an educational program was started in the southern region of Lake Maracaibo in order to increase knowledge about Guiana dolphin in the school and general population. Recently, some school books and consultation guides in non-technical language were designed to distribute among the fishing community and the local population, material available for the first time and accompanied by workshops. These activities must be replicated in other locations where the incidence of capture and hunting is high.

Furthermore, an information campaign should be generated in the fishing communities about the validity of the Venezuelan laws that prohibit the capture of this species.

Previous investigations have revealed high levels of mercury in *S. guianensis* tissue in Maracaibo lake, for this reason and considering the frequency of its meat consumption in different towns along the lake shore, a public health alert campaign should be created, information that could counteract the interest for the use of the species.

In accordance with what is stated in the national action plan for the conservation of aquatic mammals in Venezuela, the application of these interviews should continue in the other communities not reached during this study, in order to quantify the mortality caused by this illegal practice and bycatch.

Government entities should increase the enforcement of the law and the surveillance and control effort, and abide by the new recommendations to reduce mortality due to negative interactions with fishing, which would include restricting fishing with nets in areas recognized as vulnerable and breeding grounds for the species, particularly in the south of the lake. In the rest of the lake a short term investigation should be carried out to determine these areas to apply these same regulations. Establish limits on the length of fishing trains, and prohibit that these can be left in areas without the presence of fishermen so that they can realize the timely release of entangled dolphins.

At an international level, the particular case of *S. guianensis* in Lake Maracaibo has been evaluated and discussed in the last 3 years in the scientific committee of small cetaceans of the International Whaling Commission (IWC) due to the high mortality rate reported. As a result of this, it has been suggested to carry out investigations of abundance, population estimates and population trends, as well as estimation of mortality and identify the area with the highest concentration of the species in order to carry out conservation actions.

In this scenario of a potential decrease in fishing due to anthropogenic impacts, and the possible emergence of a market for Guiana dolphin meat, the threat that looms over this population, considered already vulnerable, merits immediate action to mitigate any negative effects. The short- and medium-term future of *S. guianensis* in the Lake Maracaibo system will depend on the participation of different actors, civil society and government entities.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

Ethical approval was not provided for this study on human participants because in each fishing community there is a legal figure called the Council of Fishermen, backed by the Venezuelan legal framework and led by a local fisherman. This person was consulted in each of the seven investigated communities and asked to convene a meeting of fishermen to obtain approval to conduct the interviews and ensure that participation was voluntary. In addition, it was requested that all participants be of legal age (18) in accordance with the provisions of Venezuelan law. Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

AUTHOR CONTRIBUTIONS

YB: proposing the article, data collection in the field, analysis, and preparation of the first draft. LS: data collection in the field and analysis and contributing with the first draft. FT: review of data, organization, and review of the manuscript. LF: manuscript review and data presentation. SR: contribution of historical data and collaboration in the revision of the manuscript. All authors contributed to the article and approved the submitted version.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fmars.2021.625801/full#supplementary-material

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