Threats to sea turtle populations in the Western Atlantic: poaching and mortality in small-scale fishery gears

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ABSTRACT

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Interactions between small-scale fishery activities and sea turtles were investigated in coastal fishers' population of the South and Northeast Brazilian coast, Western Atlantic. Data were collected using semi-structured questionnaires (N=418). The presence of four sea turtle species was confirmed in the studied areas: *Chelonia mydas, Caretta caretta, Eretmochelys imbricata* and *Dermochelys coriacea*. Adults are commonly seen in the water, and nesting females and hatchlings on beaches, especially at the Northeast region. The presence of the three most easily distinguishable ontogenetic phases (hatchlings, juveniles and adults) confirms the importance of the estuaries and adjacent areas for sea turtles feeding, gathering, nesting, growing and resting grounds. Fishing was considered the most important threat to sea turtles (77%). Gillnets with small mesh sizes (<60 mm) more frequently interact with sea turtles (65%), and mortality was mostly related to gillnets with larger mesh sizes (>60 mm) (100%) ($p<0.01$). Although poaching is a cultural habit still practiced by many people, fishers did not openly assume it. In addition, most fishers (82%) ($p<0.01$) do not know that it is possible or how to recover sea turtles drowned in fishing gears. Conservation measures should be adopted by fishers to reduce sea turtle mortality such as monitoring soak gillnets more frequently, avoiding nets with larger mesh sizes and thicker threads, and an awareness campaign to provide recovery procedures for turtles drowning in fishing gears. This would be the basis of the design of desirable mitigation actions enhancing conservation efforts and benefiting marine diversity as a whole.

ADDITIONAL INDEX WORDS: *Coastal population, turtle products, bycatch, gillnets, conservation efforts, marine diversity.*

INTRODUCTION

Socio-economic growth and the development of human populations have not been accompanied by solutions to their impacts on the marine environment. Innumerable threats to marine diversity and habitat loss have been identified and, nowadays are discussed and analysed: species in the process of extinction (IUCN, 2012), the spread of debris and contamination in marine environments (Guebert-Bartholo *et al.*, 2011a), the decline of nursery habitats and the increased exploitation of fishery resources (Lewison *et al.*, 2004) are only a few. Marine megafauna are mostly pan-tropical species (*e.g.* sharks, sea turtles and cetaceans) and have been hit by all of these impacts.

Marine megafauna, especially sea turtles, have been subject to a high level of incidental captures in various fishery gears around the world (Lewison *et al.*, 2004). Small-scale fisheries (artisanal, traditional and subsistence fisheries) encompass a great part of coastal activities, especially in developing countries where they are critical for food security and a potential route for poverty alleviation. Moreover, this fishing category is highlighted for contributing half of fish caught for human consumption worldwide, being an important sub-sector of the world fish supply (FAO, 2005).

Sea turtles are distributed in tropical and subtropical oceans and during their life cycle they inhabit the ocean basin, from pelagic to estuarine and coastal waters, according to their life stage and species (Bolten, 2003). Nesting occurs exclusively on tropical sand beaches and oceanic islands. The Brazilian coast is known to be an important site for sea turtles growing and nesting (Spotila, 2004). Sea turtle products (meat, eggs and shell) can be easily found, not only in Brazil, but also in Caribbean and Asian countries, where consumption habits still persists as a black market trade with local and international routes (Mancini and Koch, 2009; Peckham *et al.*, 2008).

Research and conservation actions are needed to acquire reliable data on the threats to feeding and nesting areas of sea turtle populations and illegal exploitation. As suggested by Hamann *et al.* (2010), one of the priorities in sea turtle research is identifying major causes of fisheries bycatch and evaluating feasible mitigation measures for the problem.

Since the 1950s a drastic sea turtle populations decline has been noted, due to intense exploitation (Spotila, 2004). Currently, all sea turtle species are under risk of extinction (IUCN, 2012; MMA, 2008). Even though sea turtles are protected in Brazil under the law n° 1.522 (19/12/1989) which declared their use and harvest as a crime (law no 9.605, 12/12/1998) (IBAMA, 2012), sea turtle

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products (e.g. meat, eggs, shell) are still strongly and widely appreciated one generation later.

The knowledge acquired through this study provides new insights in the threats to sea turtles. The objective was to understand the importance of the artisanal fishery activities in sea turtle bycatch, mortality and other potential threats. This study was conducted in two distinct regions of South and Northeast of the Brazilian coast in areas with Marine Protected Areas (MPA) and unprotected areas. Moreover, ecological aspects of sea turtles are presented, as perceived by traditional populations.

METHODS

Study site

The areas studied in South Brazil are subtropical environments with patches of Atlantic Rain Forest. Estuaries have developed mangrove forests, flooded plains, rivers channels, sandy beaches and rocky islands surrounding the habitats. The two studied areas from the South region are Paranaguá Estuary, located at Paraná State, which has a patchwork of protected areas (*e.g*. Superagui National Park and the Guaraqueçaba Environmental Protected Area); and the Babitonga Bay, located at Santa Catarina State, which has no protected areas determined, although estuarine habitats have been recognized as important sites for *Pontoporia blainvillei* (fransciscana dolphin) (Cremer and Simões-Lopes, 2008) (Fig. 1). In these areas fishery is artisanal and concentrated in the estuary and the continental shelf. The main landings are penaeid prawns and fish from coastal areas.

In the studied area of the Northeast Brazil, a tropical ecocline with inland river basins develops at a humid coast where climatic variations are affected by the rainfall regime. One of the studied areas from the Northeast region is Goiana Estuary, located at Pernambuco State (Fig. 1). A Marine Protected Area was created in 2007 at the Goiana Estuary, classified as an Extractive Reserve (RESEX) (Barletta and Costa, 2009). This type of unit is a traditional population-based unit where the management councils are comprised of representatives from the local population (ICMBio, 2012). The other studied area comprises villages surrounding Traição Bay, located at Paraíba State, which have low urbanized areas with an indigenous reserve (Fig. 1). Fisheries at both Northeast areas are artisanal and estuarine fish species are captured for subsistence. In coastal waters lobster is the most captured and profitable resource. Indication of overexploitation of fish stocks have been pointed as one of the main problems at the Northeast region (Guebert-Bartholo *et al*., 2011b). The both study areas (South and Northeast) are included as an extremely high biological priority region for conservation in government plans (MMA, 2008).

Field sampling

The best possible estimate of the number of fishers in each area was made based on the current registers of local fishers associations. Four areas from two regions (Santa Catarina = 440 fishers, Paraná = 340, Pernambuco = 1700, and Paraíba = 1800) were sampled and, at each village a minimum of 10% of fishers were interviewed randomly and isolated from the group.

Data were collected in three occasions: September/2009 to February/2010, June/2011 and in August/2011. Semi-structured interviews were done, as informal but guided talks, to active fishers. Questions inquired about where sea turtles were seen, species distribution, ontogenetic phases and possible threats; and

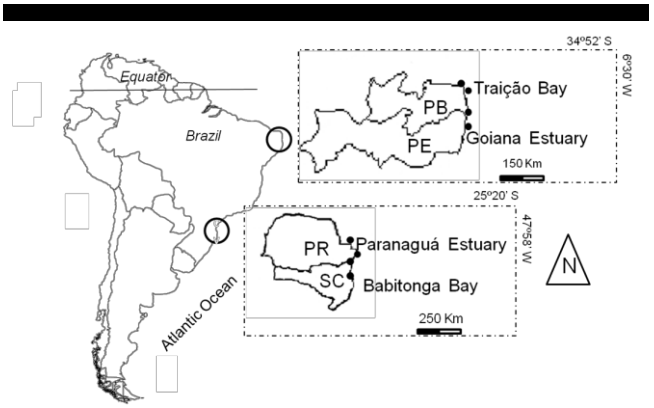

Figure 1. The two studied areas. In the South region are located Paranaguá Estuary at Paraná State (PR) and Babitonga Bay at Santa Catarina State (SC). In the Northeast region are located the Goiana Estuary at Pernambuco State (PE) and Traição Bay at Paraíba State (PB). The black circles are villages where fishers were interviewed.

fishing gears and its interactions with sea turtles as bycatch. Photographs were shown to fishers to identify the species that occur in the four areas. Fishery gears were categorized according to FAO (2012).

To avoid misinformation, interviews were done with the presence of a prominent local fisher. When the interviewee was obviously hiding or giving false information the interview was discarded later. All the interviews were made by the same person.

Statistical analysis

The Chi-square independent test was used to determine significant differences among the interviewees', with a 5% level of significance (Zar, 1999).

RESULTS

A total of 440 interviews were conducted. Considering that fishers and coastal populations attempt to hide information about illegal consumption and bycatch of sea turtles, due to the law enforcement, 4% of interviews were discarded. A total of 418 valid interviews were analysed: 43 in Santa Catarina State (SC), 33 at Paraná State (PR), 163 at Pernambuco State (PE) and 179 at Paraíba State (PB).

The presence of the four possible species of sea turtles was confirmed in the four sampling areas: *Chelonia mydas, Caretta caretta, Eretmochelys imbricata* and *Dermochelys coriacea*. At least 335 (80%, N=418) fishers could recognize one or more species by their local names. Significant differences were detected among their recognition abilities ($p<0.01$), and *E. imbricata* (hawksbill turtle) was identified by 170 (50%, N=335) fishers as the most common species.

Three hundred and eighty three (92%, N=418) interviewees reported that sea turtles are commonly observed in coastal waters, especially near rocky substrates. At the Northeast area interviewed fishers related the presence of nesting females and hatchlings on the beach (Table 1). The three more distinguishable ontogenetic phases (hatchlings, juveniles and adults) were reported by 243 fishers (58%, N=418) and the juvenile phase was the most frequent (50, 21%; N=243) compared with the other two phases (Fig. 2).

Questions	N (%)	p
Have already seen a turtle in water	383 (92)	*
Have already seen nesting females	109 (26)	*
Have already seen hatchling in sand	157 (37)	NS

Table 1. Questions presented to fishers regarding observations of sea turtles in water, nesting females and hatchling on sand. NS: non-significant, * p <0.01. N = 418 interviewed fishers.

Seventy-seven percent of fishers (295; N=384) recognized that fishing (p<0.01), mainly using gillnets with large mesh sizes (>60 mm), is the most important threat for sea turtles (p<0.01) (Fig. 3A, B). Other threats were cited in lower proportions: pollution (57, 15%; N=384), especially from industries and debris; boat collisions (21, 5%; N=384) and poaching (11, 3%; N=384) (Fig. 3A).

Fishery techniques differed among areas (p<0.01), although 188 (45%; N=418) fishers use gillnet with small mesh sizes (<60 mm). Considering sea turtle catchability 272 (65%; N=418) interviewed fishers affirmed to capture them incidentally in their fishing gears (Fig. 4). Significant differences were detected in sea turtle catchability among areas (p<0.01) where gillnets with small mesh sizes were more frequent (139, 51%; N=272). Other gears presented lower catchability rates: gillnets with larger sizes (>60 mm) (55, 20%; 272), lobster traps (29, 11%; N=272), trawl nets (14; 5%). However, sea turtle mortality is strongly related to the use of gillnets with large mesh sizes (p<0.01), considering that 55 (100%; N=55) fishers that use them affirmed to haul dead turtles (Fig. 4, 5).

When sea turtles are caught alive 270 (98%; N=274) fishers affirmed to release them back to the sea (p<0.01). Whereas, when sea turtles are caught dead (N=167) no significant differences were detected (p<0.01); 69 (41%) fishers affirmed eating the meat, especially when other fishery resources are scarce and 98 (59%) affirmed releasing them back into the sea. Significant differences were also detected for turtle poaching, especially meat consumption (p<0.01). One hundred and fifty-two (37%; N=408) fishers affirmed having eaten turtles in the past, 109 affirmed never having eaten (27%) and 147 (36%) affirmed to still do it, occasionally (Fig. 6). Egg poaching was also confirmed by 52 fishers (13.5%, N=384), although all of them affirmed that this activity was frequent only in the past, not practiced anymore.

Significant differences among areas (p<0.01) were detected in answers about recovering sea turtles drowned by fishing gears using cardiopulmonary resuscitation, and 343 (82%; N=418) fishers affirmed not knowing that it is possible or how to do it.

DISCUSSION

In general, no differences were detected between the opinions of the populations from the South and Northeast regions, including marine protected areas (MPA) and the unprotected areas. It was observed that most of interviewed fishers from RESEX Acaú - Goiana (protected area) do not know what a MPA classed as RESEX really is, or for what purpose it was created (ICMBio, 2012). In contradiction, they believe that this new status will give them new opportunities for working and for community development. This MPA was created in order to protect traditional fisher folk livelihoods; especially women who access the resource *Anomalocardia brasiliana* (Mollusca; Bivalvia). The MPA action plan still does not exist and community participation in management and decisions is apparently ineffective.

Female turtles nesting and hatchlings on sand were also reported by fishers, and the presence of the three ontogenetic phases (hatchlings, juveniles and adults) shows the importance of the areas for sea turtle populations as feeding, nesting, resting and growing grounds. The interviewed population could recognize four of the five possible species in the studied areas through photographs. The species *L. olivacea* was not recognized by the population in all areas, although it has been seen stranded at the Northeast coast (*pers.obs.*). The characteristics it shares (*e.g.* colour, size) with other turtle species (*C. mydas*) (Márquez, 1990) may have caused confusion in the identification by the fishers.

In general, fishers know about the endangered status of sea turtles, mostly because they have been extensively used as food resources, especially for coastal population and fishers in the last five hundred years (Spotila, 2004), since the beginning of the Caribbean and South American colonization. In this study, a significant awareness, declared importance and need for protection of turtles was observed amongst fishers. It was clear that the repression of the law enforcement is the main cause of this "conservationist" opinion. Considering this observation seventy-seven percent (295) of interviewed fishers believe that fishing is the main threat to sea turtles in coastal waters, especially the use of gillnets with large mesh sizes submerged for long periods (up to 12 hours). Other threats were also cited, although in fewer proportions: pollution, poaching and vessel collision.

Pollution is currently an important and alarming threat for marine animals. Fishers cited that the main sources of pollution were debris from big cities and chemical contaminants from plants near the estuaries (e.g. cement, aquaculture and sugarcane production), blaming the big centres for this problem. The sources of these pollutants are mostly land based activities (plastic debris from urban areas, agricultural run-off, effluents discarding, chemical contamination from sugarcane plantations and alcohol production) (Barletta and Costa, 2009; Liebezeit *et al.*, 2011). Plastic debris in digestive tracts and entangled in sea turtles can cause injuries and even death (Guebert-Bartholo *et al.*, 2011a). Consequences from debris ingestion are diseases and increased vulnerability to fishing gears and vessel collisions.

Gillnets with small mesh sizes (<60 mm) was the category of fishing gear with highest records of sea turtle entanglement, according to the interviewees, principally because it is the most used fishing gear at the studied areas. Gillnets with larger mesh sizes (>60 mm) were more important in sea turtle death, especially because of the stronger mesh and nylon thread that entangles sea turtles. Differently, smaller mesh size gillnets from which turtles

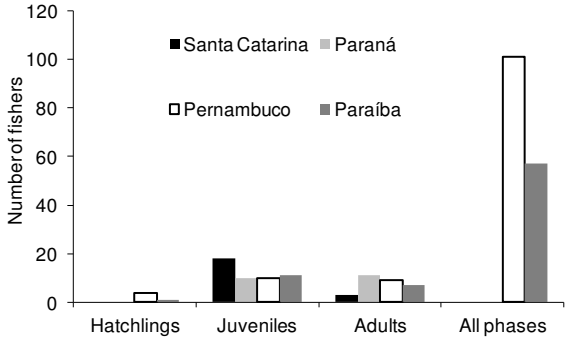

Figure 2. Number of fishers that recognized sea turtle ontogenetic phases at the four studied areas. N = 243 fishers interviewed.

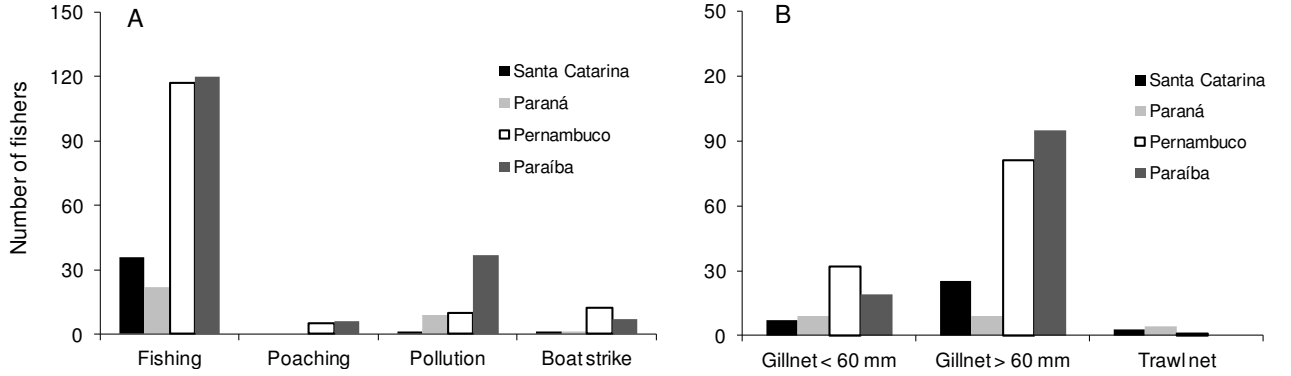

Figure 3. Fisher's opinion about the most important threats for sea turtles at the four studied areas (A). When the answer was "Fishing" a new question was made about which was the most dangerous fishery gear for sea turtles (B). N = 384 interviewed fishers.

can break out, were not significant on death cases. Gillnets have been shown to cause more damaging impacts to sea turtles and other marine megafauna organisms (rays and mammals) than other gears (Casale *et al*., 2004; Peckham *et al*., 2007; 2008; Alfaro-Shigueto *et al*., 2010) especially due to its non-selective capturing method (Gilman *et al*., 2010).

The actual total catch and mortality of sea turtles described by interviewed fishers is likely to be much higher, due both to the unknown fishery efforts in small-scale fisheries, especially regarding the use of gillnets, and to the misinformation of fishers about sea turtle mortality (Koch *et al*., 2006). This information suggests that small-scale fisheries are causing higher mortality rates than previously thought.

The submergence time of the fishing net is also a determinant factor in sea turtle mortality; especially because when turtles are entangled they may drown, first becoming in comatose and eventually dying. When turtles are in a forced apnea, the routine dive time is shorter than usual and their tolerance is further reduced (Casale *et al*., 2004). The longest dive duration reported in sea turtles ranges from 2 to 5 hours, although the routine dive is between 4 to 56 minutes (Lutcavage and Lutz, 1997). In this study, fishers reported gillnets being submerged (soak gillnets) between 8 and 12 hours, occupying the whole range of depths of coastal areas by set perpendicular to the currents, acting as a turtle barrier. Thus, all animals that may be captured will have a high probability of death.

Other fishing gears presented lower bycatch rates. Even though some studies point to shrimp trawl nets as a potential bycatch gear (Wallace *et al*., 2010), we did not observe the same. In this study, 14 fishers (5.2%, N= 272) using shrimp trawl nets reported having captured sea turtles as bycatch, with no death of the animal. Lobster traps and longline also exhibited bycatch rates, although cases of turtle death were rare, principally due to their selective methods of target-species capture.

The interview method for understanding the use and capture of sea turtles by fishing gears is suitable for obtaining general data, such as those about fishers' opinion and, if bycatch rates are important sources of impact (death or comatose cases) on the population. Quantitative/reliable data regarding the number of turtles involved in incidental mortality in fishing gears and strandings on beaches could not be assessed for several reasons. On board observers, for example, are not available to obtain reliable data (CPUE), mainly because the safety conditions on board are precarious. According to fishers, carcasses were not frequently found on the beaches mainly because currents are responsible for transporting dead animals along the coastal areas, stranding them on other beaches far away from the studied areas.

Activities concerning seismic prospection (for oil/gas) occurred at the Northeast region (PE) coinciding 100% with the sampling period. Abnormal stranding records of turtles were found in a 15 km radius (more than 10 animals per week), according to fishers. These activities could be the cause of these strandings, mostly because after this period sea turtle strandings decreased (*pers. obs*.).

Fishers that captured sea turtles admitted not knowing that it was possible and how to recover sea turtles drowned in fishing gears, releasing the animals into the sea as if they were dead, not considering their possible comatose state. Knowledge of animal safety techniques are especially important when sea turtles are found entangled in fishing gears, especially because when they are comatosed, turtles cannot swim and may therefore be unable to surface to breath (Casale *et al.,* 2004).

Poaching was reported, and was considered a cultural habit kept by traditional populations in all the world, detected on a community level and consumed during special occasions as a delicacy and a luxury item, largely related to traditional values and cultural factors (Campbell, 2003; Mancini and Koch, 2009).

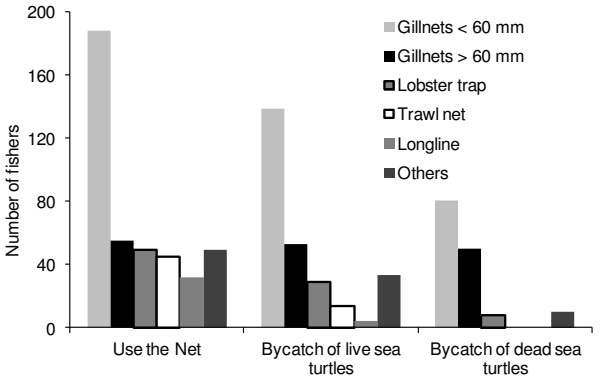

Figure 4. Number of fishers that use fishing gears and number of fishers that capture sea turtles alive and dead in these gears. The category "Others" group: dive and line and hook. N = 418 interviewed fishers.

Figure 5. *Chelonia mydas* (green turtle) found stranded and dead, entangled in a large mesh size gillnet at Paranaguá Estuary, South Brazil. Source: F. M. Guebert.

However, few fishers affirmed that a local market continues, where sea turtles products (meat and souvenirs) are sold within the population and for tourists around the region, under special request. Moreover, it must be taken into account that high percentage of fishers were not being totally accurate, due to fear of law enforcement, regarding turtle harvest and use. Considering this fact, the number of poachers must be greater than previously thought and the illegal trade on these coastal areas may remain an important threat for sea turtles during the juvenile and adult stages, difficulting population recovery and growth (Koch *et al*., 2006). The presence of poaching can also justify the rare reporting of events of stranded turtles in the studied areas. Egg poaching was observed in a lower level, and considered a more usual fact in the past (30 to 50 years ago).

In addition, some of the interviewed fishers affirmed that when a turtle is captured by chance the meat is prepared and eaten, and is considered a welcome bycatch. Some people do not eat the meat for prejudice, and some of them even believe that sea turtle meat can cause a number of diseases. In fact, the presence of bacteria, parasites and chemical contaminants in sea turtle meat can have serious effects on human health such as renal dysfunctions, gastrointestinal problems, neurotoxicity and even death (Senko *et al*., 2010).

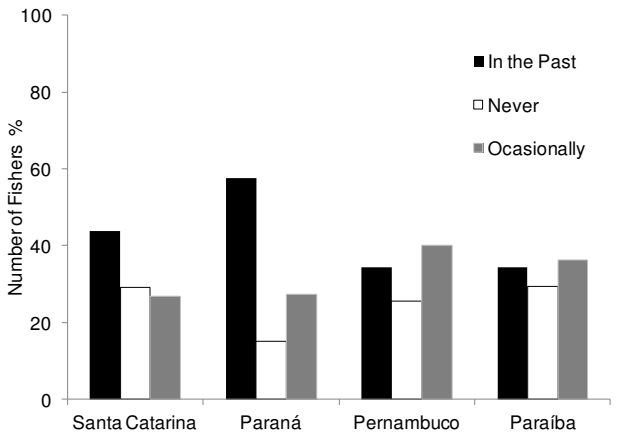

Figure 6. Fishers information (%) about the frequency of sea turtle meat consumption at the four studied areas.

Countries such as Asian, African countries and Mexico (Senko *et al*., 2010) also have similar traditional values and sea turtles products are frequently explored keeping an illegal consume and trade. Reasons as the lack of other type of reliable protein are not accepted nowadays, since the last 50 years when the access to meat protein has been possible including remote populations. In Brazil, these products are considered available and easily accessed for coastal and distant population in the last ten years. Brazilian laws for sea turtle protection are relatively new, when compared to elderly fishers interviewed. It is acceptable that new status, activities and laws take a while to be implanted, but the government agency with all stakeholders are responsible for encouraging the community on leaving these habits behind.

New options for traditional population should be encouraged, especially those aiming sea turtle protection. Conservation projects as well as tourism management could direct fishers being included in social and educational programmes (Wilson and Tisdell, 2001). These activities could be carried out by the MPA managers and all the stakeholders could participate.

Further information is urgently necessary to understand the importance of estuaries of the South American coast to sea turtle populations and to create feasible mitigation measures for sea turtle bycatch, considering that this area is used by different sea turtle species and life stages.

CONCLUSION

Conservation measures should be adopted such as an awareness campaign to provide recovery procedures for drowning turtles in fishing gears to fishers; and the development of measures to decrease sea turtles mortality, such as monitoring soak gillnets every 4 hours. The present study recommends immediate collaboration with fishers in conducting experiments to evaluate possible ways sea turtle could avoid gillnets commonly used in estuarine and coastal regions. Moreover, there are important questions that need to be answered: 1) the mean time of gillnets submersion in coastal water; 2) the identification of the hot spots of sea turtles catchability; 3) the assessment of the effects of the artisanal fishery in terms of number of catch per unit of effort; 4) the identification of trends in seasonality and catchability of sea turtles; 5) the extent of the local consumption and poaching of sea turtles, as well as the probable contamination indexes of meat that usually is ingested.

The participation of the MPA's on these actions will be essential, creating practical measures and emphasizing useful and necessary laws for conserving the fauna and natural resources. Finally, involving the local people in the correct management of protected areas and natural resources would result in locals actively participating in preservation and provide information necessary to further develop successful conservation plans. These recommendations would enhance conservation efforts and probably reduce sea turtle mortality benefiting estuarine, coastal and marine diversity.

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