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# Efforts to reduce sea turtle bycatch in the shrimp fishery in Northeastern Brazil through a co-management process

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ABSTRACT

The neritic waters of the state of Sergipe in Northeastern Brazil is adjacent to the main nesting area of the olive ridley sea turtles (*Lepidochelys olivacea*) in the Western Atlantic Ocean and an important area for shrimp trawl fishery. To address the problem of incidental mortality of sea turtles captured during trawling and reduce the risk of overexploitation of shrimp stocks, Projeto TAMAR/ICMBio, a Brazilian sea turtle conservation program, has adopted two main strategies: (1) the implementation of a marine monitoring program and (2) active participation in local forums. This paper describes the conflicts among stakeholders, the arrangements and established mechanisms of negotiation aimed to protect sea turtles and shrimp grounds, and strategies to reduce conflicts between user groups. The analysis of this co-management process highlights the importance of stakeholder participation in resource management decision-making through a cooperative process, the role assumed by non-governmental organizations as mediators, and the factors that influence this system. The key factors and actions learnt from the current study include clear identification of the conflicts, identification of stakeholders – both local and external, and local leaders, encouragement of actors and leaders to participate, support and strengthening of local groups, legitimization of the discussion forums through involvement with government, formalization of decisions taken through legislation, and monitoring of the management efficacy.



## 1. Introduction

The incidental capture of sea turtles in fisheries is one of the primary causes of sea turtle mortality globally and in Brazil, leading to reduction of their population and risks of local and global extinction of the species [1–7]. In addition to environmental damage to the threatened sea turtle species, incidental capture also negatively impacts local fisheries directly by reducing the productivity of target species, causing bait loss, or damaging fishing gear.

The development of mitigating measures through techniques that effectively reduce the capture and/or the mortality of sea turtles in fisheries has been the focus of several national and international efforts [4–6,8]. Furthermore, in fisheries management forums there is a current concern over the importance of active participation of stakeholders in the process of elaboration of regulations and guidelines regarding conservation and management of marine resources [9], as opposed to top–down legislation and enforcement [10,11].

In Brazil, the National Sea Turtle Conservation Program – Projeto TAMAR/ICMBio, a federal government initiative co-managed by Fundação Pro-TAMAR, has addressed the problem of incidental capture of sea turtles in fisheries since 1990 through a community-based conservation approach that includes 1) environmental education activities; 2) development of economic ecologically-sound alternatives; 3) and social inclusion [12–14]. Clearly, different fisheries in different areas cause distinctive impacts on sea turtles; therefore, different management strategies have been developed according to socioeconomic and environmental specificities and needs of each scenario [15].

The high level of mortality of adult breeding sea turtles has been causing increasing concern along the main olive ridley sea turtles (*Lepidochelys olivacea*) nesting beaches in the Southwestern Atlantic Ocean. The coasts of the state of Sergipe and the northern state of Bahia are the main nesting areas in Brazil with 2606 nests in

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the 2002/2003 nesting season [13,16]. The area is also important for shrimp trawling, mainly the seabob shrimp *Xiphopenaeus kroyeri* and the white shrimp *Litopenaeus schmitti* [17].

Since early 1990s there has been an increase in the number of shrimp trawlers in the area. In 1992, 55 boats operated in the area. This number increased to 158 in 2001 [17]. These boats operated close to the shoreline, increasing sea turtle mortality, which is currently the main threat to adult nesting females in the area [16]. Despite legislation that prohibits trawling within three nautical miles (3 nm) from the coast and federal legislation that requires shrimp trawlers to use Turtle Excluder Devices (TEDs), enforcement is ineffective and infringements frequent. Lack of effective enforcement is impacting local shrimp grounds and local ecosystem [17,18] in addition to conflicts among different fisher groups in a typical "legislative rich and enforcement poor" scenario.

In an effort to address the problem of sea turtle mortality in this area, the TAMAR in Sergipe has adopted two main resource management strategies. In 2000, TAMAR implemented a marine monitoring program, which consists of a range of educative actions at sea and inshore directed at shrimp fishers. TAMAR also had active participation in local forums to discuss and regulate shrimp fishery in the region. In this paper we describe the marine monitoring program implemented by TAMAR and the institutional process that has been motivated by its implementation. We also present the arrangements and negotiation mechanisms established to protect sea turtle, to foster sustainability of shrimp grounds and shrimp fishery profitability, and to reduce conflicts between user groups.

## 2. Methods

### 2.1. Study area

The coastline of Sergipe is 163 km long, bordering the states of Alagoas in the north (10°30′S; 36°23′W) and Bahia in the south (11°26′S; 37°19′W) (Fig. 1). The coast is characterized by exposed sandy beaches, water with limited visibility, and the absence of rocks. In addition to olive ridley sea turtles, loggerhead (*Caretta caretta*) and hawksbill (*Eretmochelys imbricata*) sea turtles also nest on the beach in smaller numbers [16]. Moreover, juveniles of these species and the green turtle (*Chelonia mydas*) use the area for feeding and shelter [16].

Sea turtles nest mainly along 125 km of beach, monitored by three TAMAR stations: Ponta dos Mangues, Pirambu, and Abaís (Fig. 1). These stations routinely carry out conservation and awareness activities, manage sea turtle clutches, and conduct research. On the northern beach the station is located in the Santa Isabel Biological Reserve, which protects 2776 ha along 45 km of coastline where the bulk of sea turtle nests have been recorded.

The five estuaries along the Sergipe coast are important contributors to the productivity of the coastal region, as well as the formation of a rich shrimp bank adjacent to the beach. In this context, the core subject of this study is the overlap between sea turtle nesting grounds and trawling fishing, which tend to aggregate on the same coastal areas, adjacent to rich shrimp grounds explored by the trawling fishing fleet [16,19].

### 2.2. Marine monitoring program

The bycatch of sea turtles along the Sergipe coast led TAMAR to intensify efforts to reduce incidental mortality in fisheries. Thus, in addition to the protection of nesting beaches and sea turtle nests, TAMAR provides environmental education and includes the community in sea turtle conservation efforts since 1982. TAMAR also established a marine monitoring program in 2000, which was mostly based on educational campaigns at sea.

The marine monitoring program aims to record boats operating within 3 nm from the coast, warn fishers of the importance to respect such limits, and inform fishers on resuscitation techniques of drowned sea turtles [13]. Monitoring activities were performed during the three breeding seasons – 2000/01, 2001/02, and 2002/03 – from September to March.

The areas monitored at sea were classified as South and North areas:

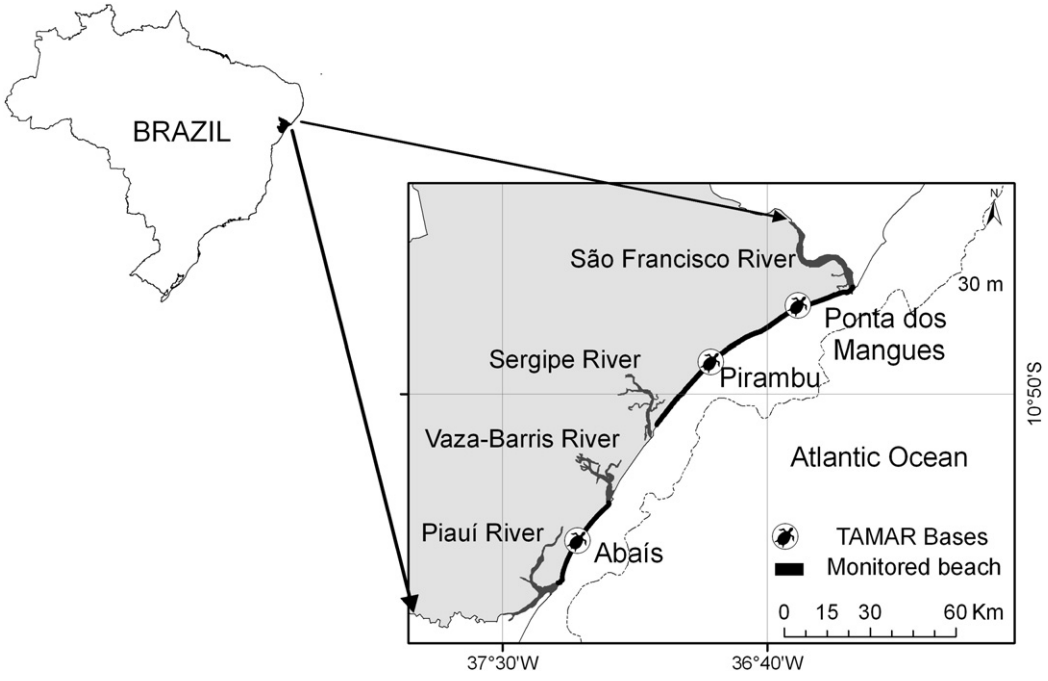


**Fig. 1.** Coastline of Sergipe State in Northeastern Brazil, with the beaches monitored for sea turtle stranding and nesting attempts indicated.

South Area – from 10°57′30″S to 11°38′00″S, extending 20 km from the Sergipe River to the Vaza-Barris River; 36 km from the Vaza-Barris River to the Real River; 40 km from the Real River to the Costa Azul locality in the state of Bahia. In all, an area of about 533 km$^2$ was monitored within the South Area.

North Area – from 10°31′55″S; 37°31′10″W to 10°48′25″S; 37°05′30″W, extending from the São Francisco River in the north, to 7 km south of the Santa Isabel Biological Reserve, an area of about 390 km$^2$.

### 2.3. Meeting with the local community to publicize the activities of the marine monitoring program

Throughout the year, meetings were held on shore with local fishers, skippers, representatives of fisher associations, as well as leaders of other *community-based* associations. These meetings publicized the theme of the campaign "*Nem tudo que cai na rede é peixe…*" ("Not everything that falls into the net is fish…") [14], discussed the overall goal of the program and shared findings gathered by the marine monitoring program. Moreover, participants were encouraged to report their experiences on establishing and development of fisheries in the area, management strategies adopted by government, and provide suggestions to the problems identified. Information obtained informally in these forums and meetings, as well as outcomes, are presented in the current study.

### 2.4. Sampling of stranded sea turtles

Recording of stranded sea turtles, dead or alive, is an activity carried out routinely by TAMAR teams as part of the monitoring of nesting beaches during the nesting seasons. The staff of TAMAR monitors these beaches on a daily basis, dead and live sea turtles are identified, their numbers recorded, and Curved Carapace Length (CCL) is measured. The aim is to create a record of the total number of dead turtles to identify a relationship or overlap with shrimp trawling fishery and sea turtle stranding. Because stranding data is a daily activity carried out routinely throughout all nesting seasons, the number of stranded sea turtles is comparable among nesting seasons.

Mann–Whitney tests, using the BioEstat software v. 5.0 [20], were used to compare CCL of nesting olive ridley sea turtles with CCL of stranded sea turtles. This test analyzed whether nesting females were similar in size to those found dead on the beach, apparently caused by adjacent fishing activities.

## 3. Results and discussion

### 3.1. Problems identified by stakeholders within the local context

The range of activities carried out in the context of the present study coupled with intense participation in local forums helped to identify three areas of concern 1) the interaction between shrimp trawling fisheries and sea turtles; 2) the reduction of shrimp stocks in Sergipe's fishing grounds; and 3) the conflict between fishers operating with trawl vessels and the spatial overlap with fishers using canoes.

#### 3.1.1. Incidental capture of sea turtles by shrimp trawling fisheries

From 1994 to 1999 a total of 283 sea turtles were found stranded dead on the beaches of Sergipe's coast. Among turtles identified to species level ($n = 188$), 56.9% were olive ridley with CCL (average ± 1 Standard deviation) of 65.9 ± 5.7 cm (range 43.0–78.0 cm) and differed from the CCL of adult females nesting during the same years (Mann–Whitney $U = 537.0$, $p < 0.0001$) whose CCL was 73.2 ± 3.3 cm (range 64–79 cm). Despite significant differences between the sizes of sea turtles stranded and nesting, 75.0% of dead turtles were larger than the smallest CCL of nesting females (64 cm), indicating extensive overlap between sizes of nesting and stranded turtles. Some necropsied olive ridley turtles showed evidence of the formation of eggs, confirming them as nesting females.

Apart from the mortality of turtles on the beach, these findings indicated the extent of impacts on the adult olive ridley turtle population and arose a feeling among TAMAR staff that the efforts to protect nesting turtles on the beach were being negated. Such perception is also felt on a global level [21].

Sea turtle interactions with shrimp trawling fishery are the cause of their high mortality in other regions around the world, such as the Gulf of Mexico [4], in the United States [1], and in Australia [22]. Such deaths are a result of an overlap between shrimp trawling fleet and the distribution of sea turtles [23]. To reduce the level of interactions, the United States government adopted the compulsory use of TEDs as a mitigation measure since 1994 and demanded its use by countries that export shrimp to United States, including Brazil. Since 1994 TEDs are required by law in Brazil through the Federal Order ('*Portaria*') No. 36/94, issued by the Ministry of Environment. Subsequently it was complemented by the Order No. 5 (19 February 1997), establishing which vessels should comply with it. The Normative Rule No. 31 (13 December 2004), defines the specifications of TEDs in Brazil. Despite federal legislation, a large proportion of the Brazilian trawling fleet, including the one which operates along the Sergipe coast, are unable to implement this Normative Rule on TEDs because the use is not economically and operationally viable for these fisheries. Thus, it is evident that an alternative mitigation measure consistent with the local conditions is needed.

#### 3.1.2. Reduction in shrimp captures/profitability

The Sergipe shrimp trawling fleet started its operations in 1979 from the Port of Pirambu on the Northern coast. At that time, shrimp stocks in the area were harvested by a fleet based at Pontal do Peba in the neighboring state of Alagoas. During these early stages of trawl fishing, high Capture per Unit of Effort (CPUE) led to expansion and modernization of the fleet based in Sergipe, which shifted from single rig trawlers to double rig trawlers [18,24].

Boats in the area are wooden boats, 8.5–15 m in length, operating with double outriggers towing one net each, and their trips last from 2 to 12 days [18]. The fishery targets seabob shrimp (75% of overall catches), white shrimp (20% of overall catches), and southern brown shrimp *Farfantepenaeus subtilis* (5% of overall catches). Shrimp accounts for 65% of overall income generated by the fishing industry and 48% of the 3851 metric tons of marine species harvested in the waters of Sergipe in 2001 [25].

The rapid increase in fishing effort led to a significant reduction in productivity and profitability culminating in the adoption of a management measure by the SUDEPE – Bureau for Fisheries Development (currently IBAMA – Institute for the Environment and Natural Renewable Resources) in 1986. The measure intended to limit the number of boats licensed for this fishery. In 1992 new licenses were issued, and the fleet strength rose again from 55 to 158 boats by 2001. In terms of productivity, in 1992 the CPUE was 26.0 kg/trawling hour, and in 1999, the last year for which data are available, the CPUE was 6.2 kg/trawling hour [17,25].

Reports from the Shrimp Studies Permanent Group (GPE)[1] suggested that the unplanned increase in fishing effort was the cause for the continued decline in CPUEs in shrimp landings, and

[1] The GPE is a group comprising scientists from universities and experts from IBAMA. The group is entrusted with carrying out technical studies intended for use as background for the adoption of procedures for the management of shrimp otter trawl fisheries.

consequently in profitability [26]. Although this conclusion was not based on a large volume of data, it is an indicator of the effects of uncontrolled fishing practices on shrimp stocks [27].

In addition to increases in fishing efforts, environmental changes in the shrimp trawling grounds resulted from the construction of large reservoirs along the São Francisco River, the largest river in Northeastern Brazil, whose mouth is located on the northern Sergipe border. This probably also had direct impact on the shrimp bank. During summer when rainfall recedes, the mud bank which is the shrimp habitat during its benthic phase shrinks. Such situation, and with limited enforcement from authorities, compelled fishers to operate illegally closer to the coast within the zone where trawling is prohibited, which according to the Federal Order ('*Portaria*') No. 62/83 is limited to 3 nm from the shoreline [18,26].

The factors mentioned above accentuated two other problems: the first, described in item 3.1.1, was the increase in the incidental capture of nesting sea turtles; and the second, described in detail in item 3.1.3: the conflict between trawling fishers and gill net fishers operating with canoes in the 3 nm zone.

In the state of Sergipe alone, the shrimp fishery network is comprised of 1500 families, 40% of whom are directly engaged in shrimp capture, and the remaining are part of the shrimp industry chain: processing, transport, commercialization, and infrastructure [18]. As stated earlier, the reduction in shrimp profitability is not only an environmental issue, but also a challenge of social and political dimensions.

#### 3.1.3. Conflicts between fishers

Fishing along the Sergipe coast is carried out by groups of fishers falling into two categories: estuarine–coastal fishing and offshore fishing. Estuarine and coastal fishers operated mainly with paddled or sail canoes in waters up to 15 m depth and usually within 3 nm from the coast, and use small gill nets, cast nets, and hook-and-line as their main fishing gears. According to IBAMA [17], in 2001, this group operated about 1209 boats, accounting for 79.2% of the whole licensed fleet by number of boats in the state of Sergipe.

In 2001, the offshore or maritime fishery fleets consisted mostly of engine-propelled vessels and numbered 166 vessels, of which 158 were engaged in shrimp fishing. Among shrimp fishing vessels, 116 were registered in the state of Sergipe, and the remaining vessels were licensed in the neighboring states of Alagoas and Bahia, but operated in Sergipe waters.

Unlicensed vessels also operated illegally in the area [24]. The Brazilian federal government grants fishing licenses and fishers are allowed to fish at sea with no restrictions confining them to a particular state or area. Thus, when valuable fishing resources are present close to the coast, as is the case of shrimp off the coast of Sergipe, conflicts with local fishers often arise. A difficulty facing coastal fishermen managing shrimp stocks is their inability to exclude outsider fishers operating medium-sized industrial vessels near the coast, a common occurrence in other maritime fisheries in Brazil [28].

In the context of fisheries in the study area, two conflicts among fishermen emerge. The first is the difficulty of small-scale fishers operating with canoes to coexist with those of the maritime trawling fishery fleet. Fishers using canoes complain of losses and damages to fishing gear, which are struck by boats trawling within the 3 nm zone. This area is close to shore and is intensively used by coastal fishers to deploy gill nets, frequently crossing the route of trawlers. The second problem is the competition between fishers based in Sergipe and those from the states of Alagoas and Bahia for access to shrimp fishing grounds. Licenses for shrimp trawling are granted for operation in the North and Northeastern Brazilian Operation Zones, allowing vessels from other states to operate in Sergipe. In fact, southern Alagoas, Sergipe, and northern Bahia comprise a single region called the "São Francisco mud bank", where shrimp grow and are targeted by the trawling fisheries.

Conflicts such as those described above are frequent when involving shared fishing resources and are classified by Ostrom et al. [29] as "common property resources" or "common-pool resources". They possess two basic characteristics 1) the difficulty to exclude or limit other users (non-excludability principle); and 2) the ability of a user to subtract from the welfare of another since the consumption of a unit of the resource makes the unit unavailable to other users (subtractability principle). With these two categories, factors such as the mobility of the resource make the management process fairly complex.

### 3.2. Outcomes and lessons learned

By March 2003 there were three planning measures in the region for shrimp fisheries, which, in theory, could minimize the incidental mortality of sea turtles. One was the Federal Order No. 62/1983, prohibiting shrimp trawling vessels from operating within the 3 nm zone from the Sergipe coast [30]. The second was the closure of the shrimp season from 1 May to 19 June each year, established by Federal Order No. 32 (13 March 2002) [31]. Lastly, Federal Order No. 5 (19 February 1997), which made the use of TED compulsory for Brazilian trawling fisheries.

Nonetheless, such measures did not contribute to the reduction of sea turtle mortality; with the fall in productivity, vessels started to operate closer to shore mainly during summer months, coinciding with the sea turtle nesting season peak. The shrimp season closure did not coincide with the sea turtle nesting season, which is from September to March, and the compulsory use of TEDs was ignored by fishermen due to lack of awareness and enforcement by the authorities.

The marine monitoring program established and carried out by TAMAR conducted 164 trips at sea from 2000 to 2003. From September 2000 to March 2001, 74 trips at sea were carried out mainly in the North Area, which was prioritized. Beach stranding teams working during the same period recorded a reduction in the number of sea turtles dead on the beach ($n = 19$ in 1999/2000; $n = 12$ in 2000/2001). However, in the South Area the number of stranded turtles rose from 14 in 1999/2000 to 30 in 2000/2001, suggesting that vessels previously operating at the North Area had transferred their activities to the South Area. Thus, instead of resolving the sea turtle bycatch problem, there was a spatial shift from the northern to the southern area.

During the second season, from September 2001 to March 2002, the marine monitoring program was extended to the South Area despite a reduction in the number of trips at sea (37) and the number of boats used for the program from three to two. Additionally, some surveillance operations were carried out by IBAMA to restrict fishing within the 3 nm zone, but the number of stranded sea turtles was greater than in the previous season, rising from 42 in 2000/2001 to 57 in 2001/2002.

Marine monitoring program activities were extended from six to nine months during the third season; from September 2002 to May 2003 a total of 55 trips at sea were carried out. The total number of stranded sea turtles in Sergipe was smaller than in the previous season, 57 in 2001/2002 and 42 in 2002/2003. This change suggests that the adjustment of procedures along the years led to a reduction in the number of turtles found dead.

Of the total 141 stranded sea turtles found dead in the three seasons mentioned, 106 were identified at the species level, of which 70.8% ($n = 75$) were olive ridleys. As in the period before the monitoring of the fishing fleet, CCL differed between the stranded and nesting olive ridleys ($U = 1997.0$ $p < 0.0001$; CCL of stranded

turtles 67.5 ± 6.2 cm, range 28.0–77.0 cm; CCL of nesting females 72.1 ± 3.1 cm, range 62.5–83.0 cm). Similarly, a large overlap in the sizes of the stranded and nesting olive ridleys was detected, with 87.2% of the stranded turtles over the minimum CCL of nesting females. Again, results suggest that shrimp trawling affected mainly adult nesting turtles, with some immatures also affected. In spite of the differences in the efforts during the three seasons in which the marine monitoring program operated, which preclude comparison of numbers of sea turtles dead, the incidental mortality of olive ridley sea turtles persisted, with a non-negligible number of individuals found dead on the beaches and fishing affecting a similar proportion of the population, mainly adults.

The factors that could influence the number of sea turtles stranded, alive or dead, on or near the nesting beaches, ranged from natural variations in number of adults approaching the coast for mating and laying to variations in fishing effort. The major objective of the marine monitoring program was to enlighten fishermen on permitted fishing practices and areas. However, it could be noted that modifications in procedures, particularly the number of trips carried out by the program, could account for the number of stranded turtles on nesting beaches. Actions at sea and simultaneous stranding records suggest that the problem of incidental mortality of sea turtles persisted despite a reduction in the number of stranded turtles over the years, or in areas adjacent to intense activities of the program. Furthermore, other factors that should be taken into account are the range of actions of the monitoring program, the surveillance operations of IBAMA, and the absence of income alternatives to fishermen who continued their activities despite the risks arising from infringement of the law and overexploitation of fishing resources.

The degree of user dependence on available resources for survival is a key factor in evolving management strategies for wildlife conservation. There is a substantial dependence on the shrimp bank in Sergipe, which accounts for a large proportion of fishing products of the state and whose exploitation benefits a large number of people [18].

However, if a crisis can increase risks for conservation and management, it can also provide opportunities to alter the overexploitation scenario [32]. In such a situation, co-management is presented as an opportunity to solve problems and not because it is "nice to do" [33]. The direct dependence of users on the resources and their motivation to preserve these resources generates among the several stakeholders a propitious environment to initiate the cooperative process. This impression was gathered during the meetings where the stakeholders from local communities participated.

As with the actions at sea, the meetings held helped mobilize a multitude of representatives of local communities such as skippers, fishermen, the Pirambu Communitarian Development Council (CONDEPI), fishermen associations, governmental agencies such as IBAMA and its Northeastern Center for Fishery Research (CEPENE), the Rural Federal University of Pernambuco (UFRPE), and state and local agriculture and fishery agencies. Apart from information shared through the marine monitoring program, such meetings evoked discussions on fishing policies in the state, the need for fishery production research, and the difficulties faced in complying with the Federal Order prohibiting trawling within the 3 nm zone.

The meetings clarified the need for reassuring fishermen that the objective of monitoring activities was to preserve sea turtles, as well as to maintain the productivity of the shrimp fishing grounds. This assessment was reinforced by a few of the surveillance operations of IBAMA, which resulted in the arrest of vessels and seizure of shrimp caught. Although a negative reaction ensued in the community towards TAMAR, these coercive measures resulted in a reduction of vessels operating within the 3 nm, but only in the short-term. Therefore, IBAMA promoted a workshop on the biology of shrimp aimed at promoting awareness among fishers and skippers on the importance of preserving shrimp habitats.

Thus, the marine monitoring program established by TAMAR encouraged the formation of a discussion forum focusing on fishing planning issues, from where the second set of achievements and lessons emerged as presented in Section 3.3.

### 3.3. Shrimp fishery planning through a participatory process

In Brazil, fishery planning[2] falls within IBAMA's scope. Beginning in 1993, a management mechanism aimed at sharing responsibilities with the administration and management of resources with users was established [34,35]. Despite participatory management of natural resources not being applied in all cases, the presence of such mechanisms led to the adoption of this system.

TAMAR was prominent not only as a conservation organization, but also as a initiator and mediator of the shrimp fishery planning process in Sergipe, stimulating participation of stakeholders in decision-making. The role as mediator was consolidated with support extended by the two main stakeholders of the local community: small-scale fishers using canoes whose interest was excluding trawler vessels from the 3 nm zone and a recognized local representative of the fishing sector whose interest was the protection of the shrimp bank. Both sought TAMAR staff in order to conciliate interests and act in partnership.

During the meetings, trawler skippers and fishers, represented by the CONDEPI, presented a proposal to extend the existing duration of the seasonal closure, from 50 to 90 days. Additionally, they requested a change in the Normative Rule reducing the exclusion zone limit adjacent to the beach from 3 nm to 2 nm, given the difficulty in complying with such regulation. The proposal received the support of TAMAR, which formally requested CEPENE/IBAMA, responsible for conducting research, to subsidize management measures for the fishing sector and to extend the duration of the seasonal shrimp closure. The request was based on two arguments 1) eliciting the cooperation of fishers in complying with the regulations; 2) extending the closure during summer would protect turtles during the nesting season by limiting the fishing effort to the 3 nm zone during this period.

Pursuant to this request, a technical group comprising technicians from IBAMA (Department of Fisheries & Aquaculture and CEPENE) and staff from TAMAR was formed to analyze the proposal. Representatives from the fishing sector (fishers and skippers) were also invited to the deliberations to present justifications for the request, as well as contribute their knowledge of the environmental and social systems of the region. The technical group decided that changes proposed should be based on scientific data, which initiated a study carried out in 2003 with the first phase completed in 2004. Discussions resumed with negotiations on the duration of the seasonal closure, the area to be covered by the new measures, and limits for the fisheries, through meetings held in several cities in the state of Pernambuco (CEPENE headquarters) and in the states of Alagoas, Sergipe, and Bahia. Thus, the coverage of the proposed legislation was expanded, and TAMAR was incorporated into the planning of the shrimp fishery in neighboring states.

[2] According to FAO [36], the concept of fishing management may be understood as the integrated process of grouping information, analysis, planning, consultation, decision-making, resources allocation, and formulation and implementation of regulations or norms that govern fishing activities, in a way to guarantee the continued productivity of resources and the attainment of other fishery objectives. In this process the objectives of the planning should be established according to each fishery, taking into account the biological traits of the stock under exploitation and the social, environmental, and economic conditions of the surroundings.

Discussion forums for negotiation were held in 2002 and 2003, culminating in the Normative Rule No. 14/2004, published by IBAMA on 14 October 2004 [37]. The main measures established by the new legislation were the extension of the shrimp trawling seasonal closure from 50 to 90 days and divided into two periods, the first in the austral winter (01 April to 15 May) and the second in the summer (01 December to 15 January); enlarging the area of coverage for the new rules by including the stretch from southern Pernambuco to central Bahia; reduction in the exclusion zone for trawling, from 3 nm to 1 nm in Alagoas and to 2 nm along Sergipe coast, while retaining 3 nm in Bahia. During the seasonal closure, fishing of all three shrimp species in the area was forbidden with any fishing gear.

Overall, these rules embrace a) requests received from the skippers, fishers, and TAMAR to institute a seasonal shrimp closure during a period which would overlap with the turtle nesting peak and when the mud bank shrinks and shrimp stay closer to the coast; b) the request of fishers for reduction of the exclusion zone for trawling fleets in Sergipe; and c) the framing of a more comprehensive legislation given that the shrimp grounds transcend the geopolitical borders of the states of Alagoas, Sergipe, and Bahia.

Apart from managing the interests of different sectors, the publication of the new Normative Rule No. 14/2004 denoted progress in establishing a cooperative process, strengthening the local organization by the effective involvement of CONDEPI, and thus the acceptance of measures initiated by resource users themselves stood a greater chance. According to Ostrom [38], when users are actively involved in formulating operational rules they feel more committed to following such rules. Similarly, it was essential to secure the willingness of governmental entities to consult with other groups, negotiate, and promote studies to support the discussions and decisions.

These factors convey the importance of administering fishing resources through the establishment of a dynamic partnership that utilizes the capabilities, knowledge, and concerns of local communities and is reinforced by the powers of governments to put in place a system with viable legislation, institutions, and other forms of support [10,39].

The search for solutions for problems and conflicts presented here generated a system known as co-management, defined as an arrangement in which responsibilities for the management of resources are shared among government, user groups, and other stakeholders through a cooperative process [40,41].

It is worth remembering that the co-management case described is current and the manner in which environmental and social systems will respond to the application of new rules is a matter which can only be assessed in the medium to long-term. Thus, it is essential to monitor the measures proposed to suggest adjustments if necessary.

## 4. Conclusion

Given the specificities of every scenario, studies carried out in several regions throughout the world on the viability of participatory management systems are valorous to indicate the key elements for success and the benefits and failures of such systems. Thus, the key factors and actions to achieve effective co-management of common resources, learnt from the current study are 1) clear identification of the conflicts; 2) identification of stakeholders both local and external; 3) identification of local leaders; 4) encouragement of the participation of actors and leaders; 5) encouragement and strengthening of local groups; 6) legitimization of the discussion forums through involvement with government; 7) formalization of decisions taken through legislation; and 8) monitoring of the management efficacy. The continued and intense presence of Non-governmental Organizations (NGOs) agents in the community is a major component for every factor mentioned above.

The legitimacy of a system to manage natural resources is not a self-generated consequence of decentralization and participation. Such approach should be created through a continuous process of involvement and strengthening of stakeholders. The viability of this type of system depends directly on the socio-political organization of users of the natural resources and the establishment of formal forums for discussion and negotiation. Improving fishing rules through discussion and agreement among users to solve emerging problems and prevent potential problems from arising is part of the long-term process in co-management decision-making. In this scenario NGOs could play an important role as mediators in similar processes elsewhere. As argued by Frazier [42], “wildlife management and biological conservation is as much managing people as managing wildlife: in the end, they are politics – not biology”.

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