Chapter 3

Sea Turtle Beach Monitoring Program in Brazil

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Additional information is available at the end of the chapter

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Abstract

Beach monitoring programs provide important information on spatial and temporal patterns of occurrence, mortality, age structure, sex ratio, and variations associated with climatic and anthropogenic events as well as for the assessment of the health of marine organisms. The purpose of the Santos Basin Beach Monitoring Project is to evaluate the possible effects of oil and gas production and transport activities at Santos Basin on marine turtles, birds, and mammals by monitoring beaches and veterinary care facilities for live and dead animals. Five species of sea turtles occur in Brazil: the green turtle (*Chelonia mydas*), loggerhead turtle (*Caretta caretta*), hawksbill turtle (*Eretmochelys imbricata*), olive turtle (*Lepidochelys olivacea*), and leatherback turtle (*Dermochelys coriacea*), all of which are endangered and are fragile organisms that suffer from the impact of human activities during their long lifecycle. This chapter reports monitoring strategy activities and preliminary results after 1 year since the implementation the monitoring project to provide an important overview of sea turtles found in the Santos Basin.

Keywords: beach monitoring, Brazil, Cheloniidae, Dermochelyidae, sea turtles

1. Introduction

Sea turtles belong to the group Testudines, considered one of the most primitive Order of reptiles, and the oldest specimen found dating back 120 million years to the lower Cretaceous period [1]. These organisms belong to the order Testudines, which includes chelonians with the body encompassed by a bony carapace formed by the fusion of ribs and vertebrae [2].

Modern sea turtles form a monophyletic group, as all derive from a common ancestor from the suborder Cryptodira [3]. There are currently seven species distributed in two families. The family Dermochelyidae has only one species: the leatherback sea turtle (*Dermochelys coriacea*). The family Cheloniidae has six species: the green turtle (*Chelonia mydas*), loggerhead turtle (*Caretta caretta*), hawksbill turtle (*Eretmochelys imbricata*), olive ridley turtle (*Lepidochelys olivacea*), Kemp's ridley turtle (*Lepidochelys kempii*), and flatback turtle (*Natator depressus*), the latter two of which are the only species that do not occur in Brazil [3, 4]. Sea turtles have broad geographic distribution, occurring in all oceanic basins, with representatives found from the Arctic to Tasmania [3]. However, the reproduction of most individuals occurs in tropical and subtropical regions [4].

Knowledge on the biology of sea turtles and their relationships with the surrounding environment is fundamental to outlining effective conservation strategies [5, 6]. Scientific research involving sea turtles began to gain momentum in the mid twentieth century, before which targeted fishing efforts and the consumption of turtle meat and eggs were common practices throughout the world, along with the intensive degradation of coastal areas, and consequent loss of habitats [7, 8]. As sea turtles have a complex lifecycle, late sexual maturity, and broad geographic distribution, many gaps in knowledge remain, despite the advances in recent decades [6].

In Brazil, there were no laws protecting sea turtles until the 1980s and the consumption of meat and eggs and the slaughter of females in coastal areas were common events [9]. Due to international pressure for nations to work together based on the argument that sea turtles are migratory animals that visit various countries throughout their lifetimes, the Brazilian government created the National Sea Turtle Conservation Program, known as the TAMAR project. In 1989, sea turtles were officially considered endangered species that merited protection [IBAMA (Brazilian Environmental Protection Agency) ordinance n°. 1522 from December 19, 1989] [9]. Since its establishment, the TAMAR project has been working in eight Brazilian states and oceanic islands at feeding and nesting areas of these animals [10]. Moreover, there has been a growing number of researchers at higher education institutions, non-governmental organizations, and other institutes that study sea turtles and are dedicated to the protection of reproduction sites and the monitoring of non-reproductive occurrence/stranding in locations beyond the reach of the TAMAR project [11].

1.1. Marine turtles distribution in Brazil

1.1.1. Green turtle (Chelonia mydas)

The green turtle has one pair of prefrontal scales and four pairs of postorbital scales on the head and four pairs of overlapping lateral scutes on the carapace [10]. Carapace coloration varies, but normally has radial striae on each horny plate with a greenish-brown color and the plastron is white; hatchlings have a black dorsum [12]. Adults have a mean curvilinear carapace length of 115.6 cm and can weigh up to approximately 230 kg [4, 13]. The primary spawning areas are located on oceanic islands, such as the Rocas Atoll (pertaining to the state of Rio Grande do Norte), Fernando de Noronha Archipelago (pertaining to the state of Pernambuco), and Trindade Island (pertaining to the state of Espírito Santo), but nests are also found on mainland beaches, especially in the northern portion of the state of Bahia) [10, 14]. Juveniles (smaller than 30 cm) have an omnivorous diet and migrate from the pelagic oceanic environment to the coastal zone when reaching 30–40 cm, changing to a predominantly herbivorous diet. Green sea turtles feed mainly on algae and sea grass, but can also consume animal material as a secondary diet, such as jellyfish, salps, and sponges, with regional variations [14, 15]. This species has coastal habits, feeds along the entire coast of Brazil, and can even use the estuaries of rivers and lakes during its development [10, 16].

1.1.2. Loggerhead turtle (Caretta caretta)

The loggerhead turtle has two pairs of prefrontal scales and three pairs of postorbital scales on the head and five pairs of overlapping lateral scutes on the carapace, the first pair of which is smaller [10]. The carapace has a yellowish-brown color and the underside is a light yellow in adults [12]. The head is triangular and proportionally large in relation to the body [4]. Adult females have a mean curvilinear carapace length of 103 cm and weigh between 100 and 180 kg [10]. The primary nesting areas are located in the state of Sergipe and the northern portions of the states of Bahia, Espírito Santo, and Rio de Janeiro. Secondary nesting areas are found in the southern portions of the states of Espírito Santo and Bahia [10]. The loggerhead sea turtle has carnivorous, opportunistic eating habits, feeding on a broad variety of organisms, such as crustaceans, mollusks, and fish [15, 17]. This species feeds in neritic and oceanic environments and adults are often caught incidentally in industrial fishing operations in these areas [10, 18].

1.1.3. Hawksbill turtle (Eretmochelys imbricata)

The hawksbill turtle has two pairs of prefrontal scales and three pairs of postorbital scales on the head and four pairs of imbricated lateral scutes on the carapace; the margin of the shell is serrated and the beak resembles that of a bird [12]. The carapace ranges in color from light to dark brown with black spots and amber striae; the underside ranges in color from light yellow to white [4, 12]. Adult females have a mean curvilinear carapace length of 97.4 cm and weigh around 80 kg [12, 19]. The primary nesting areas are located in the states of Rio Grande do Norte and Sergipe as well as the northern portion of the state of Bahia. Secondary nesting areas are found in the state of Paraíba and the southern portion of the state of Bahia [19, 20]. Juveniles and adults feed mainly on crustaceans, sea urchins, mollusks, algae, bryozoans, coelenterates, and sponges, the latter two of which are considered the preferred food items by adults [21]. Due to its feeding preferences, the hawksbill sea turtle customarily inhabits sites with hard substrates, such as coral reefs. The main known feeding grounds are the Fernando de Noronha Archipelago, Rocas Atoll, Trindade Island, Abrolhos Archipelago (state of Bahia), Saint Peter and Saint Paul Archipelagos, Arvoredo Island (state of Santa Catarina), and Cagarras Islands (state of Rio de Janeiro) [19].

1.1.4. Olive ridley turtle (Lepidochelys olivacea)

The olive ridley turtle has two pairs of prefrontal scales and three pairs of postorbital scales on the head and an irregular number (five to nine) of lateral scutes on the shell. The carapace is rounded and elevated in the anterior portion [12], with an olive green to gray color; the underside is light yellow. Adults have a mean curvilinear carapace length of 73.1 cm and weigh around 50 kg, making it the smallest sea turtle occurring in the country [10]. The primary nesting areas are located in the states of Alagoas and Sergipe and the northern portion of the state of Bahia. The secondary nesting area is located in the state of Espírito Santo [10]. The olive ridley sea turtle feeds mainly on crustaceans, mollusks, fish, and bryozoans [15]. This species feeds in neritic and oceanic environments and is often caught incidentally during bottom trawl fishing and pelagic longline fishing operations [18, 22].

1.1.5. Leatherback turtle (Dermochelys coriacea)

The leatherback turtle has a carapace formed by leathering skin covered with osteoderms (no plates or scutes) and seven longitudinal keels [12, 23]. Its color ranges from black to bluish with white to light blue spots on the entire body [12]. Female adults have a mean curvilinear carapace length of 159 cm, but can reach as much as 182 cm and mean weight is 500 kg, making it the biggest of all sea turtles in the world [10]. The only known regular nesting area in Brazil is located in the northern portion of the state of Espírito Santo, whereas occasional nesting has been recorded in the states of Piauí, Rio Grande do Norte, Bahia, Rio de Janeiro, Santa Catarina, and Rio Grande do Sul [10]. The leatherback sea turtle forages from the ocean surface to considerable depths, preferably inhabiting the oceanic region. Its diet is composed of gelatinous zooplankton, such as scyphozoans, ctenophores, hydrozoans, and cubozoans [24]. Records of incidental catches during oceanic fishing operations are common on the Brazilian coast [22, 25].

1.2. Main threats

Sea turtles are subject to diverse threats throughout their lifecycle, mainly due to anthropogenic factors [26]. The history of exploitation for the consumption of meat and eggs, together with the long lifecycle and late maturity (at around 25–30 years) and the degradation of their natural habitats, has led to a decline in populations around the world, placing sea turtles as risk of extinction [26, 27]. Indeed, all sea turtle species are currently on the Red List of endangered species of the International Union for Conservation of Nature [28] and the Brazilian Environment Ministry (ordinance n° 444/2014 and n° 445/2014) (**Table 1**).

Currently, the main threats to sea turtles are coastal development, incidental catches during fishing operations, human consumption of meat, climate change, pollution, and exposure to pathogens [10]. Many human activities exert direct and indirect impacts on sea turtles. Coastal development leads to the use of areas that are important for these animals in terms of foraging and reproduction [26]. Examples of anthropogenic interferences considered threats to sea turtles include activities such as oceanfront housing, vehicular traffic, and artificial lighting on beaches in nesting areas, real estate development, the discarding of solid waste and chemical pollutants into the sea, the construction of ports, and, especially, fishing operations [29–36].

The consumption of meat and eggs [26] and incidental catches of sea turtles by fishing gear are the human actions with the greatest impact on sea turtle populations around the world [27, 37]. Several countries are working together in search of mitigating solutions aimed at reducing the number of incidental catches in different fisheries [38]. The main fisheries that affect sea turtles in Brazil are gillnetting, seining, traps and longline (surface and bottom) operations, with the highest mortality rates attributed to gillnetting and longline operations [39].

Espécies	IUCN	MMA
Dermochelys coriacea	VU	CR
Chelonia mydas	EN	VU
Caretta caretta	VU	*
Eretmochelys imbricata	CR	CR
Lepidochelys olivacea	VU	EN

*Species included in Normative Instruction N° 3 (May 27, 2003), which describes critically endangered species of Brazilian fauna.

Table 1. Endangered status of sea turtles occurring in Brazil according to Red List of International Union for Conservation of Nature and Brazilian Environment Ministry (DD, deficient data; VU, vulnerable, EN, endangered, CR, critically endangered).

In Brazil, loggerhead and olive ridley sea turtles are more frequently caught by pelagic longline and bottom seining operations [18, 22], whereas leatherback turtles are affected mainly by pelagic longline fishing [22, 40, 41]. Green and hawksbill sea turtles are more frequently caught by coastal artisanal gillnetting and seining operations due to the more coastal habits of these species, but are also caught as bycatch in oceanic fishing gillnetting and longline operations [22, 42–44].

1.3. Beach monitoring projects

Mitigation measures, such as beach monitoring projects (BMPs), have been implemented around the world with the aim of evaluating and minimizing environmental impacts on the marine biota caused by human activities. With the increase in public pressure and the sense of corporative responsibility, some companies have gone beyond the mitigation of these impacts and have invested in enterprises that include providing financial resources for the management of protected areas as well as support for scientific research and governmental training. In countries where the capacity and resources for protecting the environment are very limited, such actions are very important as an efficient manner to conserve biodiversity in areas affected by human intervention [45].

Specific, effective protocols for the recovery and protection of marine fauna in areas under the influence of these enterprises are scarce. Thus, marine animals have been one of the focuses of environmental licensing processes due to the recognized potential for causing lethal and sub-lethal disturbances to species. Sub-lethal effects stemming from metabolic exhaustion can be as devastating as lethal impacts and provoke adverse behavioral reactions, such as panic and the loss of foraging and defense capacities, which facilitates the occurrence of incidental catches, collisions with boat and stranding, as known in cetaceans [46].

The oil and gas industry has long adopted more effective environmental practices and increased awareness with regard to the social and environmental responsibility of its operations. For industrial activities to occur in a sustainable manner, it is fundamental to conduct multidisciplinary studies that furnish reference data on the environment in which such operations are developed [47]. In this context, the BMP is a condition for environmental licensing stipulated by the General Petroleum and Gas Coordination of *Instituto de Meio Ambiente e dos Recursos Renováveis* [IBAMA (Brazilian Institute of the Environment and Renewable Resources)] for situations with unclear environmental impacts that are inherent of the industrial oil production process.

The majority of studies on stranded marine animals are conducted with mammals [48–52] and seabirds [53–56]. However, researchers have become more engaged in the monitoring of stranded sea turtles in coastal regions throughout the world, including Brazil, which is an effective approach to investigating the ecology and epidemiology of these animals [29, 57–62]. Thus, the aim of this chapter is to describe the strategies of the BMP in the state of Rio de Janeiro, Brazil, and present the results of these strategies in the first year since its implementation with marine chelonian.

2. Methods

2.1. Study area: Santos Basin

The Santos Basin has an area of 276,900 km^2 and is bordered by the Campos Basin to the north off the municipality of Cabo Frio in the state of Rio de Janeiro and the Pelotas Basin to the south off the city of Florianópolis (state of Santa Catarina). In a region with very deep waters, the development of carbonate reservoirs occurs below a layer of salt in what is known as the pre-salt layer, characterizing one of the largest petroleum provinces in the world, with accumulations of heavy oil, light oil, and non-associated gas.

The pre-salt layer is a rock formation located in the subsoil of the Brazilian coastline that extends between the states of Santa Catarina and Espírito Santo, covering an area of approximately 800 km in length and 200 km in width. This group of rocks with the potential for the formation of petroleum is located under an extensive layer of salt reaching as much as 2 km in thickness. Such formations are found at distances of approximately 300 km from the coastline at depths of approximately 5000 m, of which the water column accounts for 2000 m, sediment accounts for 1000 m, and salt accounts for the last 2000 m. The pre-salt layer of the Santos Basin, which covers an area of 149,000 km^2, has one of the largest petroleum reserves in the country. The first production in this region occurred in the "Lula" field on May 1, 2009.

2.2. Beach monitoring project

The Brazilian oil company PETROBRAS (Petróleo Brasileiro S.A) has been conducting BMPs along the following oceanic basins: Potiguar (states of Rio Grande do Norte and Ceará in the northeastern region of the country), Sergipe-Alagoas (states of Sergipe and Alagoas in the northeastern region), Campos-Espírito Santo (states of Rio de Janeiro and Espírito Santo in the southeastern region), and Santos (states of Rio de Janeiro and São Paulo in the southeastern region and states of Paraná and Santa Catarina in the southern region). The main goal of a BMP is to record the occurrence of stranded marine animals, especially chelonians, mammals, and seabirds, and determine whether there is a relationship between the stranding of these animals and the oil exploration and production activities conducted by PETROBRAS on the coast of Brazil. Discontinuous stretches of beach have been actively monitored by land and/or sea through routinely traveling the entire length of beaches in search of carcasses and debilitated animals as well as through information provided by third parties, such as the local population, tourists, and public agencies. Information is collected about the environment and stranded organisms each monitoring day and necropsies are performed of dead animals, whenever possible, in search of evidence of anthropogenic interaction and the establishment of a possible cause of death.

BMPs can be conducted by universities, institutions, or environmental consulting firms in partnership with organizations recognized by the environmental authority in Brazil (IBAMA). The aim of shared execution is to avoid the overlap of sampling efforts in areas where groups have performed their services and circumvent the "dispute for carcasses," ensuring permanent access to the data for all parties involved.

2.3. Beach monitoring project in the state of Rio de Janeiro

This chapter addresses the implementation and data obtained from the BMP conducted in the Santos Basin (BMP-SB) in coastal municipalities located between the southern limit of the municipality of Paraty and the northern limit of the municipality of Saquarema in the state of Rio de Janeiro (**Figure 1**). Approximately 985 km of beaches are located on the mainland and nearby islands, involving a variety of environments, different beach morphologies, and different degrees of land use and occupation as well as land and marine environmental areas

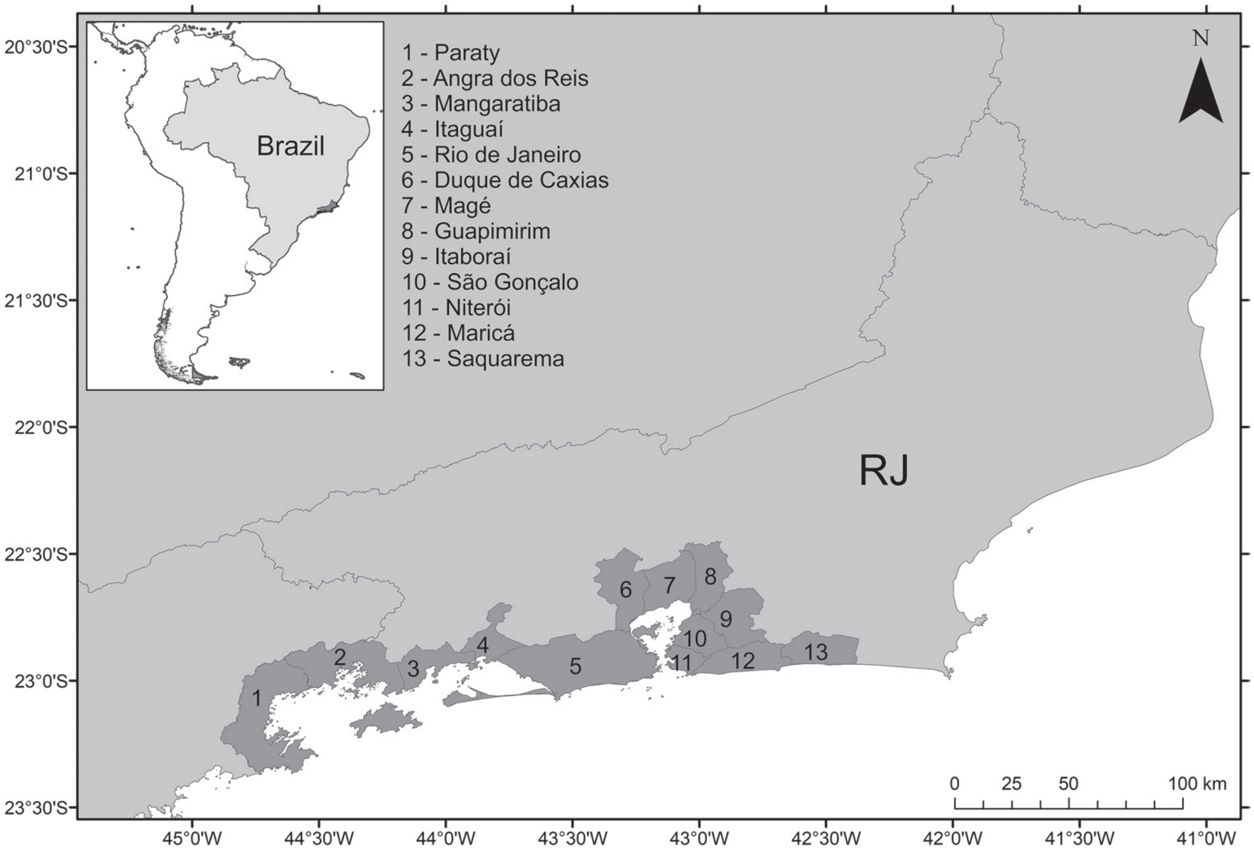

Figure 1. Area of the beach monitoring project in the state of Rio de Janeiro.

protected by state (Rio de Janeiro State Environmental Institute) and federal (Chico Mendes Institute for the Conservation of Biodiversity) institutions.

Prior to the onset of the activities, an *in situ* study was conducted to define the monitoring strategies, locations for the installation of veterinary facilities, and logistic support and determine the profile of the team needed for the execution of the intended actions. The area of coverage was then divided into five sectors, denominated "stretches": Stretch 1 corresponded to the municipalities of Saquarema and Niterói); Stretch 2 corresponded to the city of Rio de Janeiro and Guanabara Bay; Stretch 3 corresponded to the municipality of Mangaratiba; Stretch 4 corresponded to the municipality of Angra dos Reis; and Stretch 5 corresponded to the municipality of Paraty (**Figure 2**). The frequency (daily, weekly, and bi-weekly) and monitoring modality (active by land, active by boat, or notification from the network of collaborators) were based mainly on the geographical particularities of each stretch.

Three veterinary structures and four logistic support points were installed for the treatment of living (rehabilitation) and dead (necropsy) animals. The veterinary structures were installed at locations based on the premise that a debilitated animal could not be transported a distance greater than 150 km or for more than 2 h. The composition of the teams allocated to each stretch varied in accordance with the type of monitoring employed and the presence of a veterinary base. The teams included monitors (residents of local communities), field technicians (biologists, oceanographers, and scientists from similar fields), boatmen, environmental educators, communication assistants, veterinarians, veterinary assistants, general service assistants, administrative assistants, managers, and coordinators.

All field and veterinary teams received specific training prior to the initiation of the BMP-SB activities. The training involved the content of previously established protocols, which considered all actions envisaged for the project in an effort to ensure the collection of harmonious, standardized data. Eight guiding documents were drafted: (1) field activity protocol for beach monitoring by land and boat; (2) veterinary care protocol for living animals (rehabilitation, release, and destination of rehabilitated animals); (3) euthanasia protocol; (4) veterinary care protocol for dead animals (necropsies); (5) gastrointestinal content sorting protocol; (6) protocol for age and sexual maturity estimates; (7) protocol for collecting, storing, and sending samples for histopathological analysis; and (8) protocol for the collection of samples for the analysis of contaminants and biomarkers. Whenever changes are needed due to the dynamics of the activities, the protocols are revised and made available based on the functions each team exercises.

2.4. Monitoring strategies

Four monitoring modalities were defined: (1) active by land; (2) active by boat; (3) active by partners; and (4) notification from network of collaborators. Each stretch of the BMP-SB could involve one or more types of monitoring, which could be practiced at the same time (**Table 2**).

Active monitoring by land: Daily patrolling of beach by monitors and field technicians, preferably in pairs, trained to observe and record occurrences of stranded marine animals. Monitoring could be performed on foot, on a bicycle or traction vehicle (e.g., quadricycle) on 88 beaches, totaling 118.5 km/day.

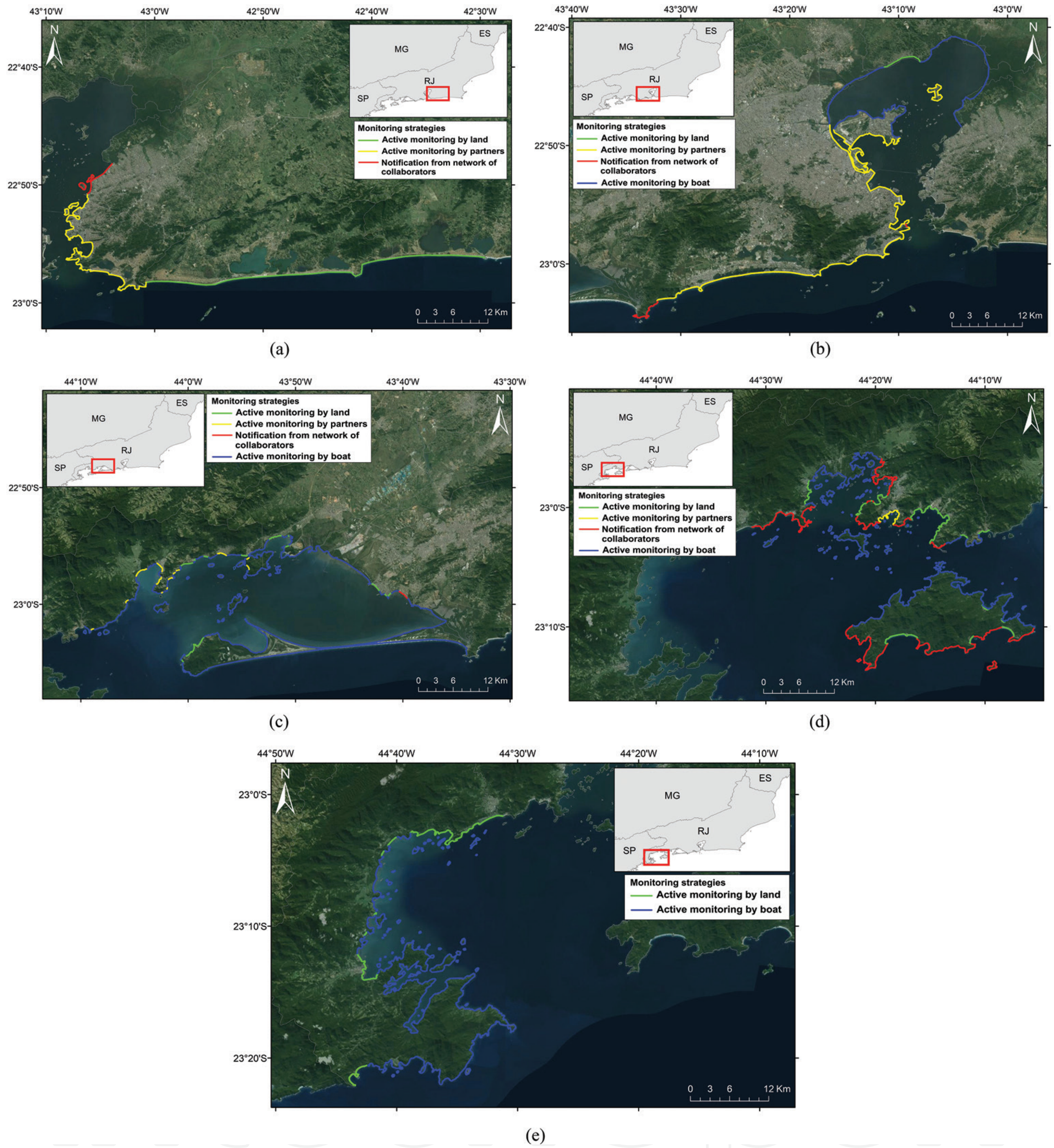

Figure 2. Sectorization of BMP-SB area. Colors indicate different monitoring modalities: green = active by land; blue = active by boat; yellow = active by partners; red = notification from network of collaborators. (A) Stretch 1: Saquarema to Niterói; (B) Stretch 2: Rio de Janeiro and Guanabara Bay; (C) Stretch 3: Mangaratiba; (D) Stretch 4: Angra dos Reis; and (E) Stretch 5: Paraty.

Active monitoring by boat: Patrolling of beaches with no access by land located on the mainland or islands performed by teams composed of at least a boatman and field technician searching for stranded or drifting animals. This modality is practiced either weekly or bi-weekly, depending on the navigation rules established by the regulating agency (Port Captaincy of the Brazilian Navy), totaling approximately 742 km/weeks.

Stretches	Monitoring efforts				
	Active by land	Active by boat	Active by partners	Notification from network collaborators	Total (Km)
1-Saquarema to Niterói	52.30	—	14.74	9.70	76.74
2-Rio de Janeiro and Guanabara Bay	6.65	62.00	51.24	1.52	121.41
3-Sepetiba to Mangaratiba	18.10	234.65	9.65	1.90	264.30
4-Angra dos Reis	22.48	219.75	4.83	30.55	277.61
5-Paraty	18.97	225.42	—	0.08	244.47
Total (Km)	**118.50**	**741.82**	**80.46**	**43.75**	**984.53**
Total (%)	**12.04**	**75.35**	**8.17**	**4.44**	**100**

Table 2. Total monitored area according to strategy employed for Santos Basin beach monitoring program in state of Rio de Janeiro, Brazil.

Active monitoring by partners: Monitoring performed indirectly on urban beaches and beaches located in private condominiums that have daily clean-up activities and/or the presence of lifeguards. When a marine animal is found by these partners, the team of the project is contacted to collect the animal.

Notification from network of collaborators: Monitoring performed by third parties. Contact could be made through the 800 number (free telephone call) or directly to any member of the project team. Permanent dissemination of the activities is performed in the communities as well as with fishermen associations, city halls, commercial establishments, and coastal enterprises.

2.5. Veterinary structure and monitoring support

Three veterinary bases were installed for the rehabilitation and necropsy of marine animals, located at Araruama, Rio de Janeiro, and Angra dos Reis municipalities; and four logistic support points were established, located at Maricá, Mangaratiba, Angra dos Reis (Ilha Grande), and Paraty municipalities, to give support to the monitoring activities. The veterinary bases were divided into two categories: rehabilitation center and stabilization unit, which were implemented following the guidelines available in IBAMA Normative Instruction N° 7 (from April 30, 2015), which stipulates use and management categories for wildlife in captivity and defines the procedures for the established categories. All structures have licenses from the environmental agency and professional class entity.

The rehabilitation center has the capacity to treat at least 70 marine animals per month, a minimum area of 700 m^2 and a structure composed of administrative, maintenance/services, and veterinary sectors as well as a specific room for environmental education activities. The veterinary sector is composed of a laboratory, clinic, infirmary with intensive care unit, stabilization, washing and drying room for oil-covered animals, animal kitchen, necropsy room, room for storing carcasses and samples, animal enclosure, and dressing rooms.

The stabilization unit is a simpler structure where debilitated animals receive first aid until strong enough to be transported to a rehabilitation center. This unit has the capacity to treat at least 20 animals per month and an area of 500 m^2. It is composed of an administrative sector and veterinary sector, which has a necropsy room, room for storing carcasses and samples, clinic, infirmary, kitchen, and animal enclosure.

The support point is a structure that provides support to the monitoring and administrative activities, containing an office, kitchen, and restrooms for the staff, enclosure for the temporary storage of carcasses, field material, and vehicles.

2.6. Field records

During the monitoring activities, the field teams collected information on the, when monitoring itself, sea turtles found either stranded or drifting in the water. A set of data was defined for each monitoring strategy to ensure standardization and the tracking of the effort performed on a given day. For such, field charts were always filled out at the beginning and end of each activity, including the date, time of the day, geographic coordinates, and environmental conditions (sky conditions, wind direction and intensity, ocean conditions, and tide). Global positioning system (GPS) equipment was also used throughout the entire course of each monitoring event. For monitoring strategies in which stranded animals were reported by third parties, the basic data (date, time when the call was received), means of notification (telephone, e-mail), state of the animal (alive or dead), size of the animal, location (name of beach and reference points), as well as the name and telephone number of the person who made the notification were recorded. This information enabled the field team to determine the best way to reach the location and the most adequate materials for the treatment of the animal.

When a sea turtle was found stranded, the field team collected a set of data on both the animal and the surrounding environment. A field chart was filled out containing the following information: date, time of day, characteristics of the environment (water, sand, mangrove, or rocks), species (to the lowest possible taxonomic level), sex, artificial markings (tags or other identification), state of the animal (alive or dead), condition of carcass (fresh, evident decomposition, advanced decomposition, or mummified) (**Table 3**), body condition (poor, intermediate, or good, based on condition of pectoral musculature, see [63]), development phase (pup, juvenile, or adult), evidence of anthropogenic interaction, presence of fibropapillomas, samples collected, and destination of the animal.

The photographic records of all sea turtles found followed a standardized guide, with obligatory images of the entire body (dorsal and ventral views), head (side and dorsal view), marks (natural and scars), tags (if present), abnormalities on the dermal scales of the head (central, lateral, and postorbital), and bodily deformations. For animals found alive, the ventral photograph was not taken by the field team in order to avoid greater harm and was performed by the veterinarian during rehabilitation or after death.

All measurements were linear, except for the carapace, which was a curvilinear measurement. A total of nine biometric variables were measured. For mummified carcasses or those with separated body parts due to decomposition or the action of predators, no measurements were made.

Code	Class	Description
2	Optimal condition (fresh animal)	Fresh normal appearance, with few or no lacerations caused by other animals, clear eyes, body firm and not inflamed, no discoloration, viscera intact and well defined.
3	Evident decomposition	Decomposed, but organs basically intact. Carcass intact, may be slightly bloated; may have missing skin in some places; may have internal or external signs of predation by necrophagous animals, but the organs are maintained.
4	Advanced decomposition	Carcass may or may not be intact; epidermis completely missing, numerous lacerations caused by necrophagous animals; strong odor; muscles with no consistency and frail, easily detached from bones; viscera missing or identifiable, but with coloration and appearance of intensive autolysis; brain reddish black.
5	Mummified state	Carcass or skin, when present, may be covering remaining skeleton; any remaining tissues are unidentifiable.

Table 3. Classification of decomposition stage of sea turtle carcasses; adapted from [64].

2.7. Rescue and transport of sea turtles

2.7.1. Living sea turtles

The rescue and transport of living sea turtles requires quickness and some basic procedures to increase the possibility of successful rehabilitation. The following were the main guidelines for rescuing living sea turtles: use gloves when handling the animal; keep the animal in a calm, shaded place in ventral decubitus; support it on foam rubber, cloth, or sand; and place wet cloth or towels on the carapace to reduce thermal stress and dehydration at temperatures above 25°C).

For transport to the veterinary base, the sea turtle was placed in a plastic box (appropriate for its size) with no sharp edges and lined with foam rubber (ideally, protective mats of smooth, impermeable material) or cloths to diminish stress and facilitate the subsequent cleaning of the recipients. The sea turtles were always transported in ventral decubitus and never in tanks with water due to the risk of drowning. Transport was executed in closed vehicles to avoid extreme temperature of heat or cold.

2.7.2. Dead sea turtles

Sea turtle carcasses found on the beach were retrieved following the criteria listed in **Table 4**, which are based on knowledge acquired from other projects and surveys, which identified that more than 90% of stranded individuals are juvenile green sea turtles (curvilinear carapace length between 30 and 50 cm). Those that did not fulfill the criteria and would therefore not be submitted to necropsy could be buried on the beach in a location above the water line of the spring tide, at a sufficient distance from urban areas and at a sufficient depth, as stipulated in the Procedures for the Monitoring of Stranded Sea Turtles in Feeding Areas and in accordance with the Management Plans for Environmental Protection Areas, or could be sent to a veterinary base to be discarded as biological waste. Burying the carcasses enables retrieval by scientific institutions that have the interest in and capacity to store the material.

	Code 2 (fresh)	Code 3 (evident decomposition)	Code 4 (advanced decomposition)	Code 5 (mummified)
Sea turtles covered in oil	All	All	All	All
Chelonia mydas	All	All	<30 cm >50 cm	None
Caretta caretta; Eretmochelys imbricata; Lepidochelys olivacea; Dermochelys coriacea	All	All	All	None

Table 4. Criteria established for retrieval of carcasses of five species of sea turtle and shipping to veterinary bases.

Sea turtle carcasses in adequate condition for necropsy were transported to the veterinary bases. The transport was planned in such a way as to optimize the travel time and avoid further decomposition. The animals were placed in specific transport cases (polystyrene chests) and kept cool with ice to slow down the decomposition process. After necropsy, the material was discarded as biological waste and collected by specialized firms. During the execution of the carcass procedures, individualized protection equipment was used to avoid contact of the skin and mucous membranes of the technicians with the biological waste of the animals.

2.8. Sea turtle care and necropsy

All living, debilitated sea turtles found stranded or drifting in the water were sent to the closest rehabilitation center or to a stabilization unit where they were given veterinary care. Prior to release back into the environment, all sea turtles were tagged using standard rings provided by the environmental agency in charge (TAMAR Center/Chico Mendes Institute for the Conservation of Biodiversity). The data on the tagged animals were entered in the national registry (TAMAR Project Information System (www.sitamar.tamar.org.br), verified, and validated by environmental analysts of the TAMAR Center/Chico Mendes Institute for the Conservation of Biodiversity, with both public access and restricted access modules.

All sea turtles found dead (fulfilling the criteria listed in **Table 4**) and those that died during the treatment were submitted to necropsy and the collection of biological material for macroscopic analysis, sorting of gastrointestinal contents, parasite taxonomic analysis, histopathological analysis and osteology in an attempt to determine the cause of death and whether there was an association with PETROBRAS activities. For recently dead animals that were not submitted to veterinary treatment, tissue samples were collected for the analysis of contaminants (polycyclic aromatic hydrocarbons and heavy metals) as well as chemical and molecular.

2.9. Aquatic biota monitoring information system

All data collected within the scope of the project are available through the *Sistema de Informação de Monitoramento da Biota* [SIMBA (Aquatic Biota Monitoring Information System), which has both private and public access modules (pmp.acad.univali.br/simba)]. The records in the system include information on the monitoring effort, records of sea turtles, biometrics, veterinary treatment, necropsy, and examinations performed. In the field, the monitoring teams used the SIMBA Mobile application to record data in real time and synchronize with SIMBA Web.

3. Results

During 1 year of activities (September 2016 to September 2017) of the BMP-SB in the area between the southern limit of the municipality of Paraty and the northern limit of the municipality of Saquarema in the state of Rio de Janeiro, 1138 sea turtles were recorded, of which 10.9% were found alive (n = 124) (**Table 5**). More than half of the specimens were in an advanced stage of decomposition (n = 599), and only 10.7% (n = 122) were fresh individuals (having died less than 24 h earlier) (**Table 5**).

All five species of sea turtle with known occurrence on the coast of Brazil were recorded. Green sea turtles accounted for 92.7% of the stranding events (1055 occurrences) (**Table 5**). Green turtles have cosmopolitan distribution from the tropics to temperate regions and exhibit more coastal habits, including the use of river and lake estuaries [14]. Hence, its predominance among the stranding events may be related to its living habits and geographic distribution.

High numbers of *C. mydas* have been recorded in other BMPs conducted in Brazil. The Campos-Espírito Santo BMP (southeastern Brazil) registered a total of 18,488 stranding events of green sea turtles in a 5-year period (2010–2015). The same monitoring project was conducted in the states of São Paulo, Paraná, and Santa Catarina by another institution recorded a total of 5221 stranding events involving the species in a 1-year period (2015–2016).

The highest number of sea turtle occurrences (n = 421; 37%) was recorded in Stretch 1 (municipalities of Saquarema and Niterói), which is the northernmost region of the study area,

	Alive	Code 2	Code 3	Code 4	Code 5	Deaths*	Total	%
Caretta caretta	2	3	5	19	6	33	35	3.1
Chelonia mydas	120	118	150	553	114	935	1055	92.7
Dermochelys coriacea	0	0	1	7	0	8	8	0.7
Eretmochelys imbricata	1	0	0	2	1	3	4	0.4
Lepidochelys olivacea	1	1	1	12	2	16	17	1.7
Undetermined	0	0	1	6	12	19	19	1.5
Total	**124**	**122**	**158**	**599**	**135**	**1014**	**1138**	—
%	**10.9**	**10.7**	**13.9**	**52.6**	**11.9**	**89.1**	**100**	—

*Deaths = total of all dead individuals in different stages of carcass decomposition.

Table 5. Sea turtle species recorded according to carcass condition.

followed by Stretch 3 (municipality of Mangaratiba) (n = 347; 30.5%), Stretch 4 (municipality of Angra dos Reis) (n = 134; 11.8%), Stretch 2 (city of Rio de Janeiro and Guanabara Bay) (n = 129; 11.3%), and Stretch 5 (municipality of Paraty) (n = 107; 9.4%) (**Table 6**). Intrinsic characteristics of each stretch, such as a predominance of exposed beaches or sheltered beaches, geographical barriers (islands and cliffs of different sizes), development of fishing activities involving drum nets/seines, type of monitoring strategy, and proximity to reproductive areas, are factors that may exert an influence on the numbers of sea turtles found on each stretch.

Only green and loggerhead sea turtles were found stranded throughout the entire study area (**Table 6**). Olive ridley, leatherback, and hawksbill sea turtles were only found in areas in the more northern portion of the state of Rio de Janeiro (Stretches 1 and 2) (**Table 6**).

Loggerhead and olive ridley turtles were found in all seasons, particularly in spring (**Table 7**). There were no records of the hawksbill sea turtle in winter (**Table 7**). With the exception of one occurrence of the leatherback sea turtle in summer, all other stranding events of the species occurred in autumn on a single beach located in the municipality

	Stretch 1	Stretch 2	Stretch 3	Stretch 4	Stretch 5	Total	%
Caretta caretta	22	6	2	4	1	35	3.1
Chelonia mydas	375	115	336	123	106	1055	92.7
Dermochelys coriacea	7	1	0	0	0	8	0.7
Eretmochelys imbricata	4	0	0	0	0	4	0.4
Lepidochelys olivacea	11	6	0	0	0	17	1.5
Undetermined	2	1	9	7	0	19	1.7
Total	**421**	**129**	**347**	**134**	**107**	**1138**	—
%	**37.0**	**11.3**	**30.5**	**11.8**	**9.4**	**100**	—

Table 6. Sea turtle species recorded per stretch of BMP-SB area of coverage.

	Spring	Summer	Fall	Winter	Total	%
Caretta caretta	13	6	8	8	35	3.1
Chelonia mydas	189	229	285	352	1055	92.7
Dermochelys coriacea	0	1	7	0	8	0.7
Eretmochelys imbricata	1	2	1	0	4	0.4
Lepidochelys olivacea	7	4	4	2	17	1.5
Undetermined	11	3	0	5	19	1.7
Total	**221**	**245**	**305**	**367**	**1138**	—
%	**19.4**	**21.5**	**26.8**	**32.2**	**100**	—

Table 7. Sea turtle species recorded per season between September 2016 and September 2017.

	Notification by Network of Collaborators	Active through partners	Active by land	Active by boat	Total
Caretta caretta	11	5	17	2	35
Chelonia mydas	315	113	558	70	1056
Dermochelys coriacea	1	3	4	—	8
Eretmochelys imbricata	1	—	3	—	4
Lepidochelys olivacea	3	4	9	—	16
undetermined	—	1	18	—	19
Total	**331**	**126**	**609**	**72**	**1138**
%	**29.1**	**11.1**	**53.5**	**6.3**	**100**

Table 8. Sea turtle species recorded by BMP-SB using different monitoring strategies between September 2016 and September 2017.

of Maricá (Stretch 1) (**Table 7**). The period in which the leatherback turtles were found coincides with the industrial fishing season in the region, during which trawlers from different states perform gillnetting activities. Incidental catches of *D. coriacea* in gillnets

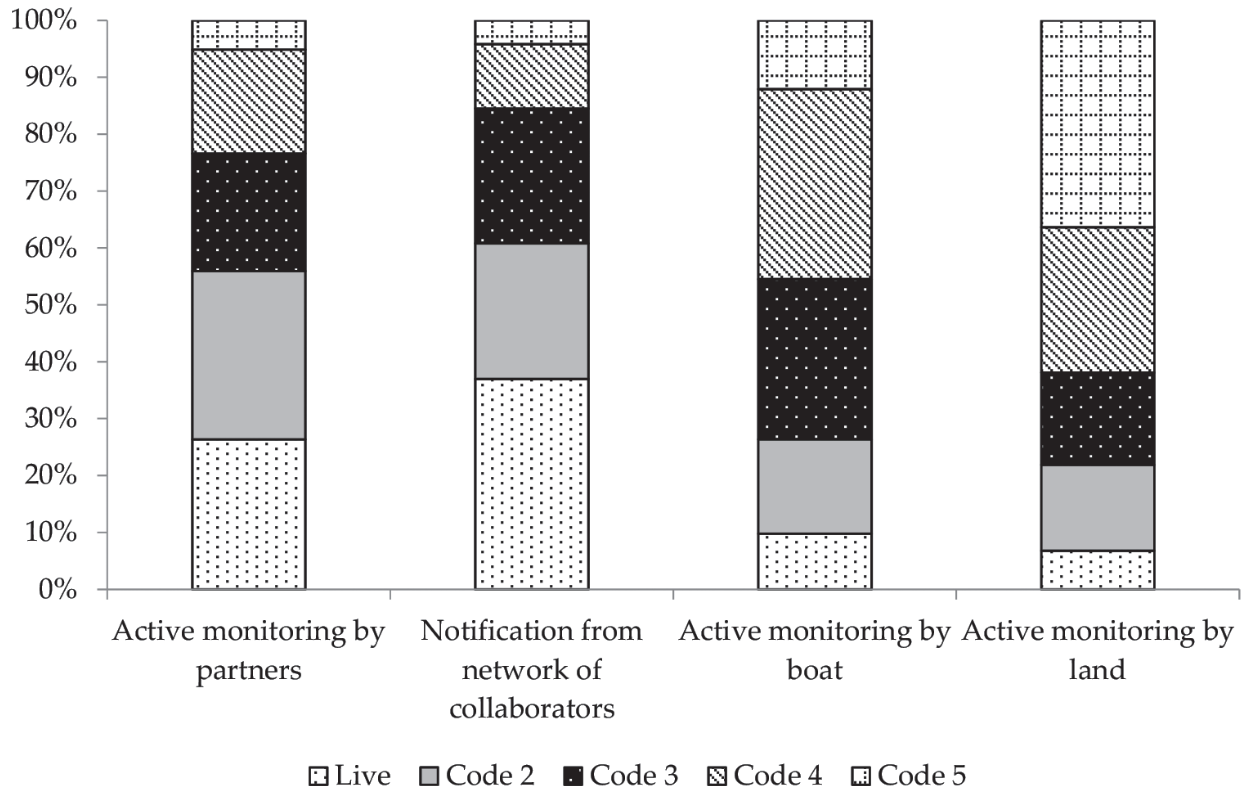

Figure 3. Proportion of sea turtles recorded with different monitoring strategies employed in BMP-SB according to condition of the carcass. Code 2 = fresh; Code 3 = evident decomposition; Code 4 = advanced decomposition; and Code 5 = mummified.

	Stretch 1		Stretch 2		Stretch 3		Stretch 4		Stretch 5		Total	%
	N	%	N	%	N	%	N	%	N	%		
Active by land	273	64.7	7	5.5	208	59.9	68	50.7	53	49.5	609	53.5
Active by boat	—	—	1	0.8	33	9.5	16	11.9	22	20.6	72	6.3
Active by partners	45	10.7	74	57.8	2	0.6	5	3.7	—	—	126	11.1
Notification by network of collaborators	104	24.6	46	35.9	104	30	45	33.6	32	29.9	331	29.1
Total	**422**	**100**	**128**	**100**	**347**	**100**	**134**	**100**	**107**	**100**	**1138**	**100**

Table 9. Total number (N) and relative frequency (%) of stranded sea turtles according to monitoring strategy and stretch recorded by BMP-SB between September 2016 and September 2017.

on the coast of the states of Rio de Janeiro and Espírito Santo have been described by other authors [65].

Considering the monitoring modalities in the BMP-SB, daily active efforts by land accounted for 609 of the total number of stranded sea turtles (53.5%) (**Table 8**). Retrieval following notifications accounted for 457 events (40.2%), 331 of which were notified by the network of collaborators and 126 through active partners, which was the modality most responsible for the retrieval of living individuals (**Figure 3**). It is hoped that the population that uses the communication channels of the BMP-SB is sensitized principally due to the debility of living animals. Carcasses in an advanced stage of decomposition or mummified were recorded largely during daily active monitoring by land (**Figure 3**). Boat monitoring was less effective, accounting for only 72 records (6.3%) (**Table 8**).

Daily active monitoring was the main form of records of stranded sea turtles in Stretches 1 and 3, whereas notifications were the main form in Stretch 2. The two forms (daily active monitoring by land and notifications) achieved similar results in Stretch 4. Boat monitoring had a better performance in Stretch 5, but still was not as effective as the other modalities (**Table 9**).

4. Discussion

In the state of Hawaii, USA, the US National Marine Fisheries Service (Pacific Islands Fisheries Science Center, Honolulu) has maintained a monitoring program since 1982, in which the community reports the occurrence of stranded sea turtles on beaches of the Hawaiian islands (Kauai, Oahu, Maui, and Hawaii) to the service by telephone and the animals are sent for either treatment or necropsy [59]. The program has led to the rehabilitation of 1000 sea turtles since its inception, demonstrating the effectiveness and success of this method [66].

In the state of California, USA, a BMP denominated "Beach Combers" was created in 1997, which occurs in the form of collaboration between the Moss Landing Marine Laboratories, Monterey Bay National Marine Sanctuary as well as other state and research institutions, including the

California Department of Fish and Wildlife and the US Geological Survey. Trained volunteers travel all beaches in Monterey Bay in search of stranded marine birds and mammals. The aim of this monitoring is to determine the health index of the sanctuary [67].

In Queensland, Australia, the Department of Environment and Heritage Protection maintains the StrandNet monitoring system. The waters are in the state marine parks, such as the Moreton Bay and Great Sandy Marine Parks in the southern portion of Queensland and the Great Barrier Reef, all of which are protected by laws that target marine fauna in these regions [67, 68]. Most stranding events are communicated by the staff of the governmental departments or park rangers of the Great Barrier Reef Marine Park Authority. Notifications are also received from the public. For such, a direct telephone line is available for use by the population. The stranding events are filed at StrandNet by registered users through a web-based interface and each record receives a unique identification number, differentiated by a single letter in the case of sea turtles. When the information of the record is inconsistent (time, location, or class of animal), the datum is entered as a non-confirmed record. After verification by a trained professional, the coordinates of the stranding, details of the location, date, sex, life stage, size, condition of the animal, and destination of the animal or carcass are recorded. When available, photographs are also uploaded [57]. Thus, the databank provides sufficient information for the development of studies that contribute to the management of endangered species and the unique ecosystem of the Queensland marine parks.

Programs have also been created to restore areas affected by accidents related to petroleum and gas activities, such as the oil spill that occurred in the Gulf of Mexico in 2010 on the Deepwater Horizon offshore drilling rig, which is considered the worst American environmental disaster [69]. Such actions are led by the Marine Fisheries Service of the US National Oceanic and Atmospheric Administration and the US Fish and Wildlife Service, with shared jurisdiction for the recovery and conservation of sea turtles listed in the U.S. Endangered Species Act [70].

In Brazil, sea turtles have been on the endangered species list since the end of the 1970s, but there was no marine fauna conservation program in the country at the time. The TAMAR project initiated its first continual monitoring efforts of the Brazilian coast with the aim of accompanying sea turtle stranding events and recognizing nesting sites [9]. Since then, different studies with the participation of Brazilian universities have been developed to identify events that impact the five sea turtle species that occur in Brazil, such as coastal development [26], fishing activities [18, 71], climate change [72, 73], pollution, and disease [29, 74–76].

The implementation of the BMPs on the coast of Brazil to evaluate the impact of activities related to the petroleum and gas industry on marine fauna occurred in 2010, with programs executed in the Potiguar Basin off the state of Rio Grande do Norte (336 km) and the Sergipe-Alagoas Basin off the states of Sergipe and Alagoas (254 km) in the northeastern region, the Campos Basin off the state of Espírito Santo (763 km) in the southeastern region, and the Santos Basin (more than 1500 km) off the states of Rio de Janeiro, São Paulo, Santa Catarina e Paraná in the southeastern and south region, totaling approximately 2853 km of coastline monitored by land and/or boat as well as notifications from 800 (free of charge) numbers.

As a complement to BMP activities, environmental education programs are offered to local populations. These programs involve recreational activities, awareness of the issue, and pertinent training of the target public in accordance with the age group. This aspect is of the utmost importance to the dissemination of the BMP, as it increases the network of collaborators and results in the awareness of the responsibility of the local population.

The BMP enables the analysis of scenarios of stranded marine animals, which, in turn, enables a clear view of possible long-term effects of petroleum activities. and generating long-term data on the mortality of these animals as well as information on threats, areas of use, age groups, migratory movements, feeding habits, etc., contributing knowledge on the biology of the monitored groups (marine birds, mammals, and chelonians) that can be used in the planning of policies directed at the conservation of species.

5. Conclusion

Beach monitoring is currently one of the main sources of information on the occurrence, diversity and biology of species of marine chelonians, especially in regions where research on these animals is incipient. Determining the exact cause of a stranding is a difficult task due to the combined influences of environmental, biological, and anthropogenic factors, which often act in a synergic manner. Moreover, symptoms and diseases can become obscured by the decomposition stage of the carcass. Stranding events can be caused by environmental factors (associated with oceanographic and climatic conditions) together with factors related to the health of the animal. Human activities developed and intensified in coastal regions are potential triggers of stranding events, such as becoming entangled in fishing nets, collisions with boats, and contact with environmental pollution, which makes populations more susceptible to infections and other health problems.

The determination of the anthropogenic impacts on fauna involves diverse difficulties that imply uncertainties and often impede coming to reasonable conclusions, especially in the short term. Such difficulties are linked to the need for a minimum monitoring time as well as fluctuations in natural and anthropogenic factors, which exert influences on the behavior of living animals and the stranding itself. Giving continuity to the acquisition of data will increase knowledge on species of marine chelonians in the state of Rio de Janeiro and the analysis of the data collected could enable the identification of the cause of death of stranded animals.

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