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Sea turtle strandings and the importance of the restinga de Jurubatiba National Park in loggerhead (Caretta caretta) nesting sites

Protected areas represent important refuges for several species of fauna, mitigating human impacts and providing food resources and reproductive sites. In this study, analyzed the stranding pattern of sea turtles and the importance of the largest restinga protected area in Brazil, the Restinga de Jurubatiba National Park, Rio de Janeiro, Brazil, as a potential nesting site for Caretta caretta. A total of 352 strandings were recorded from October 2017 to September 2020 by direct monitoring on the beaches. The species with the highest recorded stranding was Chelonia mydas (n = 146), followed by Lepidochelys olivacea (n = 100), Caretta caretta (n = 91), Dermochelys coriacea (n = 11) and Eretmochelys imbricata (n = 4). The highest number of stranding records occurred in the end of winter and during spring. A total of 223 nests were registered, mostly in spring and summer, with most records of C. caretta nesting between November and December. The occurrence of nesting in the park area demonstrates it is importance for the conservation of sea turtles, since the lack of urbanization reduces anthropogenic impacts such as overfishing, egg collection, running over and artificial lighting, which favors that these animals complete their cycle of life.

Palavras-chave: Southern Atlantic; Life cycle; Conservation; Nesting; Sea turtles; Restinga.

Encalhes de tartarugas marinhas e a importânica do Parque Nacional da restinga de Jurubatiba como sítio de desova da tartaruga-cabeçuda (Caretta caretta)

Áreas protegidas representam importantes refúgios para diversas espécies da fauna, amenizando os impactos antrópicos e disponibilizando recursos alimentares e sítios reprodutivos. Neste estudo foi analisado o padrão de encalhes de tartarugas marinhas e a importância da maior área protegida de restinga do Brasil, o Parque Nacional da Restinga de Jurubatiba, Rio de Janeiro, Brasil, como potencial sítio de desova para Caretta caretta. Foram registrados, por monitoramento direto nas praias, um total de 352 encalhes entre outubro de 2017 a setembro de 2020. A espécie com maior registro de encalhes foi Chelonia mydas (n = 146), seguida por Lepidochelys olivacea (n =100), Caretta caretta (n = 91), Dermochelys coriacea (n = 11) e Eretmochelys imbricata (n = 4). O maior número de registros de encalhes ocorreu no final do inverno e durante a primavera. Foram registradas 223 desovas, a maioria na primavera e verão, sendo a maioria dos registros de desovas de C. caretta entre novembro e dezembro. A ocorrência de desova na área do Parque demonstra sua importância para a conservação de tartarugas marinhas, já que a ausência de urbanização reduz impactos antrogênicos como sobrepesca, coleta de ovos, atropelamentos e iluminação artificial, o que favorece que estes animais completem o seu ciclo de vida.

Keywords: Atlântico Sul; Ciclo de vida; Conservação; Desova; Tartarugas marinhas; Restinga.

Topic: **Conservação da Biodiversidade**

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INTRODUCTION

The coast of Brazil is one of the longest in the world, with about 79% being composed of restingas, a phytophysiognomy of the Atlantic rainforest biome (LACERDA et al., 1993). Restingas are important marine ecosystems that influence in wind dynamics, maintenance of the sandy cord, luminosity, heat retention and coastal marine hydrodynamics (ARAUJO et al., 1998; CARVALHO et al., 2001). However, these environments are at different levels of impact, mainly due to anthropogenic threats such as urbanization, real estate speculation, roads, predatory tourism and sand extraction (BASTOS et al., 1995).

In Brazil, the largest preserved restinga area is located in the north of the State of Rio de Janeiro, the Restinga de Jurubatiba National Park, covering an area of more than 60 km along the coast (ARAUJO et al., 1998). A Park preservation area has been reported as an important refuge for plant species (MATALLANA et al., 2005; PAZ et al., 2010), birds (TAVARES et al., 2014; TAVARES et al., 2015), mammals (BERGALLO et al., 2005; TAVARES et al., 2011), fishes (CARAMASCHI et al., 2004; DARIO et al. 2013) and reptiles (MENEZES et al., 2006).

Sea turtles are susceptible to many anthropogenic impacts as they are migratory animals and have a life cycle that includes the laying of eggs in a terrestrial environment, being potential bioindicator models through the alteration of their spatiotemporal abundance (ROBINSON et al., 2009; KASCHNER et al., 2011; FLORES et al. 2021; GUIMARÃES et al., 2021). Among the seven species of sea turtles in the current fauna, five occur in Brazil and which are in different degrees of extinction threat[1] (ICMBio, 2018), which increases the need for studies that provide data for management and conservation strategies (PATINO-MARTINEZ et al., 2011; COLVERT et al., 2021). Also, as accelerated climate change threatens population dynamics, since sand temperature is one of the determining factors in the sex of hatchlings (GLEN et al., 2004; POLOCZANSKA et al., 2008; HAWKES et al., 2009; FUENTES et al., 2010). The analysis of sea turtle stranding patterns is important to understand how anthropogenic threats can affect their life cycle (LEWISON et al., 2003; TAGLIOLATTO et al., 2019a, 2019b; GUIMARÃES et al., 2021) and compare the proportions of mortality considered as a natural cause (STORELLI et al., 1998; KOPSIDA et al., 2002; CASALE et al., 2010).

In the Brazilian coast, there is a recurrent increase in the number of strandings, mainly associated with accidental fishing (PECKHAM et al., 2007) and solid waste ingestion (SANTOS et al., 2021) Being the majority of juvenile strandings of *Chelonia mydas* (REIS et al., 2017; TAGLIOLATTO et al., 2019a, 2019b; GUIMARÃES et al., 2021). The coast of Rio de Janeiro is a feeding zone and migratory corridor for the five species of Brazilian turtles, being registered in the north of the State, nesting sites of the loggerhead turtle, *Caretta caretta*. About 40 to 45% of the nesting sites registered in Brazil are associated with *C. caretta* (TOMÁS, 2016) and it is nest season takes place between the months of September to March (LIMA et al., 2012). The priority areas for *C. caretta* nests in Brazil are concentrated in the states of Sergipe and Bahia in the Northeast and in the states of Espírito Santo and Rio de Janeiro, between Farol de São Tomé, Barra do Furado and Carapebus, the latter two being southern limits of the Restinga de Jurubatiba National Park

[1] https://www.iucnredlist.org/

(MARCOVALDI et al., 2007; ICMBio 2011; REIS et al., 2017).

Considering the relevance of data from stranding records for understanding the physical, biological and anthropogenic impacts on sea turtles and the importance of preserved areas for the maintenance of nest sites, in this study we analyze data from the monitoring of beaches in the Restinga de Jurubatiba National Park, with the purpose of: (i) analyze the diversity and seasonality of sea turtle strandings and (ii) register the importance of the park as a nest site for *C. caretta*.

MATERIALS AND METHODS

Study area

The monitored beaches, Barra do Furado and Carapebus, are located in the municipalities of Quissamã and Carapebus, within the limits of the Restinga de Jurubatiba National Park, in the northern region of the State of Rio de Janeiro, Brazil (Figure 01). The monitoring area covered approximately 61.770 meters of beaches.

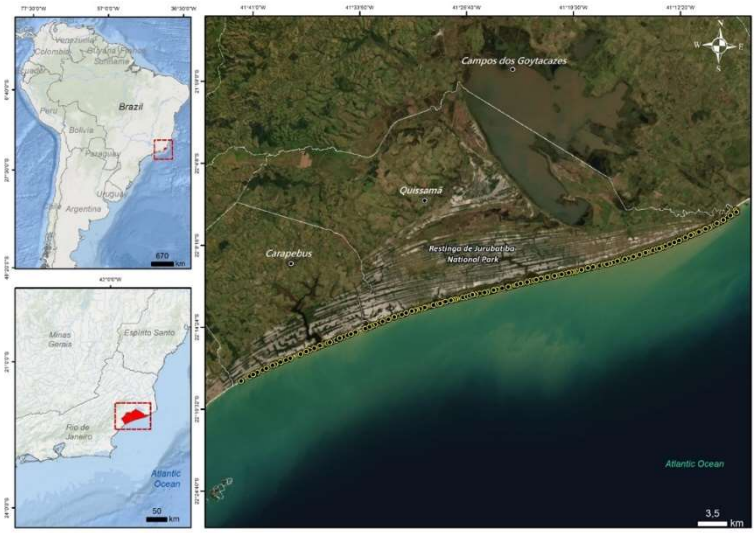

Figure 1: Geographic location map of the study area showing the Restinga de Jurubatiba National Park, in the municipalities of Carapebus and Quissamã on the coast of the State of Rio de Janeiro, Brazil. The yellow bordered circles indicate the points where sea turtle nesting was recorded during monitoring.

Fauna Monitoring and Recording

Sea turtle strandings and nests records data were used and made available to the public domain through the Campos Basin and Espírito Santo Beach Monitoring Project (PMP-BC/ES). This project was started by the company Petrobrás, as a condition imposed by the Brazilian Institute of the Environment and Renewable Natural Resources (IBAMA-Brazil) to obtain environmental licensing for the production and disposal of oil and natural gas. The data analyzed were related to the monitoring of the beaches carried out between October 2017 and September 2020 and were obtained from the SIMBA database (Aquatic Biota Monitoring Information System).

The analyzed beaches were monitored daily between 6:00 am and 12:00 am, walking along it is length or with the assistance of motorized quadricycles. In addition to active and regular monitoring on the beaches,

extensive contact was made to mobilize the passive (or indirect) monitoring method, in which the population informs about the location of stranded marine animals. People call to the free call center (0800) and the team asks the informant to explain the location of the beach (name of the beach, tourist spot), which animal, the state of the animal. The informant is then instructed on how to retain the animal or carcass and the expected arrival of the team at the site. There is no operational base for receiving animals. All calls are made through the 0800 center, from where the team travels to the location reported by the informant to answer the call. In both monitoring methods, data related to location, beach, time of monitoring duration and geographical coordinates were recorded.

For each stranded sea turtle, the following were recorded: the state of the animal (alive or dead), carcass conservation status, species identification, based on the morphology of the stranded animals, such as number of plates on the carapace, sex through observation of organs genitals or anatomopathological examination and stage of development (juvenile/adult). The evaluation of the carcass conservation status was carried out, based on the classification created by Geraci and Lounsbury (2005) for marine mammals, where five categories are used to define the state of the animal found: 1) animal still alive; 2) carcass in initial decomposition state; 3) the state of the organism is moderately decomposed; 4) the animal in an advanced state of decomposition; 5) mummified organism or when only bones are found.

To determine the influence of fishing activity on stranding and commonly in the death of sea turtles, five categories were used (total evidence, very strong, strong, without evidence and undetermined/not examined) defined by the Tamar project protocol (MARCOVALDI et al., 2000).

For each record of sea turtle behavior associated with as possible nesting, the following was analyzed: the type of record (with nest, half-moon and without nest), date of occurrence and, when there was nesting, the situation and history of the nest (nesting in the field, transfer to the beach), including accompanying eggs.

RESULTS

Stranding Data

A total of 352 sea turtle strandings were recorded during the three years of monitoring (2017-2020) on 61.77 km of beaches along the municipalities of Carapebus (n = 67) and Quissamã (n = 285). The highest number of stranding records occurred for green turtles (*Chelonia mydas*, n = 146; 41.5%), followed by the olive ridley turtle (*Lepidochelys olivacea*, n = 100; 28.5%), loggerhead turtle (*Caretta caretta*, N = 91; 25.8%), leatherback turtle (*Dermochelys coriacea*, n = 11; 3.1%) and the hawksbill turtle (*Eretmochelys imbricata*, N = 4; 1.1%) (Figure 02).

Life stage was determined in 345 individuals, the proportion between juveniles (n = 178; 51.6%) and adults (n = 167; 48.4%) being very similar. In *C. mydas* most strandings were juvenile individuals, with only one adult. Stranded adult individuals were the majority for *D. coriacea*, *L. olivacea* and *C. caretta* (Table 01). Of the total strandings, sex was defined in only 18.2% of the individuals (n = 64), with the majority being females (n = 40; 62.5%). Most of the animals were found dead (n = 348; 98.9%) and were in an advanced

stage of decomposition, being in code 1 (n = 4; 1.1%), Code 2 (n = 2; 0.6%), Code 3 (n = 12; 3.4%), Code 4 (n = 240; 68.2%) and Code 5 (n = 94; 26.7%) (Table 01).

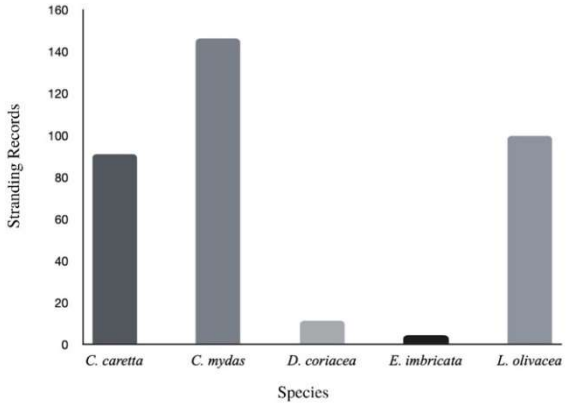

Figure 2. Total number of stranded individuals of the five species of sea turtles in the Restinga de Jurubatiba National Park, in the municipalities of Carapebus and Quissamã on the coast of the State of Rio de Janeiro, Brazil (2017-2020).

The majority of stranding records were obtained by regular active monitoring on land (n = 342; 97.2%), with the rest by passive monitoring notified by the population. There was a variation in the average number of strands per month between species along the 3 years monitored (Figure 03). For the three species with the greatest abundance of strands, *C. mydas*, *C. caretta*, and *L. olivacea*, records were higher between August and December (end of winter and during spring) and for the green turtle it extends during the summer (Figure 03). Only four hawksbill strandings were recorded and these occurred throughout the year, in all seasons except spring.

Table 1: Sea turtle strandings (n = number) recorded in the Restinga de Jurubatiba National Park, (2017-2020) in the state of Rio de Janeiro, Brazil, for *Chelonia mydas, Lepidochelys olivacea*, *Caretta caretta*, *Eretmochelys imbricata*, and *Dermochelys coriacea*. Information includes life stage, sex and external condition (see text for descriptions of Codes 1-5 (MARCOVALDI et al., 2000).

			Life stage		Sex		Condition (Code)				
Species	n	%	Juvenil	Adult	Male	Female	1	2	3	4	5
Chelonia mydas	146	41,5%	144	01	01	10	03	02	08	97	36
Lepidochelys olivacea	100	28,5%	09	86	07	19	-	-	02	69	29
Caretta Caretta	91	25,8%	22	68	11	10	-	-	02	67	22
Dermochelys coriacea	11	3,1%	-	11	04	-	-	-	-	04	07
Eretmochelys imbricata	04	1,1%	03	01	-	02	01	-	-	-	03
Total	352		178	167	23	41	04	02	12	237	97

For most strandings the causes were undetermined (n = 308; 87.5%). Of the 44 evidences of anthropogenic causes, the degree of interaction was considered strong (n = 19; 43.2%) and with similar data for total evidence and without anthropogenic evidence (n = 11; 25%). Of the anthropic interactions, 37.5% were categorized as fishing artifacts, 16% as vessels and 14% as injuries (Figure 04).

Behavior data associated with nesting

Along the three years of monitoring, 354 behaviors associated with possible nesting were recorded, and these records were categorized as: with nesting (n = 223; 63%), half-moon (n = 80; 22.6%) and without nesting (n = 51; 14.4%) (Figure 05). Most of the records, including nesting, half-moon and no nesting behaviors,

occurred in the end of spring, mainly in the months of November and December (Figure 06).

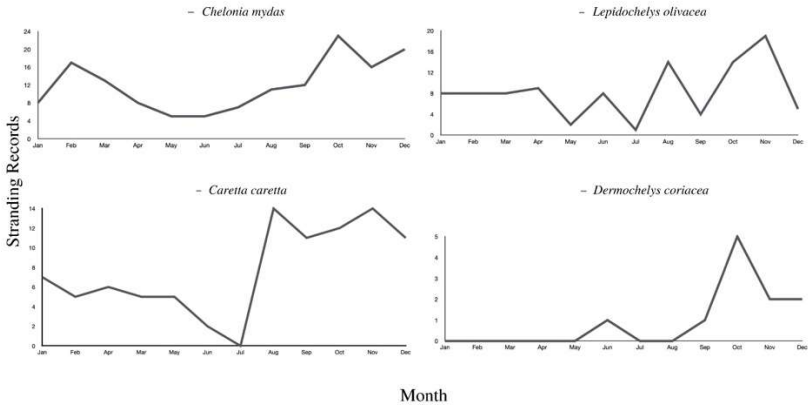

Figure 3: Average monthly distribution of sea turtle strands for each species recorded from October 2017 to September 2020 at the Restinga de Jurubatiba National Park in the state of Rio de Janeiro, Brazil, for *Chelonia mydas*, *Lepidochelys olivacea*, *Caretta caretta* and *Dermochelys coriacea*.

In only 16 records the sea turtle species was identified, 15 of which were associated with *C. caretta.* In most of the records for this species, nesting occurred (n = 12; 80%) between the months of November and January and, in all of them, the nests were successful. There was only one record for *C. mydas*, in December, however, this individual performed the half-moon behavior, with no nesting on the beach being observed (Figure 05). Among the records with associated nesting, most occurred in the field (n = 164; 73.5%) and, in some cases, there was a need to transfer the eggs on the beach (n = 45; 20.2%). Regarding the history of monitoring of the nests, in approximately half of the nesting (n= 112; 50.2%) there was predation by animals (Figure 05).

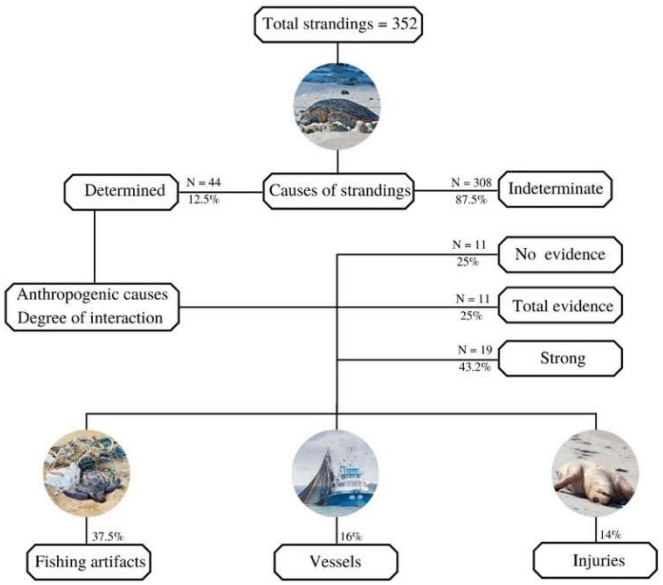

Figure 4: Flowchart with the total of strandings and their causes, including the proportions determined and associated with anthropogenic factors in the Restinga de Jurubatiba National Park, state of Rio de Janeiro, Brazil (2017-2020).

DISCUSSION

Sea turtle strandings are recurrent on the Brazilian coast (REIS et al., 2009, 2017; DOMICIANO et al., 2017; FARIAS et al., 2019; TAGLIOLATTO et al., 2019a; GUIMARÃES et al., 2021) and these records have

generated data that increase the understanding of the possible anthropogenic factors that contribute to all species being, currently, in some degree of extinction threat (ICMBio, 2018). The causes attributed to strandings are associated with physical factors (changes in sea currents, changes in migratory routes) and biological (availability of resources, pathogens), however, studies show the increase in anthropogenic threats such as pollutants, predatory fishing, vessels and waste solids such as plastics (PECKHAM et al., 2008; BORBOROGLU et al., 2010; GUIMARÃES et al., 2021). In the present study, most of the stranded animals were in an advanced stage of decomposition, and among the strandings with a determined cause, anthropogenic interactions such as fishing artifacts and vessels were evidenced.

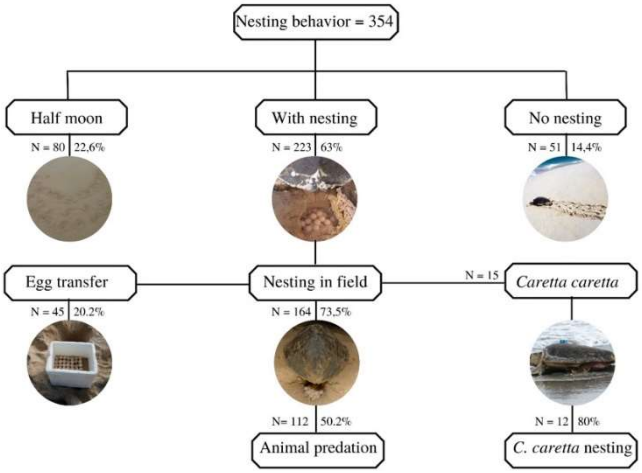

Figure 5. Flowchart with the total records of behaviors associated with sea turtle spawning, spawning rates, and egg transfer and predation data in the Restinga de Jurubatiba National Park, Rio de Janeiro State, Brazil (2017-2020).

The five species of sea turtles that occur on the Brazilian coast have different life strategies during their life cycle, involving different nesting areas, zones and food resources, which directly affects the stranding densities observed in different regions. For the South Atlantic coast, several studies reported greater abundance and frequency of strandings for the green turtle, *Chelonia mydas* (REIF, 2011; FLINT, 2013; SANTOS et al., 2015; DOMICIANO et al., 2017; TAGLIOLATTO et al., 2019a, 2019b; GUIMARÃES et al., 2021). Although *C. mydas* laying occurs on oceanic islands the Brazilian coast, during the juvenile phase they feed in coastal regions and estuarine areas (DOMICIANO et al., 2017). Most *C. mydas* strandings are dead individuals and in the juvenile stage, which increases the severity since they have not yet reproduced. The species is a potential indicator of anthropogenic impacts, with the high number of strandings associated mainly with evidence of accidental fishing and collisions with vessels (ALMEIDA et al., 2011; SENKO et al., 2014; GUIMARÃES et al., 2021).

Olive ridley turtles were the second species with the highest frequency of strandings in the Jurubatiba National Park. To the south coast of Brazil, *Lepidochelys olivacea* is indicated as not very abundant (SILVA et al., 2007), being the main nesting sites in the northeast region, mainly in the State of Sergipe (CASTILHOS et al., 2011). The large number of strandings in the north of Rio de Janeiro may be associated with the use of the site as a migratory food corridor (REIS et al., 2010, 2017; GUIMARÃES et al., 2018), as also recently reported for much of the coast of Rio de Janeiro (GUIMARÃES et al., 2021). In this study, the peaks of olive ridley turtle strandings occurred between August and December, a period in which individuals are possibly

migrating to nesting sites, since the nesting season of the species is from September to March (SILVA et al., 2007). The main causes of strandings for *L. olivacea* on the coast of Rio de Janeiro have been attributed to accidental capture in fishing activities (TAGLIOLATTO et al., 2019a, 2019b; GUIMARÃES et al., 2021).

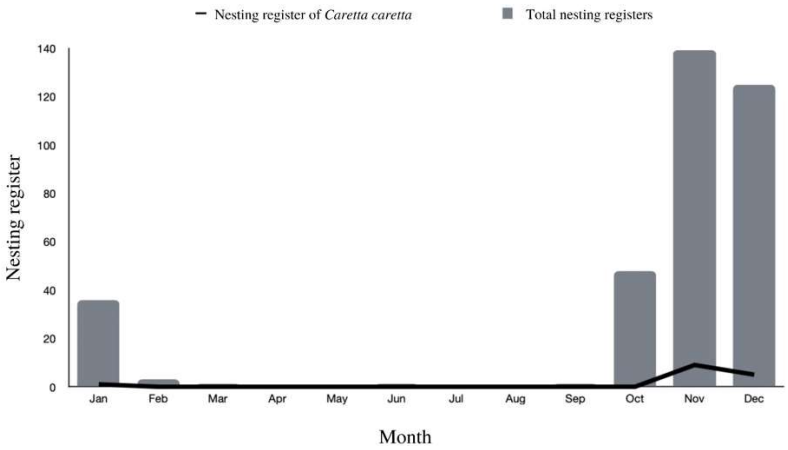

Figure 6: Average monthly distribution of total sea turtle spawning records and records for *Caretta caretta* from October 2017 to September 2020 at the Restinga de Jurubatiba National Park in the state of Rio de Janeiro, Brazil.

In the southeast coast of Brazil, strandings of leatherback and hawksbill turtles are less frequent. Leatherback turtles preferentially feed in oceanic waters and occasionally approach the coast according to the supply of resources (MENDILAHARSU et al., 2009; ROBINSON et al., 2016). In this study, strandings of *Dermochelys coriacea* occurred mainly in the end spring and early summer, when there is a greater availability of food on the north coast of Rio de Janeiro, associated with the upwelling phenomenon. (VALENTIM, 2001). Hawksbill turtles, on the other hand, have preferential feeding and reproduction zones in the northeast region of Brazil (SANCHES et al., 1999; MARCOVALDI et al., 1998), being commonly the least sampled species in the South Atlantic.

This study recorded a large number of strandings for the loggerhead turtle, *Caretta caretta* (n = 91), with greater frequency between August and November, which coincides with the time when individuals migrate to the nesting sites, since the season of reproduction for species is between September and March (MARCOVALDI et al., 2007; LIMA et al., 2012). Brazil is pointed out as one of the main nesting sites for *C. caretta*, extending from the coast of the States of Sergipe and Bahia, in the northeast region to, mainly, the state of Espírito Santo and the north of the state of Rio de Janeiro, in the southeast region (MARCOVALDI et al., 2007; SANTOS et al., 2011a, 2011b; TOMÁS, 2016). During the study period, 223 nests were recorded in the Restinga de Jurubatiba National Park, only 15 of which were related to the nest of *C. caretta*. Considering that the study area is commonly a nesting site for the species *C. caretta* only, it is believed that most of the unidentified eggs were of this species. Most of the beaches sampled within the park are not urbanized and therefore have a less risk of anthropogenic impacts, such as lighting and being run over by vehicles, which could prevent the turtles from laying in the sand. However, in about half of the nests monitored there was a record of predation, mainly associated with domestic dogs, indicating that even in the protected area there are impacts, perhaps due to the Park's buffer zones.

Among the nests found, about 20% were transferred in an attempt to increase the success of hatching eggs or hatchling after hatching. The removal of nests *in situ* is done when there are threats of degradation of the nesting habitat, artificial lighting, risk of flooding due to the regime of the tides or a very urbanized beach with traffic of people and vehicles (GARCIA et al., 2003; LIMA et al., 2012). The relocation of nests must be carried out properly to minimize changes in incubation conditions, which can interfere with hatching rates or sex ratio, due to temperature changes (ECKERT et al., 1990; REECE et al., 2002; BAPTISTOTTE et al., 2003; LIMA et al., 2012).

Sex determination throughout loggerhead turtle embryonic development under the influence of temperature during egg incubation (MARCOVALDI et al., 1997). Such as Brazil has a very long coastline, there is variation in the weather pattern and temperature conditions, which makes the sexual proportions of *C. caretta* nests different on northeast beaches (lower latitudes), with greater production of females and southeast (higher latitudes) with greater male production or tendency to greater balance in sex ratio (MARCOVALDI et al., 1997; BAPTISTOTTE et al., 1999; LIMA et al., 2012). Projections of climate change, including an increase in temperature for the next few years, are considered the greatest threat to sea turtles, as they can cause a greater proportion of females and consequently difficulty in finding sexual partners, in addition to interfering with the successful incubation of eggs and incubation rates (SANTIDRIAN et al., 2015; MONTEIRO et al., 2018, 2019; LALOE et al., 2017). Considering the study area is the southern limit of nesting of *C. caretta*, projections indicate that regions of higher, more temperate latitudes, such as the State of Rio de Janeiro, should be configured as even more important for nesting of the species in the next years old (Monteiro et al. 2019). However, the north coast of Rio de Janeiro is located in the Campos Basin, where oil and gas exploration increase vessel traffic (JABLONSKI, 2008) and may increase the incidence of *C. caretta* strandings in the region, in addition to bycatch (GUIMARÃES et al., 2021).

CONCLUSION

The Restinga de Jurubatiba National Park is the largest preserved restinga area in Brazil. In this study, we evidence a large number of strandings and the occurrence of nesting recorded over three years of monitoring, pointing out the importance of conservation in the area as evidenced by the following conclusions: (i) the area has the occurrence of five species of Brazilian turtles and is important for their life cycles, whether as a migratory corridor or feeding and reproduction zones; (ii) hundreds of nests were recorded, probably most of them *C. caretta*, reinforcing the importance of this sparsely urbanized coastal region as the current southern limit of the Atlantic for the nesting of loggerhead turtles and (iii) in a scenario of accelerated climate change, the region can be a fundamental nesting site to ensure male production and greater balance in sexual proportions, increasing the future chances of reproductive success for *C. caretta*. Acknowledgments to the field monitors of the CTA company who daily recorded strandings and the behavior associated with nesting.

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