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RESEARCH ARTICLE

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MONITORING OF MARINE TURTLES' POPULATIONS IN ILHA GRANDEBAY, RJ (2018-2022), AS AN INDICATOR OF ENVIRONMENTAL RESILIENCE

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ABSTRACT

The coast of the state of Rio de Janeiro is considered of extreme importance for the conservation of sea turtles, all classified as threatened or critically endangered. Electronuclear Tartaruga Viva program, carried out by the Faculty of Oceanography of the State University of Rio de Janeiro, monitors marine turtles in the area of influence of the Almirante Álvaro Alberto Nuclear Power Plant - CNAAA and seeks to elucidate any behavioral changes or distribution of populations in the area of influence. One of the monitoring approaches is population sampling through animal capture and recapture, with the use of ringing for recording and monitoring. In the period from September 2018 to August 2022, 99 turtles were sampled and 34 in recapture, the majority (>50%) with great body "score". All recaptured animals were in the same areas where they were first sampled, eating or resting less than 50 m from the point of the first capture, indicating their tendency to remain in areas favorable to food and rest.

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INTRODUCTION

Sea turtles are reptiles of the Testudines order and the origin of these animals is not well known, although it is known that they appeared about 220 million years ago. There are currently 13 chelonian families, with 75 genera and 260 species. Of these, there are only six genera with seven marine species (TAMAR, 2016), distributed in two families. The Cheloniidae family has six representatives (*Caretta caretta*, *Chelonia mydas*, *Natator depressus*, *Eretmochelys imbricata*, *Lepidochelys olivacea* e *Lepidochelys kempii*) and the family Dermochelidae has only one species (*Dermochelys coriacea*) (Bowen & Karl, 1997; Pough, 2003; Medina, 2013). Of the mentioned species, only five are found on the Brazilian coast: *Chelonia mydas*, *Caretta caretta*, *Eretmochelys imbricata*, *Lepidochelys olivacea* e *Dermochelys coriacea* (Márquez, 1990). All species are classified by the International Union for Conservation of Nature (IUCN, 2004) as endangered or critically endangered (including the five species of sea

turtles occurring in Brazil). Over the years, threats to sea chelonian species are leading to a sharp decline in populations, making their survival increasingly uncertain and increasing the risk of extinction for some species. The coast of the state of Rio de Janeiro is considered of extreme importance for the conservation of sea turtles, either because it shelters the bordering areas (latitudinal) of reproduction or several feeding areas spread along its entire coastal extension, including Ilha Grande Bay, where the Almirante Álvaro Alberto Nuclear Power Station is located. The monitoring of sea turtle populations, as well as implemented conservation activities, has reduced the knowledge gap about sea turtle habitats, indicating the possibility of this region being an important feeding and development area for the conservation of sea turtles, in special of the species *Chelonia mydas* (ELETROBRAS, 2006; Gallo, Macedo, Giffoni, Becker & Barata, 2006). The Tartaruga Viva Program, by Electronuclear, carried out by the Faculty of Oceanography of the State University of Rio de Janeiro, was requested by the National Center for Conservation and Management of Sea Turtles of the Chico Mendes Institute for Biodiversity Conservation (Centro TAMAR-

ICMBio) of the Ministry of the Environment (MMA), in compliance with the requirements set forth in conditions 2.16 of ALA No. 06/2013, issued by ICMBio, and 2.1.9.1 of LO No. 1217/2014 - 1st Rectification, issued by Brazilian Institute of Environment and Renewable Natural Resources (IBAMA), ABIO. The program carries out the Monitoring of Sea Turtles in the Area of Influence of the Almirante Álvaro Alberto Nuclear Power Station – CNAAA and seeks to elucidate any behavioral changes or distribution of populations in the area of influence. The approach of monitoring population dynamics, through animal banding and capture and recapture methodologies, has proven to be an extremely relevant tool in the population study of sea turtles and assessments of environmental impacts on these populations. Thus, this work aimed to monitor the occurrence of marine chelonians in the area of influence defined by the CNAAA; verify the spatial and temporal distribution of juveniles and adults of sea turtles in the CNAAA region; to identify the biological parameters of marine turtles (species, sex, stage of development, physical conditioning) and to estimate the residence time of populations of marine turtles in the area of influence defined by the CNAAA.

METHODOLOGY

Study area: Ilha Grande Bay, with approximately 1000 Km², is in the south of the state of Rio de Janeiro, between latitudes 22°50'S and 23°20'S and longitudes 44°45'W and 44°00'W. This bay consists of two bodies of water separated by a constriction formed between the mainland and Ilha Grande, presenting itself as an estuarine system partially mixed with the ocean through the east and west ends of the island. A striking feature is the high number of islands, islets and slabs, totaling 189 units, including Ilha Grande, the largest island in the state of Rio de Janeiro and the third in Brazil (Corrêa-Silva, 2000, Corrêa-Silva, 2003, Bastos, 2018; Bastos & Callado, 2009; UERJ/TRANSPETRO, 2015).

This Bay has one of the greatest biodiversity in Brazil, with peculiarities that make the territory a complex and important ecosystem of interaction between traditional populations, Conservation Units, development of the oil and gas industry, nuclear energy, fishing, mariculture, tourism, among many others, associated with a rich diversity of marine and terrestrial fauna and flora. This mosaic of elements represents a challenge to the conservation of ecosystem services, the establishment of sustainable practices and the implementation of businesses with a socio-environmental impact that aim at ecosystem health, appreciation and social inclusion (Bastos, 2018). The Central Nuclear Almirante Álvaro Alberto – CNAAA, a complex formed by the set of nuclear power plants Angra 1, Angra 2 and Angra 3 (under construction), is located on the banks of the BR-101 highway, on Itaorna beach, in the municipality of Angra dos Reis, in the state of Rio de Janeiro (Fig.1).

Sample design: Population sampling campaigns of sea turtles were carried out in Ilha Grande Bay, in the effluent locations (Piraquara de Fora), where the discharges of cooling water from the Nuclear Power Plant, which have a temperature above the local temperature, are introduced, and in the locations Praia Vermelha and Ilha do Pelado, both without direct influence of the installation's activities (Fig. 2). Dives for observation and capture were carried out by free diving (in apnea), supported by maritime displacements with a motorized vessel to pre-selected locations. In diving events, the sampling area was surrounded, with the support of a vessel, with a gillnet made of nylon (50 mm wire mesh, measuring 55 mm internodes, 120 m long and eight meters high), in order to avoid the escape of the animals caused by the agitation of the divers in the water and to maximize the capture effort. Sea turtles captured for the first time or those that already had identification rings were taken on board the vessel and/or to dry land for further analysis and technical procedures (biometrics and collection of blood samples). Animals captured for the first time were marked (banded), and their data recorded.

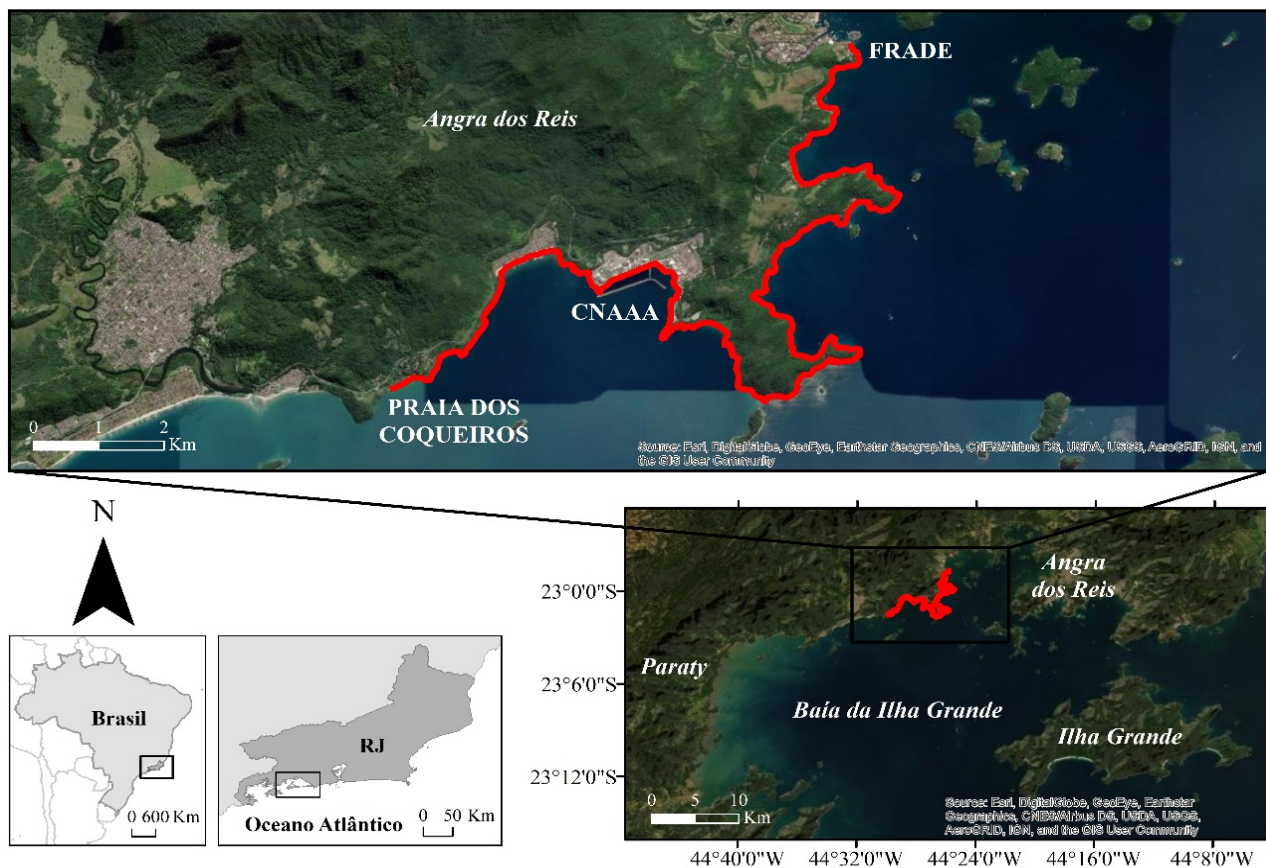


Figure 1. Location of the study area. CNAA – Almirante Álvaro Alberto Nuclear Power Plant; TEBIG – Angra dos Reis Waterway Terminal

The marking of the animals is carried out using two metallic washers, one applied to each anterior fin of the turtle. In this way, the animal is individualized and returned to the sea, making it possible to identify it in a subsequent recapture and compare the data, generating valuable information for the study of the population, such as growth rates, permanence, displacements and survival. The marking methodology follows the pattern that has already been used by the TAMAR Project: using special pliers, stainless steel tags of the inconel type (National Band and Tag Co., style 681) are attached to the front flipper (TAMAR, 2016). The washers used were provided by the TAMAR-ICMBio Center, and data from captures and recaptures feed the Database for the Conservation of Sea Turtles-BDCTAMAR. The capture, collection and transport of biological material necessary to carry out the Tartaruga Viva Program were authorized by ABIO n° 918/2018 e ABIO n° 142/2022.

RESULTS

From September 2018 to August 2022, 20 population sampling campaigns of marine turtles were carried out, with 99 animals captured and among these, 31 animals recaptured at least once and a total of 69 recaptures. The place with the highest number of records was Effluent (Piraquara de Fora) with 54 animals, followed by Praia Vermelha with 23 animals and Ilha do Pelado with 22 animals. All animals sampled by captures or recaptures showed a juvenile development stage, all of which belonged to the species *Chelonia mydas* (green turtle), represented by individuals with curvilinear carapace length (Clc) between 30 and 61 cm and no representativeness of adult animals above 96 cm. cm of Clc.

As for the capture/recapture ratio, it was possible to record that at the Effluent sampling station (Piraquara de Fora) of the 54 animals captured, 19 animals were recaptured at least once and there was a total of 41 repeat recaptures. At Praia Vermelha station, 23 animals were sampled by captures and 10 animals sampled by recaptures, with 26 repeat recaptures occurring and at Ilha do Pelado, 22 captures and 2 recaptures were recorded in all (Fig. 3). Regarding the body "Score" of the 99 turtles sampled in the first capture, 54 (55%) animals were classified with an excellent body "Score", 32 animals (32%) with a good body "Score", 12 animals (12%) were classified with thin body "Score" and 1 (1%) animal with cachectic body "Score". When analyzing the data of the chelonians sampled in recaptures, not only the first recapture of an animal was evaluated, but its successive recaptures were considered, because the body "Score" of an individual can vary between recaptures. Among the 69 recaptures, 38 (55%) were classified with an excellent body "Score", 19 (28%) had a good body "Score", 11 (16%) were classified with a thin body "Score" and 1 (1%) animal presented cachectic body score (Fig. 4). The recapture of the animals allows monitoring the growth and health evaluation of the animal throughout its stay in the feeding areas, being of vital importance in monitoring sea turtle populations. From September 2018 to August 2022, the animals were monitored through successive recaptures as described in Table 1. Of the recaptured animals, five showed a clear evolution: Animal CAP.001 has been monitored since September 2018 when it was first captured. In this capture, the animal measured 32.3 cm (Clc) and weighed 3.25 kg. This animal has already been recaptured 7 times. When monitoring this animal, it was possible to observe that its last curvilinear carapace length (Clc) measured was 43.7 cm and weight 9.77 kg (Fig.5).

Table 1. Number of successive recaptures per individual

1x	2x	3x	4x	5x	6x	7x
CAP.008	CAP.003	CAP.009	CAP.035	CAP.002	CAP.012	CAP.001
CAP.011	CAP.006	CAP.025		CAP.028		
CAP.023	CAP.007	CAP.054		CAP.045		
CAP.029	CAP.010					
CAP.036	CAP.032					
CAP.037	CAP.040					
CAP.043	CAP.046					
CAP.047						
CAP.049						
CAP.061						
CAP.063						
CAP.071						
CAP.073						
CAP.074						
CAP.084						

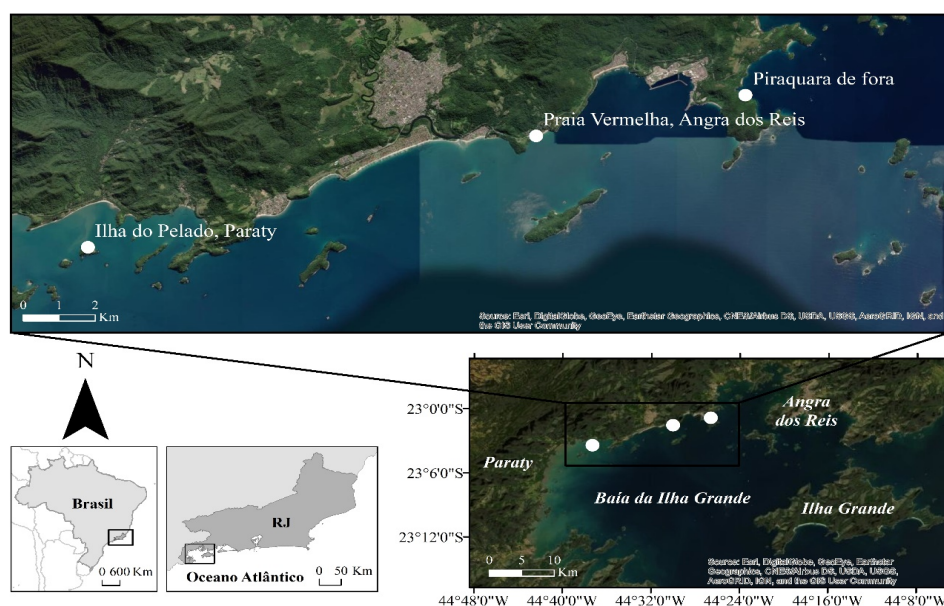


Figure 2. Population sampling stations. Ilha do Pelado (23°03'33.31" S, 44°37'19.97" W), Praia Vermelha (23°01'35.1" S, 44°30'04.84" W), Effluent (Piraquara de Fora, 23°00'41.5", 44°26'35.02")

The follow-up data for this chelonian demonstrate the successful growth and evolution of this animal throughout the study period, in addition to proving its permanence in the region. It should be noted that the six recaptures of this animal were carried out in Praia Vermelha, which demonstrates its feeding preference in this area.

and its weight was 8.07 kg (fig.7). All recaptures of this turtle were carried out in the Efluente (Piraquara de Fora), reinforcing the animal's permanence in the area. The CAP.028 was sampled for the first time in September 2019 when it measured 49.8 cm (Bcc) and weighed 17.40 kg.

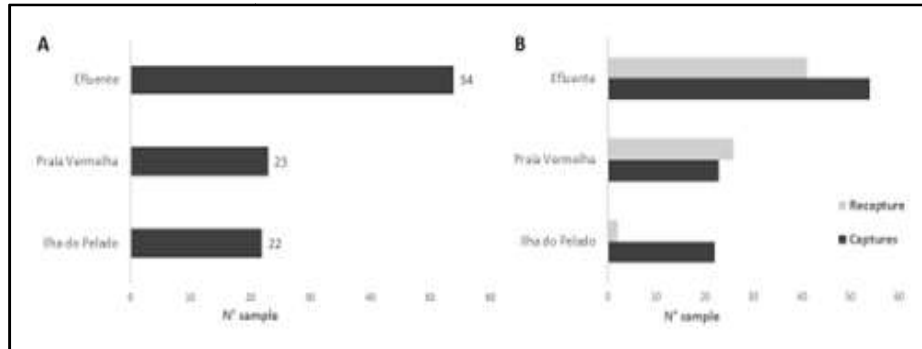


Figure 3. Number of individuals registered in the sampled locations from September 2018 to August 2022. A - Total individuals captured; B - Ratio of individuals captured/recaptured more than once. (Database of the Tartaruga Viva Program – Phase 2)

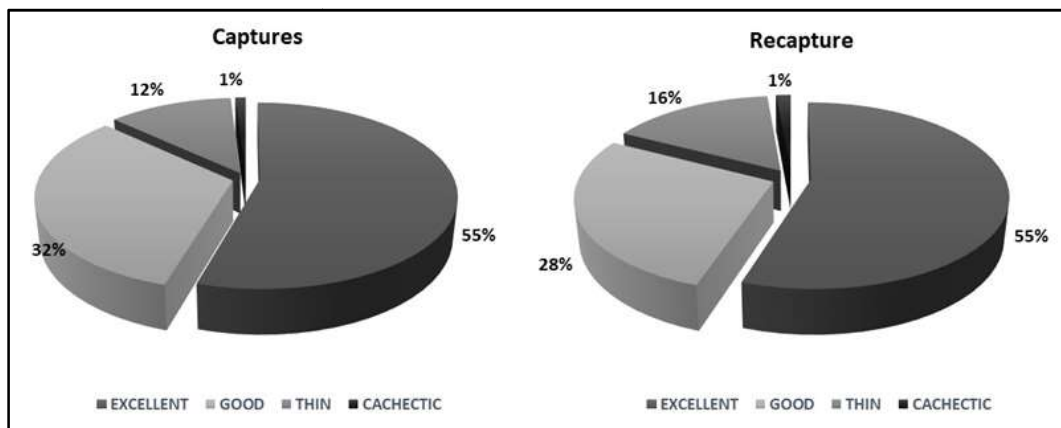


Figure 4. Percentage of body score of animals sampled by capture (A) and successive recaptures (B) in the period from September 2018 to August 2022

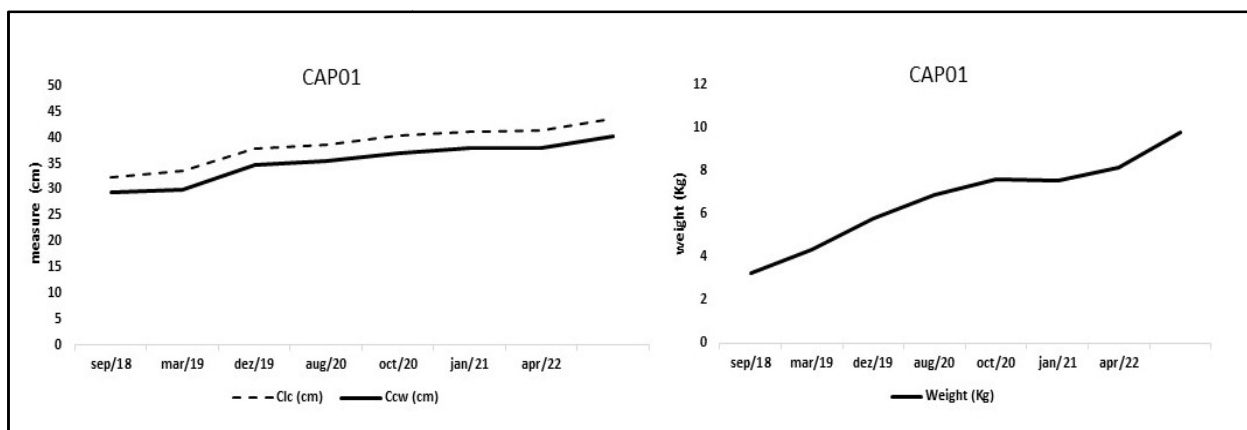


Figure 5. Growth in cm (A) and weight gain in kg (B) of the CAP.001 chelonian from September 2018 to April 2022. R- Recaptures; Clc – curved carapace length; Ccw - curved carapace width

The CAP.002 was also sampled for the first time in September 2018 when it measured 30 cm (Clc) and weighed 2.71 kg. This animal was recaptured 5 times. In monitoring the recaptures of this animal, it was possible to observe that in December 2019, its last recorded recapture, its curvilinear carapace length (Clc) increased from 30 cm to 33.50 cm and its weight from 2.71 kg to 3.8 kg (Fig. 6). All recaptures of this turtle were also carried out at Praia Vermelha. The CAP.012 was sampled for the first time in September 2018 when it measured 36.10 cm (Bcc) and weighed 4.37 kg. This animal was recaptured 6 times. In monitoring the recaptures of this animal, it was possible to observe that in February 2022 its curved carapace length (Clc) was 43.06 cm

This animal, in its first capture, already presented weight and size above the average of the animals sampled in the area. This animal was recaptured 5 times. In monitoring the recaptures of this animal, it was possible to observe that in June 2022 its curved carapace length (Clc) was 59.8 cm and its weight 23.82 kg (Fig. 8). All the recaptures of this chelonian were carried out at Praia Vermelha, reinforcing the animal's permanence in the area with abundant food and suitable for rest. The CAP.035 was sampled for the first time in March 2020 when it measured 54.5 cm (Bcc) and weighed 23.15 kg. This animal, in its first capture, already presented weight and size above the average of the animals sampled in the area. This animal was

recaptured 4 times. In its last recapture, in October 2021, it was possible to observe its curvilinear carapace length (Clc) of 61.20 cm, showing little variation over the recaptures. However, in relation to their development in weight gain, a greater fluctuation was observed than in the other individuals. In its last sampling, the animal was weighing 21 kg, that is, a lower weight than the first capture (Fig. 9). This animal was sampled in all captures in the Effluent region. Due to the residence time of the sea turtles sampled in the area covered by the program, it was possible to observe that the animals tend to remain in favorable places for resting, growing and feeding for long periods.

months, having his first capture recorded in September 2018, and recaptured every year until his last recapture recorded in April 2022. The CAP 002 was also always recaptured at Praia Vermelha during 2019, with an approximate stay of 15 months. The CAP 012 remained for 41 months in the Effluent, its capture took place in September 2018 and the last record was carried out in February 2022, the recaptures took place over five years. The CAP 028 stayed at Praia Vermelha for 32 months, captured in September 2019, recorded the following year, absent in 2021, but recaptured in February and June 2022.

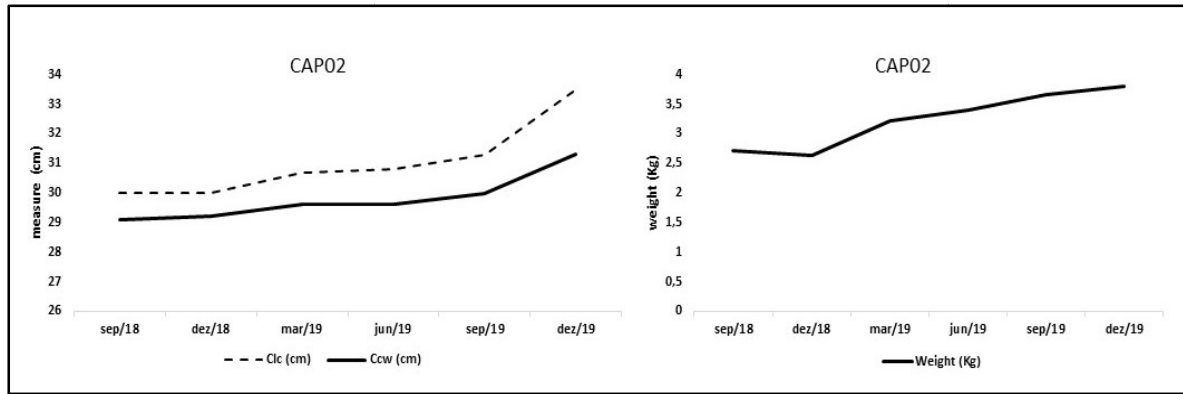


Figure 6. Growth in cm (A) and weight gain in kg (B) of the CAP.002 chelonian from September 2018 to December 2019. R- Recaptures; Clc – curved carapace length; Ccw - curved carapace width

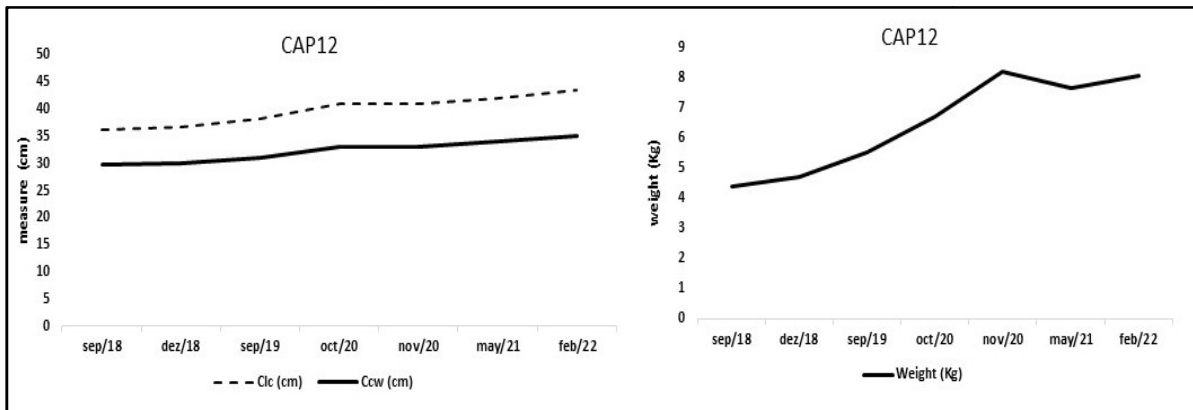


Figure 7. Growth in cm (A) and weight gain in kg (B) of the CAP.012 chelonian from September 2018 to February 2022. R- Recaptures; Clc – curved carapace length; Ccw - curved carapace width

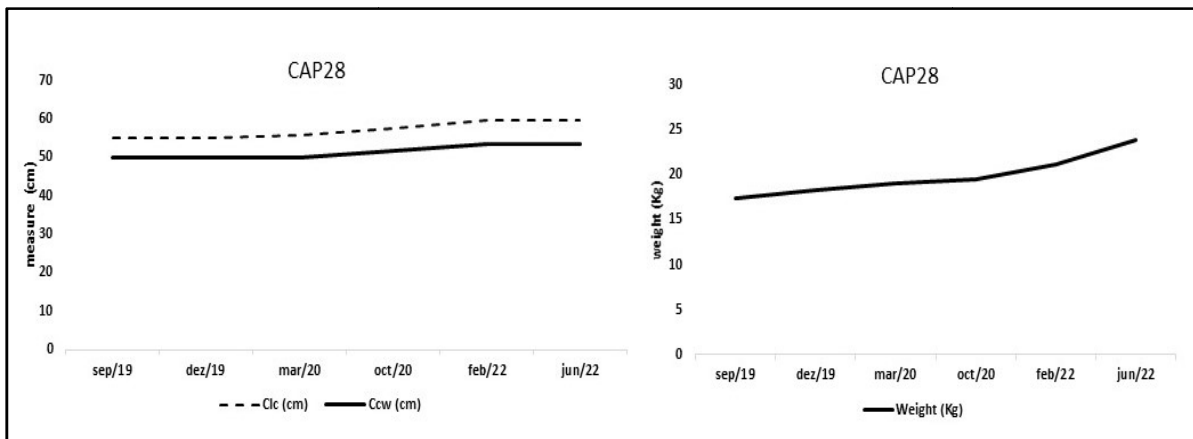


Figure 8. Growth in cm (A) and weight gain in kg (B) of the CAP.028 chelonian from September 2018 to June 2022. R- Recaptures; Clc – curved carapace length; Ccw - curved carapace width

All recaptured animals were in the same areas where they were originally marked, captured for the first time, and most were feeding or resting less than 50 m from the point of first capture. As shown in the graphs above, the CAP 001 stayed at Praia Vermelha for 43

The CAP 035 also remained in the Effluent for 45 months, with the first registration in September 2019 and the last registration in June 2022. The boxplot displays the non-parametric central tendency (median), dispersion (25% and 75% quartiles), sample distribution

shape or symmetry (minimum and maximum point values), outliers (outliers) and extremes. Figure 10 shows the values of weight and curved length of the carapace of the animals from the diving and capture samples from September 2018 to August 2022.

less than 94 cm, according to the classification by Colman et al. (2014), corroborating, once again, the classification of the region as an important feeding area for individuals of this species.

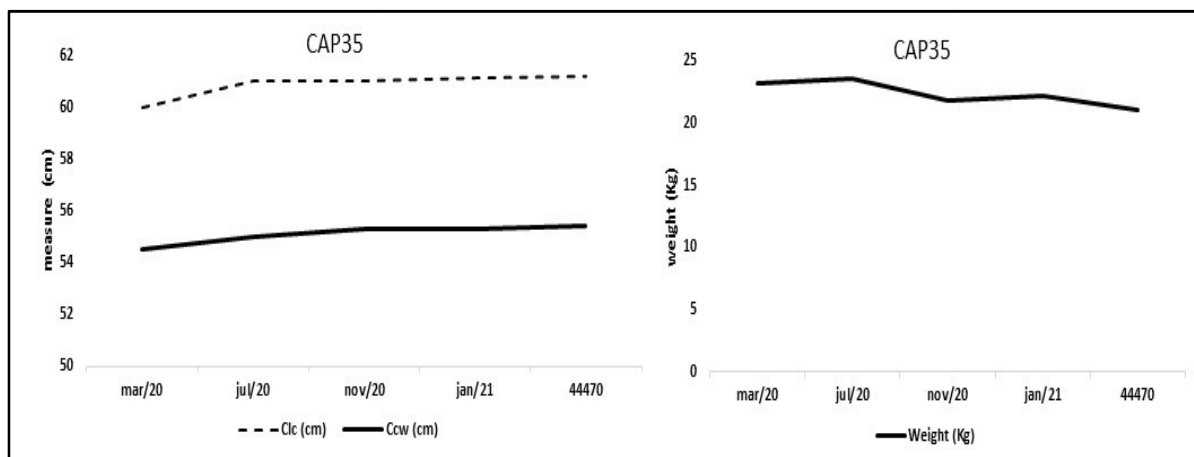


Figure 9. Growth in cm (A) and weight gain in kg (B) of the CAP.035 chelonian from September 2018 to October 2022. R- Recaptures; Clc – curved carapace length; Ccw - curved carapace width

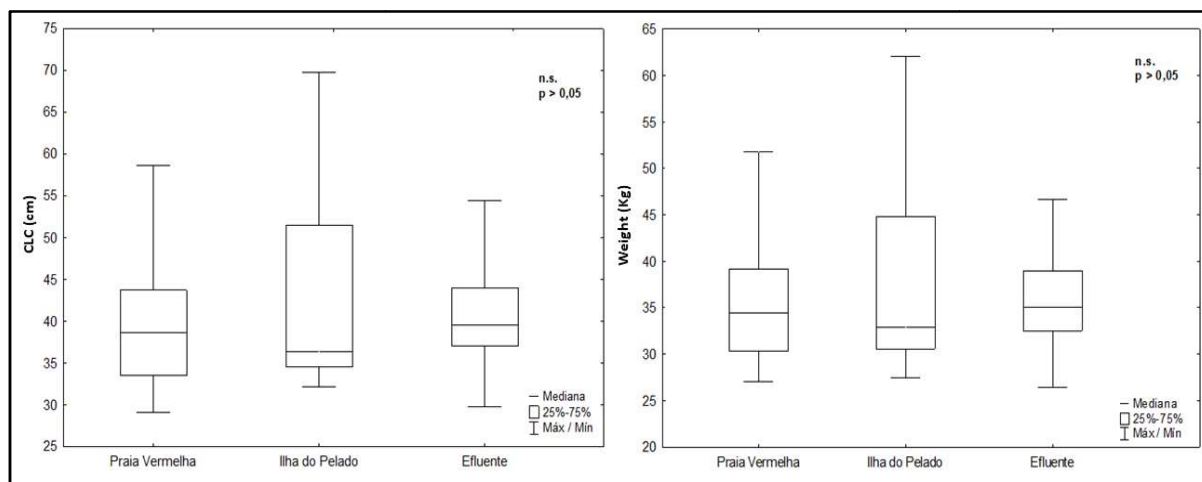


Figure 10. Mean curved carapace length (Clc) and weight values per sampled location. EF – Efluente; IP – Ilha do Pelado; PV – Praia Vermelha. The. First quartile (Q1): where ¼ or 25% of the lowest values are located. B. Median or second quartile (Q2): is where the division of the upper half (or 50%) of the lower half of the sample occurs, c. Third quartile (Q3): where 75% of the highest values are found. Max. maximum value of the data set, M'n. minimum value of the dataset

The data point to the occurrence of animals with greater weights and greater curved lengths of carapace (Clc) at Ilha do Pelado station, however the median is showing that the frequency of these larger and heavier animals is less than 50%. This can be seen from the interquartile range box that represents the highest concentration of sample data, i.e., the most recorded values of Clc and weight. The results referring to the weight (kg) and curvilinear length of the carapace (Clc, cm) collected in the diving and capture samples during the study period showed that the data distribution presented a non-homogeneous characteristic. The results of Levene's homogeneity of variances test with proven homogeneity of variances with $p < 0.05$. Data normality was tested using the Shapiro-Wilk normality test and demonstrated that most of the data were included in the non-normality curve ($p < 0.05$), even after attempting to normalize the data with $\log(x) + 1$, the data results still showed non-normal conditions. Therefore, the Kruskal Wallis non-parametric variance test was applied. For the data collected in the diving and capture samplings during the period September 2018 to January 2021, the analysis of variance did not show statistical difference ($p > 0.05$) between the collection stations both in relation to the weight (kg) and the Curvilinear carapace length (Clc, cm).

DISCUSSION

All animals sampled during the study period were juvenile individuals of the species *Cheloniemydas*, with curvilinear carapace length

This species has a greater distribution in the coastal region of Brazil, being found mainly, in the juvenile phase, in feeding areas (Rabelo, 2010). It is the only species of sea turtle with her bivorushabits in the juvenile, subadult and adult stages, feeding mainly on macroalgae, sea grasses and mangrove propagules (Bjorndal, 1997; Márquez, 1990; Moraes, 2005; Lôbo-Hajdu, 2016; TAMAR, 2016). The green turtle has a migratory habit characterized by traveling long distances between separate habitats, feeding and nesting areas. The use of sampling by capture and recapture of sea turtle populations has been increasingly proving to be an essential monitoring tool in obtaining data on growth rates, length of stay of animals in localities, movement of animals, and survival of individuals. In this sense, therelevance of banding animals captured for the first time is highlighted, since registration will provide, in subsequent captures, data on the identification and health of the animals, as well as decisive information in the study of populations. The recapture of the 41 animals in the aforementioned period allowed inferences about the permanence of the individuals in the studied areas, to draw a profile of the growth rates and state of health of these animals and to register fluctuations with recovery, without human action, in weight development (Kg) as in chelonian CAP.035. As for the residence time of the sea turtles sampled in the program's area of operation, it was possible to observe that chelonians tend to remain in places favorable to feeding, with greater availability of food, and rest, more protected areas, for long periods during their youth stage of life. All animals

recaptured in the program's population samplings were in the same areas where they were originally tagged, captured for the first time, and most were feeding or resting less than 50 m from the point of first capture. CAP.001, CAP.002, CAP.006, CAP.007, CAP.008, CAP.009, CAP.010, CAP.012, CAP.025, CAP.028, CAP.029 stand out, CAP.032, CAP.035, CAP.040, CAP.043, CAP.045, CAP.046, CAP.047, CAP.049, CAP.054, CAP.061, CAP.063 that presented successive recaptures, demonstrating weight gain (Kg) and growth (CCC).

CONCLUSION

The high incidence of juvenile *C. mydas* of different sizes, associated with recaptures and under water sightings of marked individuals, are strong indications that these animals are residents of the place, where they rest, feed and grow, until they become adults, when they will move to playback areas. The data referring to the time of residence of the animals, according to the monitoring of the recaptures, corroborate the hypothesis that there is a prolonged stay (residence) of individuals in the locations, since the frequencies of occurrence of recaptures were shown to be at a high level, and all those recaptured were recorded exactly in the locations where they were captured for the first time.

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