Nonlethal capture of green sea turtles (*Chelonia mydas*) in fishing weirs as an opportunity for population studies and conservation

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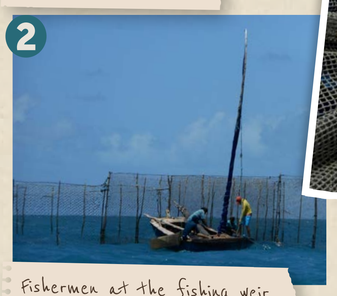
Introduction

Green sea turtles (*Chelonia mydas*) switch habitats during their development, moving from pelagic to neritic areas and then commuting between nesting and foraging grounds during adulthood. Due to their predominantly coastal habitats, they are under a range of anthropogenic threats. In 1993, Projeto Tamar started a partnership with local fishermen aiming to access information of turtle bycatch in fishing weirs. Fishing weir is a fixed wood trap using tide cycles to catch fish. (Figures 1, 2 and 3)

Objective

This study aims to determine temporal variations in capture rates, residence time, size classes and growth rates, based on recaptures of green turtles (*Chelonia mydas*) captured in weirs, along the Ceará coast (2008–2018). We also compare the historical capture rates registered in logbooks since 1962 in some weirs at the same location.

1 Line of fishing weirs

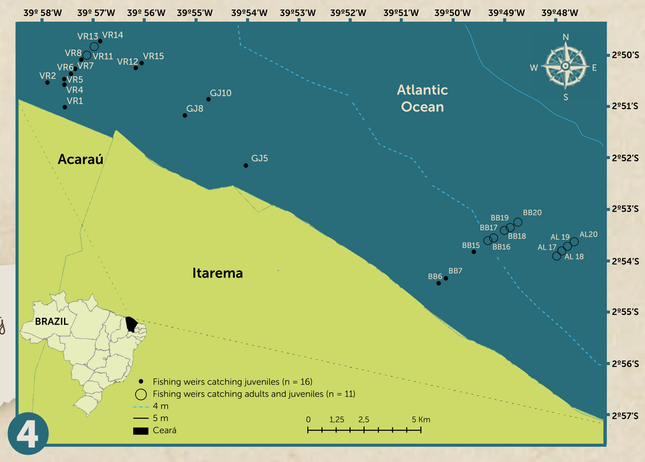


2 Fishermen at the fishing weir

3 Green turtles captured in fishing weir

Methods

- Between 2008 and 2018, 27 fishing weirs were monitored, in partnership with fishermen, at the municipalities of Itarema and Acaraú, in Ceará state, northeast Brazil (Figure 4).
- Most turtles captured had biometry information collected at the time of capture. Turtles were marked with metal tags in both front flippers and then were release;
- The capture rate was defined as the number of green turtles captured per day per weir (days weir^{-1}), as unit effort for fishing weirs was based on the number of fishing days, thus representing an integrated period of several fishing days.
- The assessment of historical data of the green turtles captured in fishing weirs from 1960 to 1977 and 1980 was carried out using references.



Site study and fishing weirs location.

4

Results

- 29,078 days of fishing monitored (2008 – 2018) and 2,335 green turtles captured (all alive).

Capture rates

- The mean capture rate ranged from 0.04 to 0.08 (2009 and 2013, P < 0.05 (Figure 5A)
- Capture rates were similar among months (F = 1.13, P = 0.35) (Figure 5B), with lower mean values from November to February (0.05 turtles day weir^{-1}) and higher from March to September (peak in May - 0.08 turtles day weir^{-1}).
- Capture rates from 1962 to 1977, 1980 and from 2008 to 2018 varied from 0 to 0.16 turtles day weir^{-1}. The highest capture rate was recorded in 1962.
- Capture rates in this historical period were higher than those recorded between 2008 and 2018. The highest rate recorded between 2008 and 2018 was 0.08 turtles day weir^{-1}, while in the historical period, the smallest rate was 0.1 turtles day weir^{-1}

Size variation

- Green turtles ranged in CCL at first capture from 24 to 123 cm (mean = 49 ± 17 cm, n = 1951). Juveniles predominated with CCLs from 30 to 49 cm (66%, n = 1296) (Figure 6)
- CCL varied among years (F = 29.84, P < 0.05) (Figure 5A).
- Monthly CCL had lower mean values during Austral winter (June to August) and peaked from late winter until summer (September to December). Most adults occurred during spring (57%) (Figure 5B).

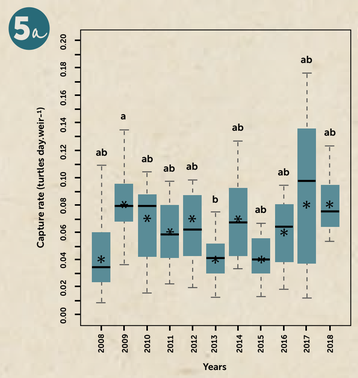
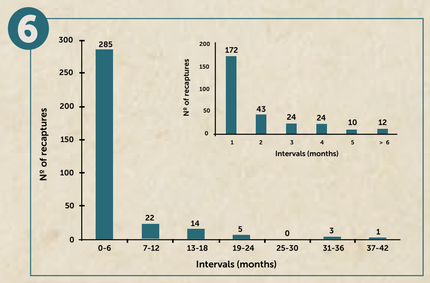


Figure 5a e 5b

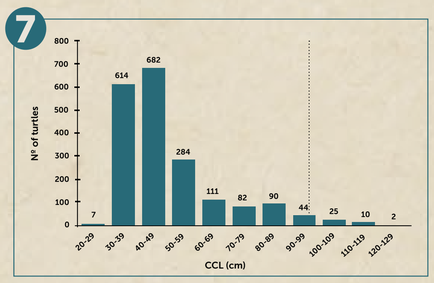
Yearly (A) and monthly (B) variations in capture rates of green sea turtles in fishing weirs. Central line is the median, asterisk is the mean, upper and lower lines of the boxes represent the 75th and 25th quartiles, respectively, and whiskers are minimum and maximum in the 95th of cases. Different letters indicate significant differences among capture rates among years.

Recaptures, residence and growth rate

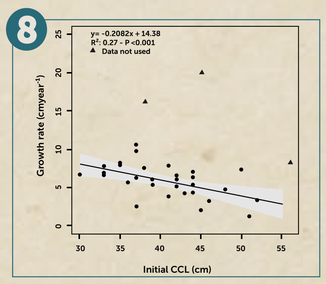
- 330 recapture events of 195 individuals were recorded, ranging from once (129 individuals, 66.1%), twice (37 individuals, 19.0%), to three to nine times (14.9%).
- Most recaptures (86%) occurred up to six months after the first capture, with a mean growth rate of 6.7 ± 3.6 cm year^{-1}. The lowest recapture interval of 1 day and the longest of 1,112 days;
- Most recapture intervals occurred within a month from release (52%, n = 172), with 86% (n = 285) occurring up to six months (Figure 7)
- A subset of 33 recaptures had intervals ≥10 months. The annual mean growth rate among the recaptured juvenile green turtles was 6.7 ± 3.6 cm year^{-1} (range = 1.29–19.95 cm year^{-1}). The linear regression indicated a correlation between the CCL of the first recapture and the growth rate (R^2 : 0.27 - P < 0.001). In general, individuals with smaller lengths in the first recapture had the highest growth rate (Figure 8).



Size class distribution of green sea turtles in fishing weirs. The dashed line indicates a curvilinear carapace length of 97 cm, after which individuals were classified as adults.



Intervals of recaptures of green sea turtles captured in weirs. The inset shows details of the first interval, from 0 to 6 months.



Linear regression between curved carapace length in the first recapture and the growth rate of green sea turtles in fishing weirs

Discussion

- Long-term monitoring of sea turtles captured in fishing weirs confirmed that the coast of Ceará state is an important feeding and developmental area for juvenile green turtles.
- Sea turtle captures from the 1960s to the 1980s allowed us to infer a depletion of stocks after an initial period of higher capture rates, probably due to the use of turtles as a fishing resource. The later increase in capture rates was possibly related to the recovery of populations nesting in distant rookeries and the reduction of intentional killing for meat consumption or market trade in Brazil
- The sizes of green turtles captured in fishing weirs indicated sharing of foraging areas by juveniles and adults, with a prevalence of juveniles in shallow waters. Juveniles, due to their small size and growth, have higher energetic demands than adults and they establish themselves in calm and sheltered coastal areas as they recruit from the pelagic to the neritic phase.
- Most turtles recaptured within six months between events could be explained by moving out of the area to deeper areas as they grow, or weir avoidance behavior.
- The mean growth rate of green turtles was higher than that of turtles in other feeding areas in Brazil, or even in other parts of the world such Akumal Bay in Mexico at 20ºN (6.2 cm year^{-1}, and the Japanese archipelago of Ryukyu at 24ºN (2.2 cm year^{-1}).

Conclusion

- The incidental capture of green turtles in fishing weirs along the coast of Ceará state is high.
- Most of turtles were juveniles with CCL <50 cm.
- Turtles had short residence times in the region and they grew faster in smaller size classes.
- Capture rates varied throughout the historical period but were mostly homogeneous between years and months, followed by a recent increase.
- Environmental awareness by fishermen and their change in behavior, avoiding killing turtles for consumption or illegal sale, could have contributed to the trends that were detected and to the conservation of wide-ranging green turtles in this tropical foraging area along the Ceará coast.

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