

Small foraging grounds, large population significance: adult- and male-rich aggregations of green turtles in Senegal

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Abstract

Green turtles (*Chelonia mydas*) undertake long-distance migrations between breeding and foraging grounds, yet foraging areas remain far less studied. West Africa is a biodiversity-rich region of global importance for green turtles, hosting one of the three largest Atlantic nesting rookeries, on Poilão Island, Guinea-Bissau, as well as major coastal foraging aggregations for which data are limited. Using a recent integrative approach, we combine nesting, satellite tracking and in-water capture data to estimate the abundance, demographic structure, and spatial distribution of green turtles in Senegal. Tracking analyses reveal that green turtles do not use the entire Senegalese coast, but instead concentrate in two small areas — Saloum Delta and Joal — that coincide with existing marine protected areas. We estimate that 12,589–14,010 green turtles forage in these sites, resulting in an exceptionally high spatial concentration. Turtles foraging in Senegal (~ 300–400 km north of the main rookery in Poilão) had a mean curved carapace length of 89.1 ± 14.3 cm and were significantly larger than those foraging in Mauritania, 1,000 km north of Poilão. The adult sex ratio was male-rich, with 1 male:1.54 females (vs. 1:3.75 reported for Mauritania), supporting emerging evidence that males forage closer to breeding grounds. This study provides the first in-water assessment of green turtles in Senegal and demonstrates how small foraging grounds can support large aggregations with distinct demographic structure, reinforcing the value of in-water studies for understanding spatial population structure in marine megafauna.

INTRODUCTION

Migratory marine megafauna present unique challenges for monitoring due to their high mobility and use of extensive areas across distant geographic regions (Block et al. 2003; Hays and Scott 2013). Their spatial distribution can vary with life stage and reproductive status, so studies focused on single areas may overlook important population segments (Runge et al. 2014; Pereira et al. 2023). Sea turtles are one such example, undertaking long-distance movements between breeding sites and foraging areas (Hamann et al. 2010; Hays et al. 2022). Because nesting female turtles come ashore on sandy beaches to lay their eggs, they are more readily accessible for study, causing research to disproportionately focus on this life stage (Robinson et al. 2023). Logistical and methodological constraints associated with in-water research limit assessments of foraging and developmental habitats, leaving non-breeding individuals and adult males—who inhabit exclusively marine environments—largely understudied (Rees et al. 2016; Robinson et al. 2023). Improving research in foraging areas is therefore essential for capturing the full spatial distribution of a population and for assessing all life stages. In-water studies provide essential information on population dynamics, habitat use and behavior, which underpins our understanding of spatial population structure and life-history strategies in marine megafauna.

Among sea turtles, the green turtle (*Chelonia mydas*) is globally distributed, nests and forages along tropical, subtropical and warm-temperate shorelines, and is one of the most coastal species (Wallace et al. 2010). Juveniles typically recruit to neritic feeding areas at sizes of ~ 25–45 cm curved carapace length (CCL), where they may remain resident for many years (Bolten 2003). Green turtles typically

exhibit long-term site-fidelity to their foraging grounds (Shimada et al. 2016; Chaloupka et al. 2004), although some plasticity is also observed (Webster et al. 2022). Among foraging grounds, the population size-structure can vary, ranging from mainly smaller juveniles (usually ≤ 65 cm in curved carapace length, e.g. Stokes et al. 2023), to groups that include mostly adults (Bell et al. 2019). Differences in adult sex ratios have also been documented among foraging grounds (Bell et al. 2019; de Almeida et al. 2021). These variations can be influenced by several factors, such as ontogenetic shifts in habitat use (Bolten 2003; Rees et al. 2016), food availability (Bjorndal 1997; Christianen et al. 2014), distance from breeding sites (Hays et al. 2014; Beal et al. 2022), predator-driven risk effects (Heithaus et al. 2007, 2008), and differing tolerance of disturbed areas (Webster et al. 2022). Few studies have estimated the abundance of foraging aggregations worldwide, using mark-recapture methods, drone surveys, and transects (Becker et al. 2019; Meylan et al. 2022; Rivera-Milán et al. 2019; Stokes et al. 2023). Recently, Catry et al. (2023) developed a novel integrative framework, combining nesting records, satellite telemetry data and in-water captures to estimate the abundance of sea turtle foraging aggregations, providing a quantitative framework for estimating neritic population size.

West Africa is one of the most important regions for green turtles globally (Catry et al. 2009; Patrício et al. 2019). There, the island of Poilão, within the Bijagós Archipelago in Guinea-Bissau, stands out as one of the top three most abundant nesting populations in the Atlantic, after Tortuguero (Costa Rica) and alongside Ascension Island (British Overseas Territories) (SWOT 2025; Broderick and Patricio 2019). Post-nesting turtles from Poilão return to their foraging grounds along the West African coast, with their main aggregations distributed in the coastal waters of the Banc d'Arguin in Mauritania, Saloum Delta and Joal in Senegal, and various sites across the Bijagós, Guinea-Bissau (Patrício et al. 2022). In Mauritania, the Banc d'Arguin supports one of the largest known green turtle foraging aggregations in West Africa and globally, with an estimated 150,000 individuals distributed across extensive seagrass habitats (Catry et al. 2023; Mestre et al. 2025).

In Senegal, early studies documented the regular presence of green turtles along the coastline (Cadenat 1949; Maigret 1983; Fretey 2001), and reported their use of nearshore waters as foraging habitat. Nesting activity also occurs in Senegal (Fretey 2001; Pollo et al. 2013), although at very low levels compared to major regional rookeries. Additionally, Patrício et al. (2022) and Beal et al. (2022) documented substantial post-nesting movements of green turtles from Poilão Island to Senegal, indicating that this area functions as a recurrent foraging destination within the wider West African migratory network. Despite the recognized ecological value of these coastal habitats, quantitative assessments of abundance, spatial distribution and demographic structure at green turtle foraging grounds remain scarce globally and have not been conducted for Senegal.

Here, we analyzed satellite-tracking data from Poilão Island—the largest green-turtle rookery in West Africa—to delineate the main foraging areas in Senegal, and conduct extensive in-water captures at these sites to provide the first ecological assessment of Senegal's green-turtle foraging aggregations. Specifically, we aimed to (1) characterize the spatial distribution and home range of green turtles along the Senegalese coast, (2) estimate their abundance within these foraging aggregations and (3) describe

their size structure and adult sex ratio. At a regional scale, this study provides new insights into population structure and demographic variation within the West African green turtle population. More broadly, our findings provide important insights into sex-specific foraging strategies and demonstrate that spatially restricted coastal areas can support large numbers of individuals, with implications for regional connectivity and population dynamics in marine megafauna.

METHODS

0. Study area

The Senegalese coast hosts two key shallow-water regions of ecological importance for green turtles: the Saloum Delta (Fig. 1B) and the coastal region of Joal (hereafter called Joal). The Saloum Delta (13.734°N, 16.674°W) encompasses a complex estuarine system of tidal channels, mudflats, and mangrove-fringed islands (Faye et al. 2024, Lombard 2024). Much of this delta area lies within the Saloum Delta National Park, a UNESCO Biosphere Reserve. The coastal area near Joal (14.179°N, 16.880°W) features an extensive shallow shelf, where depth increases gradually over several kilometers offshore, within the Joal-Fadiouth Marine Protected Area. Both areas contain shallow subtidal (and limited intertidal) seagrass meadows, mainly composed of *Zostera noltei*, *Cymodocea nodosa*, and *Halodule wrightii* (Cheikh et al. 2023, Faye et al. 2024).

The Bijagós Archipelago in Guinea-Bissau, particularly the small island of Poilão located within the João Vieira-Poilão Marine National Park, hosts the most important green turtle nesting site in West Africa (Catry et al. 2002). Thousands of adult females nest here annually, with the main nesting season lasting from July to November. The Institute of Biodiversity and Protected Areas (IBAP) has monitored the site systematically since the year 2000 (Barbosa et al. 2018). At the end of their reproductive effort, turtles migrate back to their foraging grounds, distributed along the tropical and subtropical Atlantic coast. Senegal is one of the regions where turtles return to forage after breeding (Fig. 1A).

1. Spatial distribution at foraging areas

From 2018 to 2022, we tracked nine adult female green turtles (of a total of 46 tracked to their foraging destination) and four adult males (out of nine) from their breeding site at Poilão Island to Senegal. Satellite tagging procedures are described in Patrício et al. (2022). We deployed devices on females, while they were laying, during August–October to sample throughout most of the nesting season (Catry et al. 2009). Males were captured in front of the nesting beach while mating and equipped with transmitters in July 2021, as during this month mating is easily observed from the shore (see Beal et al. 2022 for capture details). Tracking of post-nesting migrations allowed the identification of the main foraging areas in Senegal, where the turtles were subsequently captured to study the foraging population. Six adult females captured in the foraging areas of Senegal in November 2023 and June 2025 were also equipped with satellite tags; in the Saloum Delta ($n = 3$) and in Joal ($n = 3$). We used three models of Platform Transmitter Terminals (PTTs): SPOT-375B (Wildlife Computers, USA) transmitting

Argos locations, F6G-376A and F6G-376B (Lotek, New Zealand) transmitting both Argos and Fast GPS (FGPS) positions (see Table S1 for details). All tags were set to transmit every 15 seconds.

To calculate the utilization distribution area, we processed the tracking data of the 19 adult turtles foraging in Senegal following the same method as in Mestre et al. (2025). We removed Argos Z and B classes and retained Fastloc GPS positions with ≥ 4 satellites. Implausible positions were discarded with conservative thresholds on speed ($> 5 \text{ km h}^{-1}$), turning angle ($< 20^\circ$) and additional outlier screening. After filtering, the dataset comprised 3,921 locations corresponding to 1,003 tracking days (1,871 Argos, 48%; 2,050 Fast GPS, 52%). We then fit continuous-time correlated random-walk state-space models (crawl, R) with Kalman smoothing and Argos error structures, and predicted locations every 8 hours. Utilization distributions were computed in R (adehabitatHR), kernel UD per turtle were estimated using the median reference bandwidth (353 m) as smoothing parameter, from which 50% and 95% KUDs were calculated to define the core areas and home ranges. We averaged the individual utilization distributions (UDs) to estimate the population-level distribution for all turtles. Analyses were run in R v4.5.1. The full details of this methodology can be found in the Supplementary material section.

To test if the six adult females directly tagged in Senegal used the same areas as the other 13 individuals tagged at Poilão, the group-level distribution and spatial overlap was calculated and compared between three separate groups: females tracked since their nesting ground (Poilão), males tracked since their breeding ground (Poilão), and females tracked directly at their foraging ground (Senegal).

2. Size-structure and sex-ratios

We conducted in-water captures in Senegal from 2023 to 2025, between late November to April. This period was chosen to avoid the nesting season (Catry et al. 2002) and ensure that breeding adults were in their foraging grounds. Turtles were captured by local fishermen using a motorized traditional fishing boat 7–10 meter long ('pirogue'). The net deployed from the boat when turtles were sighted, forming a seine encircling the area. Alternatively, the net was deployed in a straight-line crossing channels or near rocky areas known to be frequented by turtles. Different nets were used measuring between 400–600 meters long, 8–10 m deep and with 10 cm mesh size. Following deployment, the nets were retrieved taking on average 24 minutes to complete both deployment and hauling. Turtles were captured by entanglement and brought onboard the vessel.

Captured turtles were measured for curved carapace length (CCL) to the nearest millimeter using a flexible measuring tape. Data from the breeding ground of this population indicate that the smallest nesting females have $\text{CCL} \geq 85 \text{ cm}$ (Catry et al. 2023). Accordingly, turtles $\geq 85 \text{ cm}$ CCL were classified as males if they presented a thick elongated tail and large recurved claws on the front flippers (Miller 1997, and the remaining as females. Among turtles classified as females, we estimated how many were likely to be reproductive, as in Catry et al. (2023). We did not apply a reproductive-status correction factor to males because males are, on average, smaller than females, based on available data from this population (Catry et al. 2023) and other green turtle populations (Godley et al. 2002; Mortimer et al.

2022). As the 85 cm CCL threshold was derived from nesting female sizes, males reaching this size are very likely to be sexually mature.

To place the Senegalese foraging aggregations in a broader regional context, we compared their size-frequency distribution with that of the neighboring foraging aggregation in the Banc d'Arguin, Mauritania, estimated to host approximately 150,000 green turtles (Catry et al. 2023), and examined the relationship between turtle size and water depth at both sites.

3. Foraging aggregation abundance

To estimate the number of green turtles foraging in Senegal, we used the approach from Catry et al. (2023), that combines the number of nesting females at the main source rookery with satellite-tracking data and in-water captures (Fig. 2). First, we calculated the number of nests in Poilão (Guinea-Bissau) by dividing total annual track counts by two (ascending/descending) and correcting with the laying success estimate, based on recent field data from Poilão (team unpublished data). We then converted nests to nesting females by dividing by a clutch frequency of 6.15 clutches per female per season, based on well-studied green turtle populations where clutch frequency has been estimated (Weber et al. 2013; Esteban et al. 2017). Finally, we scaled the number of nesting females for the entire Bijagós Archipelago considering that Poilão represents 84% of nesting activity, based on previous studies (Catry et al. 2009, 2010; Barbosa et al. 2018) and additional monitoring data from IBAP (unpublished).

We then calculated the proportion of nesting females from Guinea-Bissau that forage in Senegal by assigning satellite-tagged individuals to foraging grounds when transmission continued beyond the migration phase, and turtles engaged in localized movements, indicative of foraging behavior (lasting 10–288 days; Patrício et al. 2022). We then calculated the number of breeding females foraging in Senegal by weighting the number of nesting females in Guinea-Bissau each year by the percentage of tracked turtles that migrated to Senegal, summed over two consecutive years. We used two consecutive years to produce a conservative estimate, assuming that turtles nesting in successive years were different individuals. Given the high interannual variability of nesting numbers at Poilão (IBAP, unpub. data), typical of green turtles (Hays et al. 2022), we considered one low and one high nesting years, to avoid severe underestimation of the foraging population (e.g., by choosing two consecutive low years). Based on the available data, the two possible pairs of consecutive years meeting this criterion were 2019/2020 and 2020/2021.

To estimate the sexually mature females within the in-water captures in Senegal, we considered the probability of being a reproducing female based on data from the same breeding site as the present study. Not all turtles reach maturity at the same size (Bjorndal et al. 2013) and although females as small as ~ 85 cm CCL are found nesting at Poilão Island, the mean size of these nesting females is 100 cm CCL. Thus, it is likely that not all turtles with 85 cm CCL are reproducing (Catry et al. 2023). To correct for this, we categorized potential adult females in size classes (from 85 to > 105 cm, 5cm intervals) and multiplied by the size-class specific proportion of reproducing females calculated in Catry et al. (2023).

Lastly, we combined the estimated number of breeding females foraging in Senegal with their proportion within the in-water captures, to ultimately estimate the abundance of green turtles in this area.

RESULTS

1. Spatial distribution in Senegal foraging areas

All 13 post-reproductive turtles that migrated from Guinea-Bissau to Senegal settled in two well-defined areas that together represent a small percentage (~10%) of the Senegalese coast (Fig. 1B, Fig. S1). Eight turtles settled in the core of the Delta du Saloum National Park, extending through ca. 12 km along the coast on a north-south axis and covering a region of channels and shallow banks under strong tidal influence at the main entrance of the Saloum Delta. Five turtles settled along the Joal coast, which extends for ca 24 km and reaches ca 7 km offshore, over mostly sandy substrates with occasional rocky outcrops.

The foraging distribution of the turtles tagged in Guinea-Bissau largely matched that of the six adult-sized females tagged directly in Senegal (Fig. S1, Table S2), therefore we pooled the two groups for subsequent analyses. We recorded the foraging movements of the 19 turtles during 52.8 ± 44.0 days (mean $\pm$ SD). Mean individual UD areas were 18.1 ± 15.5 km² for home range and 2.8 ± 2.3 km² for core area (Fig. 3). UD surface areas were similar between the two sites (Saloum Delta: home range 18.2 ± 12.6 km², core area 2.5 ± 1.8 km²; Joal: home range 17.9 ± 18.1 km², core area 3.3 ± 2.7 km²). **All turtles remained faithful to their foraging ground, with no sporadic or permanent changes to their location and the UD of different individuals overlapped extensively in both areas.**

2. Size structure and sex ratio

During 2024–2025, we captured 79 turtles in the Saloum Delta across 7 sampling days with 25 fishing attempts, and 31 turtles in Joal over 9 sampling days with 44 fishing attempts. Sampling effort was not recorded for 2023. In total, we captured 131 green turtles in the two foraging areas: 90 in the Saloum Delta and 41 in Joal. Mean CCL was 89.1 ± 14.3 cm, ranging from 42.8 to 117.8 cm (Fig. 2, Table S3) and CCL distribution did not differ significantly between Saloum Delta and Joal (Wilcoxon rank-sum test, $W = 2240$, $p = 0.051$). However, pooled Senegal samples exhibited significantly larger CCLs than those captured in Mauritania (Wilcoxon rank-sum test, $W = 7545$, $p < 0.001$) (Fig. 4).

Of the 131 captures in Senegal, 89 individuals had $CCL \geq 85$ cm. Of these, 28 turtles were classified as adult males and 43 as adult females (after correcting for the size-specific probabilities of reproductive status, Table 1), resulting in an estimated adult sex ratio of 1:1.54 (male:female).

Table 1. For six-size classes, the percentage of reproducing female green turtles as calculated in Catry et al. (2023), the number of females captured in Senegalese coastal waters, and the resulting estimate of adult reproducing females in our sample.

CCL size class (cm)	% reproducing females (calculated in Catry et al. 2023)	Captured females in Senegal	
		Total	Reproducing
80.01–85	1.4	8	0
85.01–90	7.7	6	0
90.01–95	28.0	11	3
95.01–100	79.7	22	18
100.01–105	100.0	13	13
> 105	100.0	9	9

In Senegal, captures occurred at sites with water depths between 1.4 and 4.3 meters (2.82 ± 0.91 m) (Fig. 5), whereas in Mauritania (Catry et al. 2023) capture locations varied between 1.2 and 10.7 meters depth (4.6 ± 2.0 m). When considering only captures at depths ≤ 4.3 m (the maximum depth observed in Senegal), a linear model (LM) of curved carapace length (CCL) with site, water depth, and their interaction as predictors showed that CCL was significantly greater in Senegal than in Mauritania ($p < 0.001$). Water depth did not significantly explain variation in CCL ($p = 0.537$), nor was there a significant interaction between site and depth ($p = 0.499$). The effect of location remained consistently significant across both the full and depth-restricted linear models ($p < 0.001$), with turtles from Senegal exhibiting larger body sizes than those from Mauritania.

3. Foraging aggregation abundance

Between 2018 and 2021, we successfully tracked 46 nesting females during their post-nesting migration from Guinea-Bissau to their foraging grounds (detailed results in Catry et al. 2023). No turtle showed prolonged stopovers that might obscure foraging site assignment. From these, nine turtles migrated to Senegal corresponding to 19.6% overall: three females in 2018 (20.0% of that year's tracked turtles); two in 2019 (25.0%); and four in 2020 (33.3%). No turtles migrated to Senegal in 2021. For the same years for which post-migration was tracked (2018-2021), the number of nesting females in Guinea-Bissau had three low years and one high (Table 2).

Table 2. Estimated number of green turtles nesting in Guinea-Bissau between 2018 and 2021, when post-nesting migrations were also recorded.

No. of nesting females	2018	2019	2020	2021
	2880	1865	12397	2658

To calculate the number of breeding females foraging in Senegal, we summed the estimated quantity of females that migrated to Senegal after breeding in Guinea-Bissau for two consecutive years. For example, in 2019, 1865 females nested in Guinea-Bissau and 25.0% migrated to Senegal, and in 2020,

12397 nested in Guinea-Bissau and 33.3% migrated to Senegal, resulting in the estimation of 4599 reproductive females foraging in Senegal considering the available data for 2019+2020 ($1865 \times 0.25 + 12397 \times 1/3 = 4599$). If we consider 2020+2021, the result is 4132 reproductive females foraging in Senegal.

Assuming that 33% of the captured turtles in Senegal were breeding females (i.e., 43 out of 131 turtles), and that approximately 4132 to 4599 breeding females forage in Senegal, the total aggregation size is estimated at 12,589–14,010 green turtles across all size classes.

DISCUSSION

This study presents the first in-water assessment of green turtle foraging aggregations in Senegal, identifying the Saloum Delta and the Joal coast as key feeding hotspots within the West African migratory network. By integrating nesting counts, satellite-tracking, and in-water capture data, we estimate that ca. 20% of Poilão's nesting females forage at these two discrete sites along the Senegalese coast, which together host approximately 14,000 green turtles. Tracked individuals used relatively small foraging ranges that largely overlap existing marine protected areas, and the assemblage is male-rich when compared to other areas. Together, these findings underline the ecological and conservation importance of these habitats for the eastern Atlantic population.

The foraging aggregation estimated for Senegal (~ 14,000 turtles) is far more spatially condensed than that of the Banc d'Arguin, even though more turtles were estimated in the latter (~ 150,000; Catry et al. 2023). Of the 13 post-nesting females tracked from Poilão, 8 (61.5%) foraged in the Saloum Delta and 5 (38.5%) at Joal, suggesting an uneven distribution and higher turtle density in the Saloum Delta. Considering that the estimated population-level distribution extents (95% KUD; Fig. 3) are 68.3 km² in the Saloum Delta and 65.1 km² in Joal, and that ~ 8,610 and ~ 5,390 turtles of the 14,000 individuals forage in each area, respectively, we can extrapolate densities of 126 turtles km⁻² in the Saloum Delta and 83 turtles km⁻² in Joal. This spatial pattern is consistent with higher capture success in the Saloum Delta (4.6 turtles per attempt vs. 0.6 in Joal) and visual counts that consistently recorded disproportionately more individuals in the Saloum Delta (pers. obs.). When restricting the comparison to adult-sized turtles at West African foraging grounds, the spatial concentration observed in Senegal becomes even more pronounced. Based on adult abundance estimates and 95% KUD extents, adult turtle densities reach approximately 65 turtles km⁻² in the Saloum Delta (4,407 adults over 68.3 km²) and 42 turtles km⁻² in Joal (2,759 adults over 65.1 km²), compared to ~ 7 turtles km⁻² in the Banc d'Arguin (10,485 adults over 1,483 km²; Catry et al. 2023). Although limited, quantitative estimates of green turtle density at foraging grounds reveal substantial variability across regions and habitat types, with values spanning several orders of magnitude (e.g. Ballorain et al. 2010; Kelkar et al. 2013; Meylan et al. 2022; Stokes et al. 2023). Within this context, the densities estimated for Senegal rank among the highest reported for green turtle foraging habitats to date, and are the largest reported for Atlantic coast of Africa (Mancini et al. 2015; Rivera-Milán et al. 2023). Despite the limitations in cross-study comparability, these values highlight the spatial concentration of green turtles in Senegal.

The core foraging areas used by green turtles in the Saloum Delta and near Joal overlap extensively with two established marine protected areas: the Saloum Delta National Park and the Joal-Fadiouth Marine Protected Area. The Saloum Delta benefits from multiple conservation designations (National Park, Ramsar Site and UNESCO Biosphere Reserve) and the Joal-Fadiouth MPA is characterized by community-based co-management that integrates conservation and artisanal fishing through participatory zoning and local enforcement (WWF 2009; Merceron et al. 2024). Both MPAs implement measures relevant for turtle conservation, including awareness initiatives, law-enforcement mechanisms and livelihood diversification programs aimed at reducing pressures from artisanal fisheries (Patrício et al. 2022). However, as documented for MPAs across West Africa, limited funding, monitoring capacity and enforcement continue to constrain effective management (Merceron et al. 2024). This was evident during our fieldwork, when illegal fishing was frequently observed within the core of the Saloum Delta National Park, where most turtles gather. Since coastal communities strongly rely on fisheries and agriculture, effective conservation of these MPAs must integrate sustainable use with biodiversity goals and be underpinned by robust governance, consistent enforcement, and sustained community support (PANORAMA 2025; Senghor et al. 2023). Because green turtles move across multiple West African MPAs within a Regional Network of Marine Protected Areas, the RAMPAO network, conservation planning may benefit from operating at the scale of migratory corridors rather than rely solely on site-by-site measures (Patrício et al. 2022).

At a larger scale, Senegal's coast is intensively fished, and bycatch remains a major, yet poorly quantified, threat to sea turtles, with persistent data gaps (de la Hoz Schilling et al. 2023). Other anthropogenic pressures, such as illegal take and habitat loss documented across other regions of Africa, likely affect Senegal's turtles in similar ways, underscoring shared regional challenges (van De Geer et al. 2022). It is also important to consider the socio-cultural dimension of turtle conservation in coastal Senegal and the potential tensions or synergies between global conservation frameworks and local practices (Sabinot 2003). Protecting the foraging aggregations of turtles in Senegal will require pairing effective MPA implementation with fisheries-focused bycatch reduction along the migratory routes that connect Senegal to Guinea-Bissau (Patrício et al. 2022; van De Geer et al. 2022).

The adult sex ratio in Senegal (1:1.54, male to female) contrasts with the markedly female-biased ratio in Mauritania (1:3.75; Catry et al. 2023). Considering estimates of adult female abundance and the sex ratio, the absolute number of adult males in Senegal is of the same order of magnitude as in Mauritania (ca. 2,800 vs. 2,200, respectively), although the foraging aggregation is estimated to be ten times larger in Mauritania (Catry et al. 2023). This higher prevalence of adult males in Senegal aligns with recent evidence that males tend to remain closer to breeding sites between reproductive seasons (Beal et al. 2022; Fuentes et al. 2025), potentially reducing migration costs and thereby allowing males to breed more frequently than females (Fuentes et al. 2025). Spatial segregation, whereby males preferentially occupy coastal foraging habitats closer to breeding sites, has also been documented in Caribbean Nicaragua, likely reflecting sex-specific foraging strategies and proximity to breeding sites (Lagueux et al. 2017). Sex-specific biases at foraging grounds have important implications for population dynamics, as exposure to fisheries, habitat degradation, and other threats can differ among sites and life stages

(Lagueux et al. 2017; Rees et al. 2016). However, data on sex ratios at foraging areas remain limited, and adult males are still underrepresented in demographic studies (Robinson et al. 2023). Increasing in-water research at foraging grounds is therefore key to improving the global understanding of male ecology and sex-specific survival in green turtles.

The size structure of green turtles foraging in Senegal is skewed towards larger individuals compared to the Banc d'Arguin, Mauritania, located approximately 650 km north along the West African coast. This difference may reflect ontogenetic shifts in habitat use, whereby smaller turtles predominantly exploit northern foraging grounds that may offer higher food availability and reduced predation risk (Bolten 2003; Howell et al. 2016). As turtles grow, they may progressively move southwards along the coast, increasingly using Senegalese foraging areas that are closer to their source population in Poilão, Guinea-Bissau. In Mauritania, genetic evidence indicates that the large majority of immature green turtles (ca. 88%, Patrício et al. 2024) originate from Poilão, Guinea-Bissau, and our preliminary results suggest a similar population linkage for Senegal. Together, these findings support the interpretation that both these foraging destinations are used by the same population and linked to the large nesting aggregation in Poilão. This use of different foraging areas across successive life stages is consistent with juvenile natal homing (Hays and Scott 2013; Meylan et al. 2011; Naro-Maciel et al. 2007). In this context, the Saloum Delta and Joal appear to function predominantly as adult and sub-adult foraging grounds, complementing more northerly habitats that are largely used by juveniles of the same eastern Atlantic green turtle population (Patrício et al. 2024).

Senegalese green turtles exhibit home range areas consistent with other global studies employing Fastloc GPS on adults (Hays et al. 2024; Shimada et al. 2016). In contrast, smaller ranges have been reported in northern Australia (Gredzens et al. 2014) and larger in Mauritania (Mestre et al. 2025). In Senegal, each tracked turtle remained within a small and well-defined foraging area, as reported in other studies (e.g. Ningaloo and Queensland, Australia, Pillans et al. 2022, Gredzens et al. 2014). In contrast, turtles in Mauritania exploited several different areas and presented patchy distributions (Mestre et al. 2025), while some individuals in Mexico exploited up to three activity centers (Seminoff et al. 2002). These contrasts likely reflect regional differences in habitat structure, productivity, and resource distribution. The limited spatial distribution in Senegal possibly indicates sufficient and predictable resources and reduced anthropogenic disturbance, that obviate large-scale movements (Hays et al. 2024).

A limitation of our abundance estimation is the assumption that adult females foraging in Senegal originate exclusively from the Bijagós rookery, in Guinea-Bissau. Rare long-distance contributions cannot be excluded, as illustrated by the female recaptured in Senegal after nesting on Trindade Island, Brazil (Marcovaldi et al. 2000). Some nesting females from Senegal may also forage in these areas, but their contribution is expected to be minimal, as annual nesting numbers are limited to at most a few hundred nests and fluctuate markedly among years (Diouck pers. obs.). Nevertheless, available data indicates that post-nesting migrations typically do not exceed ~ 2,000 km, with most foraging grounds located ~ 400–2,000 km from the nesting beach (Al-Mansi et al. 2021; Hays et al. 2002; Hays and Scott 2013;

Richards et al. 2024). Within 2,000 km of Senegal, the Bijagós Archipelago is the only site known to support a large, regionally significant green-turtle rookery (Patrício et al. 2019). It is therefore reasonable to infer that the large majority of foraging adults in Senegal originate from Bijagós and to estimate abundance accordingly. Despite inherent uncertainties, the method provides a transparent, reproducible and likely conservative framework for estimating the size of foraging aggregations.

CONCLUSIONS

This study demonstrates that green turtles foraging in Senegal concentrate in two small discrete coastal areas rather than being evenly distributed along the coastline. This finding, together with pronounced differences in size structure and adult sex ratios across West Africa, underscores the importance of foraging-ground ecology for population structure and dynamics—an aspect that remains poorly documented globally due to the scarcity of in-water studies at foraging areas. The male-rich assemblages documented here contribute to a growing body of evidence that adult males and females use foraging habitats differently, highlighting the importance of expanding research at foraging grounds to improve global understanding of male ecology and sex-specific processes in green turtles. This work also establishes ecological and demographic baselines to assess future scenarios and population trends, and to inform management strategies within existing marine protected areas and across migratory corridors linking Senegal to the wider West African network.

Declarations

Conflict of interest

All authors declare that they have no conflict of interests, such as competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Ethical statement

This study was reviewed and approved by Orgão Responsável pelo Bem-estar Animal do ISPA (ORBEA - ISPA), which ensures compliance of ethical standards and animal welfare rules. Research permits were granted by the Directorate of National Parks and the Directorate of Community Marine Protected Areas of Senegal and by Instituto da Biodiversidade e das Áreas Protegidas, Dr. Alfredo Simão da Silva (IBAP), of Guinea-Bissau. Fieldwork protocols involving sea turtles followed recommended guidelines (NMFS-SFC 2008), to enhance efficiency and reduce possible disturbance to the turtles, and were conducted by trained personnel, in collaboration with national authorities for biodiversity management. Samples were exported under CITES 0002367 issued by the Direction des Eaux et Forêts, Chasses et de la Conservation des Sols, and imported under CITES 25PTLX00178I issued by the ICNF.

Supplementary information

Supplementary data associated with this article are provided as electronic supplementary material.

Data availability

The tracking data used in this study are available through the Movebank repository (www.movebank.org) under the study name 'Chelonia mydas_Senegal_foraging_2018_2025', and can be accessed upon request to the authors.

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Author contributions

Ana Rita Patrício and Paulo Catry conceptualized the study and developed the methodology. Funding acquisition and project administration were carried out by Djibril Diouck, Castro Barbosa, Ana Rita Patrício and Paulo Catry. Fieldwork and data collection were conducted by all authors. Mariana Cravo led the investigation, conducted formal analyses, and wrote the original draft of the manuscript. Ana Rita Patrício and Paulo Catry supervised the study and contributed to manuscript review and editing. All authors read and approved the final manuscript.

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Figures

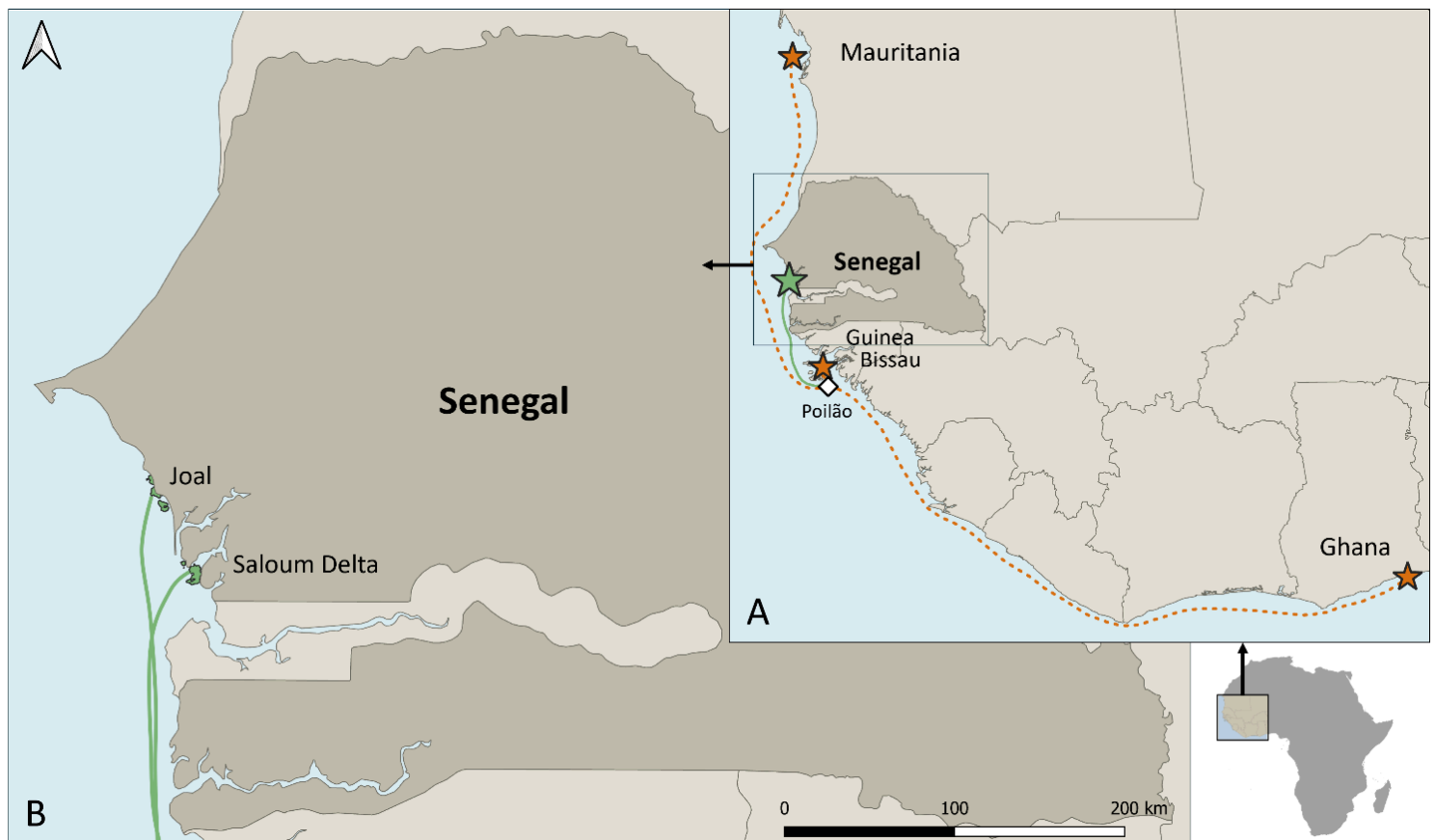


Figure 1

Panel A: West Africa coast with dashed orange and green solid lines depicting the migratory routes of post-breeding green turtles from Poilão Island (white diamond), Guinea-Bissau. Stars indicate the location of foraging areas (green star indicates the study site). Panel B: final destination of the migratory routes for turtles foraging in Senegal and respective areas used during foraging at the two study sites, Saloum Delta and Joal.

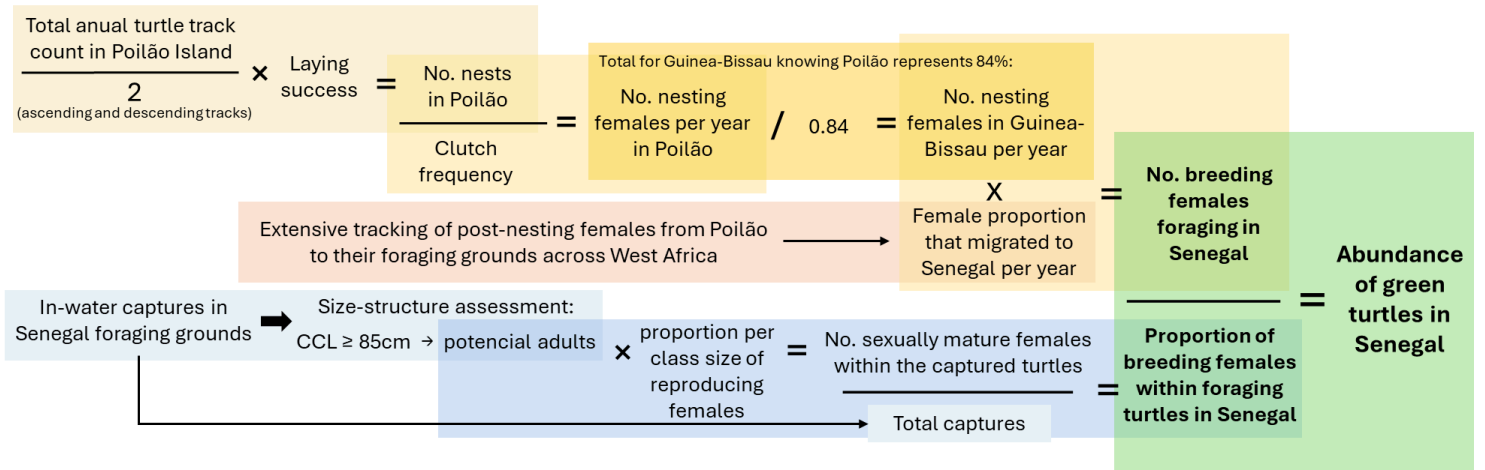


Figure 2

Overview of the sequential steps of the method used to estimate the abundance of foraging green turtles in Senegal, following Catry et al. (2023). Yellow boxes represent calculations based on nesting-beach data; orange depicts satellite-tracking information from post-nesting migrations; and blue represents calculations derived from the in-water captures in Senegal.

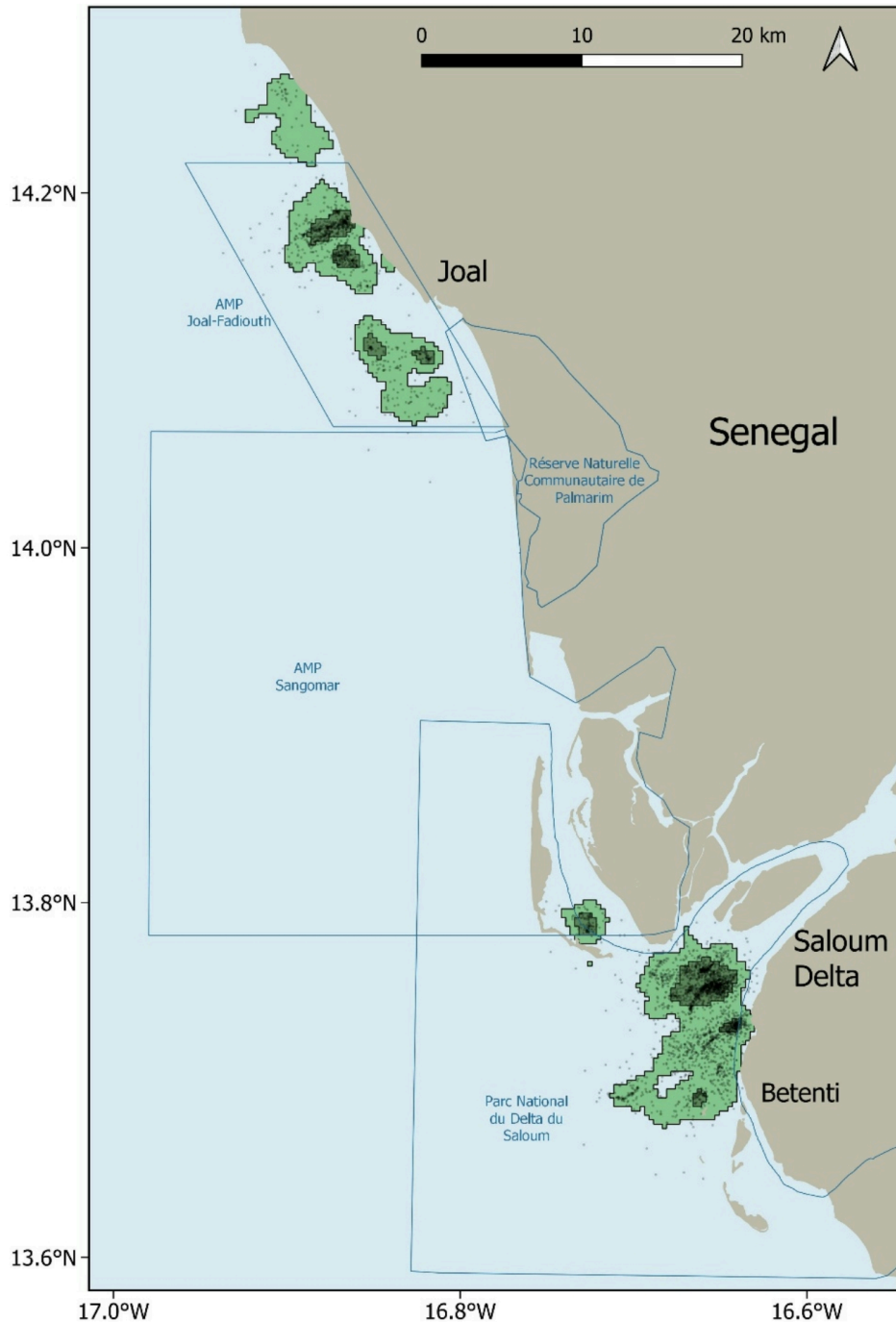


Figure 3

Estimated population-level distribution (average of individual Kernel Utilization Distributions; KUD) of 19 adult green turtles foraging in Senegalese coastal waters. The dark green and light green areas depict the core areas (50% KUD) and home ranges (95% KUD), respectively. Occurrence points of turtles after data cleaning are represented by dots. The solid blue lines depict the contour of the National parks and reserves.

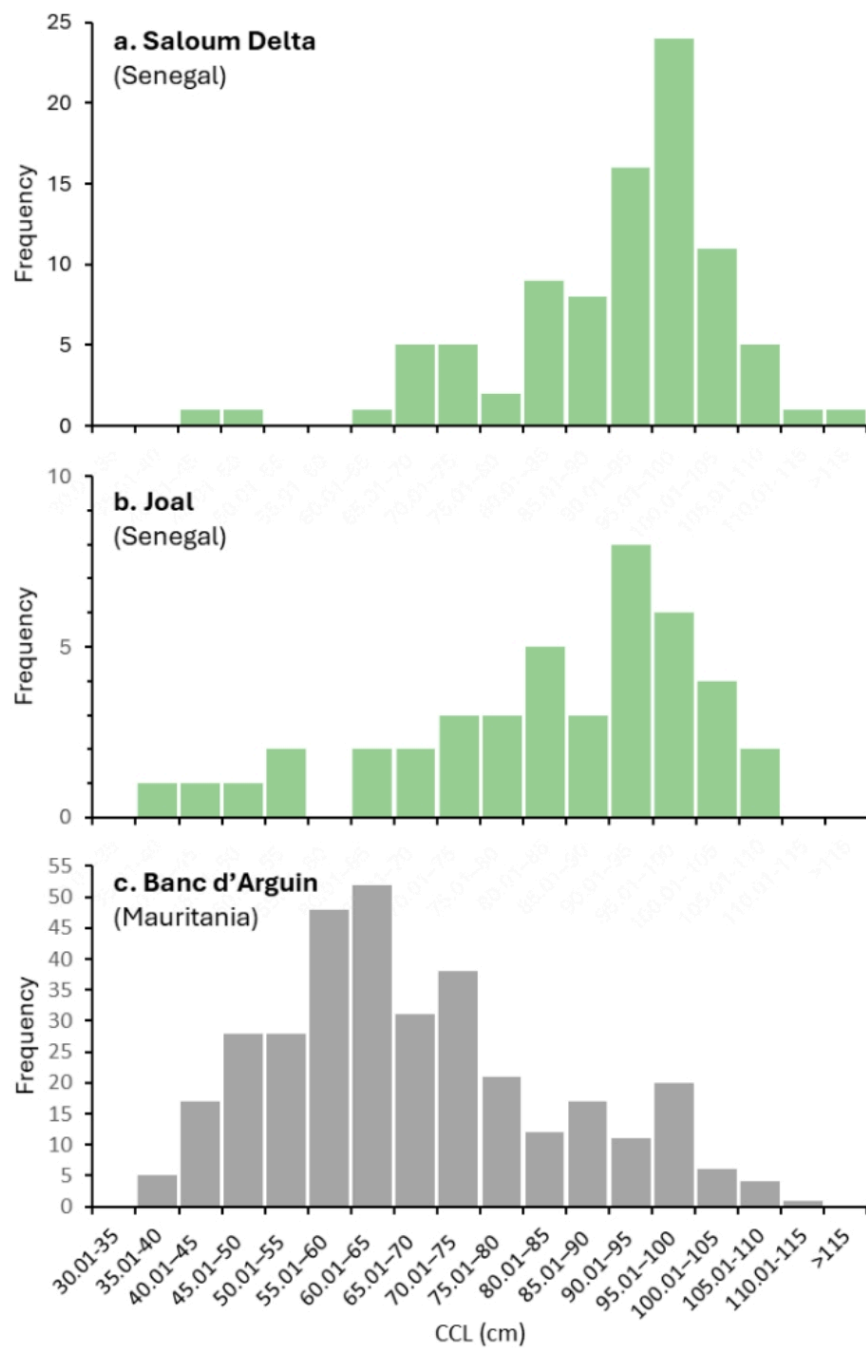


Figure 4

Size distribution of green turtles captured in two foraging areas of Senegal; (a) Saloum Delta n= 90 and (b) Joal n= 41, Senegal between 2024-25, and in (c) the Banc d'Arguin of Mauritania, between 2018-25, n= 102.

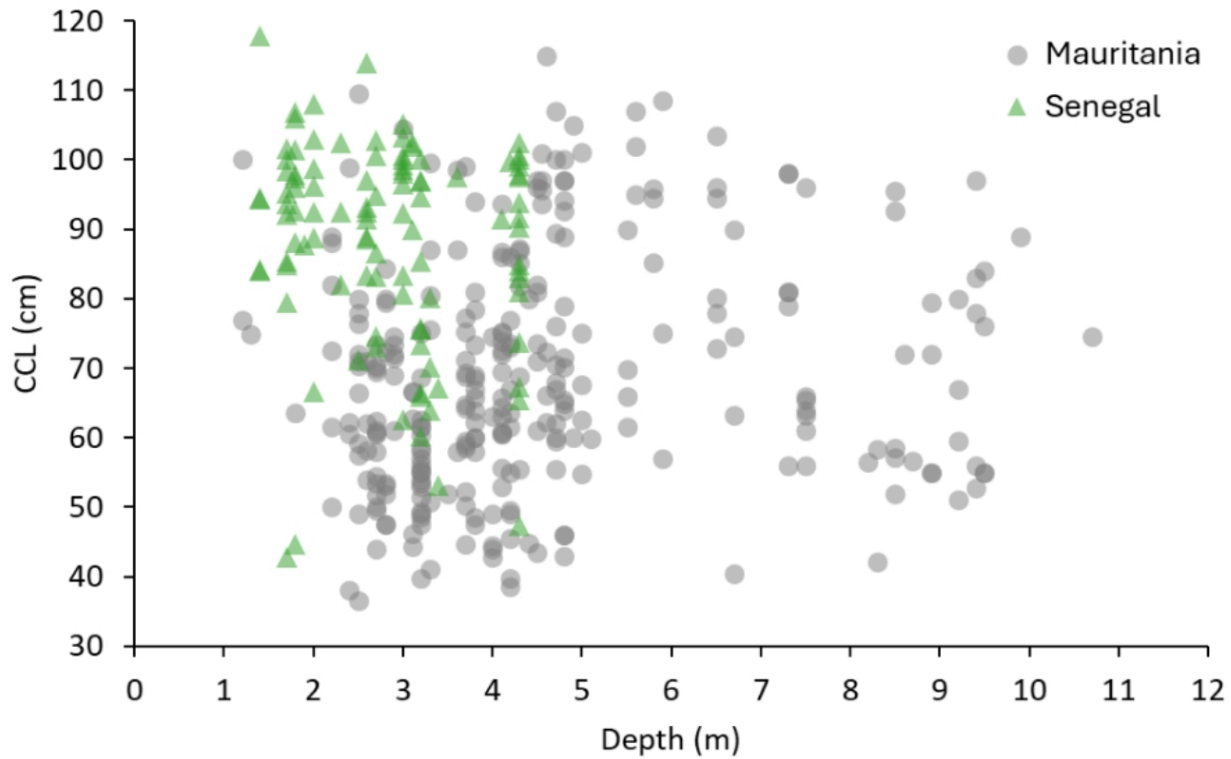


Figure 5

Curved carapace length (CCL) of foraging green turtles and corresponding water depth in capture locations in Senegal (2024-2025, green triangles) N=102 and in Mauritania (2019-2025, grey circles) N=286.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [Supplementarymaterial.docx](#)