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# Effects of Community-Based Management on Amazon River Turtles: A Case Study of *Podocnemis sextuberculata* in the Lower Amazon Floodplain, Pará, Brazil

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ABSTRACT. – ***Podocnemis sextuberculata*** **is cited as "vulnerable" on the International Union for Conservation of Nature Red List due to a decline in its population as a result of the intensive exploitation pressure throughout its range. Understanding the effects of environmental characteristics and human activities on turtle populations is essential to improve current conservation programs. We analyzed the abundance of** ***Podocnemis sextuberculata*** **in the lower Amazon, where a management experiment is under way, by comparing neighboring areas with and without community-based management (CBM) initiatives. In addition, we analyzed the influence of environmental variables on the species' abundance. Abundance was measured by captures per unit effort expressed in number of individuals ($CPUE_N$) and biomass ($CPUE_B$). The effects of CBM and environmental variables were tested by General Linear Model analysis. A total of 354 individuals were captured, 321 in the areas under CBM and 33 in areas without CBM. $CPUE_N$ and $CPUE_B$ were strongly correlated, and their values were about 10-fold higher in the areas carrying out CBM initiatives. The variable that best explained variation in $CPUE_N$ and $CPUE_B$ was CBM. Distance between the sampling point and the nearest nesting beach and river level also influenced capture rates. Results clearly show that local fishing restrictions can have a positive influence on turtle populations.**

KEY WORDS. – **Amazon floodplain;** ***varzea*****; fishing agreement; fisheries management; chelonians; turtle conservation; turtle management**

Because turtles are protein sources that can be easily captured and stored, they have been an important global source of human food for thousands of years (Thorbjarnarson et al. 2000; Moll and Moll 2004). In South America, Amazon River turtles have been consumed by indigenous peoples since precolonial times (Bates 1863; Veríssimo 1970). The intense commercial exploitation of the animals and their eggs for centuries has resulted in a marked decline of turtle populations throughout Amazonia, particularly in the case of the giant South American river turtle *Podocnemis expansa* (Smith 1974, 1979; Mittermeier 1975). Today, wild turtles are still consumed and illegally traded in the Brazilian Amazon (Fachín-Terán and Vogt 2004; Pezzuti et al. 2004; Rebêlo et al. 2005; Kemenes and Pezzuti 2007) despite protection under Brazilian laws 5.197/67 (Wildlife Protection) and 9.605/98 (Environmental Crimes). The members of the family Podocnemididae are the most exploited species, especially the conspicuous *Podocnemis expansa*, *Podocnemis unifilis*, and *Podocnemis sextuberculata* (Pezzuti and Vogt 1999; Fachín-Terán et al. 2004). All are listed in the International Union for Conservation of Nature (IUCN) Red List, *Podocnemis unifilis* and *Podocnemis sextuberculata* as vulnerable and *P. expansa* as lower risk/conservation dependent (IUCN 2011).

The effects of human exploitation on turtle populations have not been well quantified, but it is clear that in many cases human use has been the main cause of turtle population declines or even extinction (Kuchling 1997; Thorbjarnarson et al. 2000; Moll and Moll 2004; Conway-Goméz 2007). On the other hand, human use of turtles may be sustainable under management rules (Caputo et al. 2005). Turtle conservation plans usually comprise only nesting beach protection and headstarting programs, whose results indicate that they have not been effective for these long-lived and late-maturing species (Crouse et al. 1987; Heppell et al. 2005). Understanding the effects of both human activities, including exploitation and conservation, and environmental characteristics on turtle populations is essential to improve current conservation strategy programs. *Podocnemis sextuberculata*, the 6-tubercled turtle locally known as *pitiú*, is reported to be the most captured species in some areas of the Amazon

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floodplain (Pezzuti and Vogt 1999; Fachín-Terán et al. 2004; Kemenes and Pezzuti 2007). In the lower Amazon, preliminary observations indicated that *P. sextuberculata* is the most targeted species for consumption and sale (Pezzuti et al. 2008; J. Pezzuti et al., unpubl. data, 2011).

Capture of aquatic turtles is closely related to traditional fishing activity, as the fishermen catch turtles during their ordinary fishing and sometimes as by-catch of fishing tackle, such as gill nets (Kuchling 1997; Pezzuti et al. 2004; Rebêlo et al. 2005; Conway-Gómez 2007). Over the last 3 decades, communities along the Amazon floodplains, or *varzea*, have perceived that intensification of commercial fisheries using gill nets constitutes a threat to local fish stocks, mainly in the highly productive floodplain lakes. Some communities have taken control of local lakes systems through ''fishing agreements'' that consist of sets of rules to regulate fishing activities in the communities' areas (McGrath et al. 1993). Fishing agreements were first developed as informal rules by some communities in the lower Amazon in the 1980s. In 1993, the Brazilian government took steps to legalize the fishing agreements and integrate them into the formal institutional framework for fisheries management (McGrath 2000; Castro and McGrath 2003). Notably for fisheries resources, alternative management systems have been adopted as a way to overcome the fishing crisis and to avoid more fish population collapses (Sen and Nielsen 1996; Pomeroy and Berkes 1997; Johannes 2002; Berkes 2003; Kearney et al. 2007). The fishing agreement is an example of community-based management (CBM) held in the Amazon and has become the main political tool for the establishment of fisheries comanagement systems in the Amazon floodplain.

A fishing agreement itself may have a positive influence on the conservation of the whole lake environment, including other aquatic species, such as turtles. In the lower Amazon, besides the fishing agreements, communities have also implemented efforts for river turtle management, basically by protecting some nesting beaches and sustainably harvesting the turtles and their eggs (McGrath et al. 2008). The fisheries and fauna management, including turtle nesting beach protection, are held together forming a multiple-resource management system (McGrath et al. 2008; J. Pezzuti et al., unpubl. data). Multiple-resource management systems are frequently described for traditional people (Colding et al. 2003; Toledo et al. 2003), usually based on an ecosystem view and focused on sustainable exploitation of areas and not focused on a single species or group of species (Berkes 2003). In this study, we questioned if the CBM initiatives developed in the lower Amazon positively affected the local abundance of *Podocnemis* turtles by comparing areas with and without CBM practices (fishing agreements and turtle management). We also analyzed the effect of environmental characteristics on turtle capture to reach a clearer understanding of the factors affecting turtle abundance.

## METHODS

*Study Area.* — The study was carried out in the Aritapera region, located in a fluvial island in the lower Amazon floodplain (or *varzea*), Santarém, Pará state (lat 2°06′–2°09′S, long 54°34′–54°46′W; Fig. 1). The climate is hot and humid, with mean annual temperature between 25°C and 28°C (Departmento Nacional de Produção Mineral [DNPM] 1976). The Amazon basin is subject to a seasonal variation in precipitation that promotes an annual predictable fluctuation in the water levels, known as the flood-pulse concept (Junk et al. 1989). In the lower Amazon, annual precipitation is about 1900 mm, ranging from 60 mm monthly during the dry season to up to 300 mm monthly in the rainy season. The water levels rise during the rainy season, which goes from December to June, and descend in the dry season between July and November, resulting in a 7-m fluctuation in Amazon River level.

The lower Amazon floodplain is characterized by alluvial land, with elevations up to 20 m above sea level. Vegetation distribution is partially related to elevation, reflecting the plant species' abilities to withstand periods of inundation. The higher areas are covered by forests, while the lowlands are dominated by natural grasses. Lake surfaces and the edges of river channels are often partially covered by floating vegetation (DNPM 1976; McGrath et al. 1993). When water levels are high, all but the highest levees are underwater. As the waters recede, sandbars on the river channels and the littoral lakes emerge, providing nesting sites for a range of birds, iguanas, and turtles. During the low-water season, all but the deepest portions may be reduced to muddy pools (McGrath et al. 1993), and the aquatic fauna is concentrated in the remnant water bodies (Goulding 1980; Junk et al. 1989). The floodplain lakes play a major role in the productivity of this aquatic system, particularly due to the high production of phytoplankton and aquatic macrophytes, which allows floodplain lakes to serve as nursery and feeding grounds for the aquatic fauna (McGrath et al. 1993; Junk and Piedade 1997).

The Aritapera region comprises 13 communities composed primarily of fisherman. Fishing is the main economic activity that sustains local people in the lower Amazon floodplain. These 13 communities are members of 1 unique fishing agreement. However, only 2 of them actually implement the agreement (Água Preta and Ilha de São Miguel); in the other communities, neither local residents nor outside fishermen respect the fishing rules.

The communities of Água Preta and Ilha de São Miguel elaborated fishing rules for their areas 20 and 30 yrs ago, respectively. The main rules refer to restrictions on the fishing gear–gill nets–and to seasonal restrictions. The use of gill nets, especially during the low-water season when fish are concentrated in the remaining lakes, is considered the main cause of fish decline by the local fishermen (Castro and McGrath

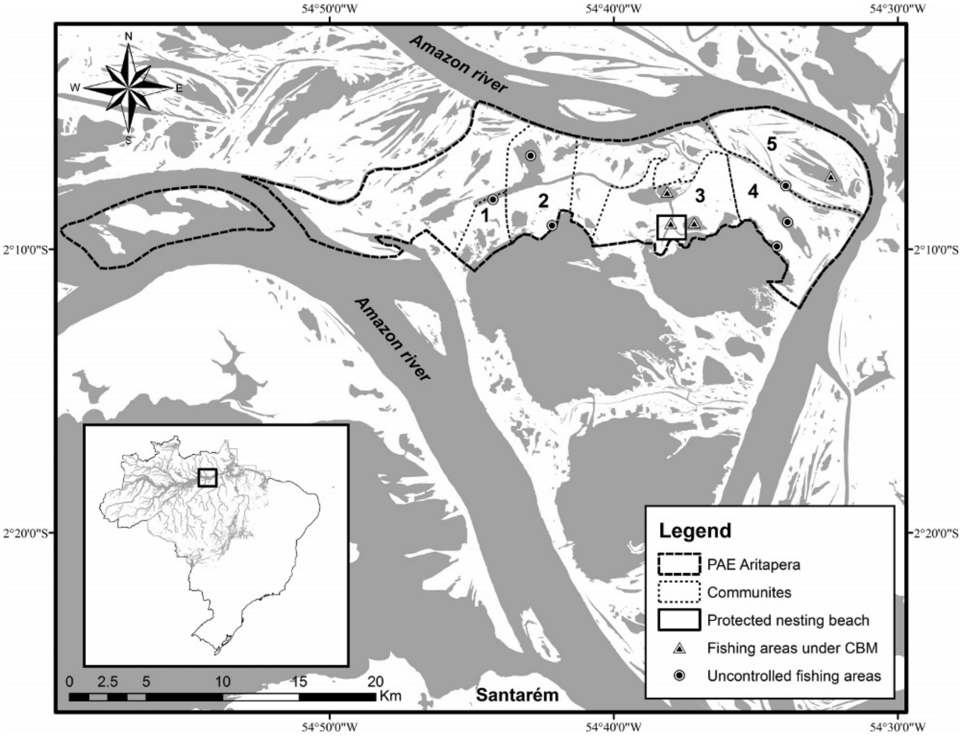

**Figure 1.** Study area, Aritapera region, Santarém, Pará, Brasil. Communities: 1. Enseada do Aritapera (without community-based management [CBM]); 2. Centro do Aritapera (without CBM); 3. Água Preta (with CBM); 4. Costa do Aritapera (without CBM); and 5. Ilha de São Miguel (with CBM).

2003). Both communities protect the turtle nesting beaches and also battle against the illegal trade in turtles in their areas, although turtle consumption is allowed. These 2 communities were classified as areas *with CBM* and were sampled for turtle abundance. The other communities without any implementation of fishing rules, beach protection, or turtle trade ban were classified as areas *without CBM*, and 3 (Centro do Aritapera, Costa do Aritapera, and Enseada do Aritapera) were sampled for turtle abundance.

*Sampling*. — Fourteen turtle samples were taken, 7 from areas with CBM and 7 from areas without CBM. As a result, we were not comparing areas with and without human pressure (fishing) but rather areas with distinct human pressure, whether or not they had community fishing restrictions. Turtle samples occurred during the falling water season, from August to October 2009. Turtles were captured using gill nets, the most used fishing gear in the lower Amazon and other areas of the Amazon (Barthem 1987; Ruffino et al. 1998). Gill nets are selective according to the mesh size (Barthem 1987; Batista et al. 2004), requiring many mesh sizes to capture a wider range of animal sizes. Gill nets are widely used by poachers to catch river turtles in the Amazon basin (Smith 1974; Rebêlo et al. 2005).

The same effort was applied at all sample sites. Each sample consisted of 15 gill nets (3 for each mesh size: 12, 16, 20, 24, and 30 cm) exposed in the same sample point for 24 hrs. The gill nets were, on average, 54 m long and 4 m high, with an area of approximately 215 $m^2$ each; however, we measured all gill nets to obtain their length and height to calculate the total area covered by the nets used in each sample. We used the same nets in all samples when possible, but we sometimes had to replace some of them due to damage. The nets were checked every 3 hrs to avoid turtle deaths by drowning. Since turtles are not easy to catch, we adopted this intensive sample design, and also the local fishermen's knowledge and practices were adopted to optimize turtle capture at all sample sites. Two local fishermen participated in each sample by indicating the best locations to catch turtles at that time of the year.

The communities' landscapes were very similar and comprised large shallow lakes, deep lakes, and inner channels that interconnect the lakes and also link them to the main river. The fisherman indicated the central lakes and inner channels as the best locations to catch *Podocnemis* because the turtles aggregate in these areas or use them as migration routes. The fishermen usually indicated sites near the margins to avoid strong current, especially in the channels. All sample points were located near community settlements or fishing areas, so that usual human activities were present at all turtle sample sites.

Sample sites were georeferenced with a Global Positioning System model Garmin 12 XL. At each sample site, we measured environmental variables, such as water temperature and depth (measured to the nearest centimeter using a marked line tied to a weight at the end), and also georeferenced the nearest nesting beach. The depth for each site was expressed as the average of 15 measurements taken from both ends and the center of

**Table 1.** Variables collected at sample sites. Original values.[a]

| Variable | | Unit of measure | Mean | Standard deviation | Minimum | Maximum |
|---|---|---|---|---|---|---|
| $CPUE_N$ | Continuous | $N \cdot 1000\,m^{-2} \cdot 24$ hrs | 6.64 | 8.84 | 0 | 28.14 |
| $CPUE_B$ | Continuous | $kg \cdot 1000\,m^{-2} \cdot 24$ hrs | 8.86 | 11.3 | 0 | 37.0 |
| CBM | Categorical | With/without | – | – | – | – |
| Distance to nesting area | Continuous | km | 2.17 | 2.43 | 0.14 | 8.1 |
| River level | Continuous | m | 4.81 | 1.6 | 2.08 | 6.48 |
| Depth | Continuous | m | 3.97 | 2.09 | 2.06 | 9.57 |
| Temperature | Continuous | °C | 31 | 0.95 | 28.6 | 32.3 |

[a] CBM = community-based management, CPUE = catch per unit effort.

each gill net. The Amazon River water level (related to the sea level) in Santarém was obtained from the National Water Agency (Agência Nacional de Águas, 2010, www.ana.gov.br). The river water level variable is important because it can be used to check the influence of flood pulse on catchability of turtles. The location of nesting grounds obtained during fieldwork was used to calculate the distance from each sample point and the nearest nesting beach (Table 1). Distances were calculated based on a Landsat dry-season satellite image (November 2008) using the ''Measure a Feature'' tool of ArcGIS 9.2 (ESRI®; Table 1).

Turtles were measured (straight-line carapace length, SCL) and weighed with spring balance Pesola® scales (1 kg, precision 0.01 kg, and 10 kg, precision 0.1 kg). The animals were individually identified by notches in the marginal scutes according to an alphanumeric code adopted in previous studies in this area (Pezzuti et al. 2008). Sex was determined from the secondary sex characteristics: males have longer and thicker tails, and cloacal openings are more distal than females (Pritchard and Trebbau 1984). Small individuals without these sexual features were considered juveniles. Captured animals were released at capture sites after the procedures described above.

*Data Analysis.* — Turtle captures were expressed as catch per unit effort (CPUE), in number of individuals ($CPUE_N$), and biomass (kg) captured ($CPUE_B$). $CPUE_N$ and $CPUE_B$ were calculated as the number of individuals and biomass, respectively, captured in 24 hrs per 1000 $m^2$ (approximately the area covered by 5 gill nets).

The continuous variables (Table 1) were first tested for normality (Kolmogorov-Smirnov test for Lilliefors distribution) and homogeneity of variances (Levene test; Gotelli and Ellison 2004; Zar 2010). Temperature and river water level values were normally distributed and homoscedastic, and their original values were used in statistical analyses. The other continuous variables were log transformed (Zar 2010). Depth maintained a nonlinear relation to CPUE values and was transformed by the ratio 1/log(depth). We performed a backward stepwise General Linear Model (GLM) analysis ($\alpha$-to-remove = 0.150) as an exploratory analysis to indicate the variables most important to explain the CPUE variability and not to use the coefficients in predictive models. The backward procedure starts with the fully saturated model and eliminates variables 1 at a time (Gotelli and Ellison 2004). The analysis was performed with the statistical program Systat® version 10.2. Body weight (kg) and SCL (cm) were compared between the sexes through the nonparametric Mann-Whitney U-test (Zar 2010) to check if this population follows the typical pattern of females being significantly larger than males.

## RESULTS

In total, 314 *P. sextuberculata*, 28 *P. unifilis*, and 12 *P. expansa* were captured. Almost 10 times as many *Podocnemis* were caught in areas with CBM (321 individuals) than in areas without CBM (33 individuals). Considering only *P. sextuberculata*, we observed a large variability in the original values of CPUE within samples with CBM and a strong tendency toward low CPUE values in areas without CBM (Fig. 2). The average $CPUE_N$ was 13.5 individuals $\cdot$ 1000 $m^{-2} \cdot 24$ hrs (SD = 9.3; 3.8–29.5) in the managed areas and only 1.6 individuals $\cdot$ 1000 $m^{-2} \cdot 24$ hrs (SD = 1.8; 0–5.4) in areas without CBM initiatives. The $CPUE_B$ was strongly correlated with $CPUE_N$ (Pearson, $r = 0.98$; $n = 14$) and supported the same trend: 20.15 kg $\cdot$ 1000 $m^{-2}$ 24 hrs (SD = 11.66; 5.4–41.5) and 3.4 kg $\cdot$ 1000 $m^{-2}$ 24 hrs (SD = 2.6; 0–6.8) in areas with and without CBM, respectively.

Water temperature and depth were eliminated from the model in 2 steps. The final models were performed with $CPUE_N$ or $CPUE_B$ as the dependent variable, CBM as the categorical factor, and distance to nesting beach and river level as independent variables. The GLM models explained 83% and 89% of the variation in $CPUE_N$ and $CPUE_B$, respectively. Presence or absence of CBM, distance to the nearest nesting beach, and river level were statistically significant determinants of variation in CPUE values (Table 2). *Podocnemis sextuberculata* were more abundant in areas under CBM, at sites closer to nesting beaches and with higher river level, earlier in the falling water season.

Captured *P. sextuberculata* consisted of 196 males, 110 females, and 7 juveniles, with females significantly longer in SCL (U = 17,696.5; $n = 306$; $p < 0.0001$) and heavier than males (U = 17,747.5; $n = 305$; $p < 0.0001$). The size of the animals did not appear to differ between sites with and without CBM (Fig. 3), although size was not compared statistically between the

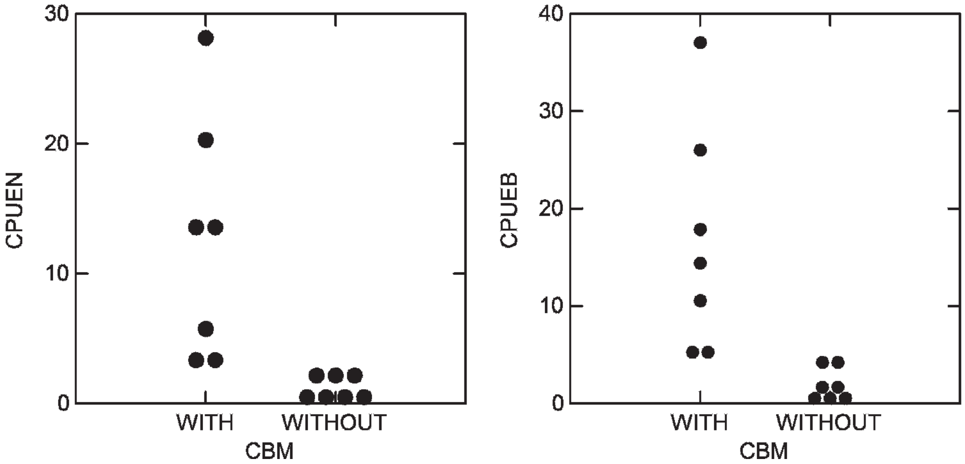

**Figure 2.** *Podocnemis sextuberculata* captures in original values of $\mathrm{CPUE_N}$ (individuals · 1000 $\mathrm{m^{-2}}$ · 24 hrs) and $\mathrm{CPUE_B}$ (kg · 1000 $\mathrm{m^{-2}}$ · 24 hrs) in areas with and without community-based management in the Aritapera region, 2009 dry season.

sites with and without CBM because of great differences in sample size and variance, with the smaller sample having the greater variance (Zar 2010).

## DISCUSSION

The abundance of Amazon River turtles and the factors that affect them are poorly known. The seasonal effect of the flood pulse (Junk et al. 1989) on the movement behavior of *P. sextuberculata* is well known (Pezzuti and Vogt 1999; Fachín-Terán et al. 2005; Haller and Rodrigues 2006); however, we do not know as much about what factor in the landscape affects the relative abundance of animals each season. Distance from nesting beaches and the river level were the environmental variables that most influenced the relative abundance of *P. sextuberculata* during the falling water season when the study was performed. That was expected because mature individuals start to migrate toward the nesting beaches when the water recedes and then aggregate near them (Fachín-Terán et al. 2005). The site sampled in the present study that had the greatest abundance was just 140 m from a nesting beach while it was still submerged, which indicates that *P. sextuberculata* aggregate near the nesting beaches even before they emerge. At this beach, 104 individuals (99 *P. sextuberculata*) were captured, and based on the minimum reproductive size for females found by Haller and Rodrigues (2006) in the Trombetas River (SCL 265 mm), 84.6% of females were sexually mature.

The beach mentioned above was located in the ‘‘Reserve’’ area of 1 community where turtle and egg poaching, as well as fishing, were prohibited. In this case, it is not possible to evaluate separately the effects of the fishing rules and the beach protection since they are enforced together. However, the positive effect of these joint CBM initiatives on the turtles’ relative abundance was clear, as shown by differences in CPUE between areas with and without CBM initiatives and by this factor being the most significant variable in the models applied. This result indicates that *Podocnemis* turtles may present a behavioral response to fishing pressure. In this case, the less intensely exploited sites, such as the protected areas where fishing and turtle harvesting are prohibited or regulated by a community decision, may be selected by turtles for reproduction or to aggregate during the dry season, when only a few appropriate aquatic habitats are available.

Some studies conducted in the Amazon have found that fishing pressure is a factor affecting Amazon River turtles’ abundance. In the Brazilian blackwater floodplain at Jau National Park, turtle captures far from human settlements obtained higher yields than those near villages due to higher exploitation pressure near human settlements (Rebêlo and Lugli 1996). Fishing pressure was an important factor limiting the abundance of *P. unifilis* and *P. expansa* in the Bolivian Amazon, where higher abundance was observed in sites up to 10 km from the villages, the distance traveled daily by local fishermen (Conway-Gómez 2007).

**Table 2.** General Linear Model analysis for models with $\mathrm{CPUE_N}$ (individuals · 1000 $\mathrm{m^{-2}}$ · 24 hrs) and $\mathrm{CPUE_B}$ (kg · 1000 $\mathrm{m^{-2}}$ · 24 hrs) as dependent variables. CBM = community-based management; $R^2$ = coefficient of determination; $n = 14$ for both models. *$p < 0.05$; **$p < 0.01$.

| | $\mathrm{CPUE_N} = a + b_1\mathrm{CBM} + b_2\mathrm{Distance} + b_3\mathrm{River\ level}$ | $\mathrm{CPUE_B} = a + b_1\mathrm{CBM} + b_2\mathrm{Distance} + b_3\mathrm{River\ level}$ |
|---|---|---|
| $R^2$ | 0.83 | 0.89 |
| CBM | $F = 11.231$** | $F = 19.308$** |
| Distance | $F = 5.644$* | $F = 11.749$** |
| River level | $F = 5.031$* | $F = 6.138$* |

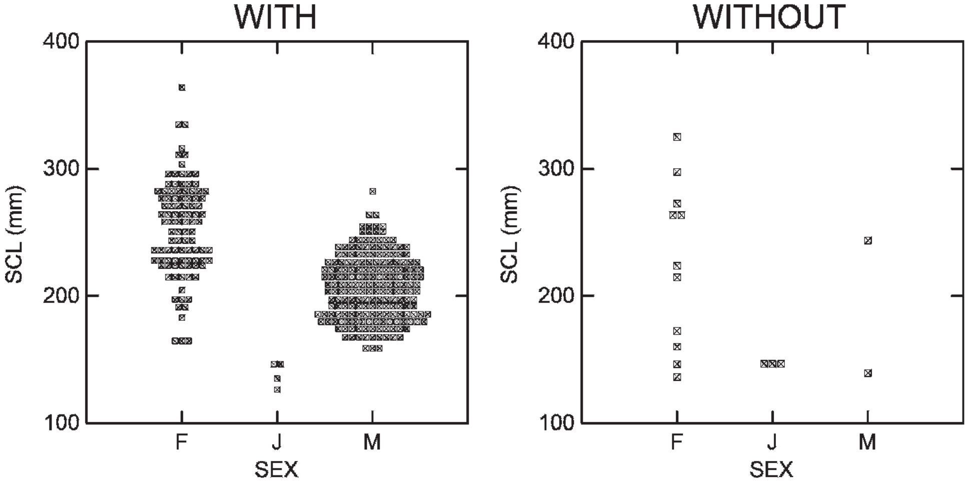

**Figure 3.** Distribution of *Podocnemis sextuberculata* straight-line carapace length (SCL) of individuals caught in areas with ($n = 298$) and without ($n = 16$) community-based management initiatives in the lower Amazon floodplain, 2009 dry season. F = females; J = juveniles; M = males.

While in these studies the fishing pressure decreased according to the distance from human settlements, in the present study the fishing pressure varied among communities according to the rules stipulated by the CBM.

The results of the present study show the importance of managing the use of fishing nets, along with nesting beach protection. It is relevant for conservation purposes in Brazil since it is common to protect the nesting beach but not so usual to control fishing activities around the nesting beaches before they are formed during the falling water season. Demographic studies have revealed that subadults and adults are the most sensitive life stages to regulate turtle population sizes (Heppell et al. 1996; Heppell 1998; Crouse 1999). More recently, Mogollones et al. (2010) identified juveniles and adults as the most sensitive life stages for the giant Amazon river turtle, *P. expansa.* Nesting beach protection may be more effective by precluding adult female poaching than by protecting the eggs and hatchlings themselves since protecting juveniles and adults, more than fecundity, is the conservation action that could recover a population that has already declined (Heppell et al. 1996; Heppell 1998; Crouse 1999; Mogollones et al. 2010). The life history traits of turtles, with a high ratio of eggs and hatchlings to adults, high rate of survivorship of large juveniles and adults, delayed sexual maturity, and long reproductive life spans, all make their populations especially sensitive to the exploitation of juveniles and adults; whereas the harvesting of eggs and hatchlings, which naturally sustain high mortality rates, is of lesser impact (Crouse et al. 1987; Congdon et al. 1993; Thorbjarnarson et al. 2000).

It was documented for the marine species *Lepidochelys kempii* (Cheloniidae) in the Gulf of Mexico that the effect of catching adult turtles may preclude an exploited turtle population from recovery, in addition to the protection of nesting beaches (Heppell et al. 2005). The authors observed that despite long-term protection of nesting beaches, the populations of Mexican coast sea turtles increased only after the adoption of turtle excluder devices (TED) in shrimp fishing nets that prevented the by-catch that was causing high mortality of adults and subadults. More than a decade before that, based on population models, Crouse et al. (1987) had pointed out that the turtle management practices were focused on the least responsive life stages (eggs on nesting beaches) and suggested that the adoption of TEDs might be far more effective. In the Amazon region, adult females are the most preferable individuals for consumption and trade and are caught mainly during the reproductive period (Rebêlo and Lugli 1996; Fachín-Terán et al. 2004; Pezzuti et al. 2004; Caputo et al. 2005; Rebêlo et al. 2005; Kemenes and Pezzuti 2007).

This study found the females were significantly larger and heavier than males, as described for all *Podocnemis* species (Pritchard and Trebbau 1984; Rueda-Almonacid et al. 2007). The sex ratio biased toward males might be a consequence of more intense pressure on the females, as some authors had indicated for podocnemidid species in other sites in Amazonia (Ramo 1982; Fachín-Terán and Vogt 2004; Vogt 2008). Fachín-Terán and Vogt (2004) also found a sex ratio biased toward males in the population of *P. sextuberculata* at Mamirauá. The authors explained that the bias was probably due to human predation mainly due to harvest of females at the nesting beaches, a practice also reported by Haller and Rodrigues (2006) at the Trombetas River Biological Reserve. However, the pressure causing sex ratio bias is just a possibility that requires continuous research to reach conclusive information since there are other factors that cause a biased sex ratio (Bury 1979; Gibbons 1990; Gibbs and Steen 2005).

A comprehensive study on the effect of CBM initiatives for the conservation of Amazon River turtles requires complete information about the species' home ranges, including foraging areas, and population dynamics. Besides that, the influence of some environmental variables needs to be better elucidated, among them the depth influence. Fachín-Terán and Vogt (2004) reported that *P. sextuberculata* concentrate in deep pools during the rising, falling, and low-water season in the Solimões River floodplain. In the lower Amazon floodplain, shallow lakes may dry up completely during severe drought, while deeper lakes concentrate fish and other aquatic fauna. Local fishermen call the deep lakes breeding ponds (McGrath et al. 1993). Deeper (or permanent) lakes may be important for maintaining the aquatic fauna during the dry season, and this perception can be a local criterion for fishing activity restrictions.

The study area recently became an agroextrativist settlement project under Brazilian land reform, where wildlife capture, consumption, and trade are not allowed. However, turtle harvesting is a culturally deep-rooted practice in the Amazon (Bates 1863; Veríssimo 1970; Rebêlo et al. 2005; Pezzuti et al. 2010), and turtle consumption for subsistence is legal for the traditional populations in the Amazon; thus, it is necessary to study ways to guarantee the sustainable use of turtle populations. Traditional initiatives like this one need to be better understood, monitored, and supported by scientific ecological research aiming to achieve conservation of turtles and other important aquatic species, either as a component of biodiversity or as a food security component for local communities. This was the first study to evaluate the effects of community initiatives of management on a turtle population in the Amazon, and studies like this one provide us with some of the necessary information to aid local communities in achieving sustainable use of turtles.

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## LITERATURE CITED

Barthem, R.B. 1987. Uso de redes de espera no estudo de ritmos circadianos de algumas espécies de peixes nos lagos de várzea do rio Solimões. Revista Brasileira de Zoologia 3:409–422.

Batista, V.S., Isaac, V.J., and Viana, J.P. 2004. Exploração e manejo dos recursos pesqueiros da Amazônia. In: Ruffino, M.L. (Ed.). A Pesca e os Recursos Pesqueiros na Amazônia Brasileira. Manaus: ProVarzea/Ibama, pp. 63–151.

Bates, H.W. 1863. The Naturalist on the River Amazon. London: John Murray, 395 pp.

Berkes, F. 2003. Rethinking community-based conservation. Conservation Biology 18:621–630.

Bury, R.B. 1979. Population ecology of freshwater turtles. In: Harless, M. and Morlock, H. (Eds.). Turtles: Perspectives and Research. New York: John Wiley and Sons, pp. 571–602.

Caputo, F.P., Canestrelli, D., and Boitani, L. 2005. Conserving the terecay (*Podocnemis unifilis*, Testudines: Pelomedusidae) through a community-based sustainable harvest of its eggs. Biological Conservation 126:84–92.

Castro, F. and McGrath, D. 2003. Moving toward sustainability in the local management of floodplain lake fisheries in the Brazilian Amazon. Human Organization 62:123–133.

Colding, J., Folke, C., and Elmqvist, T. 2003. Social institutions in ecosystem management and biodiversity conservation. Tropical Ecology 44:25–41.

Congdon, J.D., Dunham, A.E., and van Loben Sels, R.C. 1993. Delayed sexual maturity and demographics of Blanding's turtles (*Emydoidea blandingii*): implications for conservation and management of long-lived organisms. Biological Conservation 7:826–833.

Conway-Gómez, K. 2007. Effects of human settlements on abundance of *Podocnemis unifilis* and *P. expansa* turtles in northeastern Bolívia. Chelonian Conservation and Biology 6: 199–205.

Crouse, D.T. 1999. Population modeling and implications for Caribbean hawksbill turtle management. Chelonian Conservation and Biology 3:185–188.

Crouse, D.T., Crowder, L.B., and Caswell, H. 1987. A stage-based model for loggerhead sea turtles and implications for conservation. Ecology 68:1412–1423.

Departmento Nacional de Produção Mineral. 1976. Levantamentos de Recursos Naturais Projeto RADAMBRASIL. Folha SA. 21SANTARÉM, Geologia, Geomorfologia, Pedologia, Vegetação e Uso Potencial da Terra. Volume 10. Rio de Janeiro: PROJETO RADAMBRASIL, 519 pp.

Fachín-Terán, A. and Vogt, R.C. 2004. Estrutura populacional, tamanho e razão sexual de *Podocnemis unifilis* (Testudines, Podocnemididae) no Rio Guaporé (RO), norte do Brasil. Phyllomedusa 3:29–42.

Fachín-Terán, A., Vogt, R.C., and Thorbjarnarson, J.B. 2004. Patterns of use and hunting of turtles in the Mamirauá Sustainable Development Reserve, Amazonas, Brazil. In: Silvius, K.M., Bodmer, R.E., and Fragoso, J.M.V. (Eds.). People in Nature: Wildlife Conservation in South and Central America. New York: Columbia University Press, pp. 362–377.

Fachín-Terán, A., Vogt, R.C., and Thorbjarnarson, J.B. 2005. Seasonal movements of *Podocnemis sextuberculata* (Testudines, Podocnemididae) in Mamirauá Sustainable Development Reserve, Amazonas, Brazil. Chelonian Conservation and Biology 5:18–24.

Gibbons, J.W. 1990. Sex ratios and their significance among turtle populations. In: Gibbons, J.W. (Ed.). Life History and Ecology of the Slider Turtle. Washington, DC: Smithsonian Institution Press, pp. 171–182.

Gibbs, J.P. and Steen, D.A. 2005. Trends in sex ratio of turtles in the United States: implications of road mortality. Conservation Biology 19:552–556.

Gotelli, N.J. and Ellison, A.M. 2004. A Primer of Ecological Statistics. Sunderland: Sinauer Associates, Inc., 510 pp.

Goulding, M. 1980. The Fishes and the Forest. Explorations in Amazonian Natural History. Berkeley: University of California Press, 280 pp.

Haller, E.C.P. and Rodrigues, M.T. 2006. Reproductive biology of the six-tubercled Amazon River turtle *Podocnemis sextuberculata* (Testudines: Podocnemididae), in the Biological Reserve of Rio Trombetas, Pará, Brazil. Chelonian Conservation and Biology 5:280–284.

Heppell, S.S. 1998. Application of life-history theory and population model analysis to turtle conservation. Copeia 1998:367–375.

Heppell, S.S., Crouse, D.T., Crowder, L.D., Epperly, S.P., Gabriel, W., Henwood, T., Márquez, R., and Thompson, N.B. 2005. A population model to estimate recovery time, population size, and management impacts on Kemp's Ridley sea turtles. Chelonian Conservation and Biology 4:767–773.

Heppell, S.S., Crowder, L.B., and Crouse, D.T. 1996. Models to evaluate headstarting as a tool for long-lived turtles. Ecological Applications 6:556–565.

International Union for Conservation of Nature. 2011. IUCN Red List of Threatened Species. Version 2011.2. *Podocnemis expansa*. www.iucnredlist.org/apps/redlist/search (28 February 2011). Published 1996.

Johannes, R.E. 2002. The renaissance of community-based marine resource management in Oceania. Annual Reviews in Ecology and Systematics 33:317–340.

Junk, W.J., Bayley, P.B., and Sparks, R.E. 1989. The flood pulse concept in river-floodplain systems. Proceedings of the International Large River Symposium. Canadian Special Publications in Fisheries and Aquatic Science 106:110–117.

Junk, W.J. and Piedade, M.T.F. 1997. Plant life in the floodplain with special reference to herbaceous plants. In: Junk, W.J. (Ed.). The Central Amazon Floodplain: Ecological Studies. Berlin: Springer, pp. 147–185.

Kearney, J., Berkes, F., Charles, A., Pinkerton, E., and Wiber, M. 2007. The role of participatory governance and community-based management in integrated coastal and ocean management in Canada. Coastal Management 35:79–104.

Kemenes, A. and Pezzuti, J.C.B. 2007. Estimate of trade traffic of *Podocnemis* (Testudines, Podocnemididae) from the Middle Purus River, Amazonas, Brazil. Chelonian Conservation and Biology 6:259–262.

Kuchling, G. 1997. Patterns of exploitation, decline and extinction of *Erymnochelys madagascariensis*: implications for conservation. In: Van Ebbema, J. (Ed.). Proceedings: Conservation, Restoration and Management of Tortoises and Turtles—An International Conference. New York: New York Turtle and Tortoise Society, pp. 113–117.

McGrath, D.G. 2000. Avoiding a tragedy of the commons: recent developments in the management of Amazonian fisheries. In: Hall, A. (Ed.). Amazonia at the Crossroads: The Challenge of Sustainable Development. London: Institute of Latin American Studies, pp. 171–197.

McGrath, D., Cardoso, A., Almeida, O.T., and Pezzuti, J. 2008. Constructing a policy and institutional framework for an ecosystem-based approach to managing the lower Amazon floodplain. Environment, Development and Sustainability 10: 677–695.

McGrath, D.G., Castro, F., Futemma, C., Amaral, B.D., and Calabria, J. 1993. Fisheries and the evolution of resource management on the lower Amazon floodplain. Human Ecology 21:167–195.

Mittermeier, R.A. 1975. A turtle in every pot: a valuable South American resource going to waste. Animal Kingdom 78(April–May):9–14.

Mogollones, S.C., Rodríguez, D.J., Hernández, O., and Barreto, G.R. 2010. A demographic study of the arrauturtle (*Podocnemis expansa*) in the middle Orinoco river, Venezuela. Chelonian Conservation and Biology 9:79–89.

Moll, D. and Moll, E.O. 2004. The Ecology, Exploitation and Conservation of River Turtles. New York: Oxford University Press, 393 pp.

Pezzuti, J.C.B., Barboza, R., Nunes, I., Miorando, P.S., and Fernandes, L. 2010. Etnoecologia e conservação de quelônios Amazônicos: um estudo de caso. In: Alves, R.R.N., Souto, W.M.S., and Mourão, J.S. (Eds.). A Etnozoologia no Brasil. Importância, Status Atual e Perspectivas. Belém: NUPEEA, pp. 449–469.

Pezzuti, J.C.B., Nunes, I., Barboza, R.S.L., Oliveira, V., Fernandes, L., and Miorando, P. 2008. Avaliação participativa das populações de quelônios na várzea do Baixo Amazonas, Pará. Relatório Final do projeto ''Manejo Integrado da Fauna Aquática na Várzea: Pirarucu, Quelônios e Jacarés.'' Processo CNPq 557114/2005-5.

Pezzuti, J.C.B., Rebêlo G.H., Felix-Silva, D., Lima, J.P., and Ribeiro, M.C. 2004. A caça e a pesca no Parque Nacional do Jaú, Amazonas. In: Borges, S.H., Durigan, C.C., and Iwanaga, S. (Eds.). Janelas para a Biodiversidade. Manaus: Fundação Vitória Amazônica, pp. 213–230.

Pezzuti, J.C.B. and Vogt, R.C. 1999. Nesting ecology of *Podocnemis sextuberculata* (Testudines, Pelomedusidae) in the Japurá River, Amazonas, Brazil. Chelonian Conservation and Biology 3:419–424.

Pomeroy, R.S. and Berkes, F. 1997. Two to tango: the role of government in fisheries co-management. Marine Policy 21: 465–480.

Pritchard, P.C.H. and Trebbau, P. 1984. Turtles of Venezuela. Oxford, OH: Society for the Study of Amphibians and Reptiles, 404 pp.

Ramo, C. 1982. Biología del galapago (*Podocnemis vogli* Muller, 1935) em el Hato El Frio. Doñana Acta Vertebrata 9:1–161.

Rebêlo, G.H. and Lugli, L. 1996. The conservation of freshwater and the dwellers of the Amazonian Jaú National Park (Brazil). In: Jain, S.K. (Ed.). Ethnobiology in Human Welfare. New Delhi: Deep Publications, pp. 253–258.

Rebêlo, G., Pezzuti, J.C.B., Lugli, L., and Moreira, G. 2005. Pesca artesanal de quelônios no Parque Nacional do Jaú (AM). Boletim do Museu Paraense Emilio Goeldi 1:111–127.

Rueda-Almonacid, J.V., Carr, J.L., Mittermeier, R.A., Rodrigues-Mahecha, J.V., Mast, R.B., Vogt, R.C., Rhodin, A.G.J., De La ossa-Velasquez, J., Rueda, J.N., and Mittermeier, C.G. 2007. Las Tortugas e Cocodrilianos de los Países Andinos e Del Trópico. Serie de Guias Tropicales de Campo. Bogotá: Conservación Internacional, 537 pp.

Ruffino, M.L., Isaac, V.J., and Milsten, A. 1998. Fisheries ecology in the lower Amazon: a typical artisanal practice in the tropics. Ecotropica 4:99–114.

Sen, S. and Nielsen, J.R. 1996. Fisheries co-management: a comparative analysis. Marine Policy 5:405–418.

Smith, N.J.H. 1974. Destructive exploitation of the South American River Turtle. Yearbook, Association of Pacific Coast Geographers 36:85–102.

Smith, N.J.H. 1979. Aquatic turtles of Amazonia: an endangered resource. Biological Conservation 16:165–176.

Thorbjarnarson, J., Lageux, C.L., Bolze, D., Klemens, M.W., and Meylan, A.B. 2000. Human use of turtles. In: Klemens, M.W. (Ed,). Turtle Conservation. Washington, DC: Smithsonian Institution Press, pp. 33–84.

Toledo, V.M., Ortiz-Espejel, B., Cortés, L., Moguel, P., and Ordoñez, M.D.J. 2003. The multiple use of tropical forests by indigenous peoples in Mexico: a case of adaptive management. Conservation Ecology 7:9–25.

Veríssimo, J. 1970. A Pesca na Amazônia. Belém: UFPA, 130 pp.

Vogt, R.C. 2008. Tartarugas da Amazônia. Manaus: Richard Vogt, 104 pp.

Zar, J.H. 2010. Biostatistical Analysis. Fifth edition. Englewood Cliffs, NJ: Prentice Hall, 944 pp.

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