

IMPACTS OF JAGUAR PREDATION ON NESTING SEA TURTLES AT NANCITE BEACH, SANTA ROSA NATIONAL PARK, COSTA RICA

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Abstract.—Jaguar (*Panthera onca*) predation on sea turtles occurs across the Americas; however, records are scattered and not frequently presented in terms of their potential effects on sea turtle populations. In this study, we documented Jaguar predation events on nesting sea turtles at Nancite Beach, Santa Rosa National Park, Costa Rica, between the 2009–2010 and 2018–2019 nesting seasons (excluding 2012–2013 and 2013–2014). We also estimated the size of the local nesting populations for each sea turtle species to assess potential impacts of Jaguar predation. We documented 160 Olive Ridley Sea Turtles (*Lepidochelys olivacea*) and 11 Green Turtles (*Chelonia mydas*) that were eaten by Jaguars during our study period, corresponding to fewer than 1% and 8–40% of the nesting populations of Olive Ridley Sea Turtles and Greens, respectively. Relative to the size of each nesting population, these results suggest that Jaguar predation does not represent a significant threat to Olive Ridley Sea Turtles. Although Jaguars do not constitute a threat to Green Turtles at a regional-scale, they could influence the persistence of the nesting population at Nancite Beach if their predation rates continue over time.

Key Words.—*Chelonia mydas*; *Lepidochelys olivacea*; *Panthera onca*; predator-prey interaction; wild felid

INTRODUCTION

Adult sea turtles have few natural predators. In the marine environment, predators include Killer Whales (*Orcinus orca*) and at least six shark species: hammerhead (*Sphyrna* sp.), Lemon (*Nagapriion brevirostris*), White (*Carcharodon carcharias*), Bull (*Carcharhinus leucas*), Oceanic White Tip (*C. longimanus*), and Tiger (*Galeocerdo cuvier*) sharks (Stancyk 1981; Witzell 1987; Fergusson et al. 2000; Pitman and Dutton 2004; Heithaus et al. 2007). Nesting sea turtles also face the risk of predation on land by American Crocodiles (*Crocodylus acutus*; Ortiz et al. 1997), Saltwater Crocodiles (*Crocodylus porosus*; Whiting and Whiting 2011), Coyotes (*Canis latrans*; Drake et al. 2001), and Jaguars (*Panthera onca*; Arroyo-Arce and Salom-Pérez 2015). Throughout the Americas, Jaguar predation has been documented for five species of sea turtles (Table 1): Green (*Chelonia mydas*), Olive Ridley (*Lepidochelys olivacea*), Hawksbill (*Eretmochelys imbricata*), Leatherback (*Dermochelys coriacea*), and Loggerhead (*Caretta caretta*) sea turtles.

Jaguars are considered an opportunistic predator across their geographic range (Seymour 1989; Núñez et

al. 2002), adapting their hunting behavior in response to prey availability (Rabinowitz and Nottingham 1986). For example, Jaguar predation events on sea turtles occur as females return to land to lay eggs, and some authors suggest that, during the peak of the nesting season, Jaguars restrict their movement to the coastal habitat as a strategy to maximize the consumption of a highly available prey item (Carrillo et al. 2009; Arroyo-Arce and Salom-Pérez 2015; Montalvo et al. 2020). Due to the conical adaptation of their canine teeth and powerful bite force, Jaguars can kill sea turtles with a crushing bite to the skull or to the neck area (Schaller and Vasconcelos 1978; this study). Then, they use their claws to reach the internal organs from the neck area (carapace, flippers, and head are not consumed). When feeding upon small species of sea turtles (e.g., Olive Ridley Sea Turtles), Jaguars may bite through the carapace as part of the feeding process. For larger species, including Leatherbacks and occasionally in Green Turtles, Jaguars can also tear the rear flippers to facilitate access, and even bite through the carapace to feed on the eggs (Escobar et al. 2016b; Ian Thomson, pers. comm.). Because Jaguars can feed from sea turtle carcasses for several days, carcasses of all species except

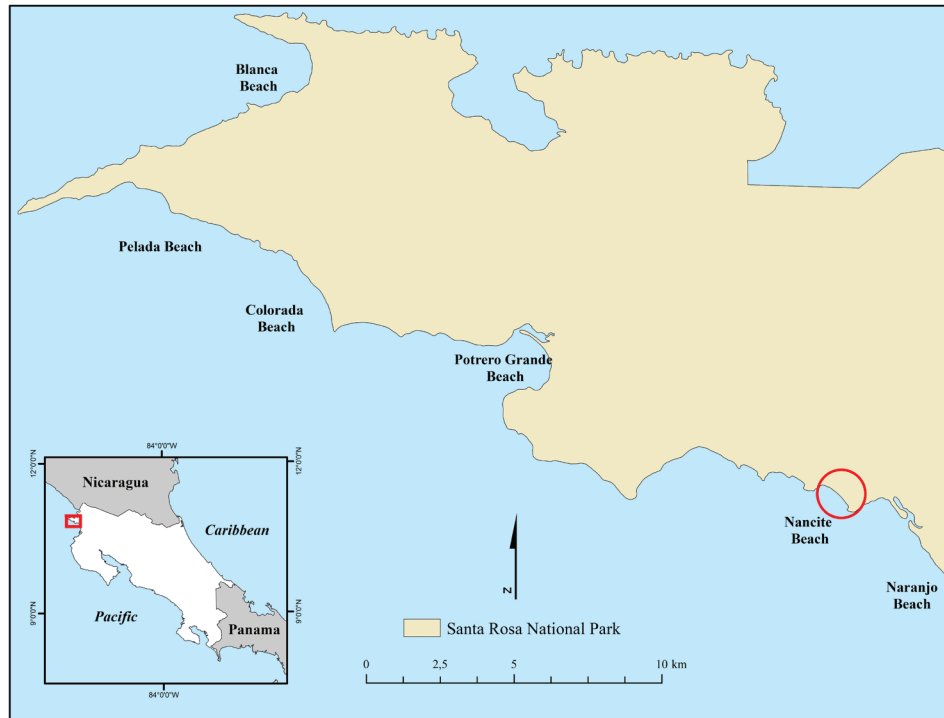


FIGURE 1. Location of Nancite Beach and other nesting beaches in Santa Rosa National Park, Guanacaste Conservation Area, Costa Rica.

Leatherbacks may be dragged deep into the vegetation to protect the remains from other wild felids (e.g., other Jaguars and Pumas, *Puma concolor*) and scavenger species (Black Vultures, *Coragyps atratus*, and Turkey Vultures, *Cathartes aura*; Guilder et al. 2015; Fonseca et al. 2018).

On Nancite Beach, located in Santa Rosa National Park, Costa Rica, Jaguar predation on sea turtles has been documented sporadically since the 1980s (Table 1). This beach is considered an important rookery for Olive Ridley Sea Turtles in the Eastern Tropical Pacific (Cornelius and Robinson 1983), as arribadas (synchronized mass nesting events) and solitary nesting occurs throughout the year (Janzen 1988; Fonseca et al. 2009). It also hosts relatively small nesting populations of Green Turtles that nest throughout the year and Leatherbacks that nest between October and February (Cornelius 1986; Fonseca et al. 2009; Herrera et al. 2016).

Prior to the establishment of Santa Rosa National Park in 1972, the landscape was dominated by agricultural and livestock farms, where illegal hunting of wild animals occurred (Janzen 1988). Since the creation of the park, however, a series of actions were adopted to protect local wildlife and their habitats, including controlling illegal activities, forest fire management, and land acquisition (Quirós-Arias 2017). Although there is little information available regarding Jaguar population estimates for Santa Rosa National Park as a whole, data has been collected at Nancite Beach as part of a long-

term camera trap monitoring project started in 2010, suggesting an increase in individuals identified (Luis Fonseca et al., unpubl. report). It is likely, therefore, that recent conservation efforts have played an important role in allowing the local Jaguar population to use the coastal habitat of Santa Rosa National Park with more frequency over the years, potentially triggering predator-prey interactions between Jaguars and sea turtles (Fonseca et al. 2017). A similar pattern was observed by Arroyo-Arce (2013) and Arroyo-Arce et al. (2014), who suggested that Jaguars have been expanding their spatial distribution to nesting beaches inside protected areas, causing the felids to increasingly select sea turtles as prey. As a result, it is crucial to monitor and assess the effects of this interaction so that conservation efforts can ensure adequate co-management of these flagship species. The goals of our study were to quantify the number of Jaguar predation events on nesting sea turtles on Nancite Beach and to compare the number of turtles predated annually by Jaguars with the size of the local nesting population for each turtle species. These data will provide a baseline for understanding the threat posed by Jaguars on these nesting populations.

MATERIALS AND METHODS

Study site.—Nancite Beach is located on the north-west Pacific coast of Costa Rica (10°48'12"N, 85°41'47"W) within the Santa Rosa National Park, Guanacaste Conservation Area (Fig. 1). The beach is

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TABLE 1. Published and unpublished records of Jaguar (*Panthera onca*) predation on nesting sea turtles across the Americas. Abbreviations are Dc = *Dermochelys coriacea*, Cm = *Chelonia mydas*; Cc = *Caretta caretta*; Lo = *Lepidochelys olivacea*, Ei = *Eretmochelys imbricata*, UN = year and number of predation events unspecified.

Country	Years	Number of turtles predated					Source
		Dc	Cm	Cc	Lo	Ei	
Amana Nature Reserve, French Guiana	UN ^a	UN ^a	0	0	0	0	Turtle Expert Working Group (2007)
Yalimapo Beach, French Guiana	1983	2	0	0	0	0	Fretey (1977)
Bigisanti Beach, Suriname	1963–1973	3	82	0	7	0	Autar (1994)
Galibi Beach, Suriname	1980	0	13	0	0	0	Autar (1994)
Galibi Beach, Suriname	1994	0	UN ^a	0	0	0	Autar (1994)
Almond Beach, Guyana	2012–2013	5	4	0	0	1	Keeran, D. 2013. Jaguars killing endangered marine turtles almost for fun. Available from http://www.kaieteurnews.com/2013/07/14/jaguars-killingendangered-marine-turtles-almost-for-fun-conservationist/ [Accessed 03 November 2019].
Sian Ka'an Biosphere Reserve, Yucatan Peninsula, México	2011	0	3	0	0	2	Cuevas et al. 2014. Marine turtles and Jaguars: two mystical species coexisting on the coast of Quintana Roo, México. Available from http://casablancafishing.com/wp-content/uploads/2013/07/Jaguars-and-Marine-Turtles.pdf . [Accessed 13 November 2019].
Corcovado Natl. Park, Costa Rica	1993–1994	0	0	0	UN ^a	0	Chinchilla (1997)
Corcovado Natl. Park, Costa Rica	1996–1998	0	2	0	14	0	Carrillo et al. (2009)
Corcovado Natl. Park, Costa Rica	2002–2003	0	0	0	7	0	Salom (2005)
Nancite Beach, Santa Rosa Natl. Park, Costa Rica	1981–1984	0	0	0	9	0	Cornelius and Robinson (1983)
Nancite Beach, Santa Rosa Natl. Park, Costa Rica	1988	0	0	0	13	0	Carrillo et al. (1994)
Nancite Beach, Santa Rosa Natl. Park, Costa Rica	1996	0	0	0	1	0	Mo et al. (1996)
Nancite Beach, Santa Rosa Natl. Park, Costa Rica	1997	0	0	0	1	0	Pankratz (unpubl. report)
Nancite Beach, Santa Rosa Natl. Park, Costa Rica	1999–2004	0	0	0	4	0	Santa Rosa Natl. Park, Ranger logbook (<i>unpublished data</i>)
Naranjo Beach, Santa Rosa Natl. Park, Costa Rica	2012–2013	0	19	0	9	0	Alfaro et al. (2016)
Potrero Grande Beach, Santa Rosa Natl. Park, Costa Rica	2015	0	0	0	0	1	Herrera et al. (2016)
Santa Rosa Natl. Park, Costa Rica	2016	0	68	0	113	1	Fonseca et al. (2017)
Pacuare Nature Reserve, Costa Rica	2014	0	1	0	0	0	Arroyo-Arce et al. (2016)
Playa Tres, Limón, Costa Rica	2017–2020	3	1	0	0	0	Coastal Jaguar Conservation, unpubl. data; Gilberto Borges, pers. comm.
Tortuguero Natl. Park, Costa Rica	1981	0	1	0	0	0	Carrillo et al. (1994)
Tortuguero Natl. Park, Costa Rica	1984	0	1	0	0	0	Troëng (2000)
Tortuguero Natl. Park, Costa Rica	1997–2004	2	370	0	0	5	Troëng (1997), Troëng et al. (1999, 2000a,b); Mangel et al. (2001); Reyes et al. (2001, 2002); Harrison et al. (2003, 2004, 2005)
Tortuguero Natl. Park, Costa Rica	2005–2013	15	1078	0	0	17	Arroyo-Arce et al. (2015)
Tortuguero Natl. Park, Costa Rica	2014–2019	34	2035	1	0	32	Arroyo-Arce et al. (2017, 2019)

approximately 1.05 km in length and is surrounded by preserved ecosystems characterized by patches of dry forest (deciduous and semi-deciduous), mangroves, lagoons, and two rocky outcrops that delimit the beach. Human activity is regulated by the National Park and also limited by the difficulty in access to the area (Alfaro et al. 2016). Average temperature ranges from 18° C to 36° C, with a mean annual precipitation of 1,500 mm (Janzen 2004).

Data collection and handling.—Between July 2009 and February 2019, we conducted morning surveys (0900 to 1100) to record Jaguar predation events and nocturnal patrols (2000 to 0400) to estimate the size of the local nesting population for each turtle species. Although Olive Ridley Sea Turtles and Green Turtles nest year-round on Nancite Beach, nesting for both species peak from September to November and December to April, respectively. For this reason, we combined data collected between June of one year and May of the following year during eight nesting seasons: 2009–2012 and 2014–2019. We made every effort to conduct both surveys on a daily basis, but funding and logistical limitations prevented daily surveys sporadically during most years, and entirely during two nesting seasons (2012–2013 and 2013–2014).

We documented Jaguar predation on sea turtles by counting sea turtle carcasses along the beach. When a carcass was found, it was examined for evidence of Jaguar predation, such as bite marks on the neck, drag marks in the sand, and Jaguar tracks in proximity (3–5 m) to the carcass. If evidence of predation was found, then we recorded the turtle species and geographic location of the carcass. Although Pumas have been recorded scavenging Jaguar kills at Nancite Beach (Escobar-Lasso et al. 2016a), there is no evidence that Pumas actively kill sea turtles (Fonseca et al. 2018) and therefore all predated carcasses were assumed to be Jaguar kills.

To estimate the size of the local nesting population of Olive Ridley Sea Turtles, we first estimated the total number of nests laid each season (see Fonseca et al. 2009, 2012 for more detailed methodology). When arribadas occurred, we estimated the number of nests based on well-established methodologies, which consisted of setting up 2-m wide transects extending from the vegetation line to the high tide line every 100 m along the beach prior to an arribada (Gates et al. 1996; Valverde and Gates 1999). Along the transects, all turtles with eggs visible in the nest chamber were counted every 2 h for the entire duration of each arribada. The estimated number of clutches deposited during arribadas was then added to the number of solitary nests each season, which were counted individually during nocturnal surveys. We then estimated the number of individuals nesting each season by dividing the annual

number of nests by the average clutch frequency for Olive Ridley Sea Turtles (2.21 nests/female/season; van Buskirk and Crowder 1994).

For Green Turtles, we estimated the local nesting population size by tagging all nesting females encountered during the nocturnal surveys with individualized tags (Inconel model 681, National Band and Tag Company, Newport, Kentucky, USA) and counting the total number of individual females encountered each season. We tagged the turtles once they finished laying their eggs and started covering the nest chamber, or when they were encountered returning to the sea. We tagged all turtles in the second proximal scale of each front flipper, after cleaning the scales with an iodine-based disinfectant.

Data analysis and interpretations.—For each season, we estimated Jaguar predation rates for each turtle species by dividing the estimated number of females in the nesting population each year by the number of turtles that were predated on and multiplying by 100 (Arroyo-Arce and Salom-Pérez 2015). To contextualize our results in terms of the effect that Jaguar predation may have on local population persistence, we compared our annual predation rates against an estimated annual mortality rate for adult sea turtles of 0.05 (e.g., each nesting female has a 5% chance of mortality each year of adult life). Because annual survivorship in adult sea turtles is predicted to be high (natural annual survivorship of approximately 0.95; Mazaris et al. 2006), we would expect a predation rate of 5% or greater to detrimentally affect the likelihood of local population persistence over time. Conversely, a predation rate < 5% would likely not represent a significant threat to population persistence.

RESULTS

Based on the morning surveys conducted between the 2009–2010 and 2018–2019 nesting seasons (mean survey days per nesting season = $279 \pm$ (standard error) 55 d; Table 2), we documented 171 carcasses of two sea turtle species that demonstrated signs of Jaguar predation (160 Olive Ridley Sea Turtles and 11 Green Turtles). Based on the night surveys, the local nesting population of Olive Ridley Sea Turtles ranged from 10,732 females in the 2009–2010 nesting season to 54,400 females in the 2017–2018 nesting season (mean number of females per nesting season = $32,040 \pm 12,149$ females; Fig. 2). The local nesting population of Green Turtles ranged from two females in the 2016–2017 nesting season to 26 females in the 2014–2015 nesting season (mean number of females per nesting season = 13.0 ± 8.2 females; Fig. 2).

We found that predation of Olive Ridley Sea Turtles fluctuated over the years (Fig. 2) with the highest number of predation events (52 carcasses) recorded during the 2016–2017 nesting season, representing 0.19% of the

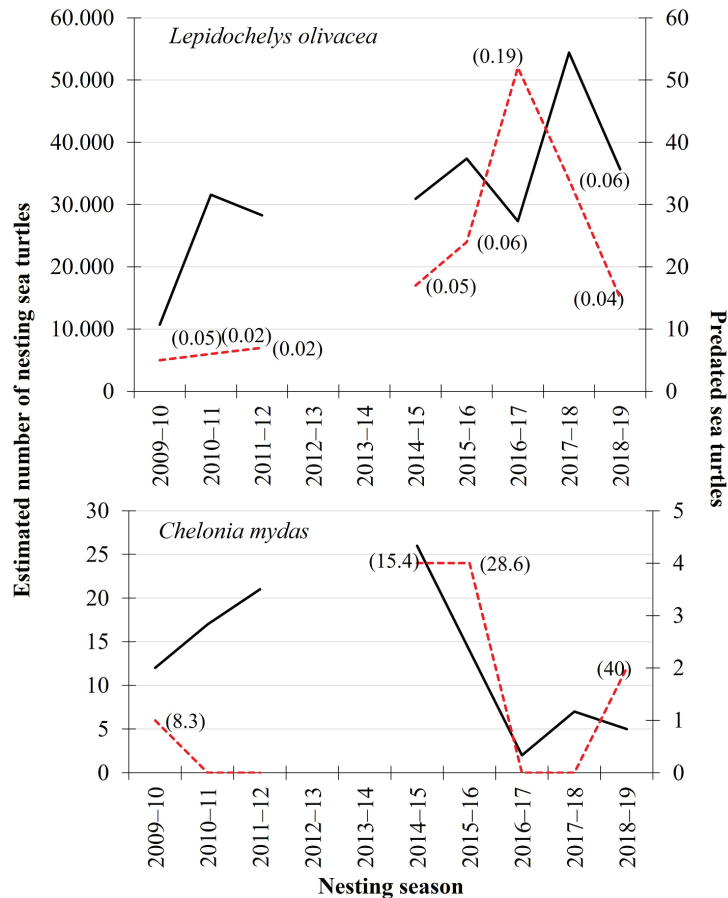


FIGURE 2. Jaguar (*Panthera onca*) predation on Olive Ridley Sea Turtles (*Lepidochelys olivacea*) and Green Turtles (*Chelonia mydas*) nesting populations at Nancite Beach, Santa Rosa National Park, Costa Rica. Solid lines are the estimated number of nesting turtles, dash lines are the total number of predated sea turtles, and numbers in parentheses are predation rate (number predated/number of nesting turtles)*100.

TABLE 2. Sampling effort per nesting season for documenting Jaguar (*Panthera onca*) predation on sea turtles on Nancite Beach, Santa Rosa National Park, Costa Rica. The abbreviation NA = no surveys conducted.

Nesting Season	Start Date	End Date	Survey Days
2009-10	1 July 2009	13 March 2010	255
2010-11	17 July 2010	30 June 2011	348
2011-12	1 July 2011	30 June 2012	365
2012-13	NA	NA	NA
2013-14	NA	NA	NA
2014-15	29 June 2014	28 February 2015	244
2015-16	7 June 2015	30 January 2016	237
2016-17	1 June 2016	15 March 2017	287
2017-18	28 May 2017	14 March 2018	290
2018-19	5 August 2018	28 February 2019	207

nesting population. Our results demonstrate that Jaguars annually consumed < 1% of the nesting population of Olive Ridley Sea Turtles (Fig. 2). We found that predation of Green Turtles also fluctuated over the years (Fig. 2), with the highest number of predation events (four carcasses) recorded in both the 2014–2015 and 2015–2016 nesting seasons, representing 15.4% and 28.6% of the nesting population, respectively. We documented no predation events in four nesting seasons. Our results demonstrate that Jaguars annually consumed between 8.33% to 40% of the local nesting population (Fig. 2).

DISCUSSION

The higher frequency of Jaguar predation on Olive Ridley Sea Turtles compared to that of Green Turtles can likely be attributed to the higher abundance and availability of the former, and not to a preference for that species. Olive Ridley Sea Turtles nest in large numbers and exhibit both arribada and solitary nesting behavior

at Nancite Beach, while Green Turtle abundance is much lower, and nesting is solitary (Plotkin 2007; Fonseca et al. 2009). Thus, the probability of a Jaguar encountering an Olive Ridley Sea Turtle, and therefore predation, is higher in comparison to Green Turtles. A similar density-dependent pattern was observed at Tortuguero National Park, Costa Rica, where Jaguars kill more Green Turtles than Leatherback, Hawksbill, or Loggerhead sea turtles, likely due to their higher abundance and availability throughout the year (Arroyo-Arce and Salom-Pérez 2015; Arroyo-Arce et al. 2017; Arroyo-Arce et al. 2018). Salom (2005) also reported density-dependent predation by Jaguars on Olive Ridley Sea Turtles relative to Green Turtles and Leatherbacks in Corcovado National Park, Costa Rica.

Given that Jaguars can drag the carcasses of all sea turtles except Leatherbacks into the vegetation regardless of their size and weight, and due to the well-known generalist and opportunistic behavior of Jaguars (Rabinowitz and Nottingham 1986), we do not believe that morphological characteristics of sea turtles explain frequency of Jaguar predation in the study area. Given that Jaguars are capable of lifting and carrying the carcasses of smaller Olive Ridley Sea Turtles (carapace length: up to 790 mm; weight: up to 60 kg; Savage 2002) into the vegetation without leaving any identifiable traces, however, a small number of predation events on this species might have been missed. In contrast, predation events by Jaguars on larger Green Turtles (carapace length: 900–1,220 mm; weight: 113–200 kg; Savage 2002) always exhibit clear dragging tracks on the sand or vegetation, making it easy to find their carcasses.

Annual predation rates on Olive Ridley Sea Turtles at Nancite Beach were consistently below 1% of the nesting population. Even though adult sea turtles are predicted to exhibit naturally high annual survivorship (approximately 0.95; Mazaris et al. 2006), a threat that affects < 1% of the annual nesting population is unlikely cause to population decline. Therefore, Jaguar predation likely does not represent a significant threat to the persistence of Olive Ridley Sea Turtles nesting at this regionally important site. Nevertheless, the Olive Ridley Sea Turtle nesting population at Nancite Beach has decreased by approximately 59% from 1971 to 2017 (Valverde et al. 1998; Fonseca et al. 2009; Luis Fonseca et al., unpubl. report). At the same time, it appears that the local Jaguar population is rising. A camera trap study initiated in 2010 identified two individual jaguars in that year, increasing to 11 in 2019, documenting a total of 22 Jaguars between 2010 and 2019 (Luis Fonseca et al., unpubl. report). Despite this apparent increase in local Jaguar abundance, predation rates have remained at < 1% throughout the study period, suggesting that the decline in the local nesting population is likely caused

by threats other than Jaguar predation.

One of the main factors that could be contributing to the Olive Ridley Sea Turtle population decline is the low recruitment within the population due to the low hatching success during the years in which the arribadas exceeded 100,000 nests (Valverde et al. 1998; Fonseca et al. 2009). Another significant source of stress for this population is the incidental capture of both juveniles and adults in fishing gear (Plotkin 2007; Mast et al. 2005; Dapp et al. 2013). Dapp et al. (2013) estimated that the Costa Rica longline fisheries caught 699,600 Olive Ridley Sea Turtles (including 92,300 adult females) between 1999 and 2010 in the Central American Pacific, a fishing area adjacent to several arribada beaches including Nancite Beach. Other hazards contributing to its decline are mortality due to take (e.g., human consumption of eggs and meat), pollution and pathogens, climate change, and the degradation or loss of feeding, nesting, migratory, and resting habitats across its geographic range (Cornelius and Robinson 1983; National Research Council 1990; Orrego 2002). These factors all amplify the natural threats already faced by nesting sea turtles, as well as their eggs and hatchlings, such as predation by crustaceans (Ghost Crab, *Ocypode quadrata*), fish, reptiles (crocodiles, lizards, snakes), birds (seabirds, vultures, pelicans, falcons) and mammals (Coyotes, Raccoons, *Procyon lotor*, Coatis, *Nasua narica*, and Jaguars; Hughes and Richard 1974; Cornelius and Robinson 1983; Francia 2004).

Despite the current Olive Ridley Sea Turtle population trend at Nancite Beach, the status of the two East Pacific Regional Management Units (RMUs) suggests a positive trend for the species at a broader population-level (Wallace et al. 2010; Wallace et al. 2011). The East Pacific Ocean Arribada RMU has been categorized as Low Risk-Low Threats, suggesting a positive population trend with low to moderate threats. Further, the East Pacific Ocean Solitary Nesters RMU is considered Low Risk-High Threats, differing from the first in that it is subject to persistent threats that could jeopardize the long-term status of turtles in the RMU. Because both RMUs encompass nesting beaches from Mexico to Peru, and Jaguar predation has only been recorded in a few locations, we would not consider Jaguar predation to be a significant threat for Olive Ridley Sea Turtles at either a local or RMU-wide scale. Further, although the Olive Ridley Sea Turtle population at Nancite Beach has declined (Valverde et al. 1998; Fonseca et al. 2009; Luis Fonseca et al., unpubl. report), there is evidence to suggest that Olive Ridley Sea Turtles could recover if the current hatching rate of the population (hatching success) remains stable, a pattern observed during the last 13 y (Luis Fonseca et al., unpubl. report).

Although the nesting population of Green Turtles

at Nancite Beach is very small on a regional-scale, the annual predation rate is consistently greater than 5% and occasionally much higher (40%). Because annual survivorship in adult sea turtles is predicted to be high, a predation rate of 5% or greater could detrimentally affect the persistence of Green Turtles nesting at this site over time. In fact, the Green Turtle nesting population at Nancite Beach has fluctuated over the years, characterized by a negative trend (a decline of 32% between 2010 to 2019), while Jaguar numbers have increased in the park over the same years. While the nesting decline could be related to the same threats faced by Olive Ridley Sea Turtles, it cannot be ruled out that Jaguar predation may have, at least in part, contributed to this decline. Despite this negative local trend, the East Pacific Ocean RMU has been categorized as Low Risk-Low Threats (Wallace et al. 2010; Wallace et al. 2011). The Green Turtle nesting population at Nancite Beach is only a small fraction of the broader population, which includes San José Island, Murciélago Archipelago, Costa Rica, one of the most important nesting sites for the East Pacific Ocean RMU (Fonseca et al. 2018). Therefore, based on the current information regarding this predator-prey interaction across the RMUs, we conclude that Jaguars do not constitute a hazard to Green Turtles at a regional level but could influence the recovery of the nesting population at Nancite Beach.

Long-term studies assessing Jaguar predation on sea turtles across the Americas are limited (Arroyo-Arce and Salom-Pérez 2015). Arroyo-Arce and Salom-Pérez (2015) and our findings for Olive Ridley Sea Turtles suggest that although this predator-prey interaction varies between locations, time, and sea turtle species, it is generally not sufficiently high to influence sea turtle populations at local-scales. Conversely, our findings for Green Turtles suggest that Jaguar predation can detrimentally affect the local persistence of small nesting populations when only a few nesting females are predated each year, suggesting that Jaguars may have the capacity to impact sea turtle populations at local-scales. Ortiz et al. (1997) and Fergusson et al. (2000) suggested that White Shark and American Crocodile predation upon sea turtles pose no population-level threat. In contrast, Heithaus et al. (2008) and Pitman and Dutton (2004) suggested that despite low predation rates, predators of adult sea turtles can influence sea turtle populations. Therefore, we consider it important to establish long-term monitoring efforts where this predator-prey interaction occurs to help fill important knowledge gaps, such as the impacts of Jaguars on sea turtle populations and the ecological factors triggering this predator-prey dynamic. For example, sea turtles may be inducing a shift in the spatial and temporal distribution of the Jaguar during the nesting season.

A greater knowledge of this subject will improve conservation efforts of both Jaguars and sea turtles in areas where both species coexist.

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LITERATURE CITED

- Alfaro, L.D., V. Montalvo, F. Guimaraes, J. Sáenz, J. Cruz, F. Morazán, and E. Carrillo. 2016. Characterization of attack events on sea turtles (*Chelonia mydas* and *Lepidochelys olivacea*) by Jaguar (*Panthera onca*) in Naranjo sector, Santa Rosa National Park, Costa Rica. *International Journal of Conservation Science* 7:101–108.
- Arroyo-Arce, S. 2013. Selección de hábitat del Jaguar (*Panthera onca*) en el Parque Nacional Tortuguero y su situación en el área de amortiguamiento, Costa Rica. M.Sc. Thesis, Universidad Nacional, Heredia, Costa Rica. 104 p.
- Arroyo-Arce, S., and R. Salom-Pérez. 2015. Impact of Jaguar *Panthera onca* (Carnivora: Felidae) predation on marine turtle populations in Tortuguero, Caribbean coast of Costa Rica. *Revista de Biología Tropical* 63:815–825.
- Arroyo-Arce, S., J. Guilder, and R. Salom-Pérez. 2014. Habitat features influencing Jaguar *Panthera onca* (Carnivora: Felidae) occupancy in Tortuguero National Park, Costa Rica. *Revista de Biología Tropical* 62:1449–1458.
- Arroyo-Arce, S., I. Thomson, K. Cutler, and S. Wilmott. 2018. Feeding habits of the Jaguar *Panthera onca* (Carnivora: Felidae) in Tortuguero National Park, Costa Rica. *Revista de Biología Tropical* 66:70–77.
- Arroyo-Arce, S., I. Thomson, C. Fernández, and R. Salom-Pérez. 2016. First record of a marine turtle predated by a Jaguar in Pacuare Nature Reserve, Costa Rica. *Cat News* 64:6–7.
- Arroyo-Arce, S., I. Thomson, E. Harrison, S. Wilmott, and G. Baker. 2017. First record of Jaguar (*Panthera onca*) predation on a Loggerhead Sea Turtle (*Caretta caretta*) in Tortuguero National Park, Costa Rica. *Herpetology Notes* 10:17–18.

- Arroyo-Arce, S., I. Thomson, A. Searchy, and B. Luke. 2019. Informe de Avances Temporada 2019: estudio de la población de Jaguares (*Panthera onca*), otros felinos silvestres y sus especies presa en el Parque Nacional Tortuguero, Costa Rica. Technical Report, Coastal Jaguar Conservation, Heredia, Costa Rica. 78 p.
- Autar, L. 1994. Sea turtles attacked and killed by Jaguars in Suriname. *Marine Turtle Newsletter* 67:11–12.
- Carrillo, E., T.K. Fuller, and J.C. Sáenz. 2009. Jaguar (*Panthera onca*) hunting activity: effects of prey distribution and availability. *Journal of Tropical Ecology* 25:563–567.
- Carrillo, E., R. Morera, and G. Wong. 1994. Depredación de Tortuga Lora (*Lepidochelys olivacea*) y de Tortuga Verde (*Chelonia mydas*) por el Jaguar (*Panthera onca*). *Vida Silvestre Neotropical* 3:48–49.
- Chinchilla, F. 1997. La dieta del Jaguar (*Panthera onca*), el Puma (*Felis concolor*) y el Manigordo (*Felis pardalis*) (Carnivora: Felidae) en el Parque Nacional Corcovado, Costa Rica. *Revista de Biología Tropical* 45:1223–1229.
- Cornelius, S.E. 1986. The sea turtles of Santa Rosa National Park. Fundación de Parques Nacionales, San José, Costa Rica. 64 p.
- Cornelius, S.E., and D.C. Robinson. 1983. Abundance, Distribution, and Movements of Olive Ridley Sea Turtles in Costa Rica. *Endangered Species Report* No.13, U.S. Fish and Wildlife Service, Albuquerque, New Mexico, USA.
- Dapp, D., R. Arauz, J.R. Spotila, and M.P. O'Connor. 2013. Impact of Costa Rican longline fishery on its bycatch of sharks, stingrays, bony fish and Olive Ridley Turtles (*Lepidochelys olivacea*). *Journal of Experimental Marine Biology and Ecology* 448:228–239.
- Drake, D.L., M.A. Hagerty, J.E. Behm, and S.J. Goldenberg. 2001. *Lepidochelys olivacea* (Olive Ridley Sea Turtle). Predation. *Herpetological Review* 32:104.
- Escobar-Lasso, S., L.G. Fonseca, M. Gil-Fernández, W.N. Villachica, S. Arroyo-Arce, I. Thomson, and J. Sáenz. 2016a. First record of consumption of Olive Ridley Sea Turtle by a Cougar. *Cat News* 64:4–5.
- Escobar-Lasso, S., L.G. Fonseca, W.N. Villachica, H. Herrera, W. Quirós-Pereira, M. Pesquero, and P.T. Plotkin. 2016b. First field observation of the predation by Jaguar (*Panthera onca*) on Olive Ridley Sea Turtle (*Lepidochelys olivacea*) at Nancite Beach, Santa Rosa National Park, Costa Rica. *Mammalogy Notes* 3:20–23.
- Fergusson, I.K., L.J.V. Compagno, and M.A. Marks. 2000. Predation by White Sharks *Carcharodon carcharias* (Chondrichthyes: Lamnidae) upon chelonians, with new records from the Mediterranean Sea and a first record of the Ocean Sunfish *Mola mola* (Osteichthyes: Molidae) as stomach contents. *Environmental Biology of Fishes* 58:447–453.
- Fonseca, L.G., S. Arroyo-Arce, I. Thomson, W.N. Villachica, and R.A. Valverde. 2017. New records of Jaguar predation on sea turtles, Pacific coast, Costa Rica. *Cat News* 66: 36–37.
- Fonseca, L.G., S. Arroyo-Arce, I. Thomson, W.N. Villachica, and R.A. Valverde. 2018. Records of Pumas scavenging at Jaguar kills in Santa Rosa National Park, Costa Rica. *Cat News* 67:4–5.
- Fonseca L.G., G.A. Murillo, L. Guadamúz, R.M. Spínola, and R.A. Valverde. 2009. Downward but stable trend in the abundance of arribada Olive Ridley Sea Turtles (*Lepidochelys olivacea*) at Nancite beach, Costa Rica (1971–2007). *Chelonia Conservation and Biology* 8:19–27.
- Francia, A.L. 2004. Predación y eclosión en nidos solitarios y de arribada de Tortugas Loras (*Lepidochelys olivacea*), Baulas (*Dermochelys coriacea*), Negras (*Chelonia mydas agassizi*) en las playas Nancite y Naranjo e incidencia humana sobre las anidaciones de tortugas marinas en Playa Junquillal, Costa Rica. M.Sc. Thesis, Universidad Nacional, Heredia, Costa Rica. 132 p.
- Fretey, J. 1977. Causes de mortalité des Tortues Luth adults (*Dermochelys coriacea*) sur le littoral guyanais. *Courrier de la Nature* 52:257–266.
- Gates, C.E., R.A. Valverde, C.L. Mo, A.C. Chaves, J. Ballesteros, and J. Peskin. 1996. Estimating arribada size using a modified instantaneous count procedure. *Journal of Agricultural, Biological, and Environmental Statistics* 1:275–287.
- Guildler, J., B. Barca, S. Arroyo-Arce, R. Gramajo, and R. Salom-Pérez. 2015. Jaguars (*Panthera onca*) increase kill utilization rates and share prey in response to seasonal fluctuations in nesting Green Turtle (*Chelonia mydas mydas*) abundance in Tortuguero National Park, Costa Rica. *Mammalian Biology* 80:65–72.
- Heithaus, M.R., A. Frid, A.J. Wirsing, L.M. Dill, J.W. Fourqurean, D. Burkholder, J. Thomson, and L. Bejder. 2007. State-dependent risk-taking by Green Sea Turtles mediates top-down effects of Tiger Shark intimidation in a marine ecosystem. *Journal of Animal Ecology* 76:837–844.
- Herrera, H., S. Escobar-Lasso, and E. Carrillo-Jiménez. 2016. Predation on the Hawksbill Turtle *Eretmochelys imbricata* by the Jaguar *Panthera onca* in the Pacific coast of Costa Rica. *Mammalogy Notes* 3:13–16.
- Hughes, D., and J. Richard. 1974. The nesting of the Pacific Ridley Turtle *Lepidochelys olivacea* on Playa Nancite, Costa Rica. *Marine Biology* 24:97–107.
- Janzen, D.H. 1988. Guanacaste National Park: Tropical ecological and biocultural restoration. Pp. 143–192 *In* *Rehabilitating Damaged Ecosystems*. Volume 2.

- Cairns, J. (Ed.). CRC Press, Boca Raton, Florida, USA.
- Janzen, D.H. 2004. Ecology of dry-forest wildland insects in the Area de Conservación Guanacaste. Pp. 80–86 *In* Biodiversity Conservation in Costa Rica: Learning the Lessons in a Seasonal Dry Forest. Frankie, G.W., A. Mata, and S.B. Vinson (Eds.). University of California Press, Berkeley, California, USA.
- Mast, R.B., B.J. Hutchinson, E. Howgate, N.J. Pilcher. 2005. MTSG update: IUCN/ SSC Marine Turtle Specialist Group hosts the second Burning Issues Assessment Workshop. *Marine Turtle Newsletter* 110:13–15.
- Mazaris, A.D., B. Broder, and Y.G. Matsinos. 2006. An individual based model of a sea turtle population to analyze effects of age dependent mortality. *Ecological Modelling* 198:1–2.
- Montalvo, V.H., T.K. Fuller, C. Saénz-Bolaños, J.C. Cruz-Díaz, I. Hagnauer, H. Herrera and E. Carrillo. 2020. Influence of sea turtle nesting on hunting behavior and movements of Jaguars in the dry forest of northwest Costa Rica. *Biotropica* 00:1–8 <https://doi/10.1111/btp.12803>.
- National Research Council. 1990. Decline of the Sea Turtles: Causes and Prevention. National Academy Press, Washington, D.C., USA.
- Núñez, R., B. Miller, and F. Lindzey. 2002. Ecología del Jaguar en la Reserva de la Biosfera Chamela-Cuixmala, Jalisco, México. Pp. 107–126 *In* El Jaguar en el Nuevo Milenio. Medellín, R.A., C. Equihua, C.L.B. Chetkiewicz, P.G. Crawshaw, A. Rabinowitz, K.H. Redford, J.G. Robinson, E.W. Sanderson, and A.B. Taber (Eds.). Ediciones Científicas Universitarias, México City, México.
- Ortiz, R.M., P.T. Plotkin, and P.W. Owens. 1997. Predation on Olive Ridley Sea Turtles (*Lepidochelys olivacea*) by the American Crocodile (*Crocodylus acutus*) at Playa Nancite, Costa Rica. *Chelonian Conservation and Biology* 2:585–587.
- Pitman, R.L., and P.H. Dutton. 2004. Killer Whale predation on a Leatherback Turtle in the Northeast Pacific. *Pacific Science* 58:497–498.
- Plotkin, P.T. 2007. Biology and Conservation of Ridley Sea Turtles. Johns Hopkins University Press, Baltimore, Maryland, USA.
- Quirós-Arias, L. 2017. Tourism and territory in natural protected areas. Santa Rosa National Park: from national monument to conservation of the tropical dry forest. *Guanacaste Conservation Area, Costa Rica. Revista Geográfica de América Central* 2:137–183.
- Rabinowitz, A.R., and B.G. Nottingham. 1986. Ecology and behavior of the Jaguar (*Panthera onca*) in Belize, Central America. *Journal of Zoology* 210:149–159.
- Salom, P. 2005. Ecología del Jaguar (*Panthera onca*) y del Manigordo (*Leopardus pardalis*) (Carnivora: Felidae) en el Parque Nacional Corcovado, Costa Rica. M.Sc. Thesis, Universidad de Costa Rica, San José, Costa Rica. 130 p.
- Savage, J.M. 2002. The Amphibians and Reptiles of Costa Rica: A Herpetofauna between Two Continents, Between Two Seas. University of Chicago Press, Chicago, Illinois, USA.
- Schaller, G.B., and J.M. Vasconcelos. 1978. Jaguar predation on Capybara. *Z. Säugetierk* 43:296–301.
- Seymour, K.L. 1989. *Panthera onca*. *Mammalian Species* 340:1–9.
- Stancyk, S.E. 1981. Nonhuman predators of sea turtles and their control. Pp. 139–152 *In* Biology and Conservation of Sea Turtles. Bjorndal, K.A. (Ed.). Smithsonian Institution Press, Washington, D.C., USA.
- Turtle Expert Working Group. 2007. An assessment of the Leatherback Turtle population in the Atlantic Ocean. Technical Memorandum NMFS-SEFSC-555, National Oceanic and Atmospheric Administration, Miami, Florida, USA. 124 p.
- Troëng, S. 2000. Predation of Green (*Chelonia mydas*) and Leatherback (*Dermochelys coriacea*) turtles by Jaguar (*Panthera onca*) at Tortuguero National Park, Costa Rica. *Chelonian Conservation and Biology* 3:751–753.
- Valverde, R.A., and C.E. Gates. 1999. Population surveys on mass nesting beaches. Pp. 56–60 *In* Research and Management Techniques for the Conservation of Sea Turtles. Eckert, K.L., K.A. Bjorndal, F.A. Abreu-Grobois, and M. Donnelly (Eds.). Publication No. 4, International Union for Conservation of Nature/Species Survival Commission, Marine Turtle Specialist Group, Consolidated Graphic Communications, Blanchard, Pennsylvania, USA.
- Valverde, R.A., S.E. Cornelius, and C.L. Mo. 1998. Decline of the Olive Ridley Sea Turtle (*Lepidochelys olivacea*) nesting assemblage at Nancite Beach, Santa Rosa National Park, Costa Rica. *Chelonian Conservation and Biology* 3:58–63.
- van Buskirk, J., and L.B. Crowder. 1994. Life-history variation in marine turtles. *Copeia* 1994:66–81.
- Wallace, B.P., A.D. DiMatteo, A.B. Bolten, M.Y. Chaloupka, B.J. Hutchinson, F.A. Abreu-Grobois, J.A. Mortimer, J.A. Seminoff, D. Amorcho, K.A. Bjorndal, et al. 2011. Global conservation priorities for marine turtles. *PLoS ONE* 6(9):e24510. doi:10.1371/journal.pone.0024510.
- Wallace, B.P., A.D. DiMatteo, B.J. Hurley, E.M. Finkbeiner, A.B. Bolten, M.Y. Chaloupka, B.J. Hutchinson, F.A. Abreu-Grobois, D. Amorcho, K.A. Bjorndal, et al. 2010. Regional management units for marine turtles: a novel framework for prioritizing conservation and research across multiple scales. *PLoS ONE* 5(12):e15465. doi:10.1371/journal.

pone.0015465.

Whiting, S.D., and A.U. Whiting. 2011. Predation by the Saltwater Crocodile (*Crocodylus porosus*) on sea turtle adults, eggs, and hatchlings. *Chelonian Conservation and Biology* 10:198–205.

Witzell, W.N. 1987. Selective predation on large cheloniid sea turtles by Tiger Sharks (*Galeocerdo cuvier*). *Japanese Journal of Herpetology* 12:22–29.

UNPUBLISHED TECHNICAL REPORTS

Harrison, E., S. Troëng, D. Nolasco, D. Crispin, C. Matthews, K. Padidar, A. Gaos, R. Towers, D. Jiménez, X. Debade, et al. 2003. Report on the 2002 Green Turtle program at Tortuguero, Costa Rica. Technical Report, Caribbean Conservation Corporation, San José, Costa Rica. <https://1431-2144.el-alt.com/pdf/reports/Tortuguero%20Green%20Turtle%20Report%202002.pdf>.

Harrison, E., S. Troëng, A. Bañados, M. Beker, D. Costalga, R. Díaz, A. Díaz-Merry, T. Egli, V. de los Llanos, J. McGonzález, et al. 2004. Report on the 2003 Green Turtle program at Tortuguero, Costa Rica. Technical Report, Caribbean Conservation Corporation, San José, Costa Rica. <https://conserveturtles.org/wp-content/uploads/Tortuguero%20Green%20Turtle%20Report%202003.pdf>.

Harrison, E., S. Troëng, M. Abrego, M. Becker, R. Beker, G. Castillo, J. Viuda, A. Guzman, S. Juarez, P. Linaza, et al. 2005. Report on the 2004 Green Turtle program at Tortuguero, Costa Rica. Technical Report, Caribbean Conservation Corporation, San José, Costa Rica. Doi: 10.13140/RG.2.1.1920.4083.

Mangel, J., S. Troëng, L. Segura, M. Stockmann, A. Ortega, C. Reyes, Z. Hudgson, A. Opazo, L. Fernández, R. Hernández, et al. 2001. Report on the 2000 Green Turtle program at Tortuguero, Costa Rica. Technical Report, Caribbean Conservation Corporation, San José, Costa Rica. <https://conserveturtles.org/wp-content/uploads/Tortuguero%20Green%20Turtle%20Report%202000.pdf>.

Mo, C.L., S. Pankratz, K. Caruso, J. Kiel, R. Forsyth, S. Donnelly, and D. Dressler. 1996. Monitoring of the Olive Ridley Sea Turtle populations at Nancite Beach, Santa Rosa National Park, Guanacaste, Costa Rica. Technical Report, Universidad Nacional, Heredia, Costa Rica. <http://copa.acguanacaste.ac.cr:8080/bitstream/handle/11606/401/Monitoring%20of%20Olive%20Ridley%20Sea%20Turtle%20Populations%20at%20Nancite%20Beach%2C%20Santa%20Rosa%20National%20Park%20Costa%20Rica.pdf?sequence=1&isAllowed=y>.

Orrego, C.M. 2002. Causas antrópicas y naturales en la mortalidad de las tortugas Baula (*Derموchelys*

coriacea), Lora (*Lepidochelys olivacea*) y Verde (*Chelonia mydas agassizi*), en la costa Pacífica de Costa Rica. Technical Report, Programa Regional de Manejo de Vida Silvestre, Universidad Nacional, Heredia, Costa Rica. https://www.setena.go.cr/documentos/Parque%20Nacional%20Marino%20Las%20Baulas/Informe_TortugasMarinas.pdf.

Reyes, C., S. Troëng, V. Cadena, A. Carmona, E. dal Pont Morisso, N. McCann, P. Allman, S. Gaines, F. St John, J. Zbinden, et al. 2001. Report on the 2001 Leatherback program at Tortuguero, Costa Rica. Technical Report, Caribbean Conservation Corporation, Technical Report, San José, Costa Rica. <https://conserveturtles.org/wp-content/uploads/Tortuguero%20Leatherback%20Report%202001.pdf>.

Reyes, C., S. Troëng, D. Boodram, G. Zapata, J. Rapetti, R. Araya, N. Osborne, S. Gaines, A. McCarthy, M. Rujas, et al. 2002. Report on the 2001 Green Turtle program at Tortuguero, Costa Rica. Caribbean Conservation Corporation. Technical Report, San José, Costa Rica. <https://conserveturtles.org/wp-content/uploads/Tortuguero%20Green%20Turtle%20Report%202001.pdf>.

Troëng, S. 1997. Report on the 1997 Green Turtle program at Tortuguero, Costa Rica. Technical Report, Caribbean Conservation Corporation, San José, Costa Rica. <https://conserveturtles.org/wp-content/uploads/Tortuguero%20Green%20Turtle%20Report%201997.pdf>.

Troëng, S., R. Zanre, C. Singer, T. Pinion, J. Castro, E. Harrinson, D. Ayala, L.M. Hinestroza, A. Polo, A. Guijada, A. Castillo, et al. 1999. Report on the 1998 Green Turtle program at Tortuguero, Costa Rica. Technical Report, Caribbean Conservation Corporation, San José, Costa Rica. <https://1431-2144.el-alt.com/pdf/reports/Tortuguero%20Green%20Turtle%20Report%201998.pdf>.

Troëng, S., J. Mangel, S. Kélez, A. Myers, J. Kashner, L. Bellchambers, D. Vizcaino, A. Rees, B. Amiteye, E. López, et al. 2000a. Report on the 1999 Green Turtle program at Tortuguero, Costa Rica. Technical Report, Caribbean Conservation Corporation, San José, Costa Rica. <https://conserveturtles.org/wp-content/uploads/Tortuguero%20Green%20Turtle%20Report%201999.pdf>.

Troëng, S., G. Cook, G. Ruthig, M. López, D. Neafsey, A.M. Suárez, X. Véñez, and E. Rankin. 2000b. Report on the 1999 Leatherback program at Tortuguero, Costa Rica. Technical Report, Caribbean Conservation Corporation, San José, Costa Rica. <https://conserveturtles.org/wp-content/uploads/Tortuguero%20Leatherback%20Report%201999.pdf>.

Herpetological Conservation and Biology



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