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EVALUATION OF THE INCIDENCE OF BOATS IMPACTING GREEN TURTLES (*CHELONIA MYDAS*) ALONG THE SOUTHERN COAST OF ISABELA, GALAPAGOS

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Evaluation of the incidence of boats impacting green turtles (*Chelonia mydas*) along the southern coast of Isabela, Galapagos

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After Mexico, the Galapagos Archipelago has the second largest reproductive stock of green turtles, the most abundant sea turtle species in the Galapagos Marine Reserve (GMR) and the most important of the Tropical Eastern Pacific (NMFS/USFWS, 1998; Seminoff, 2004). The Islands provide important feeding areas for the resident population (NMFS & USFWS, 1998; Seminoff *et al.*, 2007), which is concentrated in the coastal zone, while some turtles migrate to feeding areas in Central and South America (Seminoff *et al.*, 2007).

A significant portion of the population of the East Pacific green turtle depends on the nesting beaches and feeding sites of Galapagos. While the Islands provide good conditions for the green turtle, the increase in anthropogenic activities in both feeding areas and nesting sites threaten the local turtle population (Zárate, 2009). Threats include being hit by boats, interactions with fishing activities, and intake and consumption of waste (Zárate & Carrión, 2007; Zárate, 2009; Parra *et al.*, 2011; Denkinger *et al.*, 2013).

The objectives of this project were to provide information on the use of the nesting zones by female turtles at Quinta Playa, Isabela - the largest nesting site in the Archipelago, to determine the distribution of marine traffic in or close to this nesting beach, and to determine the incidence of boats hitting reproductive females. This article presents the data related to the impact of tourism on turtles. The results generated provide important information for the Galapagos National Park Directorate (DPNG) to use in developing future management strategies to support the conservation of this species in Galapagos.

Methods

Study site

Quinta Playa, the largest nesting site of green turtles in the Galapagos Archipelago, is a beach on southern Isabela Island, approximately 13 km west of Puerto Villamil. Quinta Playa is part of an important green turtle nesting area that consists of the following beaches: Puerto Villamil; Barahona Bay; and Segunda, Tercera, Cuarta and Quinta Playas.

Quinta Playa is located approximately 10 km to the east of two popular marine tourist attractions of Isabela, Los Túneles y El Finado, where experiential artisanal fishing, a tourism activity, is permitted (Figure 1). In recent years, the growth of daily tourism activities has resulted in an increase in boat traffic between Puerto Villamil and these tourism sites, an area that covers the entire nesting zone of green turtles.

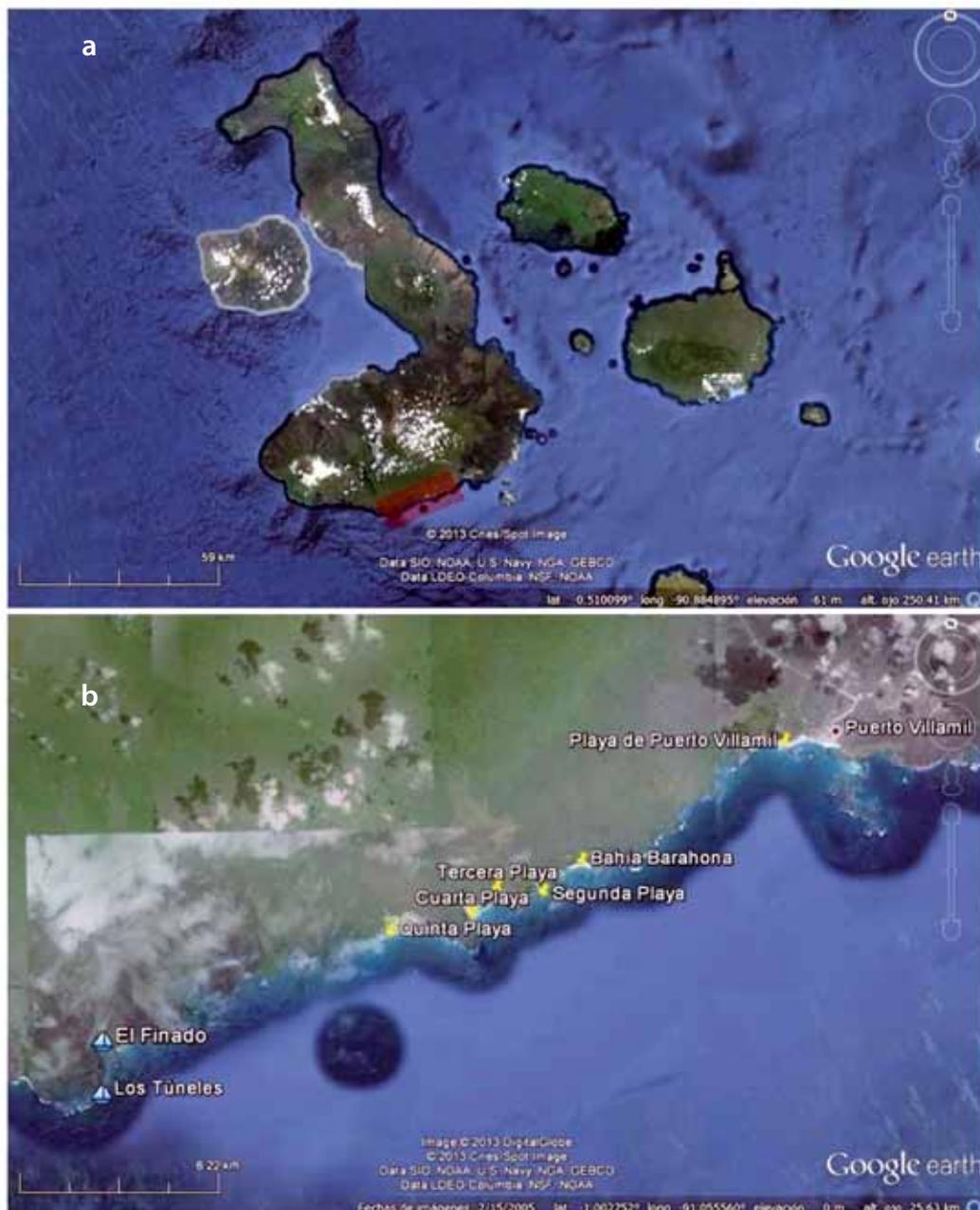


Figure 1. Map of the Galapagos Archipelago and Isabela Island green turtle nesting areas. a) General map of the Islands; the red polygon represents the area of green turtle nesting beaches. b) Map of the southern coast of Isabela Island; the yellow dots represent the six nesting beaches from east to west: Puerto Villamil Beach, Barahona Bay, Segunda Playa, Tercera Playa, Cuarta Playa and Quinta Playa; the map also indicates the urban area (Puerto Villamil) and the visitor sites El Finado and Los Túneles.

Monitoring day tour boats

Ten Mobile Action® tracking devices (GPS I - GoTU GT – 600) were used to determine the distribution and velocity of the speed boats used for day trips to Los Túneles and El Finado. The devices, carried by passengers, captains, or crew members, were programmed to automatically record geo-referencing information during each trip. When the devices were returned, the data were downloaded and analyzed using the Postgres – PostGis program, detailing the route and velocity during the trip.

Records of tour boats heading to Los Túneles and El Finado provided by the Technical Office of the Galapagos

National Park in Puerto Villamil were used to determine the frequency of tour boats visiting the sites in question.

Habitat use by nesting females

Five female turtles nesting at Quinta Playa were followed with satellite tags (FastLoc F4H 471A © Sirtrack) to determine habitat use and spatial distribution (Figure 2). The information for each female was downloaded from the Argos website (<https://argos-system.cls.fr/cwi/Welcome.do>) and then processed using the AdehabitatHR tool of the R statistical software to calculate range of activity of each turtle.



Figure 2. Turtle with satellite transmitter attached at the moment of release.

Incidence of impact of boats on nesting females

Nesting females were evaluated for any injuries during the monitoring of nesting turtles on Quinta Playa from December 15, 2012 to May 30, 2013. Each turtle was thoroughly examined for lesions on the carapace as well as on front and rear flippers, and around the head and neck area. Injuries for each female were recorded on a full body image, noting the following details: location, length, depth, and type of injury (cut, fracture, hole, lack of a piece of carapace, mutilation of limbs).

Based on criteria established in the literature, the following injuries were considered to have been caused by an impact with a boat: wounds or scars that corresponded with cuts, fractures, holes in the middle of the carapace, or loss of a portion of the carapace with a length or diameter greater than 4 cm (Phelan & Eckert, 2006; Sapp, 2010; Heinrich *et al.*, 2012; Norton *et al.*, 2013). Lesions were also classified as recent (when the injury was fresh) or old (when the injury was healed), in order to help distinguish injuries that occurred during the nesting season from those that occurred in feeding areas and/or during migration to the nesting site.

Evaluation of the risk of impact from boats

To analyze the risk of tour boats hitting turtles, the movements of the tagged turtles were mapped together with the routes of the tour boats monitored during trips between Puerto Villamil and Los Túneles and El Finado to identify areas of overlap.

Information on the frequency of tour boats on these routes was compared with the abundance of nesting turtles at Quinta Playa over time to identify the periods of the year with greater probability of interaction between turtles and boats.

Results

Monitoring of boats

Between November 2012 and June 2013, a total of 160 days of marine-based tourism records (the number of tour boats leaving port headed out for a day trip) were analyzed. Eighteen boats were identified, with an average of at least three vessels leaving port each day. From a total of 605 trips, it was possible to determine that the most visited destinations during day trips were Las Túneles and El Finado (74% of all trips, $n = 447$). The remaining 26% ($n = 158$) of trips corresponded to other destinations such as Cuatro Hermanos (1%, $n = 8$), Islote Tortuga (8%, $n = 51$), and trips with no specified destination (16%, $n = 99$).

The movement pattern was similar for all boats, with each trip starting in Puerto Villamil at approximately 8h00. The boats followed the coastline to Roca Unión where they made a brief stop, then continued on to Las Túneles, where they stopped for a short shore visit and snorkeling, then continued towards El Finado for snorkeling, and subsequently returning to Puerto Villamil at around 14h00. Average travel speed was approximately 22 knots (Figure 3).

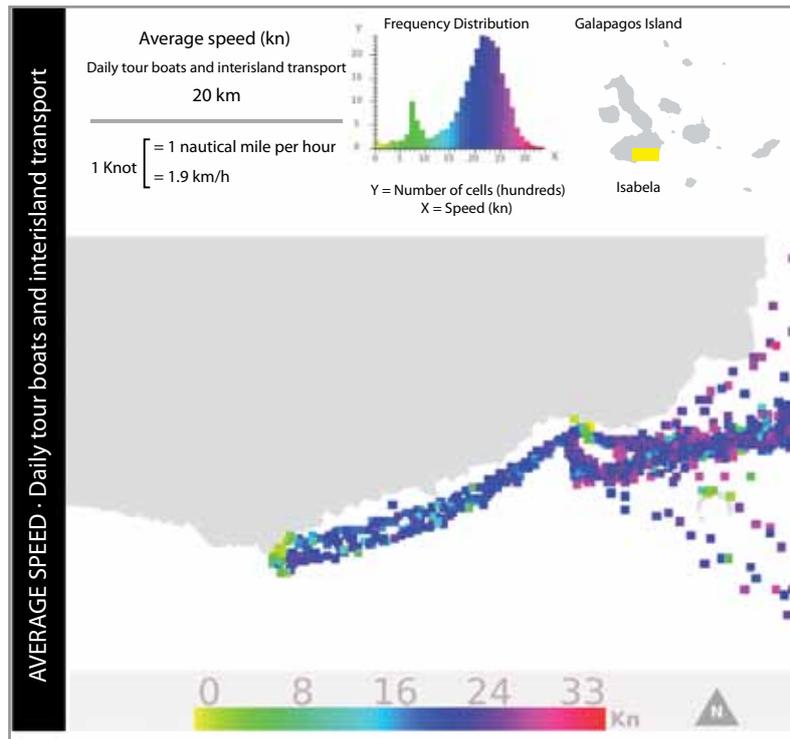


Figure 3. Speed of the day-tour boats travelling between Puerto Villamil and Los Túneles and El Finado.

Habitat use by nesting females

Telemetry data from five female turtles showed that they moved within a range of 10 km parallel to the coast, with greater movement to the east of Quinta Playa (Figure 4). The majority of turtle activity was found in areas close to the coast, with increased activity within the first three

miles. Activity decreased with increasing distance from the coast. Telemetry data were obtained most frequently during two periods of the day (09h00-10h00 and 14h00-16h00), demonstrating greater surface activity (surfacing to breathe, rest, or for thermoregulation) during these time periods.

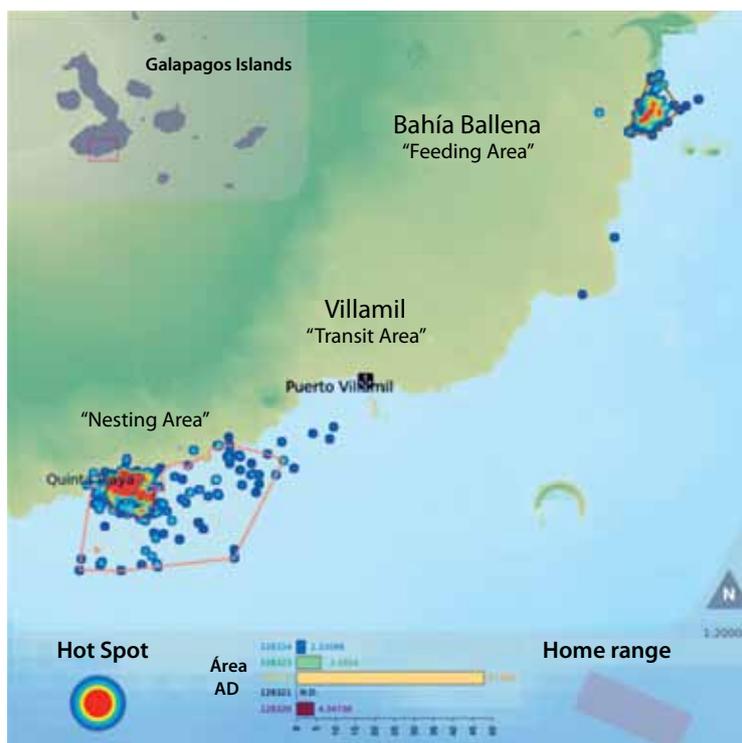


Figure 4. Distribution of turtles followed by satellite, showing an area of concentration opposite the nesting beaches. The graphics and polygons for each concentration area indicate the distribution range for each turtle.

Determining the incidence of boats hitting green turtles

Assessment of injury to turtles at the nesting zone was carried out between December 15, 2012 and May 30, 2013, during which time a total of 1458 nesting females

were examined (Table 1). Of the examined turtles, 25% (n = 366) presented injuries, mainly in the carapace, with 12% (n = 170) identified as having signs of impact by boats. The most frequent injuries observed were holes in the carapace (29%, n = 49) and cuts (28%, n = 47).

Table 1. Incidence of the different types of injuries grouped in categories of injury due to impact with a boat.

Type of damage	Number of cases	%
Cut	47	28
Cut and fracture	10	6
Cut and hole	9	5
Cut and malformation	4	2
Cut and mutilation	4	2
Cut, hole, and malformation	2	1
Missing piece of carapace	4	2
Missing piece of carapace and mutilation	2	1
Fracture	21	12
Fracture and hole	5	3
Hole	49	29
Hole and malformation	3	2
Hole and mutilation	1	1
Malformation	8	5
Mutilation	1	1
Total	170	100

Risk assessment of impact by boats

Mapping the movements and distribution of satellite tagged turtles, as well as the movement and distribution of the tour boats, showed areas of overlap (Figure 5). The analysis of the relationship between the abundance of turtles and the frequency of boat trips (Parra *et al.*, 2013) showed a greater abundance of turtles in or close

to the nesting areas from November to May, which when combined with increased activity of boats traveling to the nearby tourist sites increases the probability of accidental injuries to turtles. The DPNG data show that March is the month with the greatest frequency of trips from Puerto Villamil to Los Túneles and El Finado; this increased traffic coincides with peak nesting at Quinta Playa (Figure 6).

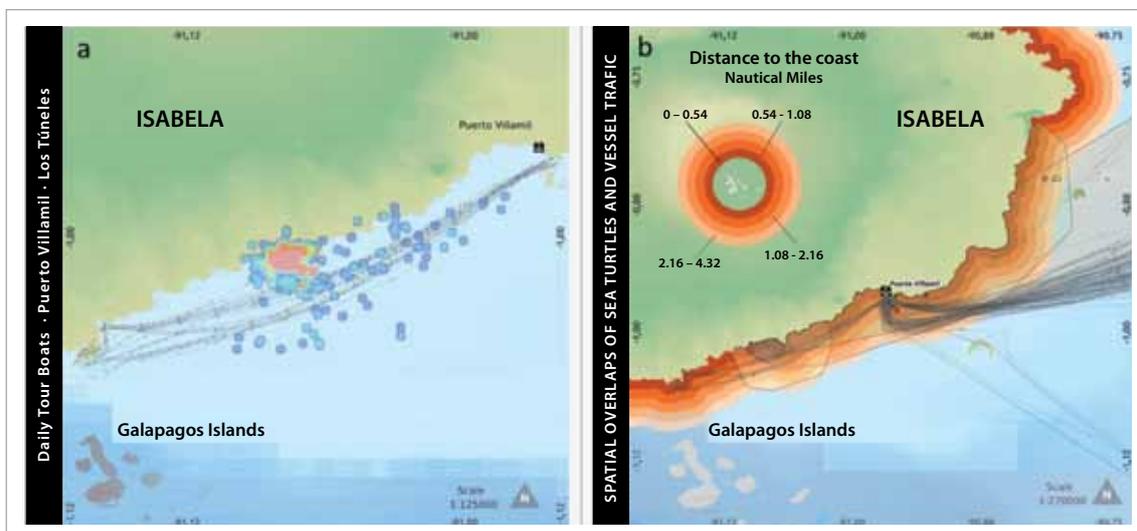


Figure 5. Map indicating the areas of interaction between sea turtles and tour boat routes. Figure “a” shows the concentration of turtles in front of the nesting areas at Quinta Playa and Barahona Bay, off southern Isabela Island, and the routes of tour boats traveling between Puerto Villamil and Los Túneles. Figure “b” shows the distance intervals of interaction between turtles and boats.

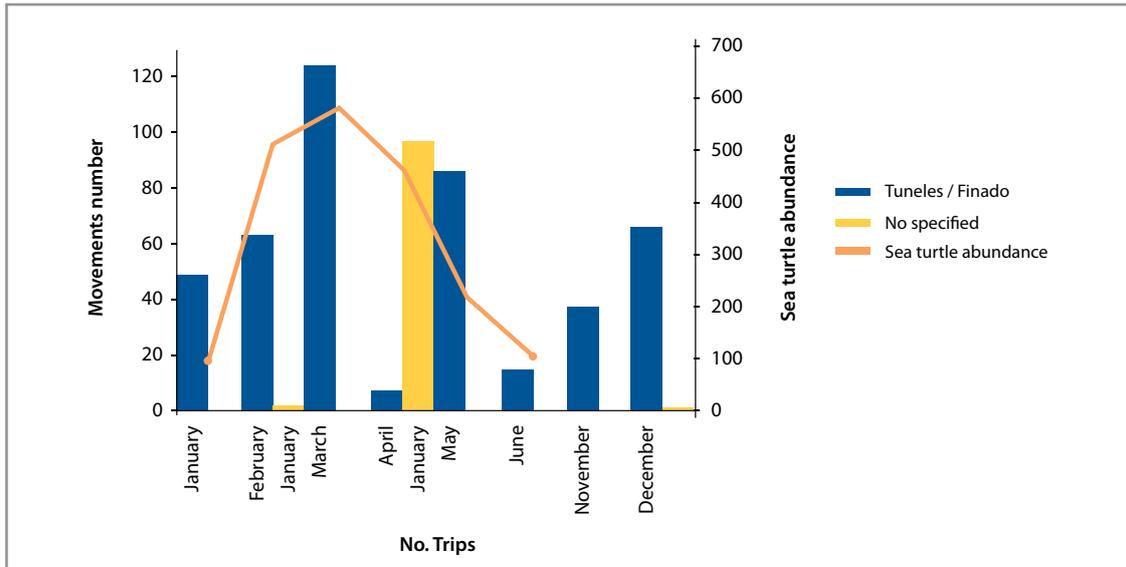


Figure 6. Movement of boats and abundance of sea turtles during the breeding season. The bars represent the number of trips per month from Puerto Villamil (Isabela Island) to the visitor sites Los Túneles and El Finado. The green bar represents trips with no defined destination, but which according to unofficial sources did make the trip to Los Túneles and El Finado. The line represents the abundance of active nesting turtles at Quinta Playa.

The period of increased surface activity of turtles, determined through satellite monitoring, coincides with the trip schedules for boats traveling between Puerto Villamil and Los Túneles (between 09h00 and 14h00).

Recommendations

This study shows that there are areas of interaction between sea turtle habitat and routes used by tour boats (day tours) within the GMR and that turtles are distributed primarily in coastal areas (within the first four miles from shore). The percent of incidents of boats impacting nesting females around Quinta Playa (12% of turtles examined) is within the incident ranges of similar incidents reported in various studies in other parts of the world, which range from 1.9-60% (Norem, 2005; Chaloupka *et al.*, 2008; NMFS/USFWS, 2008). Likewise, in a prior study in the GMR in a sea turtle feeding area near San Cristóbal Island, 19.4% of turtles examined had lesions attributable to impacts by boats (Denkinger *et al.*, 2013), which is comparable with the incidence found in this study.

Based on the findings, we recommend:

1. Develop management measures to regulate marine traffic within the GMR, accompanied by continued monitoring and evaluation of any injuries to sea turtles over time to determine the effectiveness of the management measures taken.
2. Develop a management protocol to move marine traffic four miles from the coast to minimize the number of boats in areas where sea turtles are concentrated.

3. Increase management measures during the sea turtle nesting season from November to May.
4. Implement marine transit zones for different types of boats, along with a maximum navigation speed of 10 knots in areas with higher incidence of interactions between wildlife and boats (see management plans for other sites, such as the Moreton Bay Marine Park, Australia).
5. Conduct a study of the use of propeller guards to determine whether the use of such equipment would be sufficient to minimize damage to turtles. It is important to know, however, that injuries to turtles caused by boats also include bumps, bruises, and fractures of the carapace, which are generated by hitting the boat hull or transom.

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Photo: © George Cathcart

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