

Immature East Pacific Green Turtles (*Chelonia mydas*) Use Multiple Foraging Areas off the Pacific Coast of Baja California Sur, Mexico: First Evidence from Mark-Recapture Data¹

Jesse Senko,^{2,8,9} Melania C. López-Castro,^{3,4,8} Volker Koch,⁵ and Wallace J. Nichols^{6,7}

Abstract: Since 2001, Grupo Tortuguero has been conducting monthly in-water monitoring of East Pacific green turtles (*Chelonia mydas*), also known as black turtles, at four neritic foraging areas (Bahía Magdalena, Laguna San Ignacio, Punta Abreojos, Laguna Ojo de Liebre) along the Pacific coast of Baja California Sur, Mexico. Extensive tagging (883 turtles tagged of 1,183 turtles captured) and recaptures (154 tagged turtles recaptured at least once) at these four areas suggest that immature East Pacific green turtles show strong site fidelity to their neritic foraging grounds. However, in 2007, we recaptured two immature turtles, one in Laguna San Ignacio and the other in Bahía Magdalena, that were both originally captured in Punta Abreojos. To our knowledge, this represents the first direct evidence of immature East Pacific green turtles using multiple foraging areas along the Baja California Peninsula. This report highlights the importance of long-term monitoring efforts that encompass several habitats on a relatively large spatial scale (~80 km between Punta Abreojos and Laguna San Ignacio and ~300 km between Punta Abreojos and Bahía Magdalena) to better understand the movements and habitat use of immature East Pacific green turtles on their neritic foraging areas.

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² Florida Cooperative Fish and Wildlife Research Unit and Department of Wildlife Ecology and Conservation, University of Florida, Gainesville, Florida 32611.

³ Archie Carr Center for Sea Turtle Research and Department of Biology, University of Florida, Gainesville, Florida 32611.

⁴ Grupo Tortuguero, La Paz, Baja California Sur, Mexico.

⁵ Universidad Autónoma de Baja California Sur, Departamento de Biología Marina, La Paz, Baja California Sur, Mexico.

⁶ Ocean Revolution, Davenport, CA.

⁷ Department of Herpetology, California Academy of Sciences, San Francisco, California.

⁸ Both authors contributed equally.

⁹ Corresponding author (e-mail: jsenko@ufl.edu).

THE EAST PACIFIC green turtle (*Chelonia mydas*) is currently listed as endangered in the World Conservation Union (IUCN) Red List (Hilton-Taylor 2000, Seminoff 2004). This subpopulation is frequently referred to as the black turtle due to morphological and color variations (Nichols 2003). East Pacific green turtles are highly migratory (Nichols 2003) and utilize several different habitats at different life stages (Seminoff et al. 2002a, Seminoff and Jones 2006, Koch et al. 2007). Green turtles from the Baja California Peninsula originate at Mexican rookeries located hundreds to thousands of kilometers south in the state of Michoacán and the Revillagigedos Archipelago, Tres Marias Islands, and perhaps even, to a lesser extent, from the Galápagos and Hawaiian islands (Márquez 1990, Nichols 2003, Koch et al. 2007). After hatching, it is assumed that green turtles immediately enter an oceanic stage for approximately 3–5 yr before recruiting to neritic foraging areas and undergoing a rapid ontogenetic diet shift (Balazs et al. 1987, Carr 1987, Bjorndal and Bolten 1997, Bolten 2003, Reich et al. 2007).

Neritic foraging areas are arguably the most important habitat in the life cycle of an East Pacific green turtle (Nichols 2003). Juveniles may spend 20 yr or more in these developmental areas feeding on sea grasses and algae until they reach maturity (Seminoff et al. 2002*b*, Koch et al. 2007). These areas are also used by mature turtles between nesting cycles (Seminoff et al. 2002*b*, Nichols 2003). Although the presence of green turtles in neritic foraging areas along the Baja California Peninsula is well documented (Nichols 2003, Seminoff et al. 2003, Koch et al. 2006, 2007), long-term habitat use and connectivity among these sites remains unknown. Multiple recaptures indicate that immature East Pacific green turtles may spend several years in the same foraging area and that these turtles show strong site fidelity to the foraging area to which they originally recruited (Koch et al. 2007). To date, there have been no reported movements of tagged East Pacific green turtles between foraging areas (M.C.L.-C., V.K., A. Mariscal-Loza, and W.J.N., unpubl. data). Consequently, conservation and management plans have been designed accordingly.

MATERIALS AND METHODS

Between 2001 and 2006 Grupo Tortuguero conducted in-water monitoring of sea turtles at four neritic foraging areas along the Pacific coast ($24^{\circ} 15' - 27^{\circ} 48' \text{ N}$ and $111^{\circ} 30' - 114^{\circ} 08' \text{ W}$) of Baja California Sur, Mexico. Study sites were located in Bahía Magdalena (BMA), Laguna San Ignacio (LSI), Punta Abreojos (PAO), and Laguna Ojo de Liebre (LOL) (Figure 1). These sites are important coastal foraging areas for East Pacific green turtles (Nichols 2003, Koch et al. 2006, 2007).

Since 2001, East Pacific green turtles have been captured once per month along the shallow perimeter of each monitoring site using nylon and cotton entanglement nets (100 m long, 50 cm stretched mesh size). Captured turtles were able to surface and breathe because the nets contain little weight on the lead line. We set nets at slack tide during both day and night periods for approximately 10–24 hr and monitored them regularly (≤ 1

hr) for entangled turtles. Upon capture, turtles were immediately removed from the nets and measured, weighed, and tagged at the closest landing. For each turtle, we recorded straight carapace length (SCL, $\pm 0.1 \text{ cm}$) from the nuchal notch to the longest posterior portion of the rear marginal scutes using a metal forester's caliper. We determined mass to the nearest pound using a 100 lb (45.4 kg) spring-balanced scale and then converted the measurement to kilograms. All captured turtles were tagged using metal tags (Inconel, National Band and Tag Company, Newport, Kentucky), applied proximal and adjacent to the first large scale on each rear flipper following Balazs (1999). A total of 883 turtles, out of 1,183 captured, was tagged from August 2001 to July 2006, and of these, 154 turtles have been recaptured at least once. Here we report on recaptures that were found at new foraging areas.

RESULTS

Two of 154 recaptured turtles were found at new foraging areas. On 20 January 2002, the monitoring team captured an immature East Pacific green turtle using entanglement nets in Punta Abreojos (PAO) ($26^{\circ} 49' 40.3'' \text{ N}$, $113^{\circ} 24' 46.1'' \text{ W}$). The turtle was marked with Inconel tags (R, 551 P; L, MK-722) on both rear flippers. Measurements of SCL (cm) and weight (kg) were recorded (Table 1). On 20 August 2007, this individual was recaptured using entanglement nets approximately 300 km south of the original capture location in Bahía Magdalena ($24^{\circ} 54' 34.45'' \text{ N}$, $112^{\circ} 06' 35.35'' \text{ W}$). At recapture, measurements of this turtle were recorded (Table 1). The interval between initial tagging and time of recapture was approximately 2,038 days.

The second immature East Pacific green turtle was initially captured using entanglement nets on 20 May 2007 in Punta Abreojos. The turtle was marked with Inconel tags (R, LM-988; L, LM-987) on both rear flippers, and measurements of this turtle were recorded (Table 1). On 19 November 2007, this individual was recaptured using entangle-

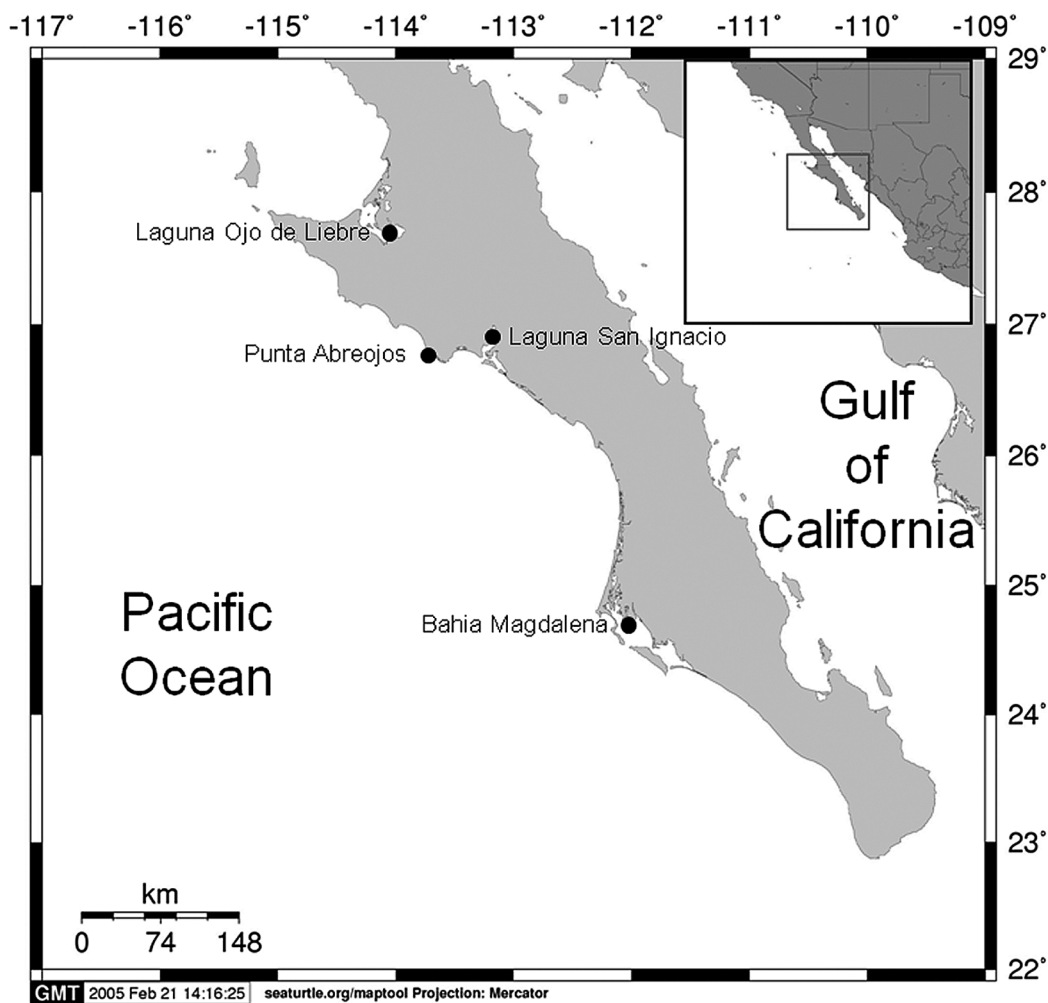


FIGURE 1. Map of the four Grupo Tortuguero eastern Pacific green turtle monitoring sites along the coast of Baja California Sur, Mexico.

TABLE 1

Morphometric Data of East Pacific Green Turtles at First Capture and Recapture in Different Neritic Foraging Areas off the Baja California Peninsula, Mexico

Turtle ID Right/Left	Initial Capture Data			Recapture Data			
	Capture Location	SCL (cm)	Weight (kg)	Capture Location	SCL (cm)	Weight (kg)	Days at large
551 P MK 722	Punta Abreojos	63.0	31.8	Bahía Magdalena	67.4	41.4	2,038
LM 988 LM 987	Punta Abreojos	45.2	10.9	Laguna San Ignacio	45.2	11.6	183

ment nets in Laguna San Ignacio approximately 80 km south of Punta Abreojos. The SCL of the turtle did not change, but there was an increase in weight (Table 1). The turtle had been at large for approximately 183 days.

DISCUSSION

In this paper, we report the first documented flipper tag recoveries of two immature East Pacific green turtles (one in Bahía Magdalena and one in Laguna San Ignacio) previously captured and tagged in Punta Abreojos. These two tag recoveries establish the first direct evidence of immature East Pacific green turtles using multiple foraging areas along the Pacific coast of Baja California after 7 yr of continuous monitoring. These results underscore the importance of long-term monitoring efforts to better understand the movements and habitat use of immature East Pacific green turtles inhabiting the coastal waters of the Baja California Peninsula.

Green turtles along the Baja California Peninsula demonstrate high site fidelity. Estimates of juvenile and adult East Pacific green turtle site fidelity at Bahía de Los Angeles, a coastal foraging area in the Gulf of California, suggested that a considerable proportion of turtles inhabit the area for extended intervals (Seminoff et al. 2003). Green turtles inhabiting other neritic foraging areas also have shown site fidelity with limited home ranges (Bjorndal 1980, Ogden et al. 1983, Brill et al. 1995). Through the end of 2006, Grupo Tortuguero has captured 1,183 East Pacific green turtles (M.C.L.-C., V.K., A. Mariscal-Loza, and W.J.N., unpubl. data) at four neritic foraging sites on the Pacific coast of the peninsula, and only the two turtles reported here have been recaptured in a different foraging area. However, recapture rates are generally low among all size classes and locations (between 9.1% and 32.8% [Koch et al. 2007]), and this may account for the lack of recaptured turtles in different foraging areas. The high mortality rates of sea turtles along the Baja California Peninsula (Nichols 2003, Koch et al. 2006, Peckham et al. 2007)

may also partially explain the lack of recaptured turtles in different foraging areas, because migrating turtles are often subjected to high mortality in commercial and artisanal fisheries in Baja California (Hays et al. 2003, Nichols 2003, Peckham et al. 2007). In addition, flipper tags may not stay on for more than a few years (Bjorndal et al. 1996) and the foraging areas are not yet tag saturated. Furthermore, the Grupo Tortuguero's monthly monitoring efforts in northwestern Mexico are conducted at discrete locations along a vast area comprising more than 2,200 km of coastline. Nevertheless, more research and long-term monitoring are needed to better understand the frequency and mechanisms of multiple foraging area use. It is especially important to understand why sea turtles may move to new foraging grounds. Is the mechanism physiological or environmental? Not all immature green turtles appear to stay in foraging areas as permanent residents, because many turtles may commence extensive developmental migrations (Bjorndal and Bolten 1997, Musick and Limpus 1997). Immature green turtles tagged on foraging grounds in the southern Bahamas remain in these coastal habitats for various lengths of time before emigrating to other foraging areas throughout the Greater Caribbean (Bjorndal et al. 2003). Juvenile Brazilian green turtles tracked on their foraging areas (Godley et al. 2003) appeared to exhibit three main patterns of behavior: extended residency with high site fidelity, moderate range movements (<100 km), and pronounced long-range movements (>100 km). These migrations to different foraging and developmental areas may be a response to differing food abundance and quality and/or population density (Bjorndal et al. 2000). Although both turtles in this study were initially captured in PAO, the foraging area with the highest catch per unit effort and density of green turtles along the entire Baja California Peninsula (M.C.L.-C., V.K., A. Mariscal-Loza, and W.J.N., unpubl. data), we do not have conclusive evidence to suggest that the higher density of turtles or limited resources play a role in the migration of green turtles to other foraging areas. Turtles tagged from

Punta Abreojos also have the highest probability of yielding a recapture in a different foraging area.

These two tag recoveries suggest that, despite high levels of bycatch and illegal poaching along the peninsula (Nichols 2003, Nichols and Safina 2004, Koch et al. 2006), at least some immature East Pacific green turtles survive and migrate to different foraging areas along the peninsula. This paper highlights the importance of long-term sea turtle monitoring efforts that encompass several different foraging habitats on a relatively large spatial scale. We encourage future research on the long-term movement patterns and habitat use of immature East Pacific green turtles on their foraging areas.

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