# ARTICLES

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# Tropical Fiord Habitat as a Year-round Resting, Breeding, and Feeding Ground for East Pacific Green Sea Turtles (*Chelonia mydas*) off Costa Rica

Golfo Dulce, located along the South Pacific coast of Costa Rica, is a fiord-like structure with an inner basin of more than 200 m depth, sheltered against the open ocean by a shallow sill of 60 m (Svendsen et al. 2006). These conditions make Golfo Dulce the only tropical fiord on the Pacific side of the Americas (Hebbeln et al. 1996) and one of only four tropical fiords in the world (Toft 2009). Current calculations list 4745 marine species in Costa Rica's Pacific waters, more than double the number reported from the Caribbean side of the country (Wehrtmann et al. 2009), and emerging data show Golfo Dulce to be a very diverse ecosystem, supporting at least 1028 species, from small invertebrates to large marine mammals (Morales-Ramírez 2011).

East Pacific Green Sea Turtles, *Chelonia mydas*, are known to utilize the waters around the Osa Peninsula, as are three other species: Olive Ridley, *Lepidochelys olivacea*; Hawksbill, *Eretmochelys imbricata*; and Leatherback, *Dermochelys coriacea* (Quesada-Alpízar et al. 2006). However, to date, limited data have been published regarding abundance and spatial and temporal distribution of *C. mydas* in the region. Sea turtle nesting activity near Golfo Dulce was first registered by Richard and Hughes (1972), who described the southwestern beaches of the Osa Peninsula as having one of the highest sea turtle track densities in the South Pacific region of Costa Rica. The Olive Ridley is the most common species on the nesting beaches just outside Golfo Dulce and while the Hawksbill is the least frequent species (Drake 1996), most of the Hawksbill nesting observations reported for Costa Rica during 2007–2009 took place in Corcovado National Park on the Osa Peninsula (Gaos et al. 2010). Here, we report the use of Golfo Dulce as a year-round resting, breeding, and feeding ground for East Pacific Green Sea Turtles.

Two onboard marine sighting surveys were conducted in Golfo Dulce from a 15-50 hp boat during the dry season months of January–February 2010 and the rainy season months of July–August 2011.The basic methodology has previously been described, including systematic interviews with 82 local fishermen and tour boat guides (Bessesen 2012), who were asked with what frequency they see sea turtles inside Golfo Dulce: always (N = 36), frequently (N = 33), occasionally (N = 10), rarely (N = 3), and never (N = 0). Combined onboard survey effort totaled 55 days (dry season, N = 30; rainy season, N = 25) and 424 observation hours. A blank on the field data sheet was used to indicate species ID reliability as definite (D), probable (P), maybe (M) or unconfirmed (U), but the two sea turtles marked M during the surveys were shifted to U for this reporting. Group size and behavior were also recorded.

A total of 177 sea turtle sightings were logged between 2010 and 2011. Forty-six of those sightings were marked U, while the remainder represented three species: *C. mydas* (N = 101), *L. olivacea* (N = 20), and *E. imbricata* (N = 10). GPS data showed each species using a different part of Golfo Dulce: Olive Ridleys were encountered in the lower half of Gulf, and Hawksbills were distributed coastally around the embayment, but 86.5% of East Pacific Green Sea Turtle sightings occurred in the upper half of the inlet. Based on areas of use by confirmed species and the locations of the U sightings, which were also concentrated in the upper half of the inlet, even more Green Sea Turtles may have been utilizing the northerly reaches of Golfo Dulce during the study period (Fig. 1). Use of the Gulf by *C. mydas* was comparable between the dry season (N = 53) and the rainy season (N = 48). In fact, *L. olivacea* was the only sea turtle species to show a distinct seasonal shift in numbers, increasing to coincide with its known nesting season on the Osa Peninsula during the rainy season (N = 19, vs. N = 3 in the dry season).

*Chelonia mydas* was the prevalent turtle species in Golfo Dulce, accounting for 57% of all turtle sightings. Digital images played an important role in species confirmation and photos or video were collected for 80% of our *C. mydas* sightings. Because a sighting could comprise one or more individuals of the same species in the same area at the same time, a single sighting might represent multiple individuals, as was the case for Green Sea Turtles when many were spotted simultaneously and could not be logged separately. Thus, the actual number of *C. mydas* counted during the study exceeded 288 individuals. Based on size, most appeared to be adults.

Green Sea Turtles were typically found floating motionless or quietly paddling at the surface in what appeared to be a resting

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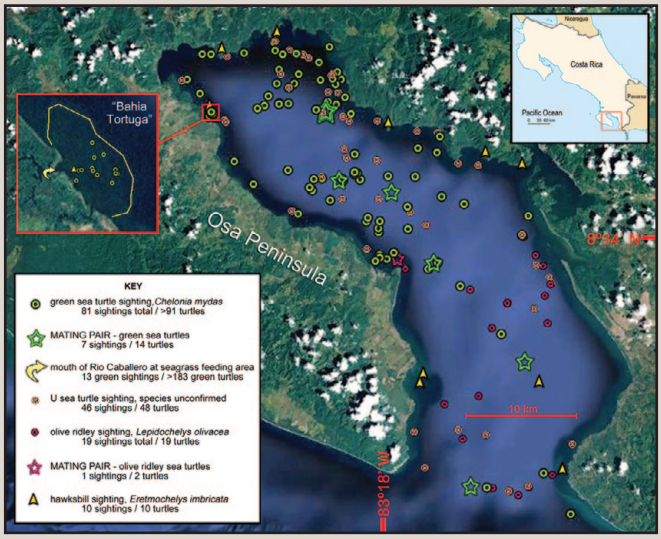


FIG. 1. Keyed GPS points for all of our 2010–2011 sea turtle sightings in Golfo Dulce. Insets: (upper right) location of Golfo Dulce in Costa Rica; (upper left) close-up view of sighting points in "*Bahia Tortuga.*"


FIG. 2. Surface behaviors of East Pacific Green Sea Turtles in Golfo Dulce. (A) Basking behavior – note the dry shell. (B) Copulating pair.

state, with liberal exposure of the carapace indicating some degree of thermoregulation (Fig. 2A). Head position was variable, from upright to hanging at or slightly below the water surface and turtles in this basking position (N = 70) often remained at the surface for several minutes. Mating pairs of *C. mydas* (N = 7) were also documented during our surveys (Fig. 2B). Although Green Sea Turtles showed positive selection for the upper half of the inlet, breeding was recorded in all four quadrants of Golfo Dulce and the behavior did not appear to be seasonally driven (dry season, N = 4; rainy season, N = 3). It should be noted that while there are a few locally known nesting sites for Green Sea Turtles along the banks of Golfo Dulce, including Playa Preciosa, nesting did not seem to be a major activity inside the inlet.

In many neritic habitats, the diet of adult *C. mydas* is predominantly herbivorous (Bjorndal 1980; Devaux and DeWetter 2000; Seminoff et al. 2002) and a coastal tracking study by Senko et al. (2010) showed Green Sea Turtles off the Pacific coast of Baja California Sur, Mexico, spent 69% of their time over areas of seagrass and 59% in depths < 5 m. In Golfo Dulce, a considerable number of Green Sea Turtle sightings occurred in a > 400 $m^2$ area where shallow subsurface topography supported an abundance of seagrass. The bed was situated around 40.058°N, 26.598°W, near the mouth of Rio Caballero. Underwater photographs revealed two species of seagrass. Only two species have been reported on the Pacific side of Costa Rica, *Ruppia maritima* and *Halophila baillonis* (Cortés 2001; Cortés and Salas 2009). While one of our specimens was clearly *H. baillonis,* the other, filamentous species was challenging to confirm via photos. It may have been *R. maritima* but was more likely *Halodule beaudettei* (J. Cortés, pers. comm.; J. Samper-Villarreal, pers. comm.), a grass found in Panamá, which Cortés (2001) believes might also grow in Costa Rica.

We came to call the seagrass bed "*Bahia Tortuga*" ("Turtle Bay") because it supported extensive cheloniid activity and appears to be a critical feeding habitat. At least 183 individual *C. mydas* were observed in the area with total estimated numbers exceeding 500 turtles. All photographs taken in Bahia Tortuga confirmed the sightings to be *C. mydas* with the exception of one obvious Hawksbill seen near the mangrove roots (described as emerging habitat for that species; Gaos et al. 2012). In Bahia Tortuga, Green Sea Turtles spent their time submerged and were never observed floating at the surface as described in other parts of the Gulf. Green Sea Turtles were sometimes visualized from the boat as they swam subsurface in the shallowest water (<3 m) and skin diving allowed one observer (BLB) to view several turtles near the seagrass floor, although actual feeding behavior was not observed. The majority of sightings in Bahia Tortuga occurred from the research vessel, floating quietly with the motor off. During these periods of silent observation, turtle heads popped up as various individuals surfaced to breathe. Carapaces were not visible and cranial exposure was fleeting, never lasting more than 1–2 sec, a behavior possibly common in foraging habitats (Hazel et al. 2009). Loud exhales indicated extended breath-holding. Since passing boats were unlikely to see any turtles, the area was generally unrecognized as a turtle hotspot and was at the time undisturbed by human activity.

Globally, Green Sea Turtle populations have fallen into collapse from anthropogenic impacts (Devaux and DeWetter 2000; Mancini and Koch 2009; Marquez et al. 1982; Seminoff et al. 2002). Numbers are said to be dropping precipitously in Golfo Dulce as well. Several interviewed fishermen with up to four decades experience in the Gulf stated that recent years have brought a decline in sea turtles of at least 30%. Understanding habitat use is fundamental to the conservation of these large marine vertebrates. In the East Pacific, the Green Sea Turtle is a highly migratory species and corridors between the Galápagos Islands and the Baja California peninsula have been identified; these serve as routes of travel between feeding grounds and nesting sites (Amorocho and Reina 2007; Amorocho et al. 2012). Tag recovery data have shown nesting females traveling from México to Colombia and from the Galápagos Islands to Costa Rica (Alvarado-Diaz and Figueroa 1990), including Golfo Dulce (Chacón et al. 2011). Our data now indicate that East Pacific Green Sea Turtles are using Golfo Dulce as a resting, breeding, and foraging area throughout the year, suggesting this tropical fiord may be an important site within the Green Sea Turtle migratory corridor in the East Pacific.

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