Spatial Ecology of Hawksbill Turtles (*Eretmochelys imbricata*) from Gandoca-Manzanillo National Wildlife Refuge, Costa Rica

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INTRODUCTION

For migrating animals, it is important to identify links between habitat use and spatial ecology. Understanding routes from nesting sites to foraging areas is important in quantifying population-level impacts of anthropogenic threats and designing effective conservation responses to these threats. In September of 2018, we deployed satellite transmitters on 4 nesting female hawksbills (*Eretmochelys imbricata*) on the beaches of the Gandoca Manzanillo National Wildlife Refuge. Here we present the internesting locations, migration routes, and the preliminary foraging locations of 4 tagged hawksbills.

Introducción

Para los animales migratorios, es importante identificar los vínculos entre el uso del hábitat y la ecología espacial. Comprender las rutas desde los sitios de anidación hasta las áreas de forrajeo es importante para cuantificar los impactos a nivel poblacional de las amenazas antropogénicas y para diseñar respuestas de conservación efectivas a estas amenazas . En septiembre de 2018, desplegamos transmisores satelitales en 4 tortugas carey (*Eretmochelys imbricata*) anidadas en las playas del Refugio Nacional de Vida Silvestre Gandoca Manzanillo. Aquí presentamos las ubicaciones de internesting, las rutas de migración y las ubicaciones preliminares de forrajeo de las 4 carey marcadas.

METHODS

- Night surveys were conducted on Playa Gandoca and Playita within the Gandoca Manzanillo National Wildlife Refuge, in southeastern Costa Rica.
- Tagging and morphometrics were obtained after nesting was complete for all turtles.
- SIRTRACK's KiwiSat 202 PTT satellite transmitters were epoxied to the turtle's carapace.
- ARGOS transmitter locations were speed filtered by >5km/hr in "argosfilter" package (Parker et al 2009).
- A state-space model (SSM; Jonsen et al. 2005) was used to discern different behaviors.
- We used the Home Range Tools for AcrGIS extension to create minimum convex polygons (MCP) to represent foraging and internesting areas.
- We used ArcGIS 10.5 to display all turtle behaviors and MCP.

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RESULTS

Postnesting migrations exhibited a counterclockwise circular path before returning close to the coast and then moving northward towards foraging grounds (Fig. 1). Hawksbills used ocean surface currents for migration. Ei04 migrated the shortest distance (620 km) and remained in a foraging area off the southern coast of Nicaragua. Ei01 and Ei03 migrated to neighboring foraging grounds that are near the shared border of Nicaragua and Honduras. Ei02 migrated the furthest (1,511 km) to the most northwestern foraging ground of northern Honduras. Foraging ground minimum convex polygons (MCP) for Ei02, Ei03, and Ei04 averaged 772 km^2 in size. The foraging ground MCP for Ei01 was drastically larger (9,9098 km^2).

Internesting MCP for Ei01 was 1,264 km^2 and shows the turtle staying close to or directly in front of the nesting beach (Fig. 2). The internesting MCP for Ei04 was 1,874 km^2 and shows the turtle ~50km to the south off the coast of Bocas del Toro islands of Panama. Ei04 has a second set of clustered locations to the north of the nesting beach.

			Internesting		Migration		Foraging	
Turtle ID	CCL	Day of Deployment	Duration (days)	MCP (km^2)	Duration (days)	Track Distance (km)	Duration (days)	MCP (km^2)
Ei01	85	24-Aug-18	55	1,264	9	870.61	52	9,098
Ei02	88	26-Aug-18	-	-	54	1,511.08	73	819
Ei03	94.5	29-Aug-18	-	-	47	1,466.52	78	793
Ei04	86	29-Aug-18	41	1,874	13	620.42	70	704

Table 1: Hawksbill (*Eretmochelys imbricata*) internesting, migration, and foraging details from tagged individuals from Gandoca-Manzanillo National Wildlife Refuge. MCP = minimum convex polygon.

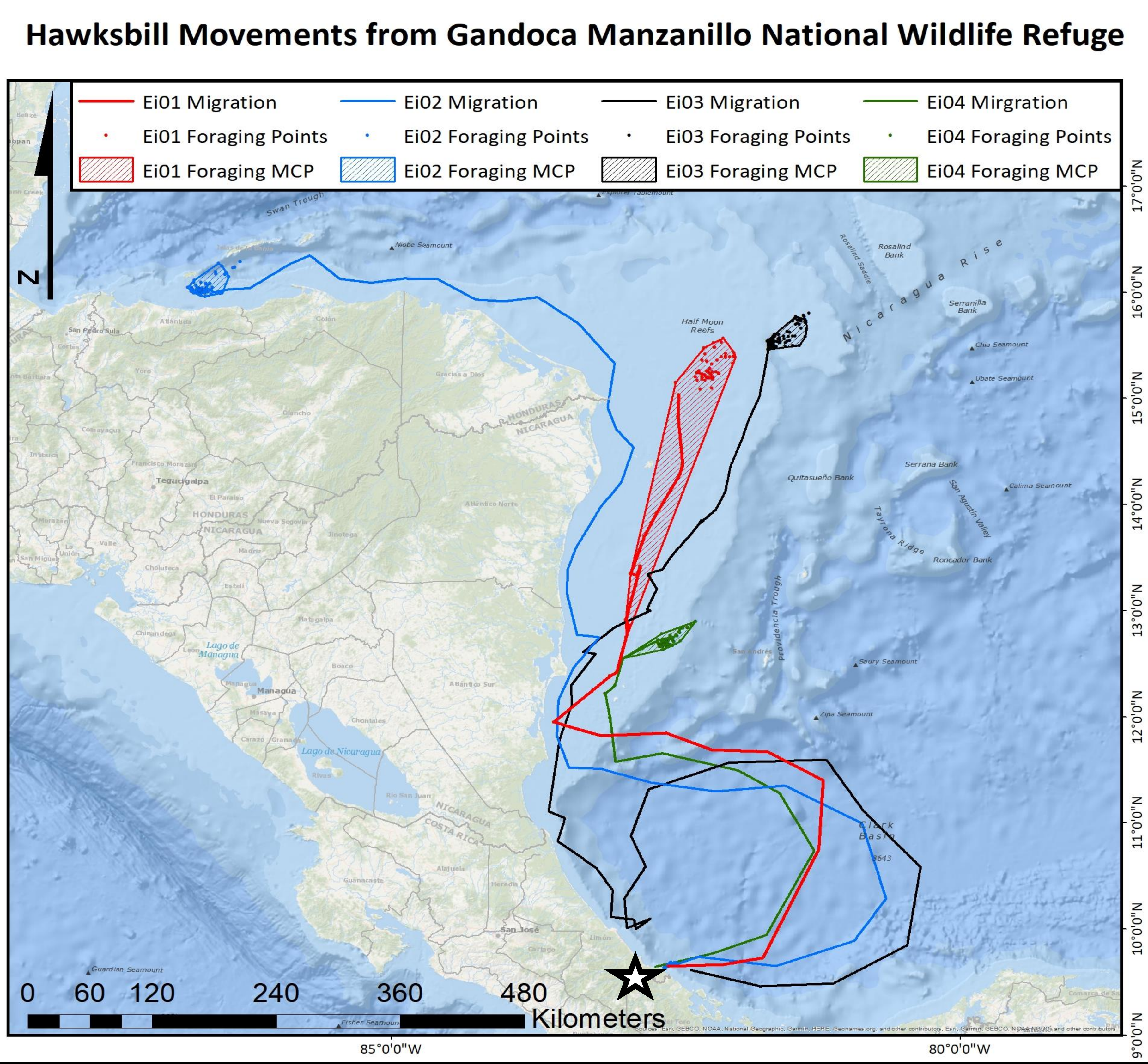

Figure 1: Migration routes and MCP of foraging areas. Migration routes from nesting beach to foraging grounds for 4 adult female hawksbills (*Eretmochelys imbricata*) tagged from Gandoca-Manzanillo National Wildlife Refuge. Star = nest beach.

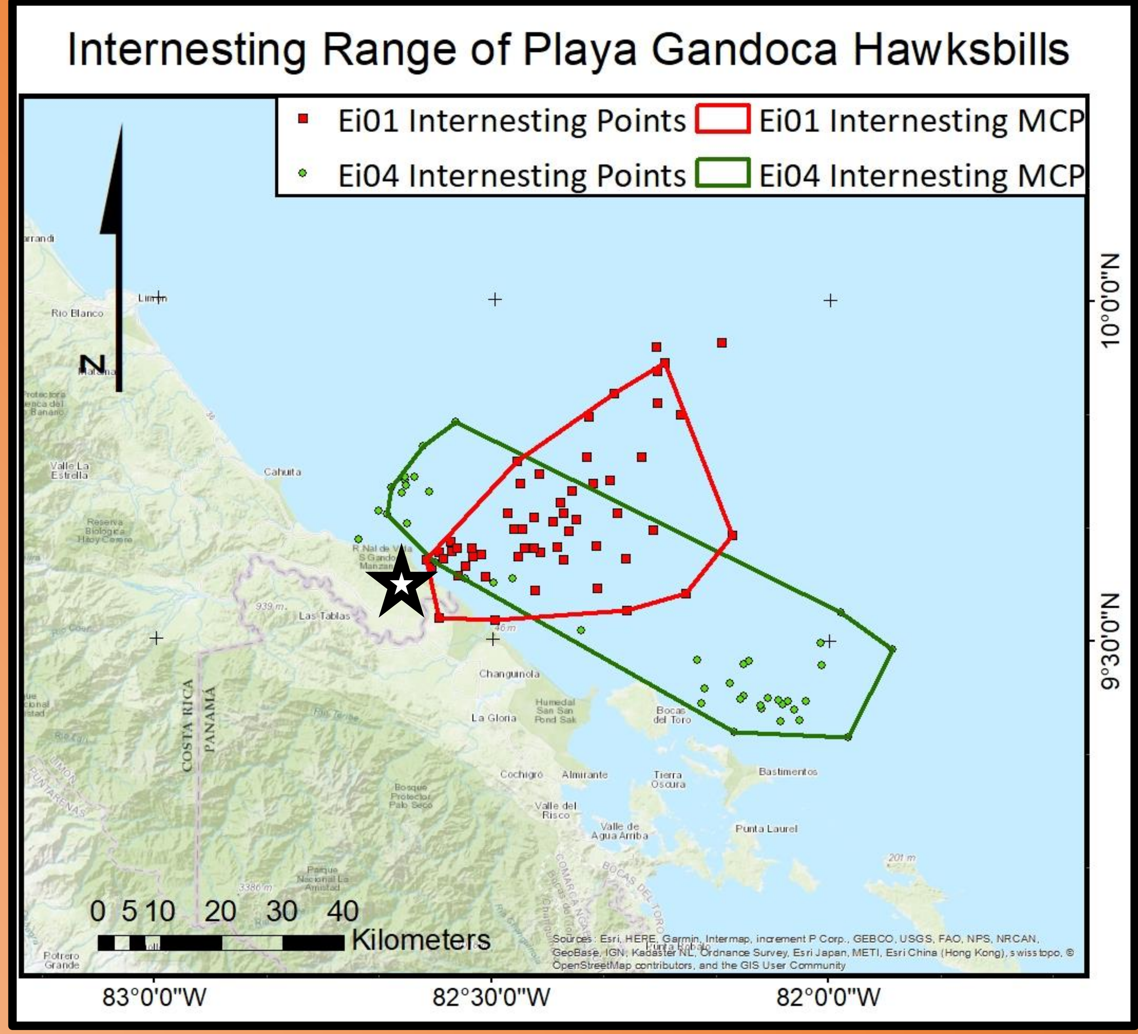

Figure 2: MCP of internesting range of hawksbills (*Eretmochelys imbricata*) tagged from Gandoca-Manzanillo National Wildlife Refuge. Star = nest beach.

DISCUSSION

Gravid turtles are known to select internesting habitats close to nesting beaches and may be exposed to anthropogenic threats such as entanglement in fishing gear, harvesting or boat strikes. Satellite tracks have revealed 2 different internesting behaviors, which include remaining directly in front of the nesting beach or moving 50 km south towards the Bocas del Toro islands of Panama. This indicates that hawksbill's internesting behavior is varied and may encompass areas significantly north or south of the nesting beach.

Tracked hawksbills used coastal currents by moving in a circular pattern in the Caribbean Sea before migrating. Postnesting migrations are northward towards Honduras, remaining relatively close to the coast. This result shows that local ocean currents may influence hawksbill behavior. In the case of Ei03, we speculate that the turtle returned to a nearby beach for nesting after making the circular track in the Caribbean Ocean.

Previous studies (Troeng et al. 2005, Van Dam et al. 2008, Moncada et al. 2009, Revuelta et al. 2015, and Hart et al. 2019) have shown hawksbills foraging near the same locations as Ei01, Ei03, and Ei04. Though no study has tracked a post-nesting hawksbill to the same location as Ei02, which this study may have shown as new foraging ground for Coast Rican nesting hawksbills.

Understanding routes from nesting sites to foraging areas is important in quantifying population-level impacts of anthropogenic threats and designing effective conservation responses to these threats.

References

Hart, K. M., Iverson, A. R., Benscoter, A. M., Fujisaki, I., Cherkiss, M. S., Pollock, C., ... & Hillis-Starr, Z. (2019). Satellite tracking of hawksbill turtles nesting at Buck Island Reef National Monument, US Virgin Islands: Inter-nesting and foraging period movements and migrations. *Biological Conservation*, *229*, 1-13.
Jonsen, I. D., Flemming, J. M., & Myers, R. A. (2005). Robust state–space modeling of animal movement data. *Ecology*, *86*(11), 2874-2880.
Moncada, F. G., Hawkes, L. A., Fish, M. R., Godley, B. J., Manolis, S. C., Medina, Y., ... & Webb, G. J. W. (2012). Patterns of dispersal of hawksbill turtles from the Cuban shelf inform scale of conservation and management. *Biological Conservation*, *148*(1), 191-199.
Parker, D. M., Balazs, G. H., King, C. S., Katahira, L., & Gilmartin, W., 2009. Short-range movements of hawksbill turtles (Eretmochelys imbricata) from nesting to foraging areas within the Hawaiian Islands. *Pacific Science*, *63*(3), 371-382.
Revuelta, O., Hawkes, L., León, Y. M., Godley, B. J., Raga, J. A., & Tomás, J. (2015). Evaluating the importance of Marine of hawksbill turtles breeding at Mona Island, Puerto Rico. Endangered Species Research, 4(1-2), 85-94. Protected Areas for the conservation of hawksbill turtles Eretmochelys imbricata nesting in the Dominican Republic. *Endangered Species Research*, *27*(2), 169-180.
Troëng, S., H. Dutton, P., & Evans, D. (2005). Migration of hawksbill turtles Eretmochelys imbricata from Tortuguero, Costa Rica. *Ecography*, *28*(3), 394-402.
Van Dam, R. P., Diez, C. E., Balazs, G. H., Colón, L. A. C., McMillan, W. O., & Schroeder, B. (2008). Sex-specific migration patterns of hawksbill turtles breeding at Mona Island, Puerto Rico. Endangered Species Research, 4(1-2), 85-94.