Spatial Features of Sea Turtle Post-nesting Migrations and Core Use Areas in the Southern Gulf of Mexico and Caribbean Sea

Patrones Migratorios y Características de Áreas Núcleo de Tortugas Marinas Post-anidantes en el Sur del Golfo de México y Mar Caribe

Schémas Migratoires et les Caractéristiques Essentielles des Zones de Tortues Marines Après Nidification dans le Sud du Golfe du Mexique et la Mer des Caraïbes

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EXTENDED ABSTRACT

Introduction

Sea turtles display important migratory movements to different aggregation areas along their life history. Adult females travel from their feedings grounds to nesting beaches every 2 - 3 years during their reproductive lifetime (Miller 1996). The migratory patterns and the features of areas they occupy after the reproductive seasons are of the highest interest because of the ecological and ethological information that can be achieved. Five of the seven sea turtle species in the world inhabit the Gulf of Mexico (GoM), where they find the necessary habitats for nesting and feeding (Valverde and Holzwart 2017). The sea turtles here have shown migratory movements from and to the GoM, traveling to Caribbean Sea and to the Atlantic Ocean (Cuevas et al., *Unpublished data*). These migratory movements integrate a connectivity network between different coastal, neritic and oceanic areas, facilitating the energy flux and genetic mix. The objectives of this work were to describe the feeding aggregation areas and migratory movements and to illustrate the connectivity between the Caribbean Sea and Gulf of Mexico by post-nesting females of four sea turtle species.

Methods

We attached 73 tags to individuals of four sea turtle species (10 *Carretta caretta*, 37 *Chelonia mydas*, 17 *Eretmochelys imbricate*, and 10 *Lepidochelys kempii*) from 35 localities in the coasts of GoM and Caribbean in Mexico. We used 51 Telonics (TAM-4510-3) and 23 Wildlife Computers tags (SPLASH 10-309 A and SPOT 352-B). The raw data were downloaded from the Argos user-interface (Argos-System 2017) and standardized for both models and brands. We used speed filtering (*vmask* function in *argosfilter*), with a maximum velocity of 1.67 m/s. Locations in each track were classified as: *internesting*, period of time between two consecutive nesting events; *migration*, directed movements for several days; and *feeding grounds*.

The characterizations of feeding grounds was done by a systematic point sampling inside the core area for each individual based on the 50% of the kernel utilization distribution (Calenge 2006). We used functions implemented in *adehabita* to delimit core areas for each turtle. The core areas were characterized using distance to the closest coast (Hijmans et al. 2005), depth (GEBCO 2016), and the slope of sea floor derived from bathymetry (*Slope* in ArcGis Spatial Analyst Tools).

The spatial characterization of sea turtle migrations was done with sample points every 10 km along a line of migration. Bathymetry and distance to coast were obtained for each point, as well as the total length and mean speed for each migration. To describe the connectivity between countries, we assigned the destination of each turtle and for connectivity between basins, we labeled the origin and destination of each individual as Caribbean, GoM or Atlantic. Median, first and third quartiles were estimated. To evaluate the statistical differences between the features of core areas and migrations, we did Pairwise Wilcoxon Rank Sum tests.

Results

Feeding grounds — We obtain 51 core areas for feeding grounds (Figure 1). The median size of core areas was 7,003 m^2 (Q_1 = 3,218 - Q_2 = 15,380) with significant differences for all species. Particularly, Kemp's Ridley showed the bigger core areas, followed by loggerheads. Greens and hawksbills displayed feeding areas closest to the coast than loggerheads and kemp's. Regarding sea floor configuration, all species have their areas in shallow waters in flat sea floor (18m, Q_1 = 13.5 – Q_2=35) with loggerheads using the deepest areas and Kemp's Ridleys the flattest ones (Table 1a).

Migrations of 60 individuals (Figure 1) were characterized with some features significantly different between species. Greens and Hawksbills did shorter migrations than Loggerheads and Kemp's Ridleys, but Loggerheads use deeper waters than the rest of the species. There were not significant differences in the distance to the coast between species. Most of the turtles stayed in Mexican waters (47), while others traveled to aggregation areas in United States (7), Nicaragua (2), Bahamas, Cuba and Honduras (1). Even though most of the turtles tagged in the GoM stayed inside it (31), some others displayed connections between the GoM and Caribbean Sea (17), and vice versa (3), and one more traveled from the GoM to the Atlantic.

Conclusions

We described the spatial distribution and migration features of 73 sea turtles using satellite telemetry. The four species analyzed here, displayed different characteristics in their feeding grounds. It is also important to know that most of the sea turtles used the 50 m isobath to migrate all along the Yucatan Peninsula. So policies for reducing impacts on sea turtle can be applied based on these ecological criteria.

Figure 1. Feeding ground and migration paths of four sea turtle species

KEYWORDS: Movement ecology, feeding grounds, blue highways, connectivity

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Table 1. Statistics of feeding areas and migrations of four species of sea turtles in the GoM

		Feeding core areas		
	Size (m2)	**Distance to coast (km)**	**Depth (m)**	**Slope (°)**
Caretta caretta	15,060 (7,648-45,509)	34 (20-60)	25 (32-16.7)	0.125 (0.083-0.242)
Chelonia mydas	5,692 (2,517-10,742)	6 (2.5-10.7)	12 (4-35)	0.132 (0.046-0.592)
Eretmochelys imbricata	3,867 (1,849-14,115)	9 (3.6-17.6)	7 (3-19)	0.058 (0.029-0.160)
Lepidochelys kempii	193,675 (21,389-380,529)	41 (29-60)	18 (35-13.5)	0.032 (0.023-0.065)
General	**7,003 (3,218-15,380)**	**9.33**	**14**	**0.087**
		Migrations		
	Length (km)	**Distance to coast (km)**	**Depth (m)**	**Speed (m/s)**
Caretta caretta	971.4 (808.8-1,532.1)	46 (18.3-86.7)	163 (18-1,362)	0.572 (0.350-0.766)
Chelonia mydas	376.8 (170.5-661.5)	28.6 (10.1-69.7)	27 (10-1,181)	0.691 (0.565-0.933)
Eretmochelys imbricata	439.4 (159.2)	44.9 (12.7-76.6)	44 (15-503)	0.633 (0.495-0.730)
Lepidochelys kempii	1,452.6 (937.1-1894.1)	29.2 (15.0-47.8)	30 (17-66)	0.571 (0.513-0.590)
General	**520.1 (210.8-971.4)**	**34 (13-69)**	**35 (14-691)**	**0.638 (0.512-0.830)**

All statistics are reported as: Median (Q1-Q2)