

Rookery contributions, movements and conservation needs of hawksbill turtles at foraging grounds in the eastern Pacific Ocean

Alexander R. Gaos^{1,2,3,26,*}, Rebecca L. Lewison¹, Michael P. Jensen³,
Michael J. Liles^{4,5,26}, Ana Henriquez^{5,26}, Sofia Chavarria^{5,26}, Carlos Mario Pacheco^{5,26},
Melissa Valle^{5,26}, David Melero²⁶, Velkiss Gadea^{6,26}, Eduardo Altamirano^{6,26},
Perla Torres^{7,26}, Felipe Vallejo^{8,26}, Cristina Miranda^{8,26}, Carolina LeMarie^{8,26},
Jesus Lucero^{9,26}, Karen Ocegüera^{9,26}, Didiher Chácon^{10,26}, Luis Fonseca^{10,26},
Marino Abrego^{11,26}, Jeffrey A. Seminoff^{12,26}, Eric E. Flores^{13,14}, Israel Llamas^{15,26},
Rodrigo Donadi¹⁶, Bernardo Peña¹¹, Juan Pablo Muñoz^{17,26}, Daniela Alarcón Ruales^{17,26},
Jaime A. Chaves¹⁷, Sarah Otterstrom^{18,26}, Alan Zavala^{19,20,26}, Catherine E. Hart^{21,26},
Rachel Brittain^{22,26}, Joanna Alfaro-Shigueto^{23,24,25,26}, Jeffrey Mangel^{23,26},
Ingrid L. Yañez²⁶, Peter H. Dutton¹²

*Corresponding author: alexander.gaos@hawksbill.org

Marine Ecology Progress Series 586: 203–216 (2018)

Author affiliations

1. Biology Department, San Diego University, San Diego, California 92182, USA
2. Graduate Group in Ecology, University of California Davis, Davis, California 95616, USA
3. Marine Mammal and Turtle Division, Ocean Associates Inc., Southwest Fisheries Science Center (NOAA/NMFS), La Jolla, California 92037, USA
4. Biology Department, University of Texas at El Paso, El Paso, Texas 79968, USA
5. ProCosta, San Salvador, El Salvador
6. Marine Turtles Department, Fauna & Flora International, Managua, Nicaragua
7. Instituto de Ciencias del Mar y Limnología, Unidad Académica Mazatlán Universidad Nacional de Mexico, Mazatlán, Mexico
8. Equilibrio Azul, Quito, Ecuador
9. Grupo Tortuguero de las Californias, A.C., La Paz, Mexico
10. Latin American Sea Turtles, Tibás, Costa Rica
11. Conservación de Recursos Costeros y Marinos, Ministerio del Ambiente de Panamá, Panama City, Panama
12. Marine Mammal and Turtle Division, Southwest Fisheries Science Center (NOAA/NMFS), La Jolla, California 92037, USA
13. Sistema Nacional de Investigación de Panamá, Panama City, Panama
14. Instituto de Investigaciones Científicas y Servicios de Alta Tecnología, Panama City, Panama
15. Campamento Tortuguero Mayto, A.C., Mayto, Mexico
16. World Wildlife Fund of Panama, Panama City, Panama
17. Marine Ecology Department, Universidad San Francisco de Quito/Galapagos Science Center, San Cristóbal, Galapagos Archipelago, Ecuador
18. Paso Pacifico, Managua, Nicaragua

19. Centro Interdisciplinario de Investigación para el Desarrollo Integral Regional, Sinaloa, Mexico
20. Instituto Politécnico Nacional, Sinaloa, Mexico
21. Red Tortuguera, A.C., Guayabitos, Mexico
22. Akazul, La Barrona, Guatemala
23. Marine Turtle Research Group, School of Biosciences, University of Exeter, Penryn, UK
24. Marine Biology Department, Universidad Científica del Sur, Lima, Peru
25. ProDelphinus, Lima, Peru
26. Eastern Pacific Hawksbill Initiative, San Diego, California 92117, USA

Table S1. Percentage contributions from each source rookery used in the six MSA simulations (Sim) to calculate the haplotypes present in the five simulated foraging grounds.

Source rookery	Contribution to fabricated FGs (%)					
	Sim 1	Sim 2	Sim 3	Sim 4	Sim 5	Sim 6
Costa Careyes	60	5	23	85	0	15
Bahia de Jiquilisco	23	2	10	15	0	0
Estero Padre Ramos	10	60	5	0	85	0
Osa Peninsula	5	23	2	0	15	0
Machailla	2	10	60	0	0	85
n =	65	65	65	65	65	65

Table S2. Number of haplotypes (H), nucleotide (π) and haplotype (h) diversities with associated standard deviation (SD), at the eight designated foraging grounds (DFGs) and five source rookeries analyzed in this study.

Location	H	π	SD	<i>h</i>	SD
<i>Foraging Areas</i>					
Mexico					
El Pardito ^a					
Isla Espritu Santo ^a	3	0.0008	0.0007	0.5381	0.0346
El Salvador					
Bahia de Jiquilisco	6	0.0011	0.0009	0.6522	0.0248
Punta Amapala	5	0.0013	0.0010	0.7000	0.0817
Nicaragua					
La Salvia ^a					
Estero Padre Ramos ^a	5	0.0009	0.0008	0.6012	0.0299
Southern Rivas	3	0.0009	0.0008	0.5238	0.1055
Costa Rica					
Golfo Dulce	4	0.0006	0.0006	0.3148	0.0710
Panama					
Coiba	6	0.0014	0.0011	0.5803	0.0536
Ecuador					
Machalilla	3	0.0004	0.0004	0.2646	0.0771
Overall	10	0.0013	0.0010	0.7069	0.0108
^a Samples pooled from two adjacent foraging grounds					
<i>Nesting Areas</i>					
Mexico					
Costa Careyes	2	0.0002	0.0003	0.1444	0.1123
El Salvador					
Bahía de Jiquilisco	3	0.0007	0.0006	0.4113	0.0583
Nicaragua					
Estero Padre Ramos	5	0.0006	0.0006	0.4555	0.0416
Costa Rica					
Osa Peninsula	3	0.0015	0.0012	0.5111	0.1643
Ecuador					
Machalilla	2	0.0001	0.0002	0.0667	0.0613
Overall	6	0.0008	0.0007	0.5600	0.0213

Table S3. Results (mean % \pm 95% confidence intervals in parentheses) from the Bayesian mixed stock analysis (MSA) from (A) the five source rookeries to the eight designated foraging grounds (DFGs) and (B) the two habitat type rookeries to the two habitat type foraging grounds.

A	Source rookery	Foraging ground							
		El Pardito-Isla Espiritu Santo (MX)	Bahia de Jiquilisco (ES)	Punta Amapala (ES)	La Salvia-Estero Padre Ramos (NI)	Southern Rivas (NI)	Golfo Dulce (CR)	Coiba (PA)	Machalilla (EC)
	Costa Careyes (MX)	94 (79–100)	6 (0–30)	12 (0–59)	7 (0–40)	3 (0–21)	2 (0–11)	7 (0–24)	14 (0–90)
	Bahia de Jiquilisco (ES)	1 (0–5)	50 (32–68)	15 (0–49)	35 (9–56)	7 (0–27)	2 (0–9)	2 (0–8)	1 (0–4)
	Estero Padre Ramos (NI)	1 (0–9)	22 (0–52)	31 (0–83)	34 (1–79)	7 (0–32)	3 (0–15)	3 (0–17)	1 (0–11)
	Osa Peninsula (CR)	2 (0–11)	14 (7–25)	25 (1–57)	9 (0–20)	79 (55–98)	91 (78–100)	85 (70–98)	7 (0–24)
	Machalilla (EC)	2 (0–14)	7 (0–31)	18 (0–69)	14 (0–50)	4 (0–23)	2 (0–13)	3 (0–19)	77 (0–100)

B	Source rookery	Foraging ground	
		Mangrove estuary	Open coast
	Mangrove estuary	83 (74-91)	6 (0-19)
	Open coast	17 (9-26)	94 (81-100)

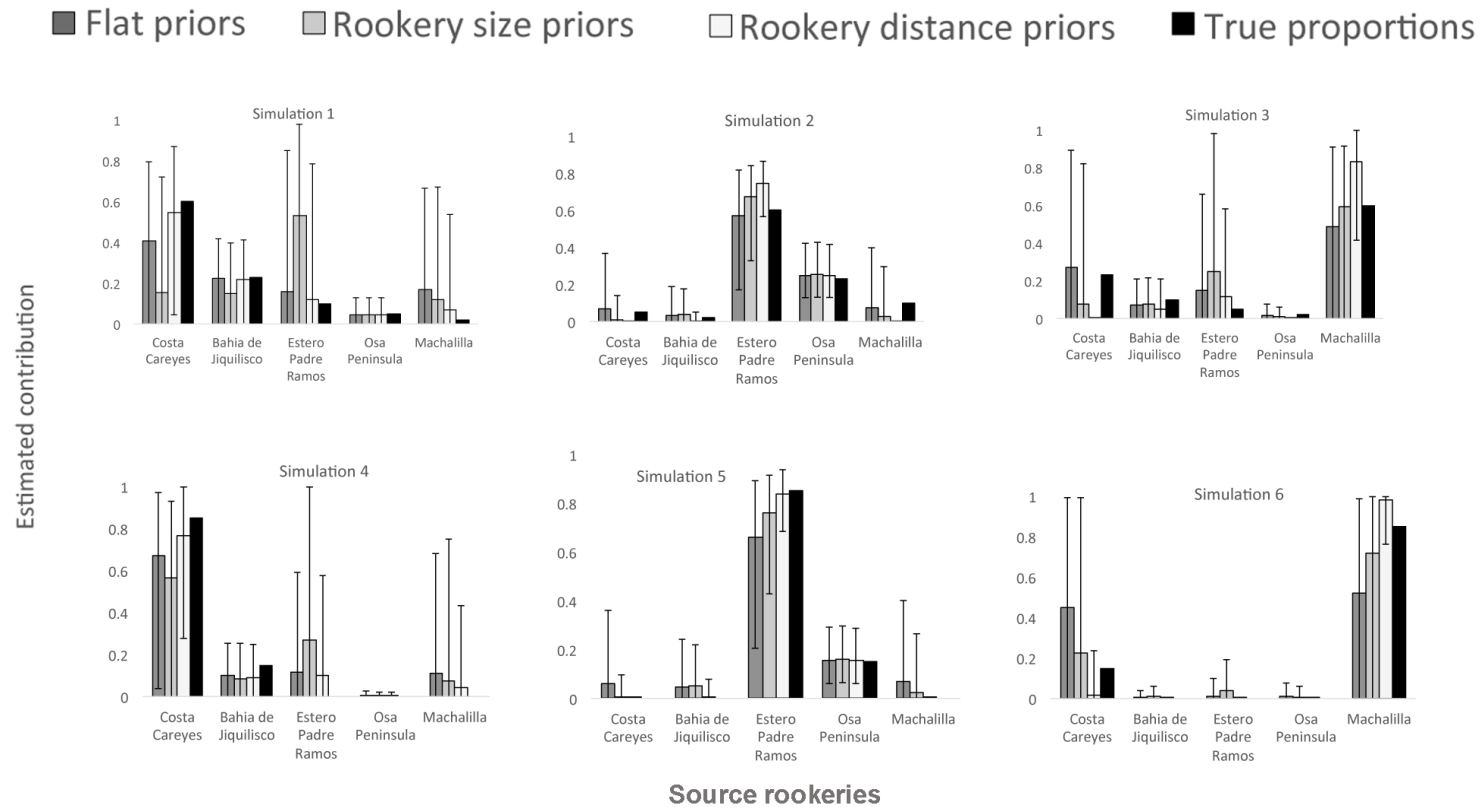


Figure S1. Bayesian mixed-stock contribution estimates from five hawksbill rookeries to six simulated foraging grounds. True proportions of simulated foraging grounds (black bars) are compared to estimates made using flat (dark grey bars), rookery size (light grey bars) and rookery distance (white bars) priors. Error bars represent 97.5% and 2.5% percentile intervals.