

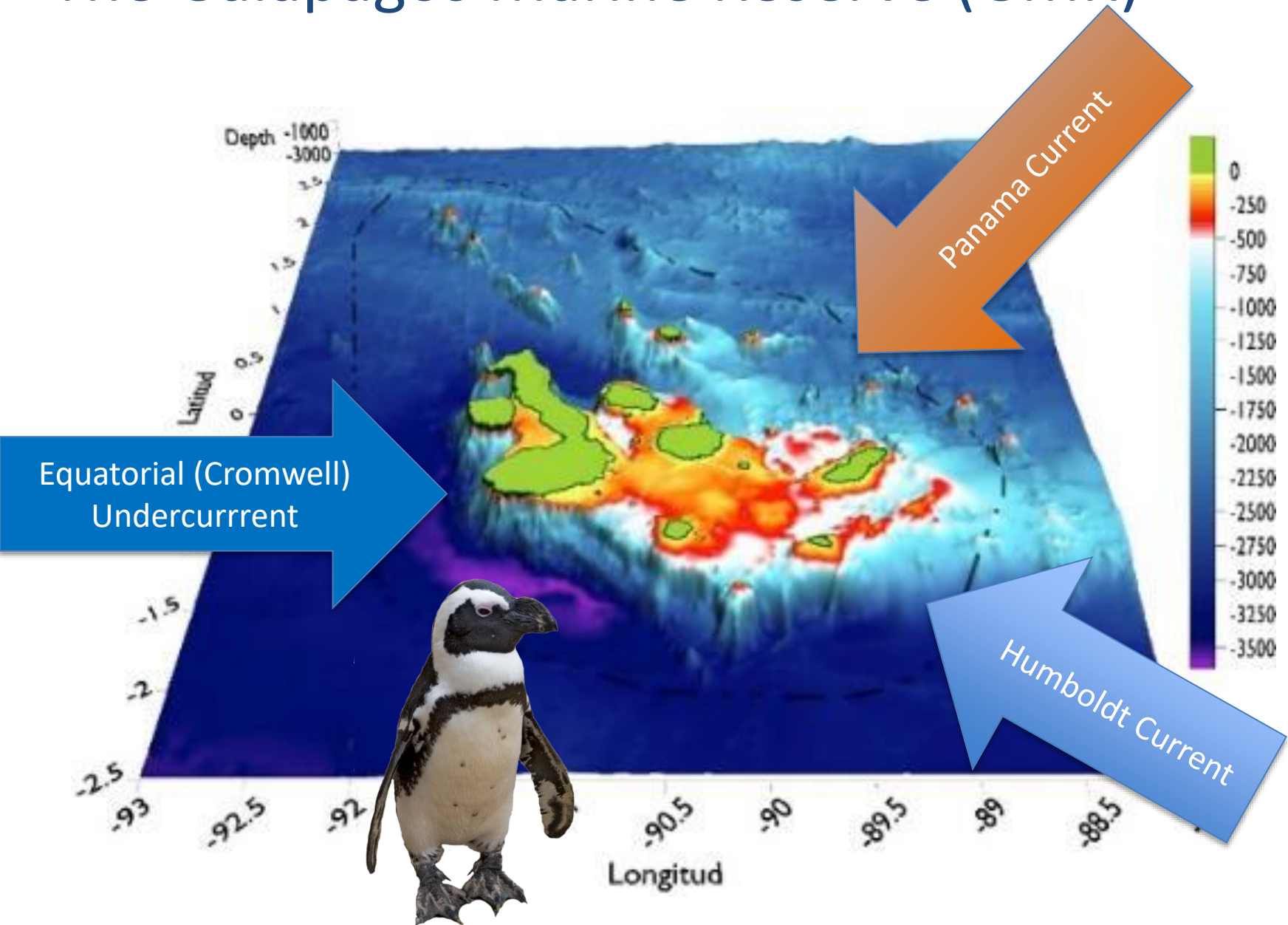
# Challenges in Monitoring and Managing Large Marine Fishes: Lessons from the Galápagos Archipelago



Adam N. H. Smith\*  
David Acuña Marrero  
Matthew D. M. Pawley  
Marti J Anderson



# The Galápagos Marine Reserve (GMR)



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91°W

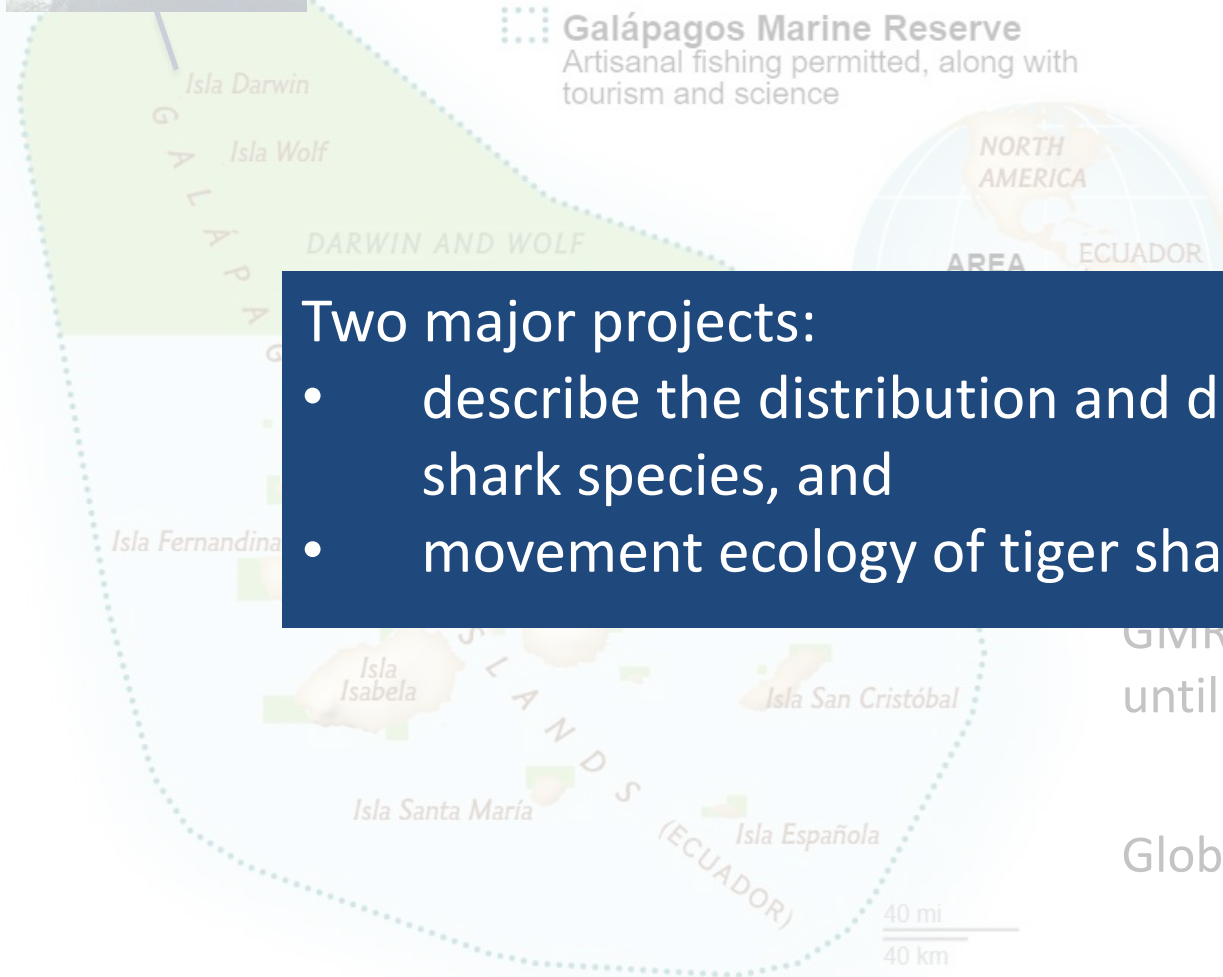
**New protections (2016)**  
Accessible for scientific use and tourism only; no extraction of natural resources (including fishing) allowed

**Galápagos Marine Reserve**  
Artisanal fishing permitted, along with tourism and science

GMR multi-use zonal management since 1989

Two major projects:

- describe the distribution and diversity of shark species, and
- movement ecology of tiger sharks.



UNESCO world site 2001

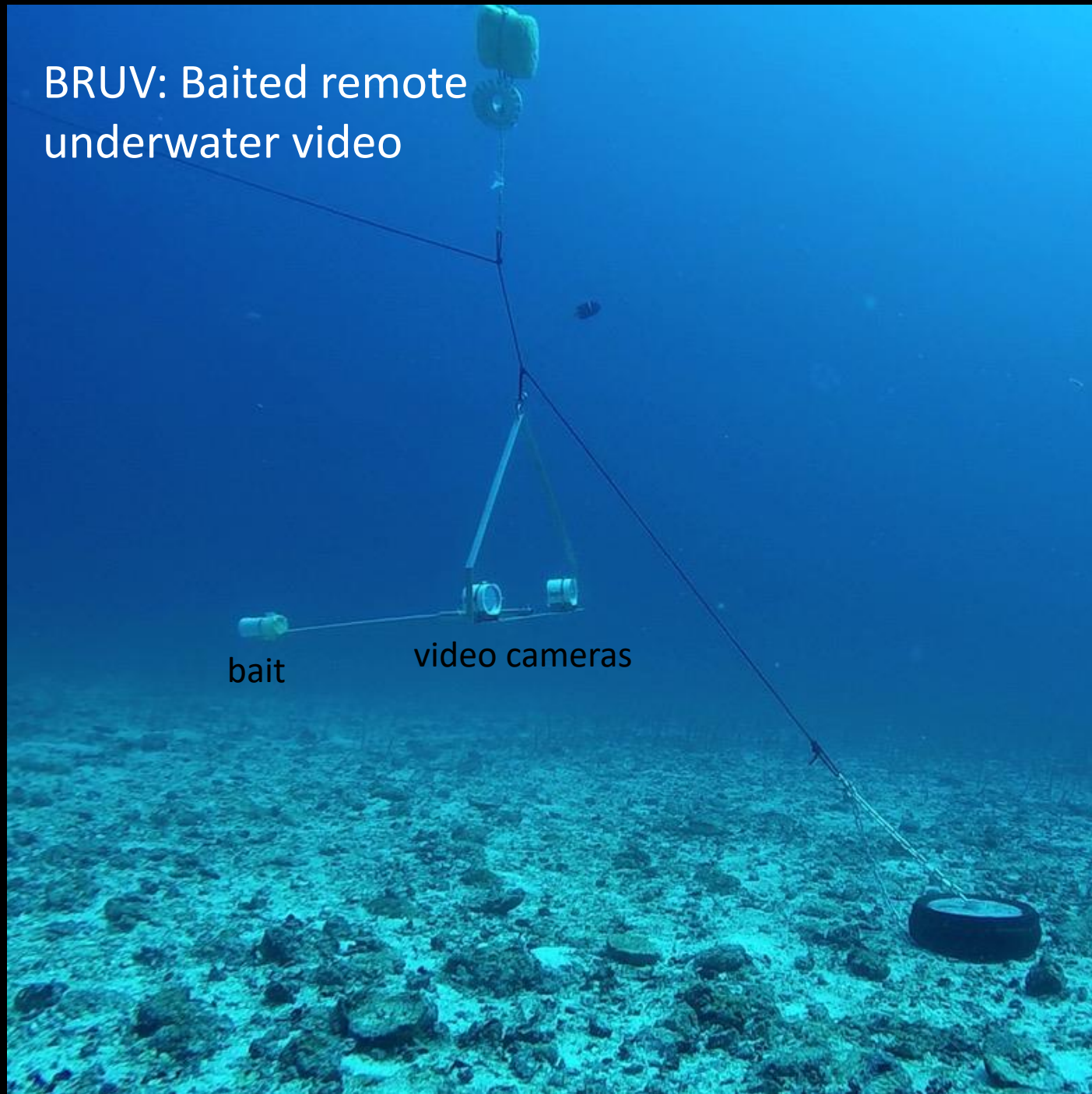
ected in the GMR, yet sightings declined until recently.

Global hotspot for sharks

BRUV: Baited remote  
underwater video

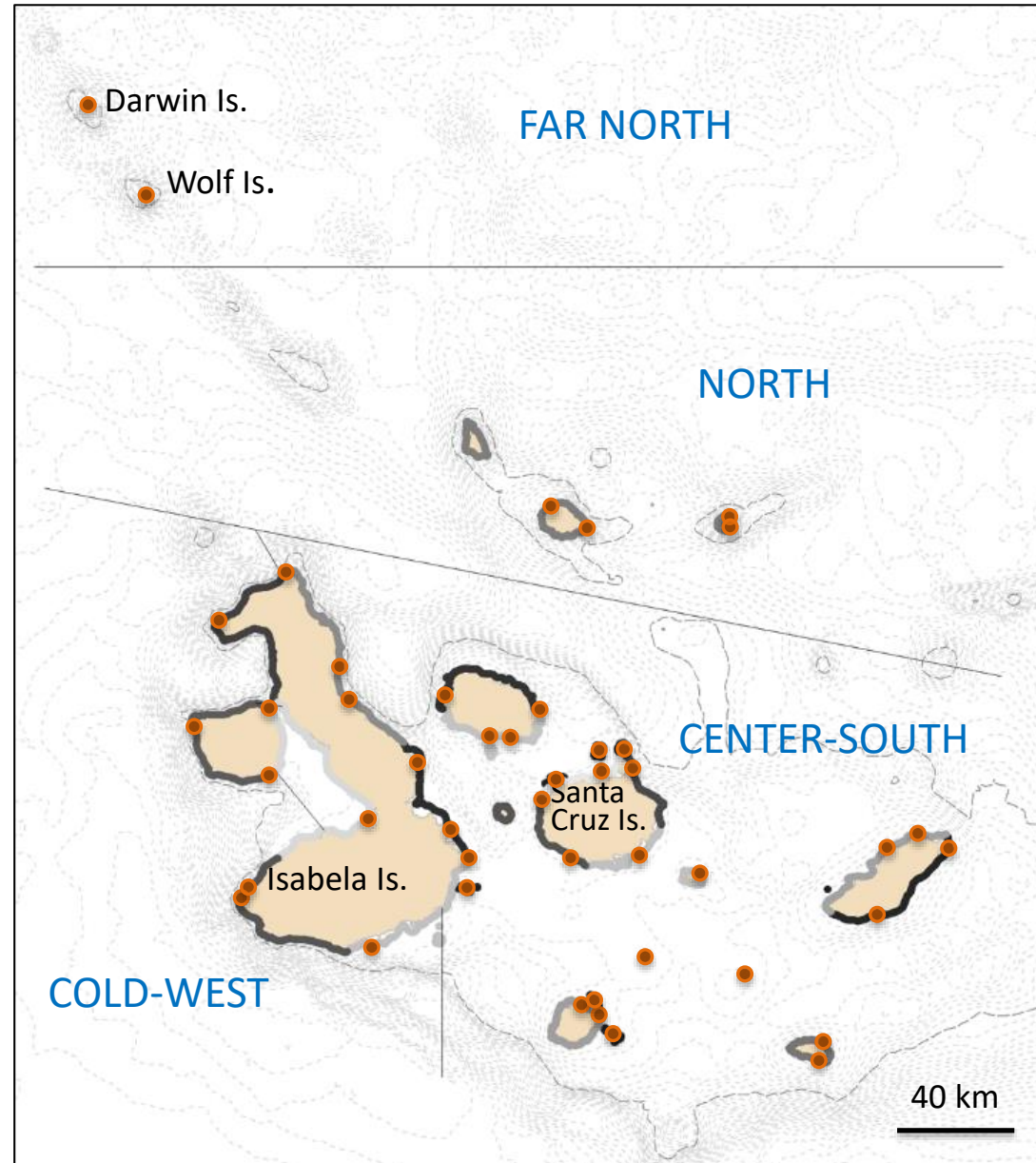
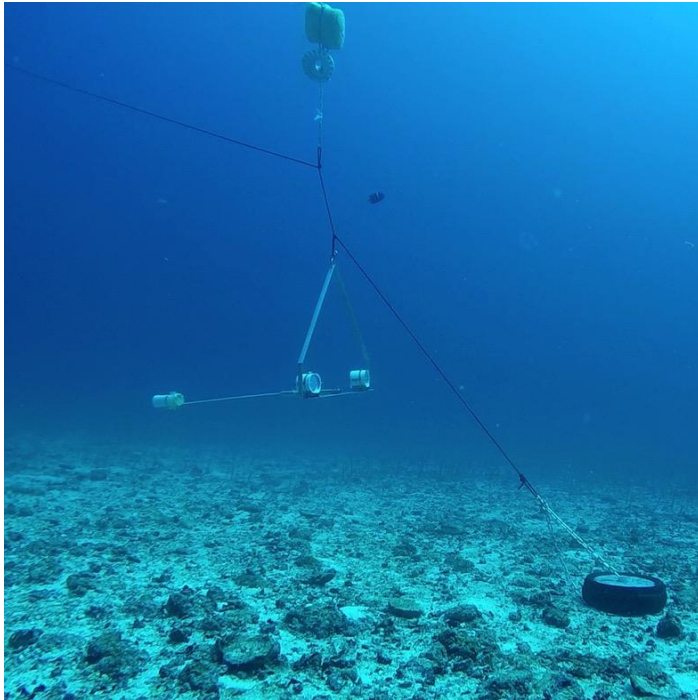
bait

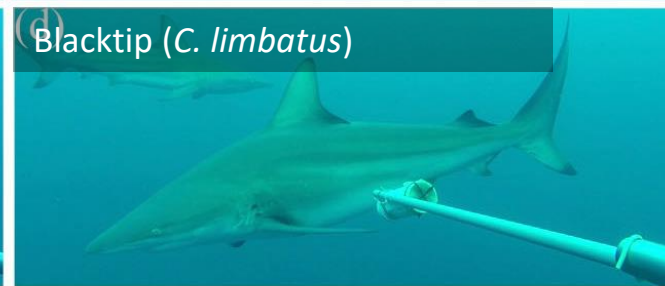
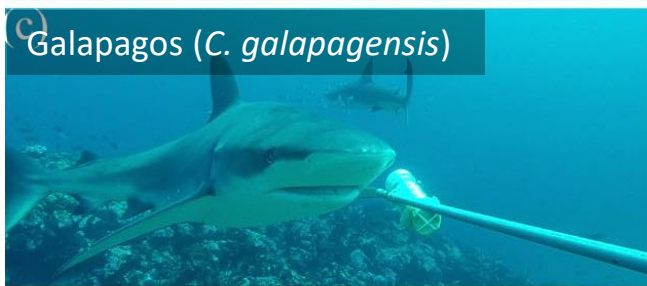
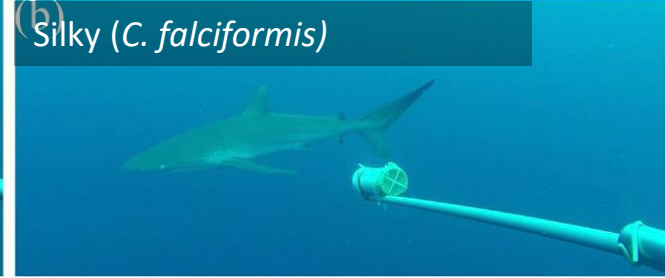
video cameras



# Sampling an archipelago

- 21 strata in 4 bioregions
- 45 sites, randomly selected
- 8 replicates per site (4 at 15 m; 4 at 25 m)
- 2 seasons





**629 deployments in total**

**Sharks**

877 individuals in total

Up to 26 individuals per deployment

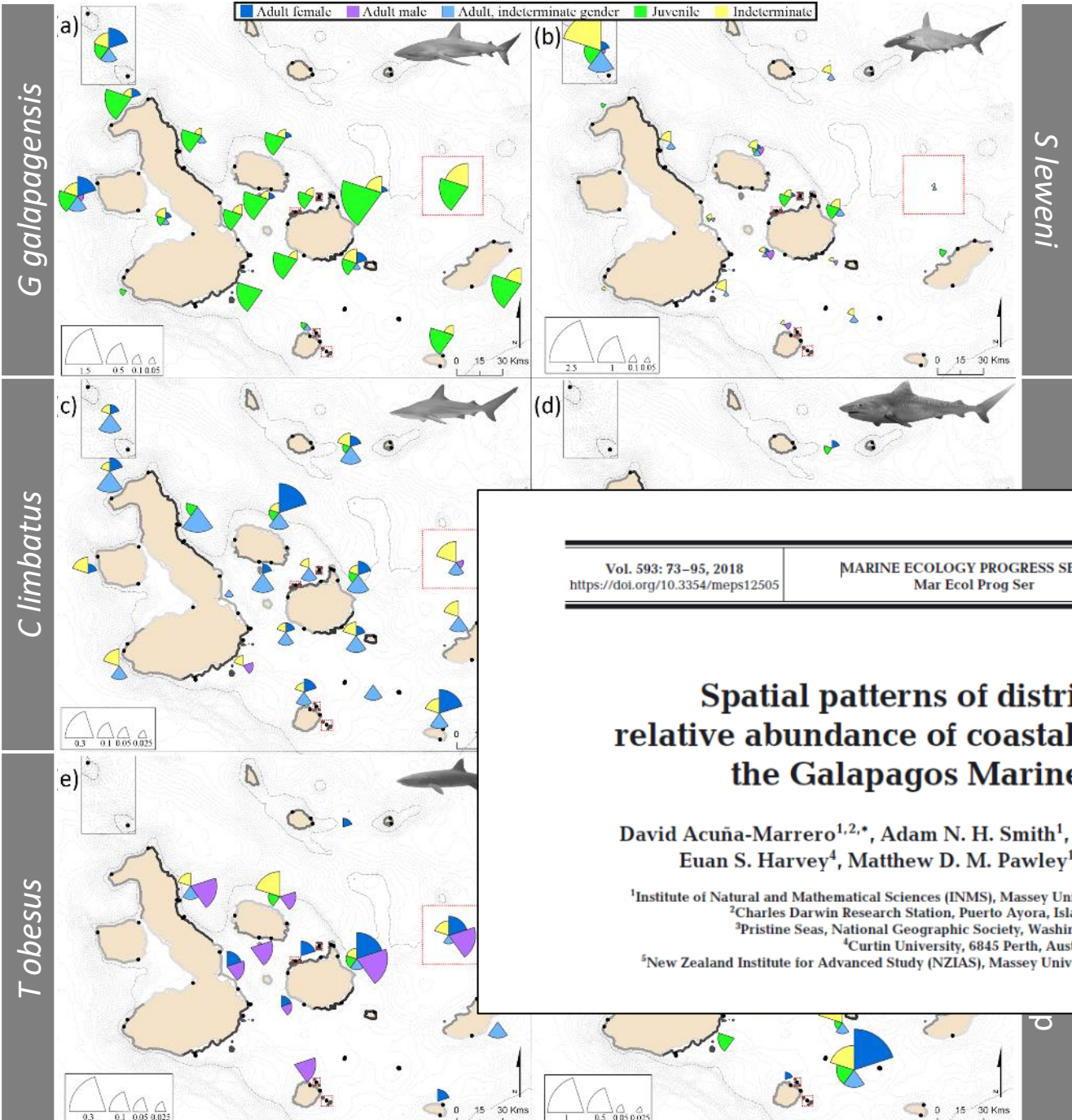
10 species in total

Up to 4 species per deployment

**62,955 records of other macrofauna**



■ Adult female  
 ■ Adult male  
 ■ Adult, indeterminate gender  
 ■ Juvenile  
 ■ Indeterminate



Many shark species segregated by size and sex

Vol. 593: 73–95, 2018 <a href="https://doi.org/10.3354/meps12505">https://doi.org/10.3354/meps12505</a>	MARINE ECOLOGY PROGRESS SERIES Mar Ecol Prog Ser	Published April 12
<h2 style="margin: 0;">Spatial patterns of distribution and relative abundance of coastal shark species in the Galapagos Marine Reserve</h2> <p style="margin: 10px 0 0 0;">                     David Acuña-Marrero<sup>1,2,*</sup>, Adam N. H. Smith<sup>1</sup>, Pelayo Salinas-de-León<sup>2,3</sup>,                      Euan S. Harvey<sup>4</sup>, Matthew D. M. Pawley<sup>1</sup>, Marti J. Anderson<sup>5</sup> </p> <p style="margin: 5px 0 0 0;"> <sup>1</sup>Institute of Natural and Mathematical Sciences (INMS), Massey University, 0745 Auckland, New Zealand  <sup>2</sup>Charles Darwin Research Station, Puerto Ayora, Islas Galápagos, Ecuador  <sup>3</sup>Pristine Seas, National Geographic Society, Washington, DC 20036, USA  <sup>4</sup>Curtin University, 6845 Perth, Australia  <sup>5</sup>New Zealand Institute for Advanced Study (NZIAS), Massey University, 0745 Auckland, New Zealand                 </p>		

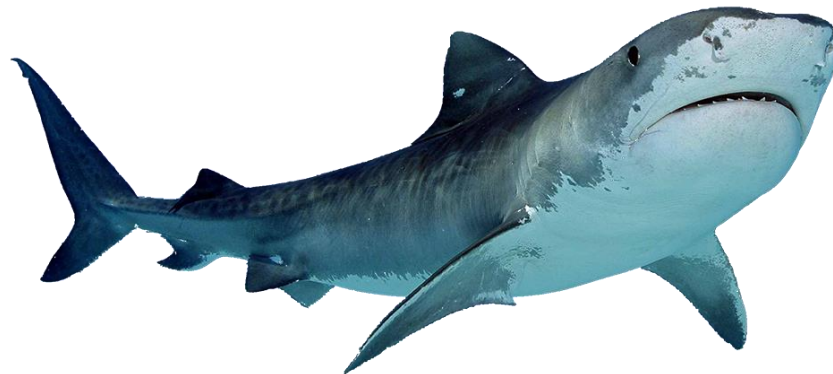
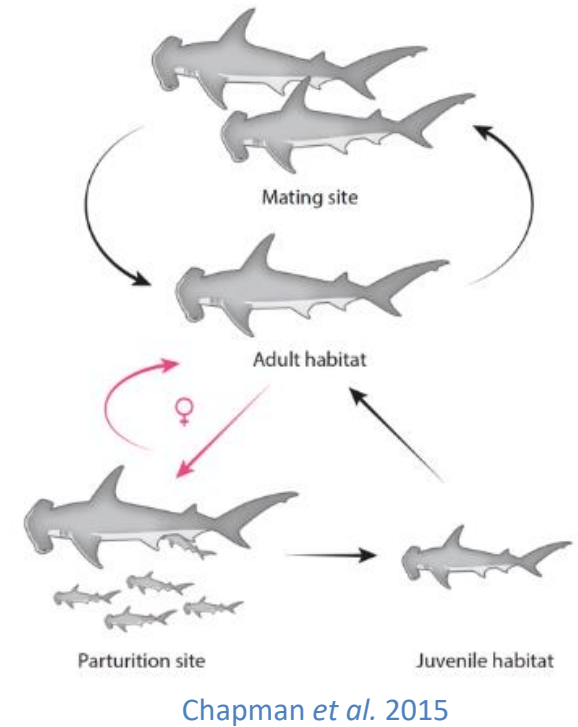


# Tiger shark (*Galeocerdo cuvier*)

- Highly migratory elsewhere (100s of km)
- Life-history and migration complicates conservation
- Juveniles are nocturnal bottom feeders; adults hunt larger prey, especially turtles

## Research questions:

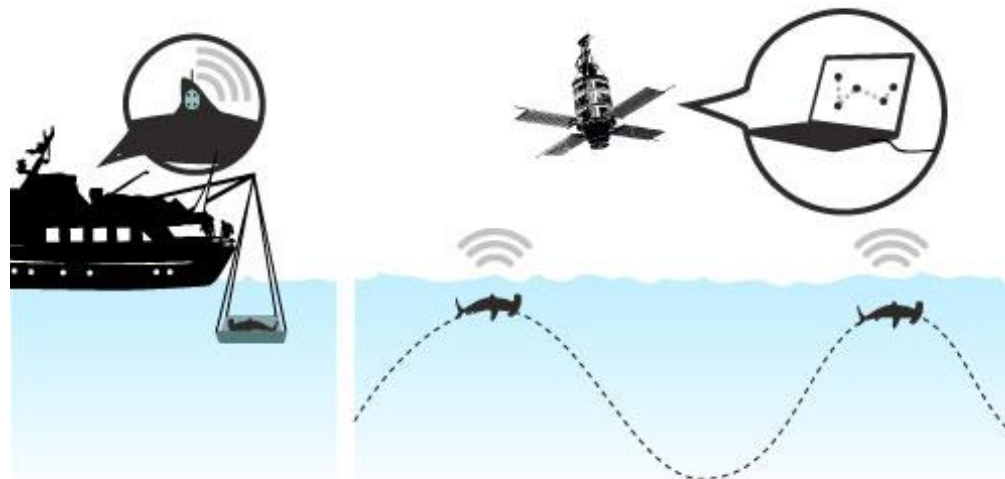
- What are the movement patterns of tiger sharks in and around the Galápagos MR?
- What habitats/food resources are tiger sharks using during their different life-history stages?



# Internal acoustic tagging

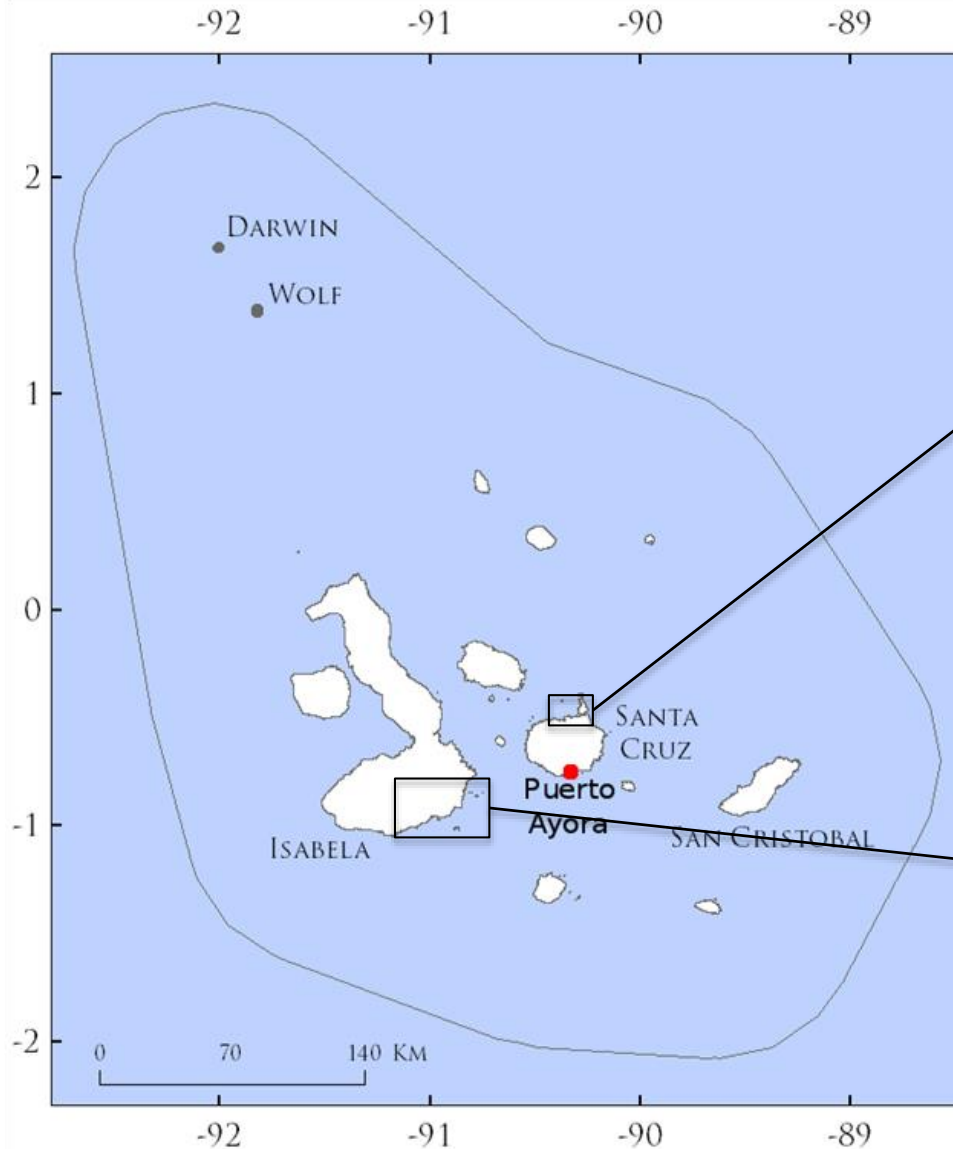


# Fin-mounted satellite tags (SPOT5)



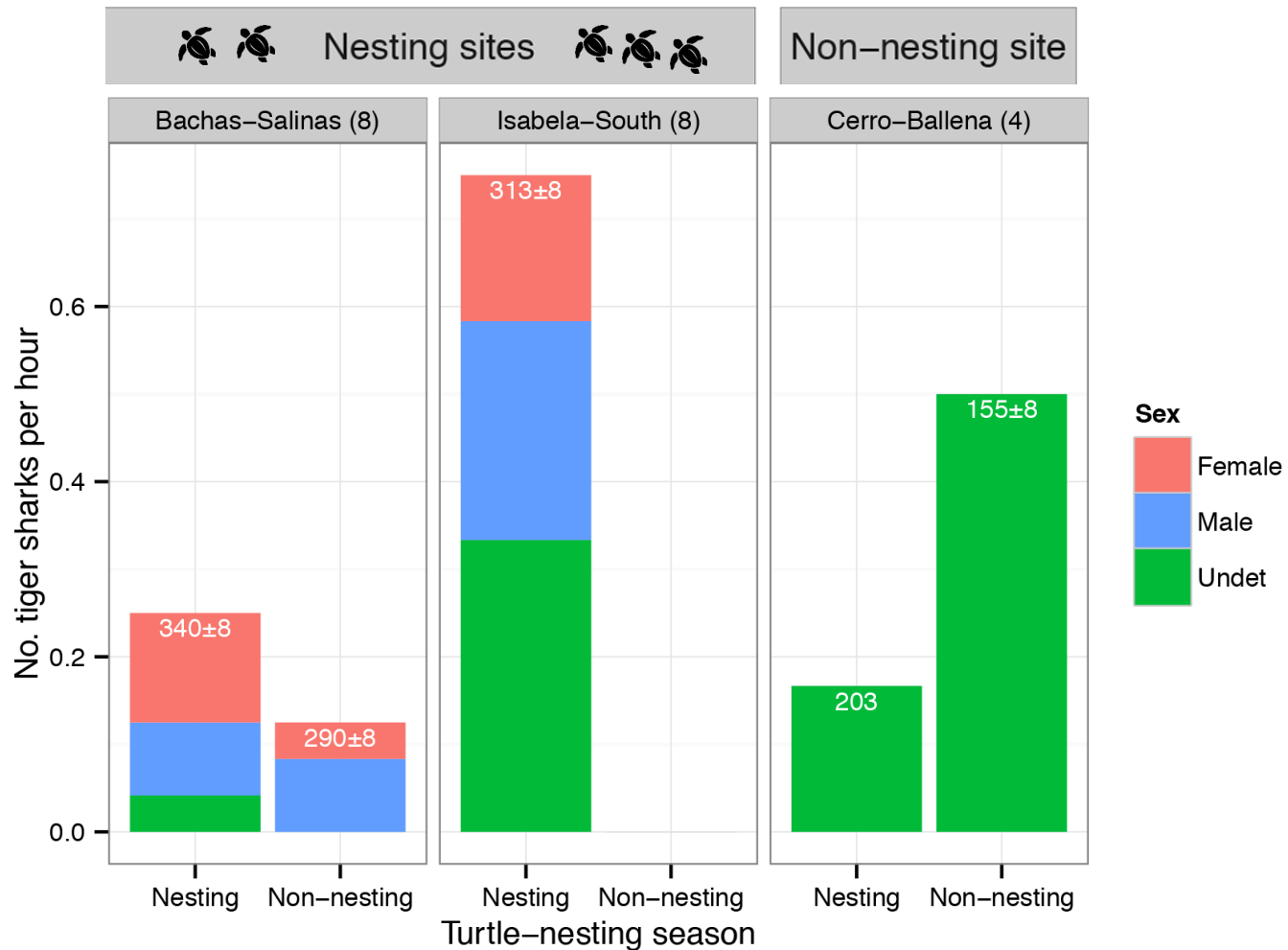
# Three study sites

(two important turtle-nesting grounds)



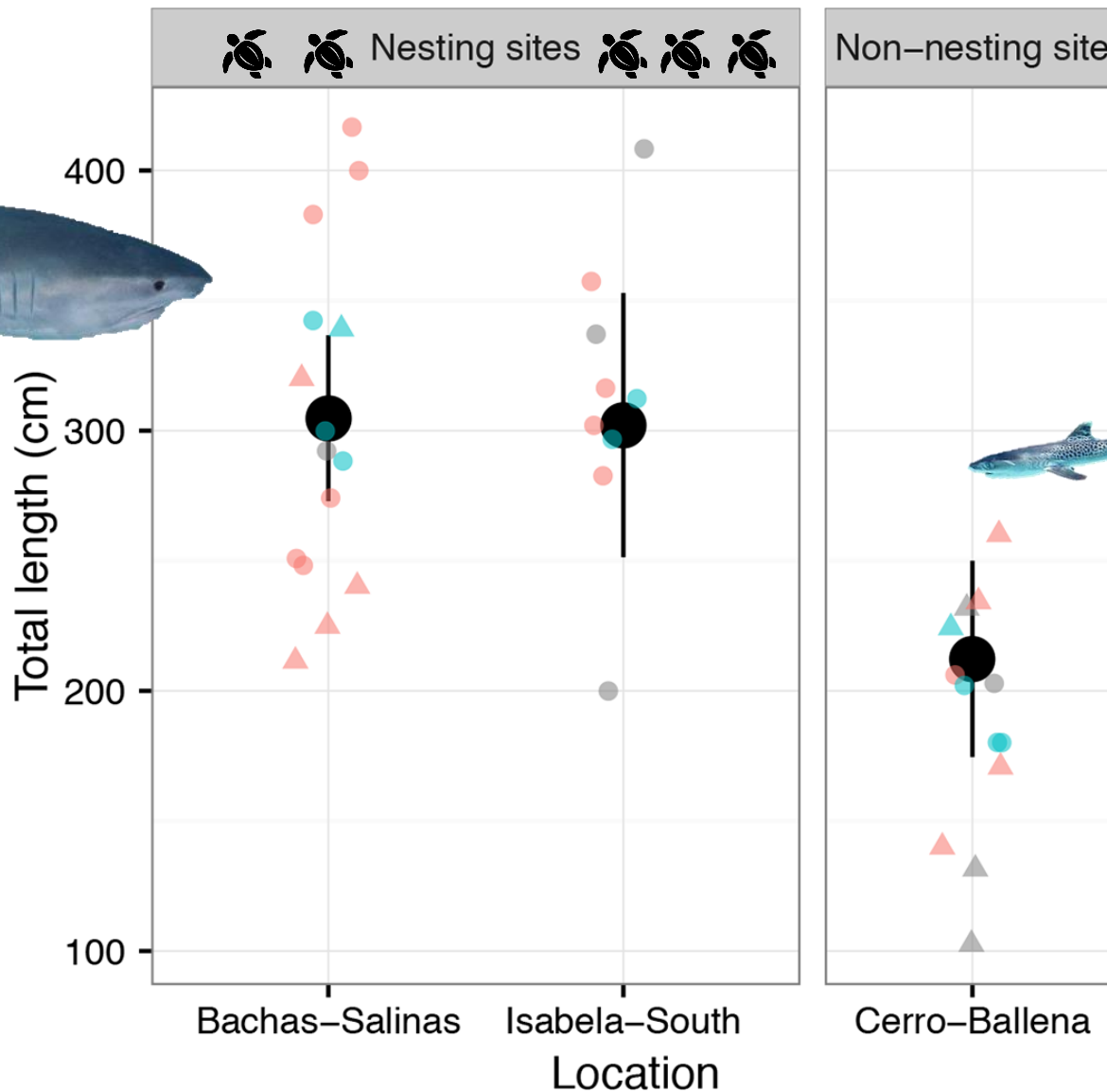
# At turtle-nesting sites, tiger sharks were

- seen more often in the turtle nesting season



# At turtle-nesting sites, tiger sharks were

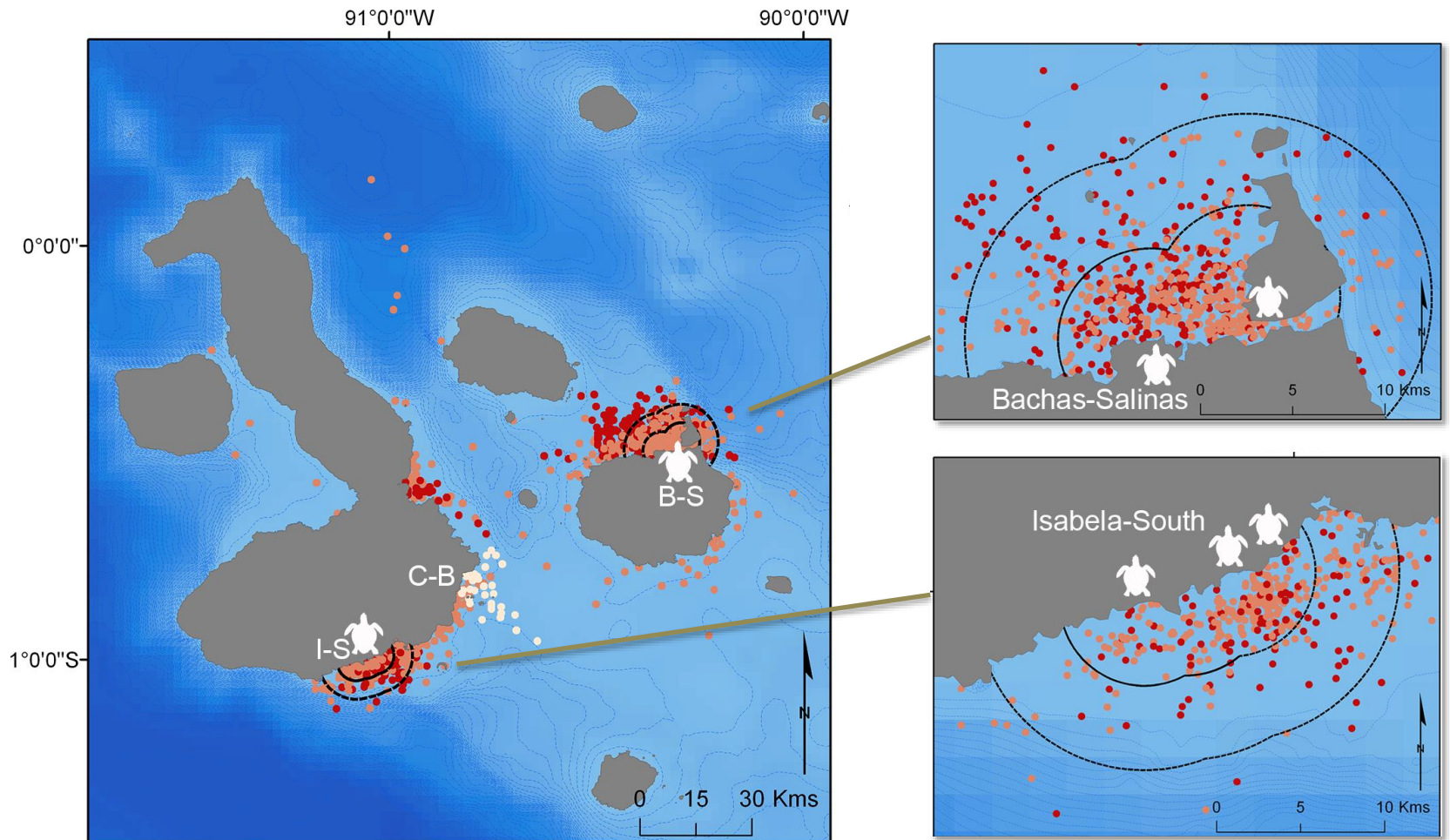
- seen more often in the turtle nesting season
- larger



20 sharks captured: 13 females, 7 males. 11 successfully sat. tagged.

Medium-to-large sharks (orange and red) spent most of their time within 5-10 km of the turtle-nesting beaches.

Small sharks (white) stayed near Cerro-Ballena where they were tagged.

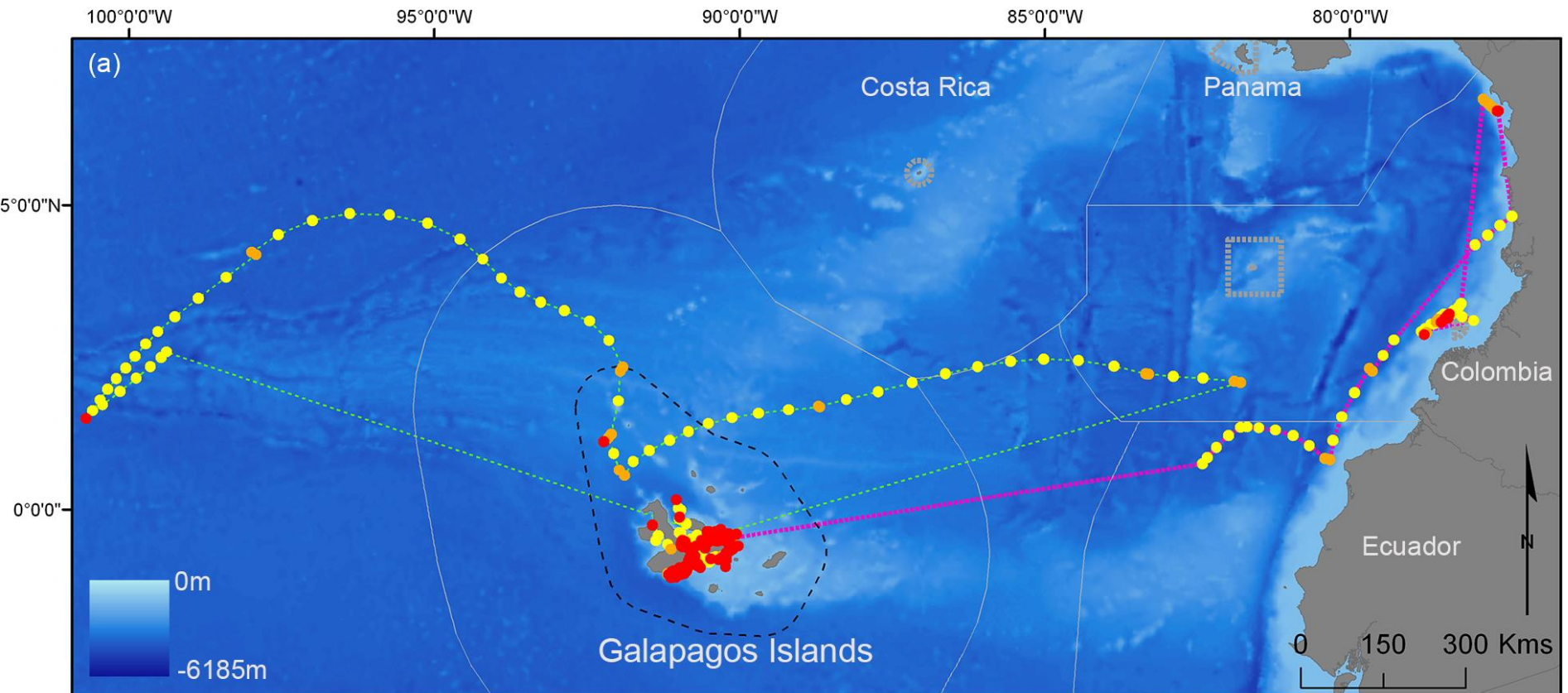


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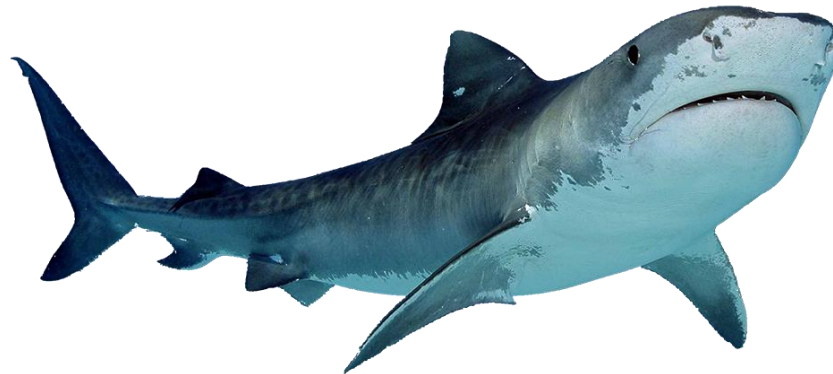
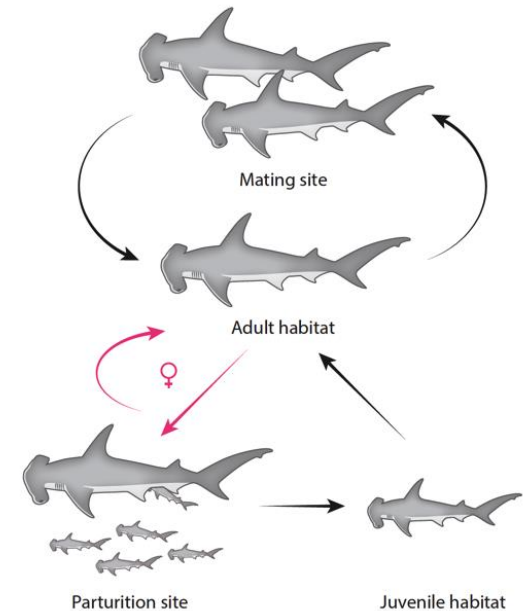
Small sharks (white) stayed near Cerro-Ballena where they were tagged.

Two female sharks left the GMR; both returned for turtle season.



# Tiger sharks at the Galápagos

- Galápagos provides
  - suitable habitats for all life history stages and reproduction
  - Abundant prey year-round, and especially in turtle nesting season
- Most tiger sharks were resident year-round. Those that left returned for turtle season.
- Galápagos Marine Reserve is a highly valuable site for tiger shark conservation





# Tiger sharks at the Galápagos

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RESEARCH ARTICLE

## Residency and movement patterns of an apex predatory shark (*Galeocerdo cuvier*) at the Galapagos Marine Reserve

David Acuña-Marrero<sup>1,2\*</sup>, Adam N. H. Smith<sup>2</sup>, Neil Hammerschlag<sup>3,4</sup>, Alex Hearn<sup>5</sup>, Marti J. Anderson<sup>6</sup>, Hannah Calich<sup>3</sup>, Matthew D. M. Pawley<sup>2</sup>, Chris Fischer<sup>7</sup>, Pelayo Salinas-de-León<sup>1</sup>

1 Charles Darwin Research Station, Puerto Ayora, Islas Galápagos, Ecuador, 2 Institute of Natural and Mathematical Sciences (INMS), Massey University, Albany Campus, Auckland, New Zealand, 3 Rosenstiel School of Marine and Atmospheric Science, University of Miami, Miami, United States of America, 4 Abess Center for Ecosystem Science & Policy, University of Miami, Miami, United States of America, 5 Universidad San Francisco de Quito, Quito, Ecuador, 6 New Zealand Institute for Advanced Study (NZIAS), Massey University, Auckland, New Zealand, 7 OCEARCH, Park City, United States of America

\* [d.acuna-marrero@massey.ac.nz](mailto:d.acuna-marrero@massey.ac.nz)

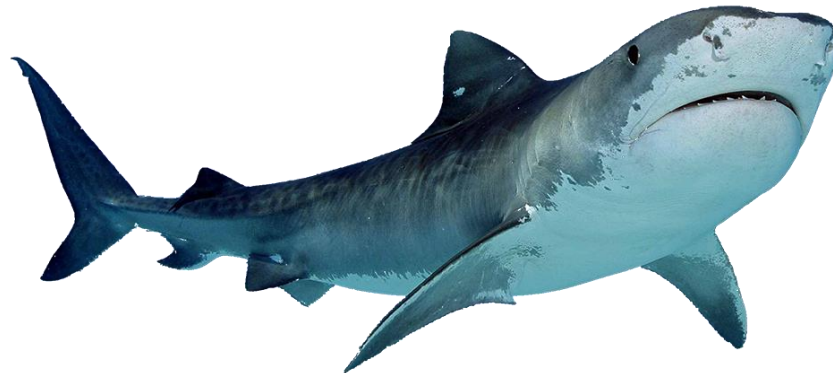
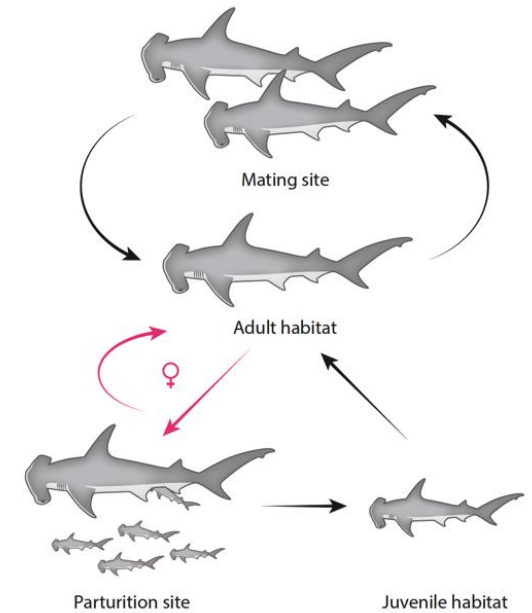
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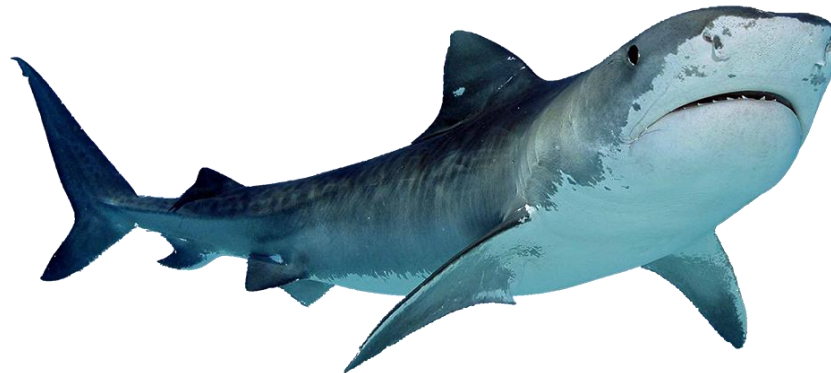
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- *Neil Hammerschlag, Hannah Calich, Rosenstiel School of Marine and Atmospheric Science, University of Miami, Miami, Florida, USA*
- *Chris Fischer, OCEARCH*
- *Ian Jonsen, Macquarie University, NSW, Australia*
- *Galapagos National Park Directorate, Ecuador*
- **Funding:**
  - Save Our Seas Foundation
  - Lindblad Expeditions
  - National Geographic
  - IWC-Schaffhausen
  - OCEARCH



Shark ID	Tagging date	TL (cm)	Sex	Satellite		Acoustic				
				days transm	% residency time	Days monitored	Days transm	No. detections	RI* (per tagging site)	
<b>Bachas-Salinas</b>										
TS1	30-Jan-2014	274	F	116	90.48	307	152	761	0.50	
TS2	30-Jan-2014	251	F	210	74.83	79	19	150	0.24	
TS3	30-Jan-2014	248	F	127	99.02	-	-	-	-	
TS4	30-Jan-2014	383	F	333	82.78	262	111	438	0.42	
TS5	11-Jun-2015	225	F	-	-	104	71	482	0.68	
TS6	11-Jun-2015	240	F	67	98.48	104	47	185	0.45	
	avg =	270.17 ± 23.49								
<b>Cerro Ballena</b>										
TS7	23-Jul-2014	140	F	-	-	180	41	140	0.23	
TS8	23-Jul-2014	224	M	25	87.50	303	68	510	0.22	
TS9	24-Jul-2014	234	F	26	100.00	271	16	82	0.06	
TS10	24-Jul-2014	171	F	21	100.00	286	45	399	0.16	
TS11	24-Jul-2014	260	F	115	100.00	-	-	-	-	
TS12	7-Oct-2014	180	M	-	-	113	23	376	0.20	
TS13	7-Oct-2014	180	M	-	-	195	93	1183	0.48	
TS14	21-Feb-2015	206	F	58	78.12	74	10	23	0.14	
TS15	21-Feb-2015	202	M	84	98.30	177	16	99	0.09	
	avg =	199.67 ± 12.14								
<b>Isabela-South</b>										
TS16	22-Feb-2015	378	F	128	100.00	-	-	-	-	
TS17	22-Feb-2015	282	F	14	100.00	58	1	1	-	
TS18	22-Feb-2015	324	M	45	100.00	118	2	2	-	
TS19	23-Feb-2015	286	M	66	95.61	-	-	-	-	
TS20	23-Feb-2015	242	M	37	100.00	68	1	1	-	
	avg =	302.40 ± 22.93								

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Smith A

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