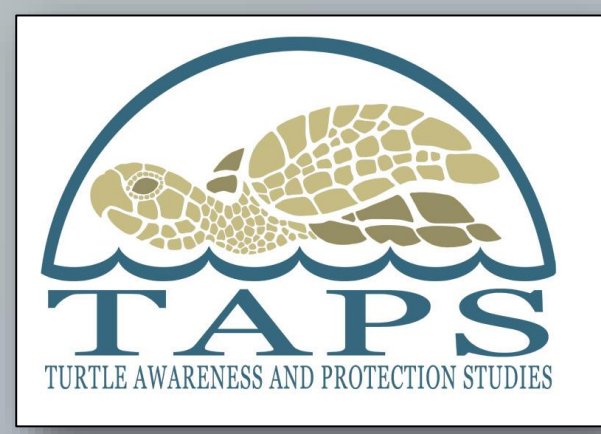
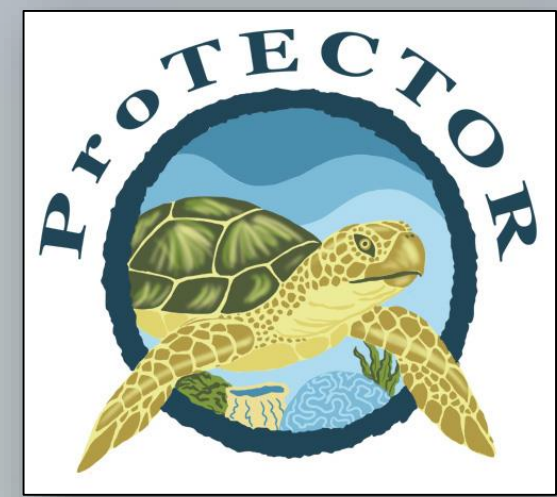


Identifying Sea Turtle Home Ranges Utilizing Citizen-Science Data From GIS Applications

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Introduction

- Sea turtles have been observed within oceans and seas around the globe.
- Flipper tags were the main method of tracking movements, until recently (Carr, 1984).
- Attaching radio transmitters to sea turtles has helped elucidate sea turtle home ranges in many locations (Van Dam and Diez, 1998; Scales et al., 2011; Carrión-Cortez et al., 2013).
- Sponge abundance in hawksbill home ranges suggests optimal foraging habitat for developing hawksbills (Van Dam and Diez, 1998).
- Determining home range has helped researchers understand more about how to further sea turtle conservation efforts (Gaos et al., 2012).
- Opportunities to help monitor in-water sea turtle locations have rarely been given to the public (Baumbach & Dunbar, 2017).
- User-friendly web-based and smartphone application GIS maps were created for the island of Roatán for dive tourists in the Sandy Bay West End Marine Reserve (SBWEMR) (Figure 1) to map sea turtle sightings after dives (Baumbach & Dunbar, 2017).
- The purpose of this study was to investigate if citizen-science data inputs could be used to estimate home ranges for individual hawksbills.

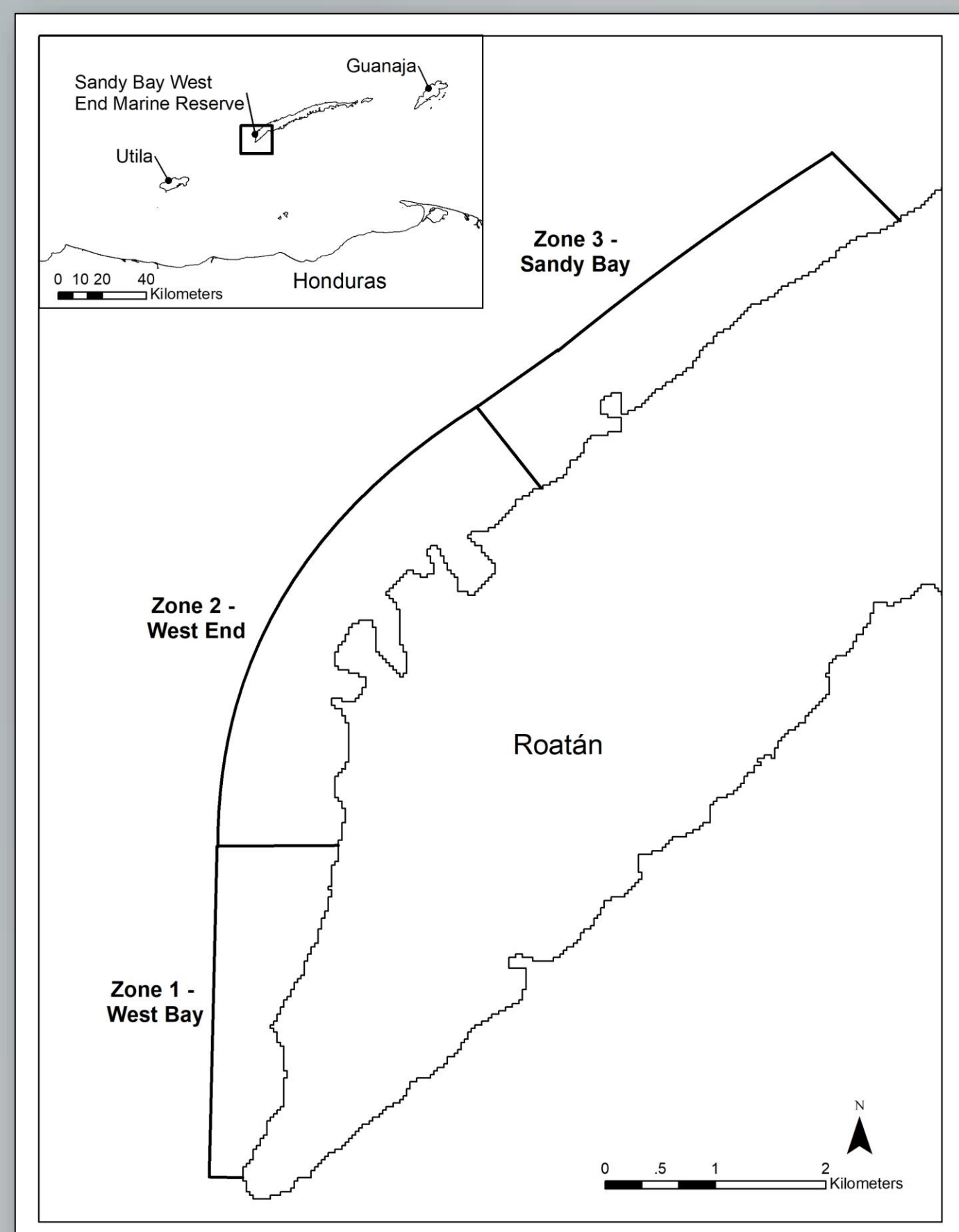


Figure 1. Geographic location of the Sandy Bay West End Marine Reserve divided into three zones on the western end of Roatán, Honduras.

Methods & Materials

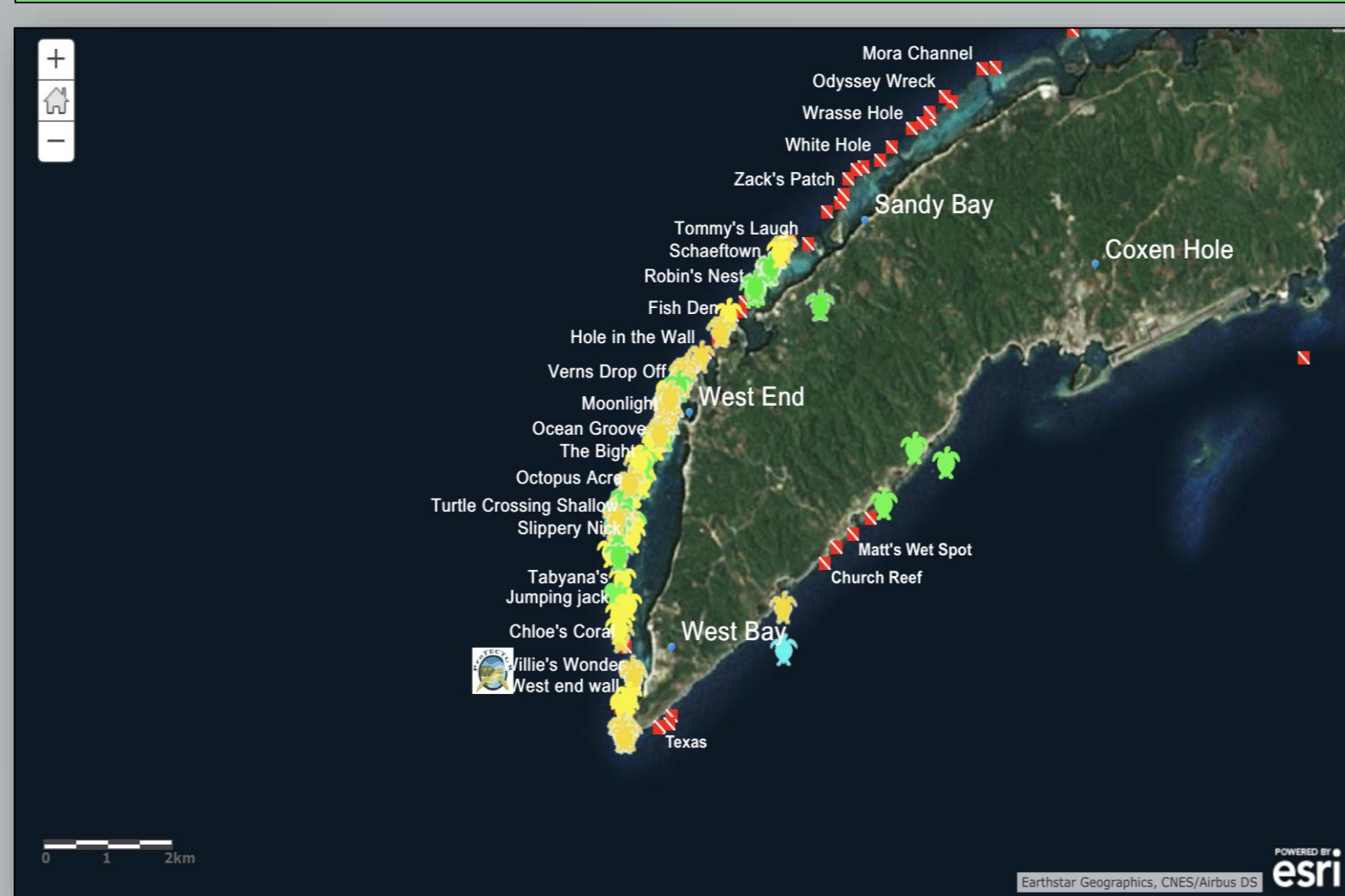


Figure 2. A citizen-scientist web-based map of Roatán, Honduras where dive tourists can log sea turtle sightings around the island.

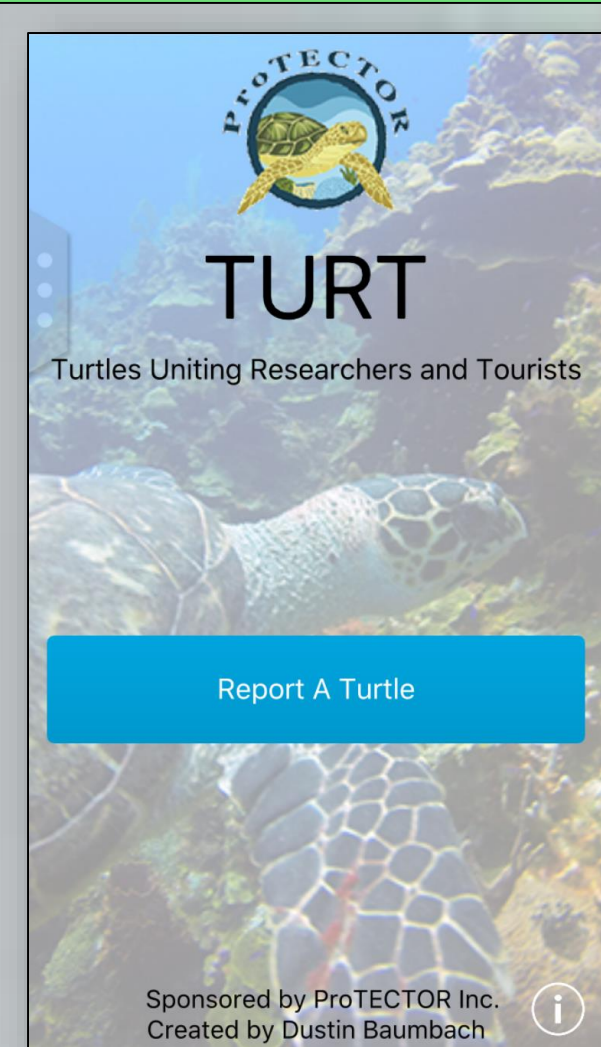


Figure 3. TURT citizen-science title screen for logging sea turtle sightings.

- In-water sponge counts of *Geodia neptuni* were conducted in three different zones within the SBWEMR (Figure 1).
- We collected citizen-scientist hawksbill sightings from our web-based map (Baumbach & Dunbar, 2017; Figure 2) and TURT smartphone Application (Figure 3) from 2014 – 2017.
- Hawksbills with two or more photos were identified with the use of a photo identification program (Dunbar et al., 2017).
- We mapped hawksbills with 10 or more individual sightings in ArcGIS Pro using the minimum bounding geometry with convex hulls as a replacement for minimum convex polygons.
- Hawksbill home ranges were mapped together to determine the extent of overlap.
- We conducted Kruskal-Wallis H tests with Mann-Whitney U post-hoc pairwise comparisons to determine if the number of sponges differed between the three zones.

Results

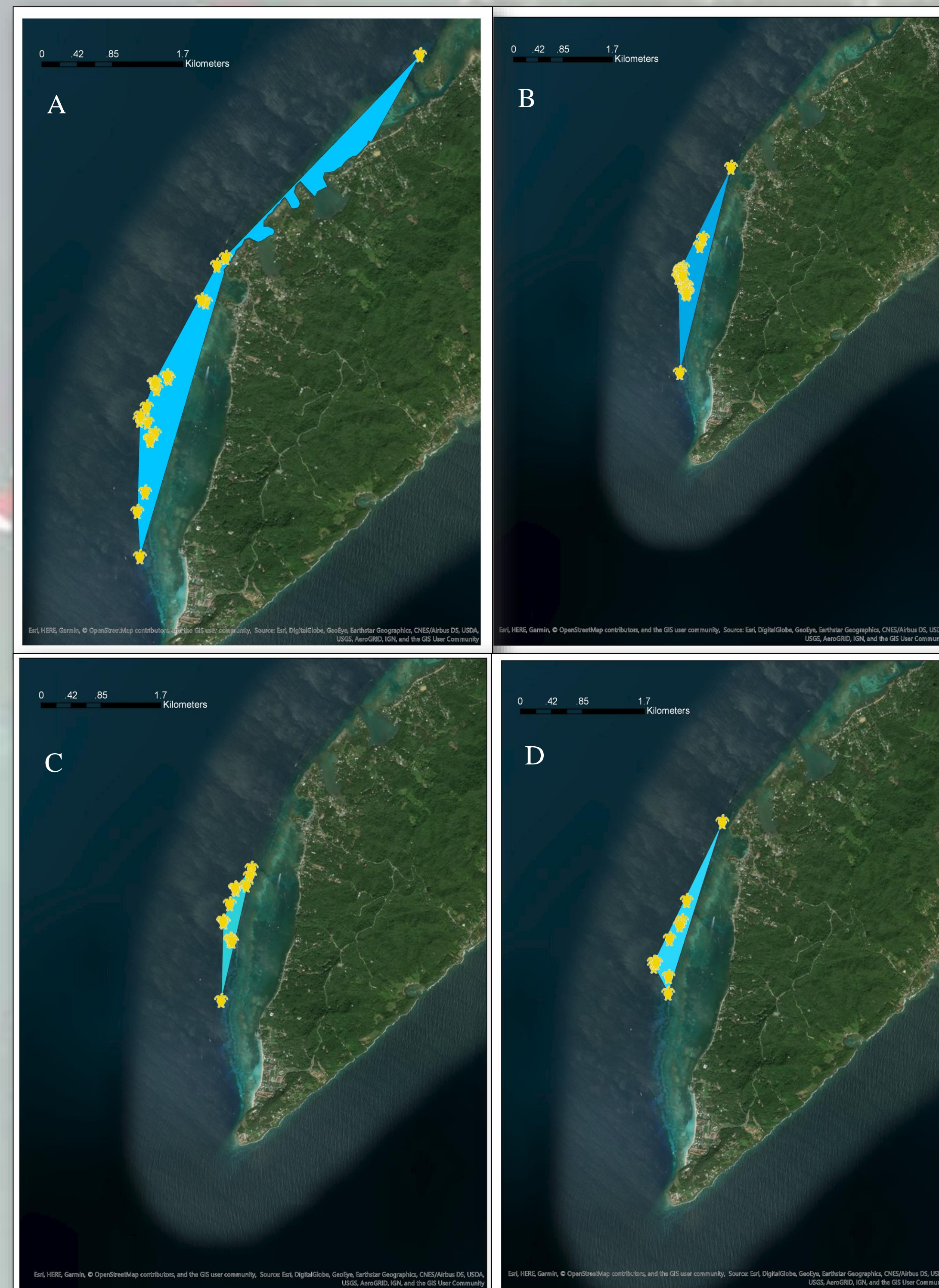


Figure 4. Sea turtle home ranges analyzed from citizen-scientist sea turtle sightings. Home ranges include A) RMP T047 = 1.44 km²; B) RMP T078 = 0.70 km²; C) RMP T048 = 0.22 km²; RMP T077 = 0.34 km²

Table 1. Sponge count comparisons at dive sites in each of 3 zones throughout the SBWEMR. ^aValue comparison between Z1 and Z2, ^bcomparison between Z1 and Z3, ^ccomparison between Z2 and Z3.

Zones	SBWEMR Zone	Dive Site	Geodia Sponge Count	Mean ± SD	Zone Comparison p-value
Z1	West Bay	Chloe's Coral	11		
		Mandy's Eel Garden	42		
	West End	Hole In The Wall	13		
Z2	West Bay	West End Wall	65	39 ± 27	0.44 ^a
		Blue Channel/ Bikini Bottom	22		
	West End	Hole In The Wall	13		
Z3	West End	Puncher's Paradise	40		
		Tabyana's	4		
	West End	Turtle Crossing	55		
	West End	Sea Quest	33	28 ± 19	0.035 ^b
	Sandy Bay	Déjà Vu	10		
		Four Sponges	4		
	Sandy Bay	Four Sponges	4		
		Hole In The Wall	23		
	Sandy Bay	Pillar Coral	10		
	Sandy Bay	Pillar Coral	2		
Sandy Bay	Pillar Coral	15			
Sandy Bay	Pillar Coral	17			
Sandy Bay	Robin's Nest	7			
Sandy Bay	Spooky Channel	2			
Sandy Bay	Zach's Patch	9	9 ± 7	0.034 ^c	

- Sponge counts in zones 1 ($\chi^2_1 = 4.45$, $p = 0.035$, $\eta^2 = 0.34$) and 2 ($\chi^2_1 = 4.49$, $p = 0.034$, $\eta^2 = 0.28$) were significantly different when compared to zone 3 (Table 1).
- Four individual hawksbills were identified with 10 or more sightings. These turtles were seen by citizen-scientists anywhere between several hours during the same day to 701 days later (Table 2).
- Hawksbill RMP T048 travelled the smallest straight line distance whereas hawksbill RMP T047 travelled the farthest straight line distance (Table 3).
- Three hawksbills had home ranges of < 1 km², whereas one turtle had a home range of 1.44 km² (Figure 4).
- Most hawksbill sightings occurred within zones 1 and 2.
- Hawksbill home ranges overlapped among all individuals except RMP T047, the only turtle seen in zone 3 (Figure 5).

Table 2. Dates and the number of days between individual citizen-science hawksbill sightings within the SBWEMR.

Turtle ID	# of Days	Turtle ID	# of Days	Turtle ID	# of Days	Turtle ID	# of Days		
RMP T048	RMP T077	RMP T078	RMP T047	RMP T048	RMP T077	RMP T078	RMP T047		
8/4/14	8/27/14	23	6/29/16	7/24/16	26	9/1/14	7/5/16	674	
8/27/14	6/30/16	674	7/24/16	9/24/16	63	7/5/16	7/22/16	18	
6/30/16	7/14/16	15	9/24/16	10/8/16	13	7/22/16	7/24/16	2	
7/14/16	8/26/16	44	10/8/16	2/18/17	136	7/24/16	8/23/16	31	
8/26/16	8/30/16	4	2/18/17	2/19/17	1	8/23/16	9/12/16	21	
8/30/16	9/20/16	22	2/19/17	3/23/17	33	9/12/16	9/13/16	1	
9/20/16	11/1/16	43	3/23/17	6/26/17	96	9/13/16	9/26/16	14	
11/1/16	1/26/17	87	6/26/17	6/30/17	4	9/26/16	10/21/16	26	
1/26/17	2/15/17	21	6/30/17	9/15/17	78	10/21/16	12/17/16	58	
2/15/17	2/19/17	4				12/17/16	12/22/16	6	
2/19/17	3/29/17	39				12/22/16	12/24/16	2	
3/29/17	7/14/17	108				12/24/16	12/26/16	2	
						12/26/16	12/29/16	3	
						12/29/16	1/8/17	9	
						1/8/17	1/15/17	10	
						1/15/17	2/16/17	33	
						2/16/17	6/25/17	130	
						6/25/17	9/15/17	83	
							3/29/17	3/29/17	2
							3/29/17	7/17/17	111

Table 3. Morphometric data for the four individual turtles with 10 or more sightings that were used to map home ranges and straight line distances travelled.

Turtle ID	CCLmin (cm)	Weight (kg)	Tag Number	Sightings	Maximum Distance Traveled (km)	Home Range (km ²)
RMP T048	57.1	17.6	BBQ260	13	1.87	0.22
RMP T077	48.9	14.2	BBQ346	10	2.33	0.34
RMP T078	62.3	28.6	BBQ205	19	3.46	0.70
RMP T047	62.4	28.3	BBQ150	20	6.90	1.44

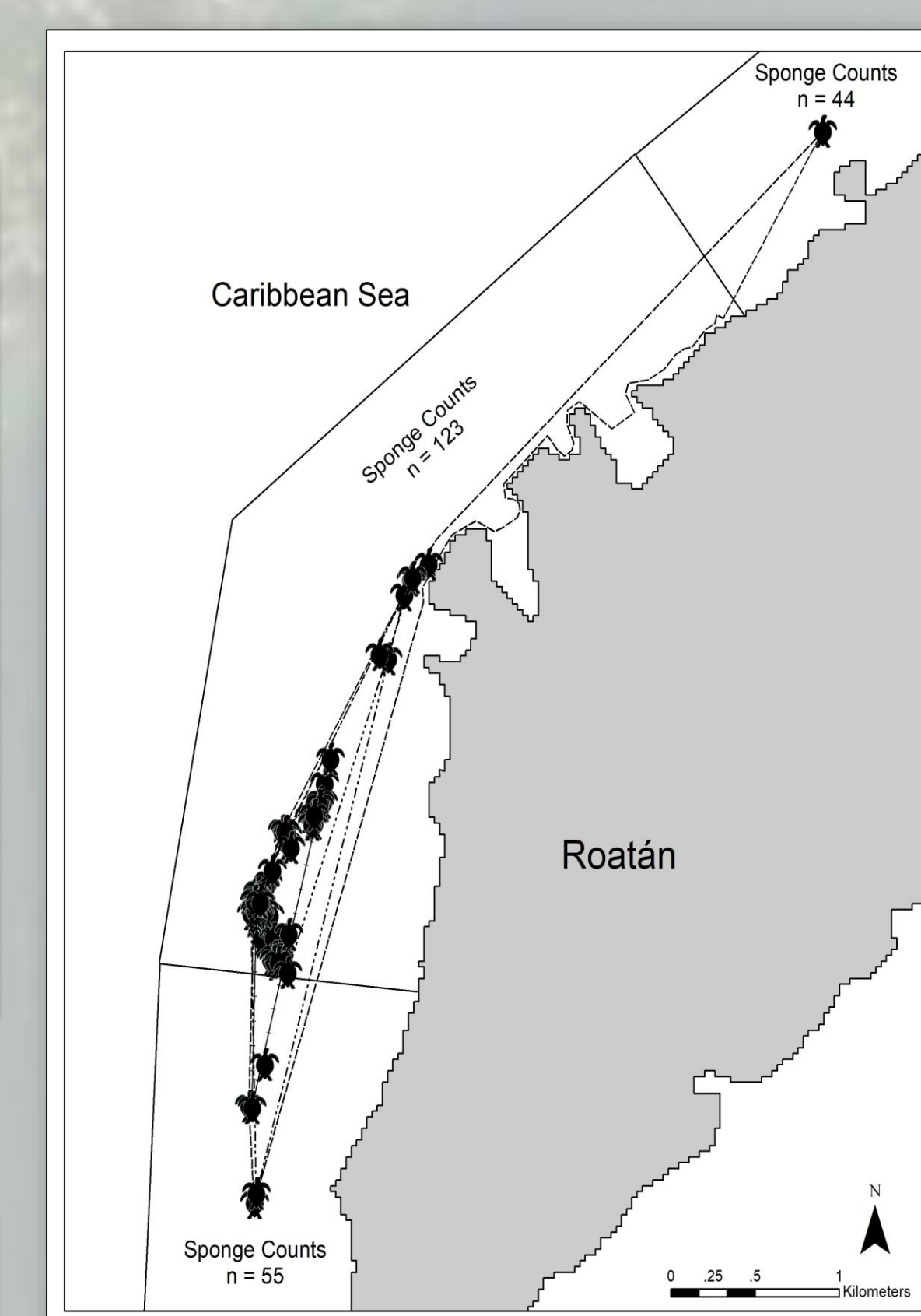


Figure 5. The extent of home range overlap among four individual citizen-scientist sea turtle sightings.

Discussion

- A previous study outside the SBWEMR by Berube et al. (2012) analyzing home ranges of juvenile hawksbills also showed home ranges of < 1 km².
- We suggest that juvenile hawksbills in our study had small home ranges that overlapped, likely due to the abundance of sponges within zones 1 and 2 (Figure 5).
- Other studies have reported a high degree of home range overlap for juvenile hawksbills and suggest those areas have adequate food supplies to support large populations of developing hawksbills (Van Dam & Diez, 1998; Scales et al., 2011; Berube et al., 2012).
- Hawksbill RMP T047 may have a larger home range due to low numbers of sponges within zone 3, thus needing to extend its range to zones 1 and 2.
- Citizen-scientists can provide sea turtle sightings throughout the year, when researchers are unable to be in the field for extended periods of time.
- After developing and advertising the interactive web-map in 2015, hawksbills in this study were sighted throughout each of the subsequent years.
- In order to apply a user-friendly approach, as suggested by Newman et al. (2010), TURT supplies a help document that describes required fields and provides descriptions of each sea turtle species.
- We demonstrate the positive effects of citizen-scientist sea turtle sightings in the use of mapping home ranges.
- However, some caution is warranted in the interpretation of these results, as dive tourists do not dive outside the bounds of the SBWEMR and thus, cannot provide turtle sightings from outside the marine protected area.

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