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Cover Photograph: Adult Tabaco Mud Turtle captured during a population monitoring project at BFREE. Photograph © Eric Munscher.

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Quantifying Turtle Species Diversity, Richness, and Abundance in Southern Belize

Eric Munscher[1,2*], Jaren Serano[3], Arron Tuggle[2], Andrew Weber[4], Collin McAvinchey[1], Jonathan Dubon[3], Thomas Pop[3], J. Brian Hauge[1,5], Heather Barrett[3], Jacob Marlin[3], Brian P. Butterfield[6], Jeff Stein[2], and Andrew. D. Walde[1].

Abstract - Species inventories and distributional analyses at local resolutions provide essential data on distribution, species richness, diversity, and abundance that can inform resource conservation and management. The country of Belize has 9 native freshwater and terrestrial turtle species including *Claudius angustatus* (Narrow-Bridged Musk Turtle), *Chelydra rossignonii* (Central American Snapping Turtle), *Dermatemys mawii* (Central American River Turtle), *Kinosternon leucostomum* (White-Lipped Mud Turtle), *Kinosternon acutum* (Tabasco Mud Turtle), *Kinosternon scorpioides* (Red-Cheeked Mud Turtle), *Rhinoclemmys areolata* (Furrowed Wood Turtle), *Trachemys venusta* (Mesoamerican Slider), and *Staurotypus triporcatus* (Northern Giant Musk Turtle). The majority of research on turtles in Belize has focused on the critically endangered Hicatee and the northern portion of the country. Very little information regarding species richness, diversity, abundance, and distribution of freshwater turtles exists for the southern half of the country. In July 2021, the Turtle Survival Alliance (TSA) and the Belize Foundation for Research and Environmental Education (BFREE) conducted a freshwater and terrestrial turtle inventory of the 467 ha BFREE property. The survey resulted in the capture and marking of 272 unique turtles representing 7 of the 9 species native to Belize. Species richness and diversity of the BFREE property is high with species such as the White-Lipped Mud Turtle and the Tabasco Mud Turtle seemingly abundant. Here we update species maps for the Central American Snapping Turtle and the Tabasco Mud Turtle to more accurately reflect both species' range. This work contributes to the understanding of freshwater and terrestrial turtle ecology within BFREE and provides important baseline data for long-term monitoring and future research on turtle species within the BFREE property as well as across southern Belize and into further south-Central America.

Introduction

Species inventories at regional or localized scales can provide essential data for conservation and resource management (Oliver and Beattie 1993, Platt et al. 1999). Data on local species diversity, richness, and abundance is fundamental to understanding local communities and, on a larger scale, ecosystem function and dynamics. There is a need for baseline data on the distribution and status of species perceived as abundant or even common (Dodd

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and Franz 1993, Platt et al. 1999). Considering the high rate of biodiversity loss across all major taxa, it has become evident that conservation efforts should also be provided for species that are either considered common, relatively abundant, or even understudied. These understudied species are now commonly referred to as data deficient (DD) meaning there is no real knowledge regarding their conservation status or what role the species take in their environment (Baker et al. 2018, Lindenmayer et al. 2011, Munscher et al. 2020). Some common species may be vulnerable to decline, localized extirpation, and even eventual extinction (Lindenmayer et al. 2011), and such declines would go unnoticed.

Chelonians are arguably the most threatened of the major faunal vertebrate groups in general and are proportionately more so than birds, mammals (barring primates), fishes, and even amphibians (Hoffmann et al. 2010, Lovich et al. 2018, Rhodin et al. 2018). As of 2021, 357 turtle species are recognized worldwide (Turtle Taxonomy Working Group [TTWG] 2021), of which approximately 47.9% (171 species) are threatened or endangered, with some facing localized extirpation and potential extinction. Approximately 9% of all chelonians are classified as data deficient (International Union for the Conservation of Nature [IUCN] 2016, TTWG 2021). Developing a knowledge base of species diversity, richness, demographics, and movement patterns at local resolutions is fundamental to understanding community and ecosystem form and function. These data can then assist with the creation of conservation and management plans for species (Enríquez-Mercado et al. 2018, McDiarmid 1994, Platt et al. 1999). The life history and ecology of many Neotropical species of freshwater and terrestrial turtles is poorly understood. For instance, Mexico has the second most diverse turtle fauna in the world (Rhodin et al., 2018; Enríquez-Mercado et al. 2018), yet long-term mark-recapture, radiotelemetry, and species assessment studies are few to non-existent and what studies do exist are typically on a single species such as the critically endangered *Dermatemys mawii* Gray (Central American River Turtle) (Rainwater et al. 2012, Legler and Vogt 2013, Enríquez-Mercado et al. 2018). Continuing south, the turtle faunas of Guatemala, Belize, and El Salvador are even less studied, which is somewhat surprising given the level of tourism to the former two countries. This is largely due to infrequent investigation and the lack of long-term studies in the region (Moll 1990). Studies of Neotropical turtle ecology by Legler (1966), Moll and Legler (1971), Medem (1975), Dean (1980), Pritchard and Trebbau (1984), Vogt and Guzman (1988), and Moll (1990) are important contributions, but they do not include long-term studies. Field guide type books (e.g., Campbell 1998; Lee 1996, 2000; Stafford 1999) provide scant details on the natural history of turtle species and focus more on providing broad geographic distribution notes, ex. northern Belize. This region has a diverse turtle fauna, but many species have large distributional gaps that may not signify an accurate representation of the species range limits (Moll 1990).

The country of Belize has 9 native freshwater and terrestrial turtle species with a few other species that have ranges that directly abut or come very close to the Belize country border (Table 1). The majority of research on turtles in Belize has focused on the northern portion of the country, or the critically endangered *D. mawii*, locally known as the Hicatee. Very little information regarding species richness, diversity, abundance, and distribution of freshwater turtles exists for the southern half of the country, of which 8 species are listed as near threatened, vulnerable, of least concern, or data deficient (Table 1: Tortoise and Freshwater Turtle Specialist Group [TFTSG], 1996a, b, c; TTWG, 2021).

In an effort to increase awareness of the turtles in Latin America, and specifically Belize, we surveyed the Belize Foundation for Research and Environmental Education (BFREE) in the Toledo District of southern Belize. We describe the habitats sampled, methods used

Table 1. Records of previously documented distribution of Chelonian Species within the Yucatan Peninsula and northern Guatemala (i.e., region), the local Toledo District in southern Belize (i.e., District), in contrast to the findings of the present study within the Belize Foundation for Environmental Education (i.e., BFREE). X's identify whether a species has been previously recorded within the region and district. O's represent species observed during our study at BFREE. Species current IUCN Red List status is also listed. Species that have not been previously recorded or observed during our study are identified with NO (not observed). Note that the Central American Snapping Turtle observation represents a new most northern observation of the species in the country. Note the *Claudius angustatus* observation is a recent published range extension for the species (Munscher et al. 2022).

Species	Region	Toledo District	BFREE	IUCN Red List
Chelydridae				
Central American Snapping Turtle (Chelydra rossigonii)	X	X	O	Vulnerable
Emydidae				
Meso American Slider (Trachemys venusta)	X	X	O	Not Evaluated, Data Deficient
Uhrig's Slider (Trachemys venusta uhrigi)	X	NO	NO	Not Evaluated, Data Deficient
Dermatemydidae				
Central American River Turtle (Dermatemys mawii)	X	X	NO	Critically Endangered
Kinosternidae				
White Lipped Mud Turtle (Kinosternon leucostomum)	X	X	O	Not Listed - Least Concern
Red-cheeked Mud Turtle (Kinosternon scorpiodies cruentatum)	X	X	O	Not Listed - Least Concern
Tabasco Mud Turtle (Kinosternon acutum)	X	X	O	Near Threatened
Creasers's Mud Turtle (Kinosternon creaseri)	X	NO	NO	Least Concern
Giant Mexican Musk Turtle (Staurotypus triporcatus)	X	X	O	Near Threatened

Species	Region	Toledo District	BFREE	IUCN Red List
Narrow Bridged Musk Turtle (*Claudius angustatus*)	X	NO	O	Near Threatened
Rhinoclemmydinae				
Furrowed Wood Turtle (*Rhinoclemmys aerolata*)	X	X	O	Near Threatened

to capture and process turtles, and species richness, relative abundance, and geographical distributions of turtle species found within the BFREE property during a preliminary survey in July 2021. The results of this survey will be used as a benchmark for future surveys within BFREE and the surrounding ecosystems.

Methods

Study site

We evaluated several potential study sites within the Privately Protected Area and Biological Field Station located in the neotropical jungles of southern Belize. The Belize Foundation for Research and Environmental Education Privately Protected Area compromises a total of 467 ha. The land borders 4 protected areas: the Bladen Nature Reserve, Cockscomb Basin Wildlife Sanctuary, Deep River Forest Reserve, and Maya Mountain Forest Reserve. All are part of the larger Maya Mountain massif which includes 16 protected areas covering almost 2 million acres (ca. 809,000 hectares) of continuous tropical forest, making it one of the largest contiguous tracts of rainforest in the western hemisphere. Based on a variety of factors, such as accessibility, size (length, depth, and width), anthropogenic disturbance, and vegetation, we selected 6 sites, which we will refer to as Cacao Creek, Creeky Blanco, Agami Lagoon, Interior Pools, Bladen River, and Boundary Road Refugia Pools and Drainages (Fig. 1).

Cacao Creek is a slow-moving seasonal stream which is adjacent to a young, organic cacao agroforest. The water is tannic with moderate turbidity, resulting in limited visibility. The channel is narrow and generally <5 m wide with protruding logs and is approximately <1.8 m deep in the center. Both banks are heavily vegetated with riparian vegetation such as palmetto (family Arecaceae) and *Pterocarpus officinalis* Jasq. (Swamp Cawe). We trapped 4 segments of this stream at locations that were suitable for small traps that could stay submerged and yet have portions of the trap above the water level so that an air project could be provided. During our sampling efforts, the stream was mainly composed of shallow disconnected pools.

Creeky Blanco is a faster moving stream compared to the slow-moving Cacao Creek, with its deepest point being < 2 m deep. The water clarity within this site was semi-opaque. Creeky Blanco varies in width across its length. The stream has sections that are approximately 3 meters wide and shallow, measuring less than 30 cm deep with a rocky bottom and a dense forested canopy. In contrast, other areas are deeper (> 2 m), with slower moving water, organic bottoms, dense shrub vegetation on the sides, minimal canopy cover, and ample sunlight.

The Agami Lagoon is likely an ancient oxbow which was once connected to the Bladen River. The water is tannic and stagnant with poor visibility. It has a sandy substrate and the

depth in the center during the time of study was <2.5 m, however during the rainy season this can be doubled. The vegetation is comprised of trees boasting extensive and large buttresses providing additional structure for turtles and other aquatic wildlife. Floating mats of grasses and sedges often choke the aquatic areas; similar vegetation was also observed along the face of the shore.

Figure 1. Habitats surveyed across the Belize Foundation for Research and Environmental Education property, Toledo District, Belize. Cacao Creek (A, image courtesy of Thomas Pop) in the upstream reaches where the channel narrows. On the bank the buttress from the *Pterocarpus officinalis* (swamp cawe) Creeky Blanco (B, image courtesy of Jonathan Dubon), downstream of the point of crossing utilized by forest rangers. This is a wide sized pool approximately seven m in diameter at its widest point. Agami Lagoon (C, Jonathan Dubon), during the rainy season. The tannic and slow-moving waters within this oxbow lagoon provides ideal habitat for *Trachemys venusta* (Mesoamerican Sliders) and *Staurotypus triporcatus* (Mexican Musk Turtles). Interior Pools (D, image courtesy of Thomas Pop) and extension of Creeky Blanco. In the dry season this site was typified by a narrow channel and deep pools with a sandy substrate. The Bladen River (E). Boundary Road Refugia Pool (F, image courtesy of Collin McAinchy) being surveyed by NAFTRG – BFREE research team.

Interior pools and extension of Creeky Blanco was the last habitat trapped. This was the area where trapping was done for most days during the study. It is a continuous slow-moving stream with several freshwater springs. The depth of the water was <3 m at the deepest points, with clear water and high visibility. This section is roughly <1.5 m across and the substrate is sandy with protruding logs. The riparian vegetation was an assortment of *Heliconias*, *Astrocaryums* (palm), and other neotropical broadleaf plants hanging over the water's edge.

The Bladen River, a large river and tributary, is part of the Monkey River Watershed, the 4th largest watershed in Belize. The portion of river surveyed is a semi-shallow fast-moving river with a limestone bottom. Habitats here included overhanging vegetation, fallen logs, cut banks, riffle areas, and deep pools. This river is bordered on either side with a dense riparian zone and thick jungle. This habitat was not trapped; all turtles captured within the Bladen River were captured by hand during snorkeling surveys.

The BFREE Boundary Road, a 2-track dirt road wide enough to drive an all-terrain vehicle down, has frequent vernal pools and ephemeral drainages. BFREE has many dirt roads that cross and surround the property. During heavy rainfall events, refugia pools filled up along and in these dirt roads. Some are as deep as 15+ cm. Many species utilize these ephemeral refugia pools for sources of water as well as habitat for mating and potential food sources.

Capture method

Turtles were captured using a variety of methods: by hand while snorkeling, by hand while surveying ephemeral refugia pools, and by an assortment of bait trap types. Trap types included collapsible crab traps (81.3 cm × 50.8 cm × 30.5 cm; Promar, Gardena, CA), Promar TR 503 Collapsible Crawfish/ bait traps (30.48 cm x 30.48 cm x 60.96 cm; Promar, Gardena, CA), D-frame WCS collapsible turtle trap (60.96 cm x 60.96 cm x 121.92 cm; Suffield, CT), and large cylinder-shaped traps made from chicken wire that the researchers made on site (Iverson 1979).

Traps were baited with fresh cut chicken or a fish mixture (Dolores Sardinas En Salsa De Tomate - Sardines in Tomato Sauce, 15 Ounce, Zocalo foods, Mexico). Collapsible crawfish and crab traps were set in the morning for approximately 2 hours and then checked. Larger hoop nets and D-frame nets were left overnight and set so that a portion of the trap was above the water's surface, ensuring that trapped turtles could breathe. Turtles were removed and placed in marked containers to be transported to a central processing station. Once processed, turtles were taken back to their location of capture and released. Traps were pulled to be rebaited and set the following morning. Each study site was trapped using a 3-day/2-night trap schedule with traps being set and baited on day 1, checked and rebaited on day 2, and checked and removed on day 3.

Other means of turtle capture included snorkeling within the Bladen River. Five snorkelers and one canoer surveyed approximately 2 km of the Bladen River. Turtles captured were place in the canoe and taken to a central processing station. Once processed, the turtles were released back into the river. Additionally, during heavy rainfall events, ephemeral refugia pools and drainages were located and surveyed by hand. All habitats had GPS points taken so that captured turtles could be returned to the exact refugia pool they were found.

Marking method

Turtles were marked using a notching variation of the technique described by Cagle (1939) and with passive integrated transponder (PIT) tags as a secondary identification

method for turtles with a CL greater than 70 mm. We inserted PIT tags under the turtle's right bridge (Buhlman and Tuberville 1998, Runyan and Meylan 2005). Capture and handling protocols conform to the animal use guidelines of the American Society of Ichthyologists and Herpetologists, the Herpetologists League, and the Society for the Study of Amphibians and Reptiles (2001).

Data analysis

For each site, we counted the number of species captured to determine species richness (S) and calculated relative abundance (RA); relative abundance was calculated as the proportional representation of each species relative to the total number of individuals within the turtle assemblage in each pond (House et al. 2011). For each site, we calculated a natural log Shannon Index (H') to describe diversity and Equitability (J') to estimate heterogeneity. We determined potential range extensions by utilizing current species distribution maps. This involved measuring the distance from recorded accounts to our location at BFREE using ARC GIS software (ESRI 2022).

Results

From July 11th–July 29th, we captured 272 turtles representing 7 species including the following: *Chelydra rossignonii* Bocourt (Central American Snapping Turtle), *Rhinoclemmys areolata* Dumeril and Bibron in Dumeril and Dumeril (Furrowed Wood Turtle), *Trachemys venusta* Gray (Mesoamerican Slider), *Staurotypus triporcatus* Wiegnmann (Northern Giant Musk Turtle), *Kinosternon scorpioides* Dumeril and Bibron in Dumeril and Dumeril (Red-Cheeked Mud Turtle), *Kinosternon acutum* Gray (Tabasco Mud Turtle), and *Kinosternon leucostomum* Dumeril and Bibron in Dumeril and Dumeril (White-Lipped Mud Turtle) (Tables 1–2). *K. leucostomum* was the most abundant species across the study area with 158 unique individuals captured and marked. Of the 6 different habitats surveyed, the Boundary Road Refugia Pools and Drainages and Cacao Creek had the most captures (Table 2). Creeky Blanco and the Boundary Road Refugia Pools and Drainages had the highest species diversity; the remaining 4 habitats had the same species diversity, but the Bladen River had the lowest relative abundance (Table 3).

Known occurrence data and distributions maps were evaluated and distances were measured using ARC GIS to those taken at our study site at BFREE (The Global Biodiversity Information Facility [GBIF] 2022; Lee 1996, 2000; TTWG 2017, 2021). We generated updated range maps for *K. acutum* and *C. rossignonii*. This was prompted by our literature review, which revealed localities missing from the most current and comprehensive maps (TTWG 2017, 2021). Additionally, we incorporated our own observations into these new maps.

Discussion

During a preliminary survey, we marked 272 unique turtles representing 7 of the 9 native Belizean species (Table 1). We found turtles in all sampled habitats with species richness highest for the Creeky Blanco and the Boundary Road Refugia Pools and Drainages. Creeky Blanco is the largest perennial stream that cuts through the BFREE property. This stream has diverse habitats available with shallow runs and deep pools, abundant aquatic vegetation, and thus potential diverse food sources. Species richness and diversity found within the Boundary Road Refugia Pools and Drainages was more surprising. These pools only

Table 2. Comparison of turtle species composition among six surveyed habitats across the Belize Foundation for Research and Environmental Education property, Toledo District, Belize. Data presented as number of individuals (relative abundance).

Species	Agami Lagoon	Bladen River	Boundary Road Refugia Pools and Drainages	Cacao Creek	Creeky Blanco	Interior Pools	Species Totals
Chelydra rossignonii	0 (0.0)	1 (0.1)	0 (0.0)	1 (0.014)	0 (0.0)	0 (0.0)	2
Kinosternon acutum	0 (0.0)	0 (0.0)	54 (0.61)	0 (0.0)	0 (0.0)	0 (0.0)	54
K. leucostomum	3 (0.14)	0 (0.0)	22 (0.25)	65 (0.93)	30 (0.83)	38 (0.83)	158
K. wscorpioides cruentatum	0 (0.0)	0 (0.0)	3 (0.034)	0 (0.0)	0 (0.0)	0 (0.0)	3
Rhinoclemmys areolata	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (0.03)	0 (0.0)	1
Staurotypus triporcatus	9 (0.41)	1 (0.1)	0 (0.0)	0 (0.0)	4 (0.11)	4 (0.09)	18
Trachemys venusta	10 (0.46)	8 (0.8)	9 (0.10)	4 (0.06)	1 (0.03)	4 (0.09)	36
Total	**22**	**10**	**88**	**70**	**36**	**46**	**272**

Table 3. Comparison of Species Richness (S), Shannon Diversity (H'), and Equitability (J') of turtles among six surveyed habitats across the Belize Foundation for Research and Environmental Education property, Toledo District, Belize.

Survey Site	**Number of Individuals Captured (*n*)**	**S**	**H'**	**J'**
Agami Lagoon	22	3	0.1	0.91
Boundary Road Refugia Pools	88	4	0.1	0.72
Bladen River	10	3	0.64	0.58
Cacao Creek	70	3	0.29	0.27
Creeky Blanco	36	4	0.6	0.43
Interior Pools	46	3	0.58	0.53

fill up during the wet season during heavy rainfall. The most abundant species found in these habitats were *K. acutum* of all age and size classes. We also found hatchling *T. venusta* and *K. leucostomum* in similar pools (Skibsted et al. 2023). This is noteworthy because little is known about hatchling habitat use for these species. Variation in numbers captured, species richness, and species diversity may be a function of capture method. For example, we only sampled the Bladen River by snorkeling. Further sampling is required to determine if the observed species richness and diversity results among sites are accurate or artifacts of our sampling methods.

Two of the seven species observed, *K. leucostomum* and *K. acutum,* appear to occur at high densities within the BFREE property. These 2 species accounted for 212 (78%) of the 272 captures. The *K. leucostomum* were found in all sampled habitats except the Bladen River. This species is known to have an extensive distribution from Mexico to northern Argentina and is known to occupy diverse habitat types across its range (TTWG, 2021), so this observation is not surprising. *K. acutum* was found in only one habitat type, the Boundary Road Refugia Pools and Drainages. Surprisingly, we were unable to capture *K. acutum* by trapping in aquatic habitats and only found the turtles after significant rainfalls filled ephemeral refugia pools along manmade roads and similar habitats. The discovery of a seemingly substantial breeding population of *K.acutum* in a previously undocumented region for the species is important. The species is considered as near-threatened status on the IUCN Red List, primarily attributed to factors such as deforestation, drainage and wetland habitat conversion into agriculture, and local consumption (Tellez et al. 2017, Rhodin et al. 2018, TFTSG 1996b)

T. venusta was the third most common species, found at all surveyed habitat types. This habitat generalist is known elsewhere to occur at high relative abundances and densities (Moll 1990). We captured a total of 18 *S. triporcatus* from 4 permanent water body habitats. Lee (2000) describes this species as "a moderately common inhabitant of slow-moving bodies of water such as lakes, marshes, and lagoons of large rivers." The last 3 species, *C. rossignonii*, *K. scorpioides*, and *R. aerolata*, were encountered much less frequently than the other species.

Variation in capture rate, species richness, and species diversity among habitats are likely functions of season and/or capture method. For example, mud turtles may estivate underground during the dry season (Lee 2000), which may influence capture rates seasonally (Moll

1990). Likewise, we only sampled the Bladen River by snorkeling, whereas we trapped the other habitats. Further sampling is required to determine if species richness and diversity among sites vary seasonally and if sampling methods affect these metrics.

Published range maps and distribution data show that *R. areolata*, *T. venusta*, *Staurotypus tripricatus* Wiegmann (Giant Mexican Musk Turtle), *K. scorpioides*, and *K. leucostomum* have known and documented occurrence ranges within the Toledo District (GBIF 2022; Lee 1996, 2000; TTWG 2017, 2021). However, published maps by the Taxonomy Working Group (TTWG 2017, 2021) and localities in Brown et al. (2021), GBIF (2022), Platt and Rainwater (1998), Sunyer et al. (2009), and Vasquez-Cruz et al. (2021) would support that *C. rossignonii* and *K. acutum* observations at BFREE would constitute range extensions. The most recent TTWG (2021) depicts a location dot in the Toledo District in the region of BFREE for *C. rossignonii*; however, we were not able to locate any publications or voucher specimens for this locality. Further follow up with Anders Rhodin (A. Rhodin, IUCN Tortoise and Freshwater Turtle Specialist Group, Ojai, CA, 2022 pers. comm.) confirmed that the locality was based on a verbal communication with one of our coauthors. We hereby present verification of this anecdotal record. Further literature review discovered additional records of *C. rossignonii* in southern Belize, originally published by Moll and Dodd (1985). We present updated range maps and finer detailed Belize maps for *C. rossignonii* in Figures 2–3.

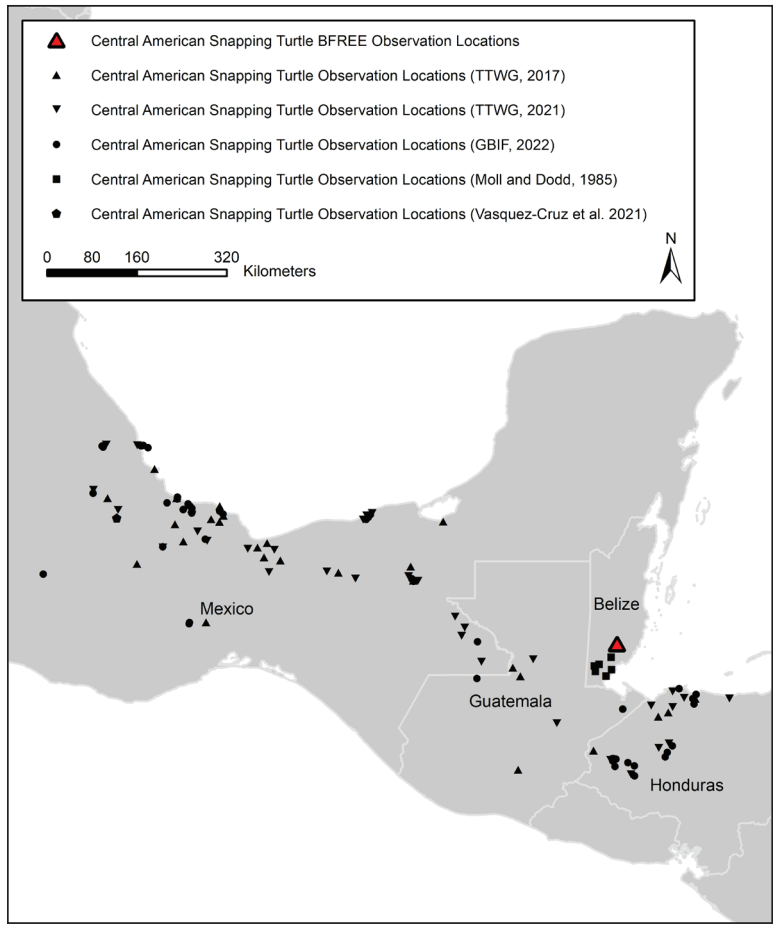

Figure 2. Updated range of the Central American Snapping Turtle (*Chelydra rossigonii*)

Similarly, TTWG (2021) does not show any records for the *K. acutum* south of the Belmopan/Belize Zoo region. During our literature review we found a single record for this species in the coastal region of the Toledo District (Tellez et al. 2017). We present updated maps for the *K. acutum* in Figures 4–5.

Based on these records, our new observations do not represent significant range extensions; however, they do provide verification of these species existing at viable population levels in this southern region of Belize. Many regions and habitats of Central America, including large parts of the Mexican Yucatan, Guatemala, and southern Belize, are not well studied for many faunal groups including freshwater and terrestrial turtles (Macip-Rios et. al. 2015, Rios-Solis et al. 2021). The southern region of Belize is under increased anthropogenic pressure where many habitats outside of protected preserves are being converted and utilized for agriculture (Flowers et al. 2020, Folkard-Tapp 2020, Young 2008). Significant deforestation has occurred in northern Belize with increased incidents occurring along the

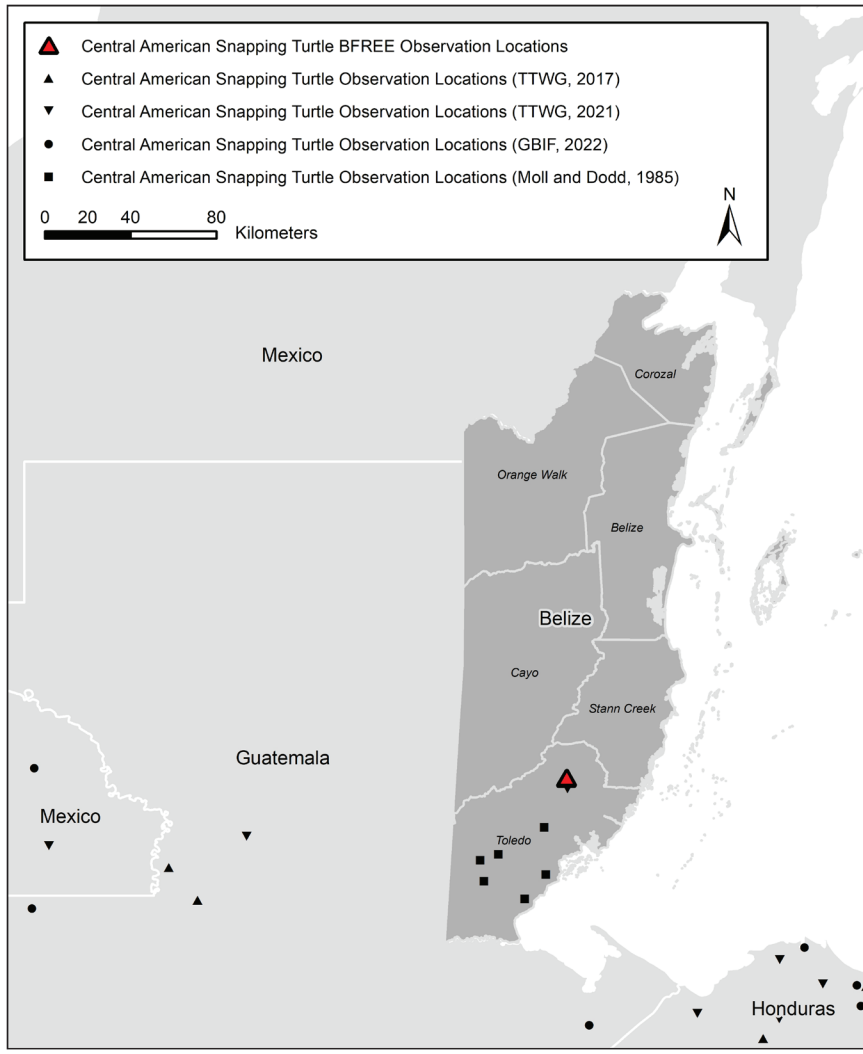

Figure 3. Verified observations of the Central American Snapping Turtle in Belize.

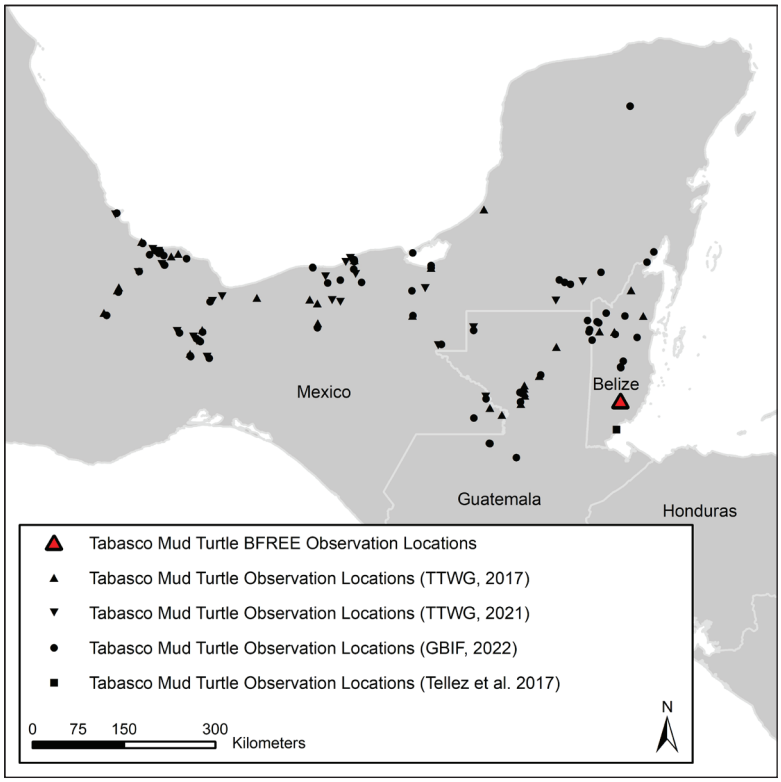

Figure 4. Updated range of the Tabasco Mud Turtle (*Kinosternon acutum*).

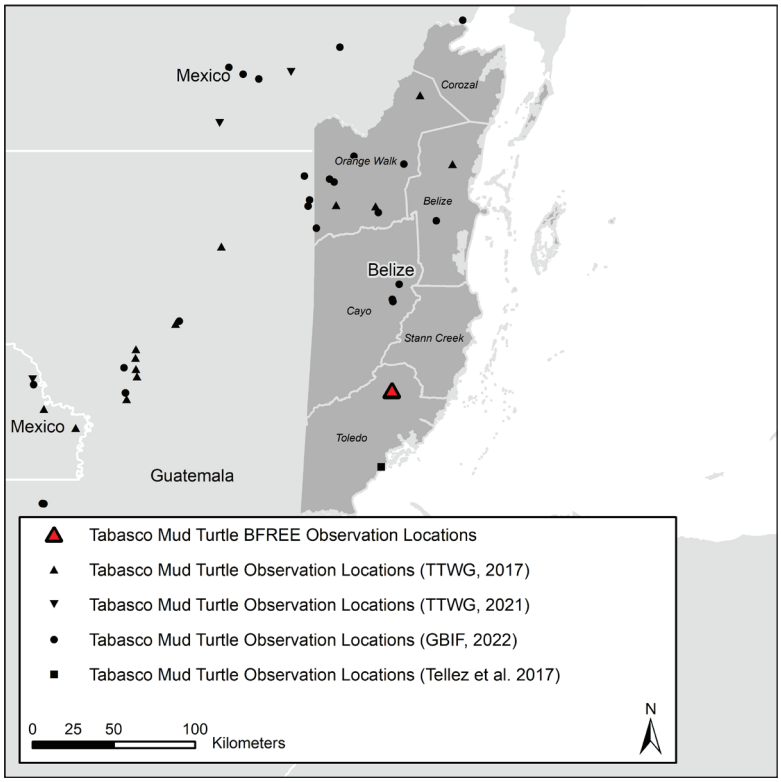

Figure 5. Detailed observations of the Tabasco Mud Turtle in Belize.

southern coast and into the southern interior in habitats that are not a part of the country's preserves or under conservation easement (Flowers et al. 2020). The southern central region of Belize contains many large preserves including the Bladen Nature Reserve, Cockscomb Basin Wildlife Sanctuary, Maya Mountain Forest Reserve, and the Deep River Forest Reserve, equating to over 2 million acres of preserved habitat. Species inventories in protected areas allow researchers and conservation biologists the ability to understand how ecosystems should look and function (Oliver and Beattie 1993, Platt et al. 1999). Freshwater and terrestrial turtle species are under threat from poaching and habitat loss globally; these forces are increasingly pronounced in Central America (Gibbons et al. 2000, Lovich et al. 2018). Many of the species native to Belize are not well studied and we have significant knowledge gaps in our understanding of population metrics, species' movements, home ranges, and even species' geographic ranges and distributions (Enríquez-Mercado et al. 2018, Legler and Vogt 2013). Continued surveys and life history studies should be done on BFREE as well as other regions of southern Belize and Guatemala to better understand species' demographics, ranges, and distribution limits as well as provide data for future conservation efforts.

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