Chelonian Conservation and Biology, 2012, 11(1): 97–107

A Recent Countrywide Status Survey of the Critically Endangered Central American River Turtle (*Dermatemys mawii*) in Belize

THOMAS R. RAINWATER[1,7], THOMAS POP[2], OCTAVIO CAL[3], ANTHONY GAREL[4], STEVEN G. PLATT[5], AND RICK HUDSON[6]

[1]*Department of Obstetrics and Gynecology, Medical University of South Carolina, Hollings Marine Laboratory, 331 Ft Johnson Road, Charleston, South Carolina 29412 USA [trrainwater@gmail.com];*
[2]*Belize Foundation for Research and Environmental Education (BFREE), PO Box 129, Punta Gorda, Belize [jungletom24@yahoo.com];*
[3]*Ya'axché Conservation Trust, PO Box 177, Punta Gorda, Belize [octavio.cal@yaaxche.org];*
[4]*Belize Herpetarium and Aquarium Park (BHAP), PO Box 339, Belize City, Belize [vivarium@btl.net];*
[5]*Wildlife Conservation Society, 2300 Southern Boulevard, Bronx, New York 10460 USA [sgplatt@gmail.com];*
[6]*Turtle Survival Alliance, 1989 Colonial Parkway, Fort Worth, Texas 76110 USA [RHudson@fortworthzoo.org];*
[7]*Present Address: US Fish and Wildlife Service, Ecological Services Field Office, 176 Croghan Spur Rd, Suite 200, Charleston, South Carolina 29407 USA*

ABSTRACT. – The Central American river turtle (*Dermatemys mawii*) is a large Critically Endangered freshwater turtle historically found in the coastal lowlands of southern Mexico, northern Guatemala, and Belize. Due to years of intense harvesting for its meat, *D. mawii* has been virtually eliminated from much of its former range in southern Mexico, while its status in Guatemala remains unclear. During April and May 2010, we conducted a countrywide survey in Belize to assess the current conservation status of *D. mawii* in what is believed to be its last stronghold. We surveyed approximately 30 localities from deep southern to extreme northern Belize, including 17 areas previously surveyed during the early 1980s and 1990s. Results indicate *D. mawii* is heavily depleted in most of Belize, but healthy populations remain in a few remote areas (including multiple, previously unsurveyed localities in southern Belize), especially those receiving some level of protection. While this mirrors the trend observed in previous surveys, the current findings are of particular concern because the number of localities where turtles were observed and the number of turtles observed at these localities were both much reduced compared to earlier surveys. Large turtles (reproductive adults) continue to be targeted during harvests, significantly reducing the most demographically important segment of the population. Further, interviews with fishermen and hunters indicate that laws and regulations enacted for the protection of *D. mawii* are largely ignored by locals, as broad-scale enforcement is difficult or impossible to achieve. In this paper, we discuss survey results in the context of previous investigations, describe levels and sources of exploitation, and provide conservation recommendations.

KEY WORDS. – Reptilia; Testudines; Dermatemydidae; *Dermatemys mawii*; Central American river turtle; conservation; exploitation; Belize

The Central American River Turtle (*Dermatemys mawii*) is found in the coastal lowlands of southern Mexico, northern Guatemala, and Belize (Alvarez del Toro et al. 1979; Iverson and Mittermeier 1980; Iverson 1986; Ernst and Barbour 1989; Lee 1996) and is the lone surviving representative of the family Dermatemydidae (Iverson and Mittermeier 1980). Throughout its restricted range, *D. mawii* has been intensely harvested for its meat (Moll 1986; Polisar 1994, 1995). As a result, it has been virtually eliminated from much of its former range in southern Mexico, while its status in Guatemala remains unclear (Polisar 1994). Currently, *D. mawii* is considered one of the world's most heavily exploited turtles and is classified as Critically Endangered by the IUCN, listed as endangered under the US Endangered Species Act, and listed on Appendix II of CITES (CITES 2009; IUCN 2009; USFWS 2009). It is currently considered one of the top 25 most endangered turtle species in the world (Turtle Conservation Coalition 2011).

In Belize, a countrywide survey of *D. mawii* (locally known as ''hicatee'') conducted in 1983 and 1984 found that the species was still common to abundant in areas sparsely populated by humans, but declining in more developed areas where turtles were more accessible to fishermen (Moll 1986). Additional research conducted in north-central Belize from 1989 through 1991 indicated that exploitation of *D. mawii* persisted in more populated areas and that the level of harvesting was unsustainable (Polisar 1992, 1994, 1995, 1996, 1997; Polisar and Horwich 1994). As a result, in 1993 the Belize Fisheries Department drafted nationwide comprehensive legislation for the protection and management of *D. mawii* (Statutory Instrument No. 55 of 1993) which included year-round possession limits, a brief closed (nonhunting) season, a complete prohibition on selling and purchasing *D. mawii*, and a series of protected zones in the major waterways of northern Belize (Polisar 1994, 1995, 1997; Polisar and Horwich 1994). Surveys conducted in north-central

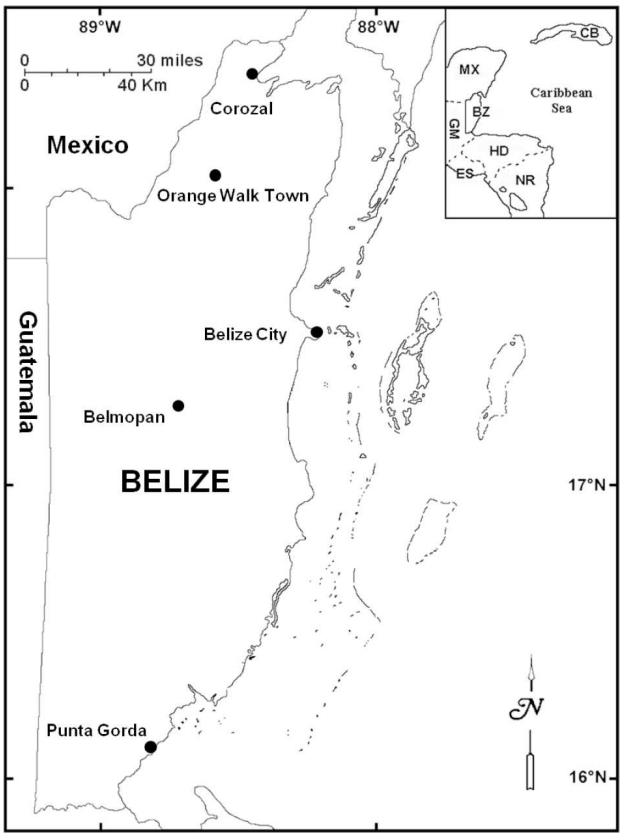

Figure 1. Map of Belize showing major population centers and location relative to other Caribbean countries.

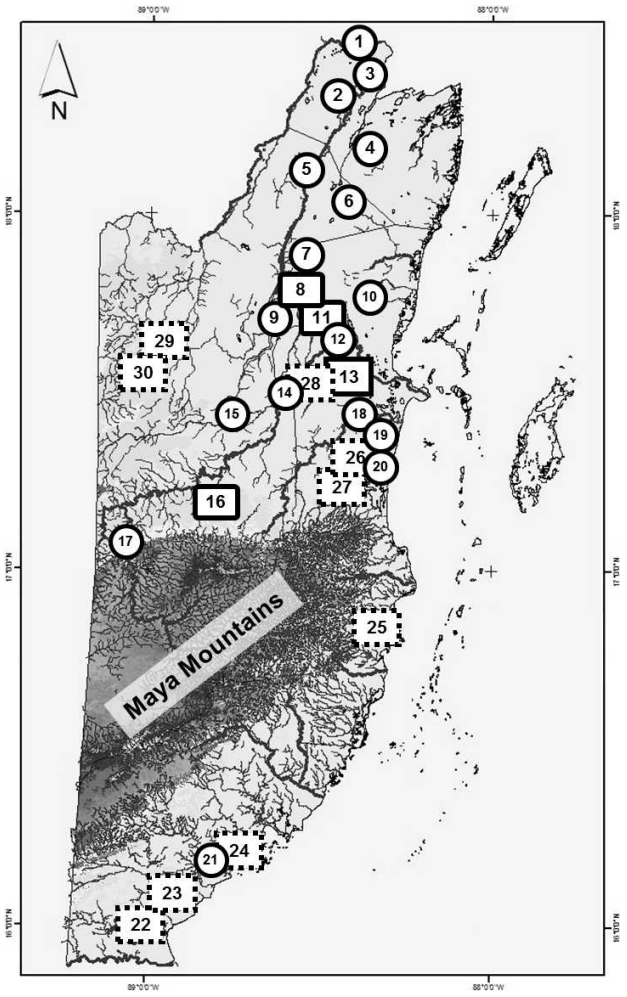

Figure 2. Map of Belize showing general localities surveyed for *Dermatemys mawii* in 1983–1984 (Moll 1986) and 2010 (present study). Circles denote localities surveyed in both 1983–1984 and 2010. Squares with solid outlines denote localities surveyed in 1983–1984 but not in 2010. Squares with dotted outlines denote localities surveyed in 2010 but not in 1983–1984. Numbers within circles and squares correspond to locality names listed in Table 1.

Belize in 1998 and 1999 suggested *D. mawii* was still common to abundant in some remote localities but declining in more developed areas (Garel 1998; Collins 1999).

In April and May 2010, we conducted a countrywide survey to examine the current status of *D. mawii* in Belize, approximately 25 yrs after the first countrywide survey was conducted (Moll 1986). The primary objectives of this effort were to resurvey localities previously surveyed in the early 1980s so that general comparisons of *D. mawii* abundance could be made, and to survey other areas not included in earlier surveys to investigate the occurrence of previously unreported *D. mawii* populations.

METHODS

Fieldwork in Belize (Fig. 1) was conducted from 12 April to 31 May 2010, a period coinciding with the peak of the dry season (Platt et al. 2006, 2008). During this period, turtles are easier to locate because water levels are lower, water bodies are relatively clear due to reduced turbidity, and turtles are more concentrated in smaller areas (Polisar 1995). Consistent with previous studies, we employed multiple survey methods, including nocturnal spotlight searches, trammel netting, and diving (free and scuba) (Moll 1986; Polisar 1995; Garel 1998; Collins 1999). One of our primary objectives was to resurvey localities previously surveyed in the early 1980s (Fig. 2). However, exact survey locations (e.g., maps or GPS coordinates) and routes from the 1980s surveys were not available (detailed notes were lost in a boat accident in the New River in 1984; D. Moll, *pers. comm.*, 2011). Therefore, once at the general locality previously surveyed, we based our survey routes on criteria similar to those used in the earlier surveys, including accessibility and habitat likely to contain *D. mawii* (Moll 1986).

Spotlight surveys were conducted from either a motor boat traveling at low (‘‘trolling’’) speed (Moll 1986) or a canoe. Spotlights (3 million candle power) were used during surveys conducted from motor boats, while a combination of spotlights and headlamps (6 V) were used during surveys conducted from canoes. When circumnavigating an area (e.g., lagoon, stretch of river) only one side of the boat (closest to shore) was illuminated at a

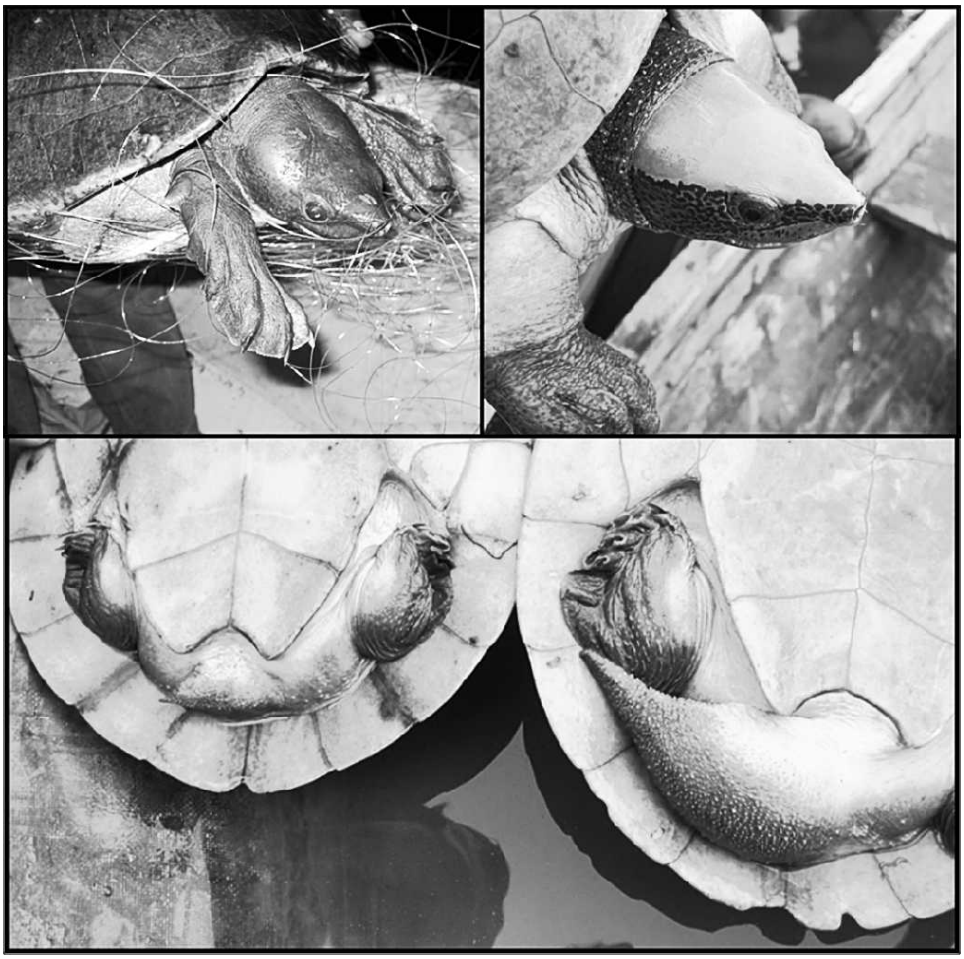

Figure 3. Photographs illustrating sexual dimorphism in *Dermatemys mawii* in Belize (2010). Adult males generally exhibit a yellowish coloration on the dorsal surface of the head (top right), while adult female heads are more uniformly brown or olive (top left). Adult males (bottom right) also exhibit a considerably larger tail than adult females (bottom left). (Photographs by Thomas Rainwater.)

time to reduce the risk of counting the same turtle multiple times in a survey. The beginning and endpoints of each survey route and the distance traversed were determined with a Garmin® GPS Map 60. Trammel nets (137 m long, 3 m deep, mesh diameter = 10 cm^2, walling = 36 cm^2, lead core bottom line, foam core top line; Memphis Net and Twine, Memphis, TN) were set in habitat likely to contain *D. mawii* or specific localities where *D. mawii* had previously been observed. Nets were set during both day and night, depending on the locality. The large mesh sizes of the nets generally selected towards captures of subadult and adult turtles. Dive surveys were conducted in the Belize and Sibun rivers only. In the Belize River, we were led by local fishermen who routinely harvest *D. mawii* there and surveyed (free diving with masks only) a stretch of river where the species was considered common to abundant. In the Sibun River, we were led by one of the authors (AG), who surveyed and observed *D. mawii* at the same localities in 1998 and 1999 (Garel 1998; Collins 1999). At each locality in the Sibun River, surveys were conducted by one scuba diver (AG) and 2 free divers (with masks only).

For each turtle captured during surveys, straight-line carapace length (CL) and plastron length (PL) were measured (to nearest 0.5 cm) using aluminum tree calipers, and body mass was determined (to nearest 0.5 kg) using spring scales. Sex was determined by examining head coloration and tail size. Adult male *D. mawii* characteristically display yellow (although sometimes cream or reddish-brown) coloration on the dorsal surface of the head, whereas the heads of adult females are typically uniformly brown, olive, or gray (Fig. 3; Ernst and Barbour 1989; Lee 1996). Additionally, males have considerably larger tails than females (Fig. 3; Ernst and Barbour 1989; Lee 1996). The capture location of each turtle was determined with a GPS Map 60, and each turtle was permanently marked for future identification by drilling holes in a unique series of marginal scutes. Following data collection, all turtles were immediately released at their corresponding sites of capture. When possible, we also interviewed fishermen and other knowledgeable individuals regarding the natural history and local occurrence of *D. mawii*, hunting methods, and levels of exploitation (Platt et al. 2004).

Table 1. Information regarding *Dermatemys mawii* surveys conducted in Belize in 1983–1984 (Moll 1986) and 2010 (this study).

Locality[a]	Spotlight surveys	Net surveys
1. Rio Hondo/Four Mile Lagoon	1983–1984, 2010	1983–1984, 2010
2. Four Mile Lagoon (near Corozal Bay)	1983–1984, 2010	—
3. Corozal Bay/mouth of New River	1983–1984, 2010	—
4. Progresso Lagoon	1983–1984, 2010	1983–1984, 2010
5. New River	1983–1984, 2010	—
6. Honey Camp Lagoon	1983–1984, 2010	—
7. Northern Lagoon (Crooked Tree)	1983–1984, 2010	1983–1984
8. Spanish Creek[b]	—	—
9. New River Lagoon	1983–1984	2010
10. Jones Lagoon	1983–1984, 2010	—
11. Southern Lagoon (near Spanish Creek)	1983–1984	—
12. Mussel Creek and tributaries	1983–1984, 2010	—
Mucklehenny Creek	1983–1984	—
Mucklehenny Lagoon	2010	—
Cook's Creek	1983–1984, 2010	—
Botlass Creek	1983–1984	—
13. Cook's Lagoon	1983–1984	—
14. Belize River[c]	1983–1984, 2010	1983–1984, 2010
15. Labouring Creek and tributaries	1983–1984	—
Cut and Throw Away Creek	1983–1984	—
Freshwater Creek	2010	2010
Graham Creek	1983–1984	—
16. Roaring Creek	1983–1984	—
17. Macal River	1983–1984, 2010	2010
18. Sibun River[c]	1983–1984	1983–1984, 2010
19. Northern Lagoon	1983–1984	1983–1984
Tum Tum Creek	2010	2010
Wagner Creek	2010	—
20. Southern Lagoon	1983–1984	1983–1984
Manatee River	2010	2010
Cornhouse Creek	2010	—
21. Rio Grande	1983–1984, 2010	1983–1984, 2010
22. Temash River[d]	2010	—
23. Moho River	2010	—
24. Golden Stream	2010	—
25. Sittee River	2010	2010
26. Western Lagoon (Sapodilla Creek)	—	2010
27. Myers Pond	—	2010
28. Cox Lagoon	2010	—
29. Rio Bravo	—	2010
30. Laguna Verde (near Gallon Jug)	2010	2010

[a] Numbers to the left of locality names correspond to numbers in Fig. 2.
[b] Moll (1986) observed a single *D. mawii* in Spanish Creek from the shoreline in 1984 but was unable to conduct a formal spotlight survey at this locality (D. Moll, *pers. comm.*, 2011).
[c] Includes a dive survey conducted in 2010.
[d] Moll (1986) was unable to survey the Temash River, but rather found specimens of *D. mawii* in a market in Punta Gorda. The person who collected the specimens informed Moll that the origin of the turtles was ''near the mouth of the Temash River'' (Moll 1986).

RESULTS AND DISCUSSION

From 12 April through 31 May, we surveyed 30 different localities in Belize for *D. mawii* (Table 1; Fig. 2). Approximately 17 of these had been previously surveyed by Moll (1986) in 1983–1984, and an additional 2 (Cox Lagoon, Rio Bravo) were previously surveyed by others (Polisar 1990, 1995, 1996; Garel 1998). Localities surveyed ranged from the deep south of Belize (Temash River) to the extreme north of the country (Rio Hondo) and were characterized by variety of habitats, including the estuarine, brackish, and freshwater sections of rivers, brackish and freshwater creeks, lagoons, and ponds, and a coastal bay. Associated topography and vegetation varied widely among these habitats, from coastal mangrove swamps to montane broadleaf forest along the lower slopes of the Maya Mountains (Stafford and Meyer 2000).

Spotlight surveys were conducted at 25 different localities in Belize in 2010 (Tables 2 and 3). A total of 18 *D. mawii* was observed at 5 (20%) of the localities surveyed: Rio Grande (8), Moho River (1), Temash River (6), Manatee River (Southern Lagoon, 1), and Mucklehenny Lagoon (2) (Table 3). Encounter rates at these localities ranged from 0.16 (Moho River) to 0.67 (Rio Grande) *D. mawii* per kilometer of the survey route (Table 3). Number of *D. mawii* observed per hour ranged

Table 2. Locality information for *Dermatemys mawii* spotlight surveys conducted in Belize in 2010. Locality names correspond to those listed in Table 1.

Locality	Date	Survey start location	Survey end location
Rio Grande	15 April	16°11′11.6″N, 88°50′03.5″W	16°10′13.1″N, 88°48′37.4″W
Golden Stream	18 April	16°18′05.7″N, 88°45′10.4″W	16°13′30.0″N, 88°44′04.2″W
Moho River	19 April	16°06′07.9″N, 88°57′46.7″W	16°05′51.6″N, 88°55′42.5″W
Temash River	20 April	15°59′38.1″N, 89°05′22.1″W	15°57′48.7″N, 89°01′41.9″W
Sittee River	23 April	16°49′09.4″N, 88°20′58.8″W	16°49′18.3″N, 88°16′06.7″W
Cox Lagoon[a]	26 April	17°26′31.6″N, 88°32′58.5″W	17°26′05.9″N, 88°33′08.9″W
Manatee River (Southern Lagoon)	28 April	17°13′36.5″N, 88°21′14.2″W	17°13′14.3″N, 88°22′29.7″W
Cornhouse Creek (Southern Lagoon)[a]	28 April	17°13′39.2″N, 88°21′50.4″W	17°13′39.2″N, 88°21′50.4″W
Cook's Creek	30 April	17°32′18.1″N, 88°28′16.9″W	17°33′14.2″N, 88°28′22.7″W
Mussel Creek	30 April	17°33′14.2″N, 88°28′22.7″W	17°34′09.5″N, 88°28′24.9″W
Belize River	3 May	17°27′25.8″N, 88°36′04.8″W	17°29′51.1″N, 88°35′08.7″W
Mucklehenny Lagoon[a]	5 May	17°29′24.6″N, 88°29′48.5″W	17°29′24.6″N, 88°29′48.5″W
Tum Tum Creek (Northern Lagoon)	7 May	17°23′11.1″N, 88°20′51.9″W	17°23′14.7″N, 88°21′01.5″W
Wagner Creek (Northern Lagoon)	7 May	17°18′07.5″N, 88°21′08.4″W	17°18′10.5″N, 88°21′35.1″W
New River	10 May	17°46′40.2″N, 88°38′26.1″W	17°48.54.4″N, 88°37′05.0″W
Northern Lagoon (Crooked Tree)[a]	15 May	17°46′10.5″N, 88°31′42.0″W	17°46′10.5″N, 88°31′42.0″W
Freshwater Creek	16 May	17°25′43.8″N, 88°41′19.2″W	17°24′29.1″N, 88°42′58.2″W
Jones Lagoon[a]	17 May	17°41′13.3″N, 88°25′06.5″W	17°41′13.3″N, 88°25′06.5″W
Four Mile Lagoon (near Corozal Bay)[a]	20 May	18°21′56.2″N, 88°24′04.8″W	18°21′56.2″N, 88°24′04.8″W
Rio Hondo/Four Mile Lagoon[a]	21 May	18°27′39.8″N, 88°24′17.5″W	18°27′39.8″N, 88°24′17.5″W
Progresso Lagoon	22 May	18°11′48.0″N, 88°24′50.5″W	18°13′20.0″N, 88°24′01.8″W
Corozal Bay/mouth of New River	23 May	18°21′30.5″N, 88°21′10.6″W	18°20′59.3″N, 88°23′18.8″W
Honey Camp Lagoon[a]	24 May	18°02′22.1″N, 88°27′02.2″W	18°02′22.1″N, 88°27′02.2″W
Laguna Verde (near Gallon Jug) [a]	25 May	17°36′19.4″N, 89°04′19.2″W	17°36′19.4″N, 89°04′19.2″W
Macal River[a]	27 May	17°01′57.9″N, 89°03′32.2″W	17°01′57.9″N, 89°03′32.2″W

[a] Survey circumnavigated all or part of the lagoon or stretch of river.

from 0.4 (Moho River) to 2.9 (Rio Grande) (Table 4). Moll (1986) also reported number of *D. mawii* observed per hour during spotlight surveys conducted in 1983–1984, allowing for general comparisons with results from the present study (Table 4). Of the 17 localities surveyed in both studies, *D. mawii* was observed at all (100%) sites in 1983–1984 and only 3 (17.6%) in 2010 (Table 4). Number of *D. mawii* observed per hour was greater in the Mucklehenny Creek/Lagoon (1.7-fold) and Southern Lagoon (near Gales Point) (3.3-fold) areas in 1983–1984

Table 3. Number of *Dermatemys mawii* observed per kilometer of survey route traveled during spotlight surveys in Belize in 2010.

Locality	Date	Survey vessel	Distance traveled during survey (km)	No. of turtles observed	Encounter rate (turtles/km survey route)
Rio Grande	15 April	Motor boat	11.9	8	0.67
Golden Stream	18 April	Motor boat	13.2	0	0
Moho River	19 April	Canoe	6.2	1	0.16
Temash River	20 April	Motor boat	20.1	6	0.30
Sittee River	23 April	Motor boat	16.0	0	0
Cox Lagoon	26 April	Canoe	10.2	0	0
Manatee River (Southern Lagoon)	28 April	Motor boat	4.8	1	0.21
Cornhouse Creek (Southern Lagoon)	28 April	Motor boat	3.9	0	0
Cook's Creek	30 April	Canoe	1.3	0	0
Mussel Creek	30 April	Canoe	2.1	0	0
Belize River	3 May	Motor boat	10.4	0	0
Mucklehenny Lagoon	5 May	Canoe	5.6	2	0.35
Tum Tum Creek (Northern Lagoon)	7 May	Motor boat	0.8	0	0
Wagner Creek (Northern Lagoon)	7 May	Motor boat	2.6	0	0
New River	10 May	Motor boat	5.74	0	0
Northern Lagoon (Crooked Tree)	15 May	Canoe	1.5	0	0
Freshwater Creek	16 May	Canoe	5.3	0	0
Jones Lagoon	17 May	Canoe	9.3	0	0
Four Mile Lagoon (near Corozal Bay)	20 May	Motor boat[a]	10.6	0	0
Rio Hondo/Four Mile Lagoon	21 May	Motor boat[a]	12.3	0	0
Progresso Lagoon	22 May	Motor boat[a]	3.7	0	0
Corozal Bay/mouth of New River	23 May	Motor boat	6.7	0	0
Honey Camp Lagoon	24 May	Canoe	13.3	0	0
Laguna Verde (near Gallon Jug)	25 May	Canoe	2.4	0	0
Macal River	27 May	Canoe	0.42	0	0

[a] Canoe with outboard motor attached.

Table 4. Comparison of the number of *Dermatemys mawii* observed per hour during spotlight surveys in Belize at localities visited in both 1983–1984 (Moll 1986) and 2010 (this study).

	1983–1984			2010		
Locality	No. turtles observed	Survey duration (hr)	No. turtles observed/hr	No. turtles observed	Survey duration (hr)	No. turtles observed/hr
Belize River (above Burrell Boom)	97	42	2.3	0	1.6	0
Cook's Creek	6	3	2.0	0	1.1	0
Corozal Bay	20	42	0.5	0	1.9	0
Four Mile Lagoon (Corozal)	52	30	1.7	0	2.7	0
Rio Hondo/Four Mile Lagoon	88	80	1.1	0	2.8	0
Labouring Creek and tributaries[a]	48	12	4.0	0	3.2	0
Honey Camp Lagoon	18	4	4.5	0	2.8	0
Jones Lagoon	96	12	8.0	0	2.4	0
Macal River	2	8	0.3	0	0.4	0
Mucklehenny Lagoon/Creek	6	6	1	2	3.2	0.6
Mussel Creek	12	24	0.5	0	1.1	0
New River	16	16	1.0	0	1.9	0
Northern Lagoon (Crooked Tree)	72	16	4.5[b]	0	0.7	0
Northern Lagoon (Gales Point)[c]	8	8	1.0	0	0.9	0
Progresso Lagoon	370	168	2.2	0	0.9	0
Rio Grande	46	20	2.3	8	2.7	2.9
Southern Lagoon (Gales Point)[d]	20	8	2.5	1	2.4	0.4

[a] Freshwater Creek was considered a tributary of Labouring Creek in 2010.
[b] Value reported as 8.0 in Moll (1986).
[c] Includes Tum Tum Creek and Wagner Creek.
[d] Includes Cornhouse Creek and Manatee River.

than in 2010, but higher in the Rio Grande (1.3-fold) in 2010 than in 1983–1984 (Table 4).

Trammel net surveys were conducted at 18 different localities in Belize in 2010 (Table 5). Thirty-nine *D. mawii* were captured in trammel nets at 6 (33%) of the localities surveyed: Manatee River (Southern Lagoon, 1), Belize River (8), Myers Pond (5), Irish Creek (New River Lagoon, 4), Rio Hondo (6), and Rio Bravo (15) (Table 5). Moll (1986) also reported the number of *D. mawii* captured in trammel nets in 1983–1984, allowing for general comparisons with our results. Of the 6 localities surveyed in both studies, *D. mawii* was captured at all (100%) sites in 1983–1984 and only 3 (50%) in 2010 (Manatee River/Southern Lagoon, Belize River, Rio Hondo) (Fig. 4). The number of turtles captured was greater at all 3 sites in 1983–1984 than in 2010 (Fig. 4).

Comparisons between survey results in 1983–1984 (Moll 1986) and our study are included to examine general trends in *D. mawii* occurrence, but quantitative comparisons (e.g., number turtles surveyed per hour, number turtles captured in trammel nets) between the 2 studies should be interpreted with caution. Because no specific locality data (e.g., map coordinates) were provided for spotlight survey start and end points or trammel netting locations in the previous study (Moll 1986), with the exception of a few lagoons, it is unlikely that localities surveyed in the present study were exactly the same as those surveyed in 1983–1984. In addition, differences in survey methodologies between the 2 studies make direct comparisons between them problematic. For example, all spotlight surveys conducted by Moll (1986) were performed from a boat powered by an outboard motor, while several surveys in 2010 were conducted using both a motor boat and canoe (with and without a motor). The use of a motor may influence survey results by allowing researchers to travel greater distances over a shorter time period and by the potential effect of motor sound and vibrations on turtle behavior and subsequent observability. Indeed, during spotlight surveys in the Rio Grande and Temash River, we observed most turtles swimming toward the shore or overhanging vegetation as we slowly passed by in motor boats, presumably as a result of turtles fleeing the sound or vibration of the motor and seeking cover. Further, multiple fishermen and turtle hunters informed us this technique is commonly used to bring turtles to the water's surface where they can more easily be harpooned, netted, or hand-captured. Another important difference between the 1983–1984 and 2010 studies was time spent surveying each locality. Moll (1986) spent approximately 6 mo surveying 21 localities in Belize, while in the present study we spent approximately 2 mo surveying 30 localities. More time spent at each locality allows for longer spotlight survey routes, more netting localities, and longer netting sessions, which may increase the likelihood of encountering or capturing turtles. Finally, time of year in which surveys are conducted may also affect survey results, as seasonal changes in water levels and temperature affect turtle behavior (Wallace et al. 2007) and access to survey sites. Moll (1986) surveyed *D. mawii* in Belize during both the wet and dry seasons, while our survey was conducted during the dry season only.

Dive surveys were conducted at 2 localities in Belize in 2010, the Belize and Sibun rivers (Table 6). The dive survey in the Belize River was conducted in the Big Falls area along an approximately 1.5-km stretch of river

Table 5. Location and number of *Dermatemys mawii* captured in trammel nets in Belize in 2010.

Locality	Date	Net no.	GPS coordinates	Start time (hr)	Hours deployed	No. turtles captured
Rio Grande	16 April	1	16°11′30.8″N, 88°49′46.9″W	1600	3.5	0
Rio Grande	17 April	1	16°10′42.4″N, 88°49′52.6″W	1100	8.3	0
Rio Grande	17 April	2	16°10′42.4″N, 88°49′52.6″W	1148	7.0	0
Sittee River	24–25 April	1	16°48′40.5″N, 88°19′36.4″W	1130	21.0	0
Sittee River	24–25 April	2	16°48′46.4″N, 88°19′40.4″W	1145	20.8	0
Manatee River (Southern Lagoon)	28 April	1	17°13′37.5″N, 88°21′51.6″W	1924	2.6	1
Belize River	3 May	1	17°28′02.3 N, 88°36′00.9″W	1435	1.6	5
Belize River	3 May	2	17°27′53.9″N, 88°36′01.5″W	1450	2.7	3[a]
Myers Pond (near Gales Point)	5 May	1	17°12′15.9 N, 88°22′19.6″W	1515	1.0	5
Tum Tum Creek (Northern Lagoon)	7 May	1	17°23′14.8″N, 88°20′53.1″W	2055	0.3	0
Sapodilla Creek (Western Lagoon)	8 May	1	17°16′05.5″N, 88°22′43.3″W	1022	1.9	0
Sapodilla Creek (Western Lagoon)	8 May	2	17°16′01.1″N, 88°22′40.7″W	1030	1.9	0
New River Lagoon	9 May	1	17°45′38.0″N, 88°39′09.8″W	2106	5.9	0
New River Lagoon	9 May	2	17°45′35.5″N, 88°39′10.1″W	2115	5.6	0
Dawson Creek (New River Lagoon)	10 May	1	17°45′48.5″N, 88°38′10.5″W	1046	1.9	0
Dawson Creek (New River Lagoon)	10 May	2	17°45′48.5″N, 88°37′50.7″W	1101	1.7	0
Irish Creek (New River Lagoon)	11 May	1	17°39′55.0″N, 88°39′13.1″W	1100	3.7	1
Irish Creek (New River Lagoon)	11 May	2	17°39′58.8″N, 88°39′14.1″W	1110	3.3	2
Irish Creek (New River Lagoon)	11 May	3	17°40′02.3″N, 88°39′19.9″W	1509	2.0	1
Irish Creek (New River Lagoon)	11 May	4	17°40′01.0″N, 88°39′23.3″W	1523	2.1	0
Barbour Creek (New River Lagoon)	12 May	1	17°46′51.2″N, 88°38′33.4″W	0756	2.9	0
Barbour Creek (New River Lagoon)	12 May	2	17°46′47.9″N, 88°38′28.3″W	0820	2.1	0
Sibun River	13 May	1	17°21′00.4″N, 88°30′59.7″W	1300	2.3	0
Sibun River	13 May	2	17°21′00.4″N, 88°30′59.7″W	1315	2.3	0
Freshwater Creek	16 May	1	17°24′52.2″N, 88°42′05.8″W	1600	5.7	0
Freshwater Creek	16 May	2	17°24′58.6″N, 88°42′06.6″W	1621	5.1	0
Rio Hondo/Four Mile Lagoon	20 May	1	18°28′42.5″N, 88°22′52.9″W	1832	2.8	2
Rio Hondo/Four Mile Lagoon	20 May	2	18°28′43.3″N, 88°22′55.3″W	1843	3.3	4
Progresso Lagoon	21 May	1	18°11′48.0″N, 88°24′50.5″W	1545	3.9	0
Progresso Lagoon	21 May	2	18°11′49.6″N, 88°24′52.1″W	1617	3.1	0
Laguna Verde	25 May	1	17°36′19.4″N, 89°04′19.2″W	1735	6.9	0
Laguna Verde	25 May	2	17°36′21.8″N, 89°04′14.0″W	1753	6.9	0
Rio Bravo	26 May	1	17°41′27.5″N, 89°01′55.0″W	0920	4.5	6
Rio Bravo	26 May	2	17°41′26.0″N, 89°01′55.7″W	0930	3.8	9
Macal River	27 May	1	17°01′57.9″N, 89°03′32.2″W	1830	4.3	0
Macal River	27 May	2	17°01′58.9″N, 89°03′32.9″W	1850	4.2	0
Macal River	28 May	1	17°02′54.5″N, 89°03′36.7″W	1005	3.0	0
Macal River	28 May	2	17°02′55.6″N, 89°03′41.3″W	1016	2.9	0

[a] One turtle freed itself from the net before being collected; therefore measurements were collected from only 7 turtles from the Belize River.

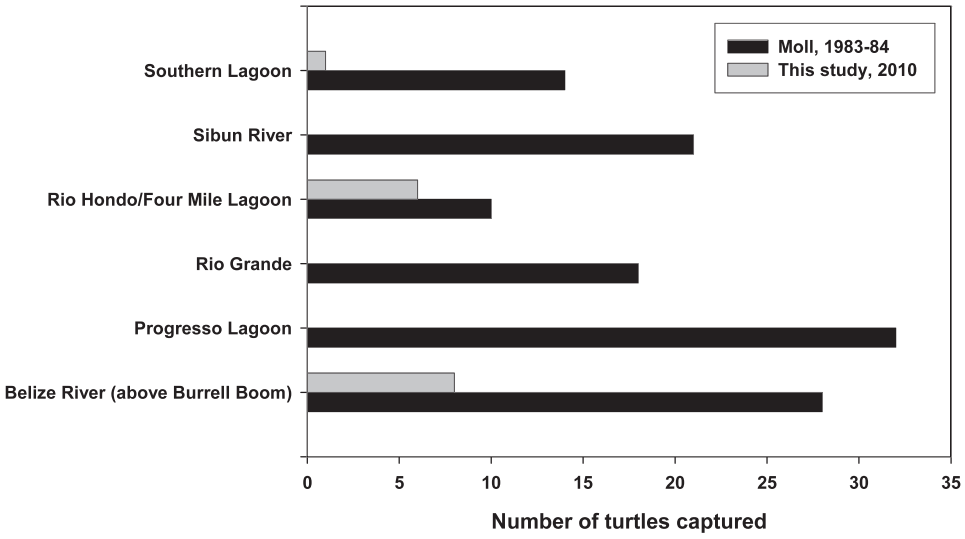

Figure 4. Comparison of the number of *Dermatemys mawii* captured in trammel nets in Belize in 1983–1984 (Moll 1986) and 2010 (this study).

Table 6. Number of *Dermatemys mawii* observed during dive surveys in Belize in 2010. All surveys in the Sibun River included one scuba diver and 2 free divers using only masks. The Belize River was surveyed by free divers using only masks.

Locality	Date	GPS coordinates of dive start	No. of divers	Hours of diving	Man-hours of diving	No. turtles observed	No. turtles observed/man-hour
Belize River	2 May	17°27′45.8″N, 88°36′34.0″W	7	3.25	22.8	16[a]	0.7
Sibun River	13 May	17°21′00.4″N, 88°30′59.7″W	3	0.58	1.74	0	0
Sibun River	13 May	17°20′54.6″N, 88°30′48.6″W	3	0.53	1.59	0	0
Sibun River	13 May	17°21′24.3″N, 88°30′45.6″W	3	0.37	1.11	0	0
Sibun River	13 May	17°21′07.5″N, 88°30′00.2″W	3	0.45	1.35	0	0
Sibun River	14 May	17°21′44.7″N, 88°29′02.2″W	3	0.20	0.60	0	0
Sibun River	14 May	17°21′39.3″N, 88°27′18.0″W	3	0.25	0.75	0	0
Sibun River	14 May	17°24′22.2″N, 88°26′10.3″W	3	0.15	0.45	0	0
Sibun River	14 May	17°24′39.2″N, 88°25′17.5″W	3	0.38	1.14	0	0
Sibun River	14 May	17°24′31.8″N, 88°25′41.1″W	3	0.25	0.75	0	0

[a] Unsubstantiated. Local fisherman hired to assist in dive surveys claimed to have seen 16 turtles during this diving event, but none were seen by our core survey team, which also dove. No turtles were captured during dive surveys.

upstream from an old rice mill, a familiar landmark on the river. We were brought to this particular locality by local fishermen who claimed *D. mawii* was abundant there, and to their knowledge the area had not yet been hunted in 2010. Five local fishermen and 2 members of our team surveyed this area for approximately 3 hours, concentrating efforts primarily near the shoreline among submerged trees, limbs, and logs as we worked our way downstream. Collectively, the fishermen claimed to have seen 16 *D. mawii* during the survey. However, because no turtles were captured and none were seen by the 2 members of our survey team, this figure could not be verified. The river was considerably turbid on the day of the survey, presumably from large-scale sand and gravel extraction occurring farther upriver. The fishermen insisted that under less turbid conditions, more turtles would have been observed and many would have been captured. This is likely true because we captured several *D. mawii* in trammel nets in the same general area the following day. In the Sibun River, we conducted dive surveys in 9 specific eddies in which *D. mawii* had been previously observed and captured by TG and others (Garel 1998; Collins 1999; T. Garel, *pers. comm.*, 2010) (Table 6). However, no turtles were observed in the Sibun River during the 2010 dive surveys.

A total of 39 *D. mawii* was captured and examined in Belize during the 2010 survey. One captive specimen and 5 shells from recently harvested turtles were also examined. Mean (± SE) CL of male and female *D. mawii* captured during the survey was 38.2 ± 0.7 cm ($n = 17$) and 34.8 ± 1.3 cm ($n = 22$), respectively. *Dermatemys mawii* was captured in the Temash River, Southern Lagoon (Manatee River), Belize River, Myers Pond, New River Lagoon (Irish Creek), Rio Hondo, and Rio Bravo. Importantly, at least 4 of these localities receive varying forms of protection (e.g., ranger patrols, protected private property). In addition to *D. mawii*, 6 Mesoamerican sliders (*Trachemys venusta*) and one Mexican giant musk turtle (*Staurotypus triporcatus*) were also captured during the 2010 survey. Morphometric attributes and locality data for all turtles captured during this study are listed in Rainwater et al. (2010).

Exploitation

Exploitation of *D. mawii* appears to continue unabated in Belize, and as previously reported (Polisar 1995), fishermen primarily target larger turtles (subadults and adults). We observed shells of recently harvested turtles (discriminated from naturally predated turtles by a lack of scratch and bite marks on the carapace [Platt and Rainwater 2011] and by location [found in villages]) at multiple localities, encountered animals held in captivity, and heard accounts from villagers and hunters countrywide suggesting large numbers of *D. mawii* continue to be harvested each year. For example, in the Belize River valley, where exploitation has been notoriously high for years (Polisar 1992, 1994, 1995, 1996, 1997; Polisar and Horwich 1994), locals estimate that ca. 400 *D. mawii* are harvested annually from the stretch of river between Flowers Bank and Big Falls, with ca. 300 taken in 2010. Villagers relayed recent accounts of ca. 30, 60, and 75 *D. mawii* taken in a single day, sometimes by only one person, in the Belize River, New River Lagoon, and Rio Hondo, respectively. Polisar (1995) reported *D. mawii* exploitation levels in 1989–1990 to be heavy and unsustainable in certain reaches of the Belize River, and suggested that if all adult and maturing turtles continued to be removed, only immigration from less disturbed sections of the river could prevent local population extinctions. Indeed, fishermen and turtle hunters we spoke with on the Belize River in 2010 believe that each wet season when high water levels peak, the river is ''replenished'' by turtles that move in from less disturbed or inaccessible areas otherwise isolated during the dry season. Perceptions of local abundance by villagers in the Belize River valley were that the number of *D. mawii* in the river is lower than in years past; however, that large numbers of turtles continue to be removed from this stretch of the river after several decades of heavy exploitation supports the notion of turtle immigration from less disturbed areas.

Turtles are primarily harvested by striking with a spear and peg (''harpooning''), netting, and free-diving (Polisar

1995). With spear and peg hunting, turtles that come to the surface to breathe or forage are struck in the carapace with a barbed metal tip attached to a long wooden staff by strong twine (Polisar 1995). Once a turtle is retrieved, fishermen often pack the barb hole with wax (presumably to reduce bleeding and delay infection) and place the turtle in a ''corral'' made of vertically placed sticks in shallow water. We observed these corrals (empty at the time) in New River and Progresso Lagoon. Fishermen said that plugging the barb holes with wax allows turtles to ''last several days.'' With netting and free diving, hunters often work in teams to drive turtles into nets or to the surface where they can more easily be captured by hand. This is often accomplished by beating the surface of the water with large sticks and boat paddles, and by using a large chain doubled over on itself and tied to a rope, which is lowered to the bottom of the river and ''shaken'' (raised and dropped rapidly), making a noise audible even above water. Fishermen in the Rio Grande and Temash River also described capturing *D. mawii* with a hook and line baited with leaves and fruit of bribri (*Inga edulis*) and fig (*Ficus* sp.), and sometimes banana (*Musa* sp.)., and commented that a person could capture 7–8 turtles in one location using this technique. Villagers contend that *D. mawii* is no longer sold in public markets but is instead available for purchase through word of mouth from people's homes. Additionally, *D. mawii* is still commonly sold in village restaurants, especially during days preceding and following Easter.

Conservation Assessment and Recommendations

The continued exploitation and subsequent population decline of *D. mawii* in Belize over the last approximately 20 yrs appears to be reflected in the reduced number of turtles observed in our surveys compared to those conducted in 1983–1984 (Moll 1986) and 1998–1999 (Garel 1998; Collins 1999). We observed *D. mawii* at only 17% (spotlight surveys) and 50% (trammel net surveys) of localities previously surveyed by Moll (1986), and observed no turtles during dive surveys in the Sibun River where they had commonly been found in 1998–1999 (Garel 1998; Collins 1999). Following our survey of the Sibun River, a hunter from a riverside village (Butcher Burns) informed us that every year, from December through May, local turtle hunters dive for *D. mawii* in the same stretch of river we surveyed, until turtles are gone.

Overall, the results of the 2010 survey indicate *D. mawii* is heavily depleted in most of Belize, but healthy populations remain in a few remote areas, especially those receiving some level of protection. While this mirrors the trend observed in surveys conducted during the 1980s and 1990s, the current findings are particularly alarming in that the number of localities where turtles were observed and the number of turtles seen at these localities were both much reduced compared with previous surveys. In addition, interviews with fishermen and hunters indicate that the laws and regulations enacted in 1993 for the protection and management of *D. mawii* are largely ignored by locals, as broad-scale enforcement is difficult or impossible to achieve. For example, we saw evidence of *D. mawii* harvesting in several of the protected zones where fishing for hicatee is illegal (Polisar and Horwich 1994).

We regard the current level of *D. mawii* harvesting in Belize as unsustainable and consider it a serious threat to the continued viability of *D. mawii* populations in the country. Turtles are long-lived organisms characterized by a unique suite of life history traits that include low survivorship of eggs, hatchlings, and juveniles; delayed sexual maturity; and high survivorship among subadults and adults (Congdon et al. 1993). Consequently, turtle populations are demographically sensitive to any increase in mortality among the larger size classes, especially reproductive adults (Brooks et al. 1991; Congdon et al. 1993). Thus, even a low-intensity subsistence take has the potential to decimate turtle populations (Thirakhupt and van Dijk 1994; Platt et al. 2003). Indeed, it is doubtful whether any level of turtle harvest can be truly sustainable (Thorbjarnarson et al. 2000). In Belize, exploitation of *D. mawii* by humans has introduced high predation rates to size classes accustomed to high survival rates (Polisar 1995). Therefore, as Polisar (1995) has previously stated, increasing adult survival should be the focus of any *D. mawii* conservation or management program.

The occurrence of *D. mawii* at multiple, previously unsurveyed localities in southern Belize is encouraging. More comprehensive surveys of these and other areas where *D. mawii* populations appeared to be secure during the 2010 survey will be vital in developing new conservation strategies, potentially including prioritization of areas for more intensive (and enforceable) protection. In addition, the 2010 surveys generated much interest and support in Belize from the government (Belize Fisheries Department), several nongovernmental organizations, and many individual conservationists, scientists, students, guides, and general citizens. This momentum resulted in a Hicatee (*Dermatemys*) Conservation Forum and Workshop held at the University of Belize in December 2010, at which a National Hicatee Conservation and Monitoring Network (NHCMN) was formed. The NHCMN is currently working on 3 primary focal areas for *D. mawii* conservation in Belize: education and outreach, legislation and enforcement, and science.

Based on the results of the 2010 survey, the following are our conservation recommendations for *D. mawii* in Belize:

1. Increase law enforcement to curb illegal harvest of *D. mawii* and other wildlife and protect riparian habitats. Priority should be given to localities where *D. mawii* is still common to abundant (e.g., Temash River, Rio Grande, Belize River, New River Lagoon [Irish Creek], Southern Lagoon [Manatee River area], Rio Bravo, Rio Hondo).
2. Initiate a monitoring program to better determine the status of *D. mawii* in Belize and prioritize localities for more intensive protection. More time should be spent surveying each locality and a variety of standardized

survey techniques should be employed. Surveys should be a collaborative effort between the Belizean government, university faculty and students, national and international NGOs, and other interested parties.

3. Initiate a conservation education program, particularly in towns and villages adjacent to *D. mawii* habitat. This education program should attempt to raise public awareness of wildlife conservation, inform villagers of the protected status of wildlife in Belize, instill general conservation values, and stress the global uniqueness of *D. mawii* and its endemism.
4. Initiate a pilot captive breeding program. Such a program should focus on generating hatchlings that can be headstarted and released in protected habitats to help restore depleted wild populations.

ACKNOWLEDGMENTS

We thank George Myvett, James Azueta, Rigoberto Quintana, and the Belize Fisheries Department for support and permission to conduct *D. mawii* surveys in Belize. John Polisar and Richard Vogt provided helpful advice regarding survey methodology. We also wish to thank the following groups and individuals in Belize for their support during this project: Alton Jeffords and Oceanic Society Expeditions, Benjamin Cruz, Bill Hasse, Bruce and Carolyn Miller, Karl Tillett, Celia Mahung, Elmar Requena, Santiago Cucul, Luis Ishim, Chris Hamley, and the Toledo Institute for Development and Environment (TIDE), Chrissie and Anita Tupper (Cheers Restaurant), Clifton and Nancy Bailey (Manatee Lodge), Derrick Hendy and the Belize Audubon Society, Dion Andrews, Doyle Forman, Egbert Valencio, Thomas Ishim, Narco Nakin, and the Sarstoon Temash Institute for Indigenous Management (SATIIM), Eddie Romero (Programme for Belize), Elma Kay (Environmental Research Institute, University of Belize), Frank Mazzotti, Geraldine and Lionel Fermin (Community Baboon Sanctuary), Giovanni Fernandez and Black Rock Lodge, Graham Sampson, Isabelle Paquet-Durand (Galen University), Jacob Marlin and the Belize Foundation for Research and Environmental Education (BFREE), Jan Meerman, Jerry Larder and Nikki Buxton (Belize Bird Rescue), Kevin Andrewin, Lewis Medlock, Lloyd and Walter Cassosola, Leonard Myers, Marcelo Windsor, Andre Lopez, Rasheda Sampson, and the Belize Forest Department, Marga Miller, Anna Zabrowksi, and Monkey Bay Wildlife Sanctuary, Mark Howells, Ruben Arevalo, and Lamanai Outpost Lodge, Nick Wicks, Ginny Fuhs, Lee McLoughlin, and Ya'axché Conservation Trust, Paul Walker (Wildtracks), Percy Flowers, Jr., Reynaldo and Sergio Gorosica, Richard and Carol Foster, Robin Brockett, Sharon Matola and the Belize Zoo, Steve Lawson, Steve Usrey, Tamara Sniffin (San Pedro Sun), Udell Forman, and Vince and Cherie Rose (American Crocodile Education Sanctuary [ACES]). Richard Vogt and Don Moll provided helpful comments on an earlier draft of this manuscript. Finally, we are grateful to the Turtle Survival Alliance (TSA), Turtle Conservation Fund (TCF), the Mohamed bin Zayed Endangered Species Conservation Fund, and the Delta Foundation for generously providing financial support for this project. This paper is dedicated to the memory of Bruce Cullerton (1963–2010), friend and collaborator in our turtle (particularly *D. mawii*) and crocodile research in Belize since 1992. The findings and conclusions in this article are those of the authors and do not necessarily represent the views of the US Fish and Wildlife Service.

LITERATURE CITED

ALVAREZ DEL TORO, M., MITTERMEIER, R.A., and IVERSON, J.B. 1979. River turtle in danger. Oryx 15:170–173.

BROOKS, R.J., BROWN, G.P., AND GALBRAITH, D.A. 1991. Effects of a sudden increase in natural mortality on a population of common snapping turtle (*Chelydra serpentina*). Canadian Journal of Zoology 69:1314–1320.

CITES. 2009. Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). http://www.cites.org.

COLLINS, D. 1999. Belize trip report. Report to the Philadelphia Zoological Garden, Philadelphia, PA.

CONGDON, J.D., DUNHAM, A.E., AND VAN LOBEN SELS, R.C. 1993. Delayed sexual maturity and demographics of Blanding's turtle (*Emydoidea blandingii*): implications for conservation and management of long-lived organisms. Conservation Biology 7:826–883.

ERNST, C.H. AND BARBOUR, R.W. 1989. Turtles of the World. Washington DC: Smithsonian Institution Press, 314 pp.

GAREL, T. 1998. Central American river turtle (*Dermatemys mawii*). Report to the Zoological Society of Philadelphia, Philadelphia, PA.

IUCN. 2009. International Union for Nature and Natural Resources (IUCN) Red List of Threatened Species. Version 2009.2. http://www.iucnredlist.org.

IVERSON, J.B. 1986. A Checklist with Distribution Maps of the Turtles of the World. Richmond, IN: Paust Printing, 283 pp.

IVERSON, J.B. AND MITTERMEIER, R.A. 1980. Dermatemydidae, *Dermatemys*. Catalog of American Amphibians and Reptiles. 237:1–4.

LEE, J.C. 1996. The Amphibians and Reptiles of the Yucatán Peninsula. Ithaca: Cornell University Press, 500 pp.

MOLL, D. 1986. The distribution, status, and level of exploitation of the freshwater turtle *Dermatemys mawei* in Belize, Central America. Biological Conservation 35:87–96.

PLATT, S.G., KALYAR, AND RAINWATER, T.R. 2004. Inle Lake turtles, Myanmar with notes on Intha and Pa-O ethnoherpetology. Hamadryad 29:5–14.

PLATT, S.G. AND RAINWATER, T.R. 2011. Predation by neotropical otters (*Lontra longicaudis*) on turtles in Belize. IUCN Otter Specialist Group Bulletin 28:4–10.

PLATT, S.G., RAINWATER, T.R., FINGER, A.G., THORBJARNARSON, J.B., MCMURRY, S.T., AND ANDERSON, T.A. 2006. Food habits, ontogenetic dietary partitioning, and observations of foraging behaviour of Morelet's crocodile (*Crocodylus moreletii*) in northern Belize. Herpetological Journal 16:281–290.

PLATT, S.G., RAINWATER, T.R., THORBJARNARSON, J.B., AND MCMURRY, S.T. 2008. Reproductive dynamics of a tropical freshwater crocodilian: Morelet's crocodile in northern Belize. Journal of Zoology 275:177–189.

PLATT, S.G., WIN KO KO, LAY LAY KHAING, KHIN MYO MYO, THANDA SWE, TINT LWIN, AND RAINWATER, T.R. 2003. Population status and conservation of the critically endangered Burmese star tortoise *Geochelone platynota* in central Myanmar. Oryx 37:464–470.

POLISAR, J. 1990. An inventory of the turtle fauna of the Rio Bravo Conservation and Management Area: a preliminary report. Technical report submitted to Programme for Belize, Belize City, Belize.

POLISAR, J. 1992. Reproductive biology and exploitation of the Central American river turtle *Dermatemys mawii* in Belize. MS Thesis, University of Florida, Gainesville, 178 pp.

POLISAR, J. 1994. New legislation for the protection and management of *Dermatemys mawii* in Belize, Central America. Herpetological Review 25:47–49.

POLISAR, J. 1995. River turtle reproductive demography and exploitation patterns in Belize: implications for management. Vida Silvestre Neotropical 4:10–19.

POLISAR, J. 1996. Reproductive biology of a flood-season nesting freshwater turtle of the northern neotropics: *Dermatemys mawii* in Belize. Chelonian Conservation and Biology 2:13–25.

POLISAR, J. 1997. Effects of exploitation on *Dermatemys mawii* populations in northern Belize and conservation strategies for rural riverside villages. In: Van Abbema, J. (Ed.). Proceedings: Conservation, Restoration, and Management of Tortoises and Turtles: An International Conference. New York: New York Turtle and Tortoise Society and the WCS Turtle Recovery Program, pp. 441–443.

POLISAR, J. AND HORWICH, R.H. 1994. Conservation of the large, economically important turtle *Dermatemys mawii* in Belize. Conservation Biology 8:338–342.

RAINWATER, T.R., POP, T., CAL, O., PLATT, S.G., AND HUDSON, R. 2010. A recent survey of the Critically Endangered Central American river turtle in Belize. Final report to the Belize Fisheries Department, Belize City, Belize.

STAFFORD, P.J. AND MEYER, J.R. 2000. A Guide to the Reptiles of Belize. San Diego: Academic Press, 356 pp.

THIRAKHUPT, K. AND VAN DIJK, P.P. 1994. Species diversity and conservation of turtles in western Thailand. Natural History Bulletin of the Siam Society 42:207–259.

THORBJARNARSON, J., LAGUEUX, C.J., BOLZE, D., KLEMENS, M.D., AND MEYLAN, A.B. 2000. Human use of turtles. In: Klemens, M.W. (Ed.). Turtle Conservation. Washington DC: Smithsonian Institution Press, 334 pp.

TURTLE CONSERVATION COALITION [Rhodin, A.G.J., Walde, A.D., Horne, B.D., van Dijk, P.P., Blanck, T., and Hudson, R. (Eds.)]. 2011. Turtles in Trouble: The World's 25+ Most Endangered Tortoises and Freshwater Turtles—2011. Lunenburg, MA: IUCN/SSC Tortoise and Freshwater Turtle Specialist Group, Turtle Conservation Fund, Turtle Survival Alliance, Turtle Conservancy, Chelonian Research Foundation, Conservation International, Wildlife Conservation Society, and San Diego Zoo Global, 54 pp.

USFWS. 2009. U.S. Fish and Wildlife Service (USFWS) Endangered Species Program. http://www.fws.gov/Endangered/wildlife.html.

WALLACE, J.E., FRATTO, Z.W., AND BARKO, V.A. 2007. A comparison of three sampling gears for capturing aquatic turtles in Missouri: the environmental variables related to species richness and diversity. Transactions of the Missouri Academy of Science 41:7–13.

Received: 2 May 2011

Revised and Accepted: 22 December 2011