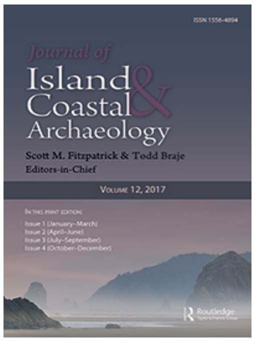

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Late Holocene Historical Ecology: The Timing of Vertebrate Extirpation on Crooked Island, Commonwealth of The Bahamas

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ABSTRACT

*We report eight new accelerator-mass spectrometer (AMS) radiocarbon (^{14}C) dates performed directly on individual bones of extirpated species from Crooked Island, The Bahamas. Three dates from the hutia (*Geocapromys ingrahami*), recovered from a culturally derived bone assemblage in McKay's Bluff Cave (site CR-5), all broadly overlap from AD 1450 to 1620, which encompasses the time of first European contact with the Lucayan on Crooked Island (AD 1492). Marine fish and hutia dominate the bone assemblage at McKay's Bluff Cave, shedding light on vertebrate consumption by the Lucayans just before their demise. A fourth AMS ^{14}C date on a hutia bone, from a non-cultural surface context in Crossbed Cave (site CR-25), is similar (AD 1465 to 1645) to those from McKay's Bluff Cave. From Pittstown Landing (site CR-14), an open coastal archaeological site, a femur of the Cuban crocodile (*Crocodylus rhombifer*) yielded an AMS ^{14}C date of AD ~1050–1250, which is early in the Lucayan cultural sequence. From a humerus in a non-cultural surface context in 1702 Cave (site*

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*CR-26), we document survival of the Cuban crocodile on Crooked Island until AD ~1300–1400, which is several hundred years later than the well-documented extinction of Cuban crocodiles on Abaco in the northern Bahamas. We lack a clear explanation of why Cuban crocodiles likely survived longer on Crooked Island than on a larger Bahamian island such as Abaco. One AMS ^{14}C date on Crooked Island's extinct, undescribed species of tortoise (*Chelonoidis *sp.) from 1702 Cave is BC 790 to 540 (2740 to 2490 cal BP), which is ~1500–1700 years prior to human arrival. A second AMS ^{14}C date, on a fibula of this tortoise from McKay's Bluff Cave, is AD 1025 to 1165, thereby demonstrating survival of this extinct species into the period of human occupation.*

Keywords Bahamas, chronology, extinction, islands, vertebrates

INTRODUCTION

Research in historical ecology emphasizes the interface of biology and culture over time (Fitzpatrick and Keegan 2007). The goals have included reconstructing human subsistence behavior, identifying the overexploitation of key indigenous species, identifying the introduction of exotic species, and establishing baselines for sustainable practices (Swetnam et al. 1999). The present paper seeks to pursue the first two goals by coordinating evidence from natural, social, and historical ecology. We believe that a multi-disciplinary perspective will improve our understanding of biodiversity dynamics in an island setting (Martin and Steadman 1999).

The Bahamas provide an outstanding location for achieving our objectives. The islands were approximately ten times larger than their current land area at the end of the last glaciation (Steadman and Franklin 2015). These larger late Pleistocene landmasses attracted colonizing species from neighboring higher, older islands (i.e., Cuba, Hispaniola) and supported much more diverse vertebrate communities than today (Steadman et al. 2007, 2015). Subsequent sea-level rise led to the fragmentation of terrestrial landscapes until the islands reached essentially their modern configuration (smaller, more isolated) in the mid-Holocene.

The Bahamian islands remained human-free for thousands of years during the Holocene. It was only from AD ~700 to 1000 that humans began to affect the environment of the Bahamas. The arrival of Lucayan peoples led to the extirpation of some species (e.g., tortoises), the exploitation of others (e.g., conchs, sea turtles), and the introduction of non-native species of plants, especially cultigens (Carlson 1999; Carlson and Keegan 2004; Keegan et al. 2008; Newsom and Wing 2004).

In spite of their proximity to Florida, the Bahamian islands share most of their cultural and biological history with other West Indian islands rather than the North American continent (Keegan 1992; Seidemann 2001; Steadman et al. 2015). This statement holds true across the entire 900-km-long chain of Bahamian islands, which nevertheless vary greatly in the amount of attention they have received from archaeologists and other scientists. With this in mind, we visited Crooked Island in December 2014 and March 2015, in the hope of gathering paleoecological information to compare with what we had recently learned on Abaco, a larger Bahamian island to the north (e.g., Hastings et al. 2014; Morgan and Albury 2013; Soto-Centeno and Steadman 2015; Steadman et al. 2014). In reporting new evidence for long-term faunal change on Crooked Island, we are particularly interested in how vertebrate communities were affected during the past millennium or so that people have occupied the island.

Our research will focus on three species that no longer occur on Crooked Island. The hutia (*Geocapromys ingrahami*) is a large rodent that once was widespread in the Bahamian Archipelago, but now survives only on remote East Plana Cay. The Cuban crocodile (*Crocodylus rhombifer*), now confined to Cuba, also was widespread on Bahamian islands in prehistory (Morgan and Albury 2013). Finally, an undescribed species of tortoise (*Chelonoidis* new sp.) from Crooked Island once was part of a major evolutionary radiation of Caribbean tortoises, none of which survives (Franz and Franz 2009).

STUDY AREA

The Bahama archipelago extends from 90 km east of West Palm Beach, Florida (Grand Bahama), to less than 150 km from Cuba and Hispaniola (Great Inagua, Turks & Caicos Islands). The archipelago (Figure 1) comprises 17 main islands and thousands of smaller cays. The Bahamian islands lie on four large and 13 smaller shallow-water banks, much of which was exposed above the ocean during the late Pleistocene and Early Holocene. The sea-level-controlled expansion and contraction of land on these banks through the Quaternary (Hearty et al. 1998) had profound influences on the development of plant and animal communities across the island group. Human colonization of the Bahamas (in the Late Holocene) also was strongly influenced by the size and isolation of the islands (Keegan et al. 2008).

Crooked Island is located in the southern Bahamas. The island trends east to west for ~40 km. Along with the north-south trending Long Cay/Fortune Island (34 km, including the west coast of Crooked Island) and Acklins Island (120 km long), Crooked Island forms an open, horseshoe-shaped landmass surrounding a very shallow bank called the Bight of Acklins (~1400 km^2; Figure 1). All of these islands are narrow, averaging less than 5 km in width. Most elevations on these low-lying, carbonate islands are below currently 10 m. The highest elevation (35 m) is at Bullet Hill (eastern Crooked Island). The karst landscape is riddled with caves, which attracted our research. The vegetation is a broadleaf dry forest locally called "coppice" (Franklin et al. 2015). Various parts of the coppice forest have been cleared for agricultural and residential use since first human arrival.

LOCAL SETTING, MATERIALS, AND METHODS

While exploring Crooked Island (Figure 2) in December 2014, we came upon a shallow walk-in cave developed in the seaward-facing cliff at McKay's Bluff. Charles Hoffman visited the cave in September 1971, and published illustrations of five petroglyphs on the cave wall (Hoffman 1973). This is the first mention of the McKay's Bluff Cave site in the literature, although Hoffman did not provide a name for the site. Keegan and Steven Mitchell conducted an archaeological and geological survey of Crooked Island in 1983 (A report of this work is available from WFK). The name McKay's Bluff Cave was in archaeological use at that time. Keegan and Mitchell returned to Crooked Island in 1987 to investigate locations where Columbus may have anchored and/or visited in AD 1492 (Keegan and Mitchell 1987; Mitchell and Keegan 1987). At this time, they excavated at site CR-14 near Pittstown Landing (N 22.83°, W −74.32°), and at site CR-8 (Major's Landing or Major's Cay Harbour; N 22.72°, W −74.13°) (Keegan 1992), but not at McKay's Bluff Cave (site CR-5; N 22.75°, W −74.17°). A very distinctive petroglyph in McKay's Bluff Cave, drawn by Hoffman (1973:fig. 2), was photographed by WFK in 1983, providing Figure 3.1 of Keegan (1997). It appears to be a non-native individual kneeling before a cross. The possible significance is that Christopher Columbus went ashore on Crooked Island in late October 1492. This and many other petroglyphs on the cave's wall were photographed by NAA in March 2015; they are currently under study.

Three other sites mentioned in this article are Crossbed Cave (site CR-25; N 22.83°, W −74.30°), 1702 Cave (site CR-26; N 22.83°, W −74.30°), and Owl Roost Cave (site CR-27; N 22.83°, W −74.30°).

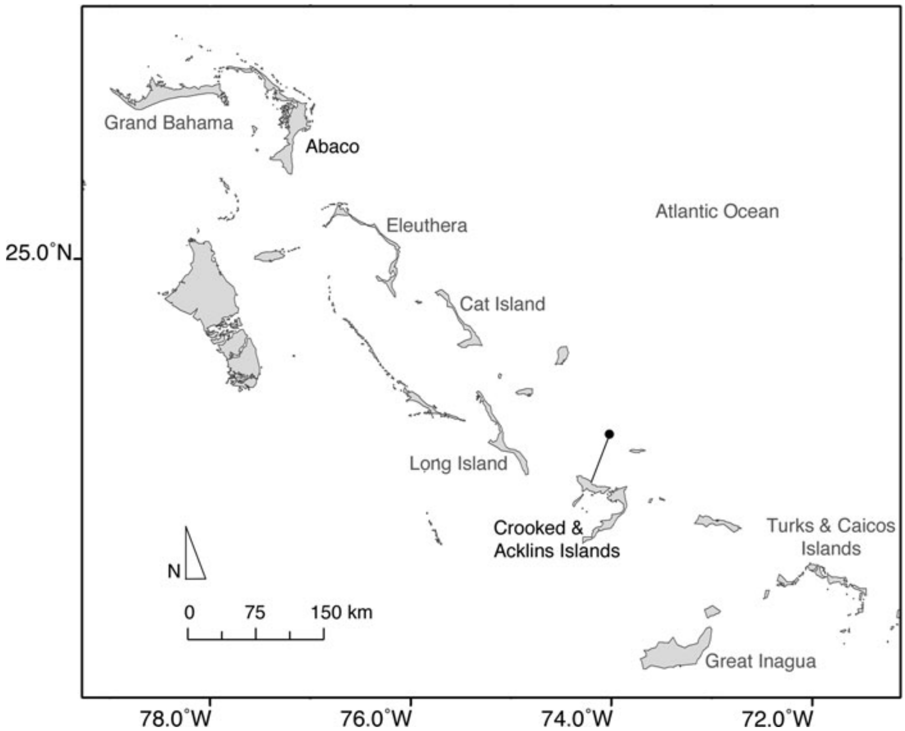

Figure 1. *Map of The Bahamas Archipelago. Crooked Island is indicated in the map with a pin. Abaco is indicated in bold as a reference (see text).*

These sites are flank-margin caves with roughly horizontal (walk-in) entrances, developed in the cliff face along Gordon Hill (Mylroie and Mylroie 2013). We conducted no excavations in these three caves during our brief half-day of exploration along Gordon Hill at the end of our trip in March 2015. It could be that one of these sites, perhaps especially CR-26, is in fact the Gordon Hill site that was excavated by Froelich G. Rainey in 1934 and reported upon by Granberry (1978). The Gordon Hill site was one of seven caves along this cliff that were excavated by Rainey. We can confirm or reject this suspicion only by visiting Gordon Bluff again with Granberry's paper in hand, comparing his photos with the caves.

In March 2015, we mapped McKay's Bluff Cave using a Brunton compass and tape. Excavations were done with trowel, in arbitrary levels of ca. 10 cm each, following natural stratigraphic breaks when feasible. All excavated sediment was sieved through nested screens of 12.5, 6.4, 3.3, and 1.6 mm mesh. Dated materials were bulk-collected from screens because piece-plotting was impossible in the powdery, loose sediment. The materials excavated from CR-5 are property of the National Museum of The Bahamas, currently on loan to the Florida Museum of Natural History, University of Florida (UF). After being picked from the sediment, the bones were sorted by DWS into broad taxonomic categories and then dispersed to the appropriate specialists for identification (HMS and KD for fish, JAS-C for bats, and DWS for others). The modern skeletons used in our osteological comparisons are from UF collections in the divisions of Environmental Archaeology, Herpetology, Mammalogy, Ornithology, and Vertebrate Paleontology. All radiocar-

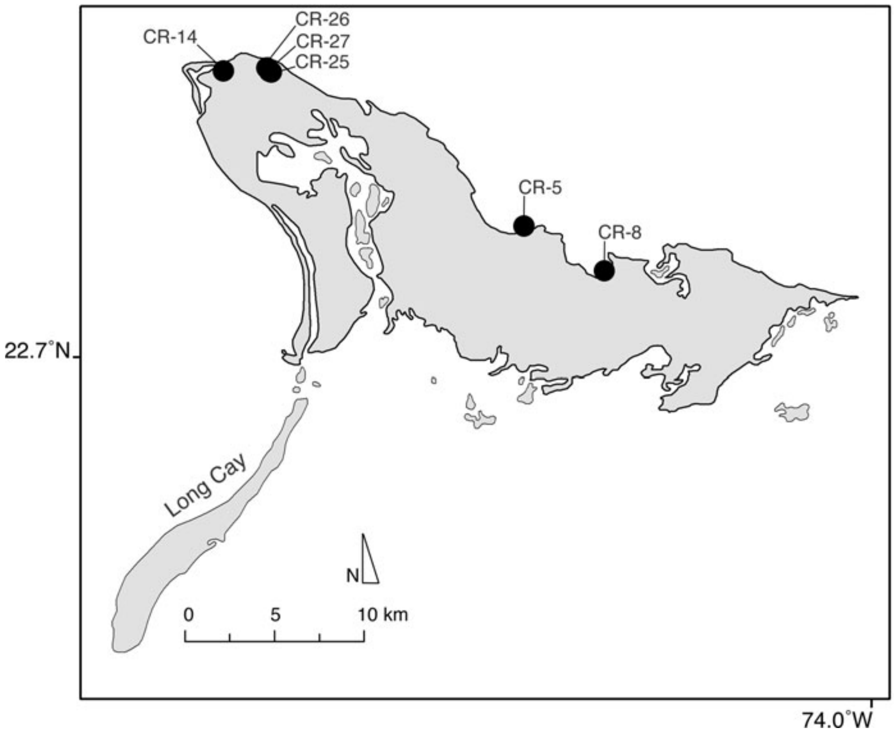

Figure 2. *Map of Crooked Island, The Bahamas. A dark outline highlights Crooked Island. Dots represent sites mentioned in this study. CR-5 = McKay's Bluff Cave; CR-8 = Major's Landing/Major's Cay Harbour; CR-14 = Pittstown Landing; CR-25 = Crossbed Cave; CR-26 = 1702 Cave; CR-27 = Owl Roost Cave.*

bon dating and associated stable isotope analyses were done at Beta Analytic, Inc.

RESULTS

Chronology

Our chronology for McKay's Bluff Cave (site CR-5) is based primarily on three AMS ^{14}C dates on individual, unburned bones of the extirpated hutia *Geocapromys ingrahami*, a rodent that is the largest indigenous non-marine mammal on Crooked Island or elsewhere in the Bahamas. The three AMS ^{14}C dates, which vary stratigraphically from the surface of the sediments down to Level 4, overlap broadly in the vicinity of AD 1450 to 1620 (500 to 330 cal BP), suggesting rapid sedimentation at site CR-5 (Table 1). Christopher Columbus sailed around Crooked Island in October of AD 1492 (Keegan 1992); thus the indigenous materials that we recovered from site CR-5 reflect cultural activities on the island roughly at the time of first European contact.

Another AMS ^{14}C date based on a hutia bone we collected in March 2015 (Beta-411055, hutia femur; Crossbed Cave, site CR-25, surface; AD 1465–1645) overlaps broadly with the three hutia-based AMS ^{14}C dates from site CR-5 (Table 1); Beta-411055 strengthens the likelihood that hutias survived into historic times (post-AD 1492) on Crooked Island.

The two bones of *Crocodylus rhombifer* (Cuban crocodile) from Crooked Island that we radiocarbon dated are re-

Table 1. **AMS radiocarbon (^{14}C) dates on bones of hutia (*Geocapromys ingrahami*), Cuban crocodile (*Crocodylus rhombifer*), and tortoise (*Chelonoidis* sp.) from McKay's Bluff Cave (site CR-5), Crossbed Cave (site CR-25), 1702 Cave (site CR-26), and Pittstown Landing (site CR-14), Crooked Island, The Bahamas.**

Lab number	Material dated	Provenience	Measured ^{14}C age (BP)	$^{13}C/^{12}C$ (‰)	$^{15}N/^{14}N$ (‰)	2 δ calibration Cal AD/BC	2 δ calibration Cal BP
Beta-411059	*G. ingrahami* Femur	CR-5: surface	310 ± 30	−20.7	+4.7	1445–1525, 1555–1630	505–425, 395–320
Beta-411057	*G. ingrahami* Tibia	CR-5: Unit 1, Level 2	280 ± 30	−20.7	+5.1	1450–1640	500–310
Beta-411058	*G. ingrahami* Ulna	CR-5: Unit 1, Level 4	300 ± 30	−19.1	+5.2	1440–1520, 1595–1620	510–430, 355–330
Beta-411055	*G. ingrahami* Femur	CR-25: surface	250 ± 30	−20.1	+6.9	1465–1645	485–305
Beta-411056	*C. rhombifer* Humerus	CR-26: surface	460 ± 30	−17.3	+9.1	1295–1370, 1380–1415	655–580, 570–535
Beta-445997	*C. rhombifer* Femur	CR-14: Test Pit 2, Layer 4	860 ± 30	−16.9	+8.3	1050–1080, 1150–1250	900–870, 800–700
Beta-445995	*Chelonoidis* new sp. Costal	CR-26: surface	2510 ± 30	−19.7	+10.2	BC 790–540	2740–2490
Beta-451745	*Chelonoidis* new sp. Fibula	CR-5: Unit 2, Level 2	870 ± 30	−21.1	+12.4	AD 1025–1165	925–785

ferred to that species rather than to the more estuarine-inhabiting *C. acutus* (American crocodile) based on these characters. Humerus (1702 Cave)—delto-pectoral crest located more distally on shaft (closer to dorsal tuberculum in *C. acutus*); in distal aspect, delto-pectoral crest sharper and protrudes more from the shaft; shaft much more robust. Femur (site CR-14)—depressional scar for insertion of iliotibialis major located more distally on shaft (closer to obturator ridge in *C. acutus*); much deeper depression on shaft just medial to obturator ridge; shaft more robust and more curved.

The AMS ^{14}C date on the Cuban crocodile femur from Pittstown Landing (site CR-14; see Keagan 1997:fig. 4.2), excavated on July 31, 1987, is AD 1050–1080, 1150–1250 (900–870, 800–700 cal BP), which is slightly younger than the next youngest AMS ^{14}C date on *C. rhombifer* from the Bahamas (AD 980–1030 from Gilpin Point, Abaco; Steadman et al. 2014).

Another new AMS ^{14}C date (Beta-411056) on the Cuban crocodile humerus from 1702 Cave is even younger than that from Pittstown Landing, and therefore is the youngest direct age determination on *Crocodylus rhombifer* from any Bahamian island; at AD 1295–1370, 1380–1415 (Table 1), the date from 1702 Cave is ~200 years younger than the AMS ^{14}C date on *C. rhombifer* from site CR-14. Combined with historic evidence that crocodiles survived on Crooked Island to the time of European contact in the vicinity of site CR-14 (see "Discussion and Conclusions" section), the young AMS ^{14}C date from 1702 Cave corroborates the contemporaneity of humans and crocodiles for a number of centuries.

Our first AMS ^{14}C date for the extinct, undescribed species of tortoise *Chelonoidis* sp. is based on a single adult left costal bone from the surface of 1702 Cave. The result (BC 790 to 540; 2740 to 2490 cal BP) is likely to be ~1500–1700 years before human arrival on Crooked Island. Another adult costal bone of *Chelonoidis* sp., from the surface of Owl Roost Cave, did not yield enough collagen for an AMS ^{14}C date. Our second AMS ^{14}C date for the tortoise, from McKay's Bluff Cave, is much younger (AD 1025–1165) and lies within the period on human occupation of Bahamian islands. This date is ~400 years older than any of the three dates on hutia bones, and thus suggests vertical mixing of the loose, dry sediment in McKay's Bluff Cave.

Stable Isotopes

Our stable isotope data for organic carbon (^{13}C/^{12}C) are generally similar to those reported from fossils of crocodiles and tortoises on Abaco (Hastings et al. 2014; Table 1 herein). For crocodiles, the two ^{13}C/^{12}C determinations (−17.3, −16.9) lie within the range of eight specimens from Abaco (−20.9 to −16.4). For tortoises, the two ^{13}C/^{12}C determinations (−19.7, −21.1) are slightly less negative than the range of three specimens from Abaco (−22.9 to −21.1). For nitrogen (^{15}N/^{14}N), the two crocodile specimens from Crooked Island (+8.3, +9.1) are more positive than in the Abaco crocodiles (+5.70 to +7.4, $N = 8$), as are both tortoises from Crooked Island (+10.2, +12.4) vs. +2.48 to +8.85 ($N = 3$) from Abaco. Taken together, the stable isotope data suggest a somewhat larger marine-derived component in the prehistoric terrestrial food web of Crooked Island than on the larger island of Abaco.

Cultural Sediments at McKay's Bluff Cave

With stratigraphic control, we excavated two adjacent 1m^2 test units in site CR-5, just ESE of an earlier, collapsed (not backfilled) pit (Figure 3) that may represent an old excavation described as follows by Hoffman (1973:9): "There was a small hole in the center of the cave floor. It was about a meter across and a few centimeters deep. I learned a few months later that a visitor from a Canadian university had dug a small test pit in the cave. What was recovered, I do not know." The sediments in both of our test units are loose, unconsolidated cobbly, pebbly, slightly sandy silt. We recognized two strata (Layer I, Layer II;

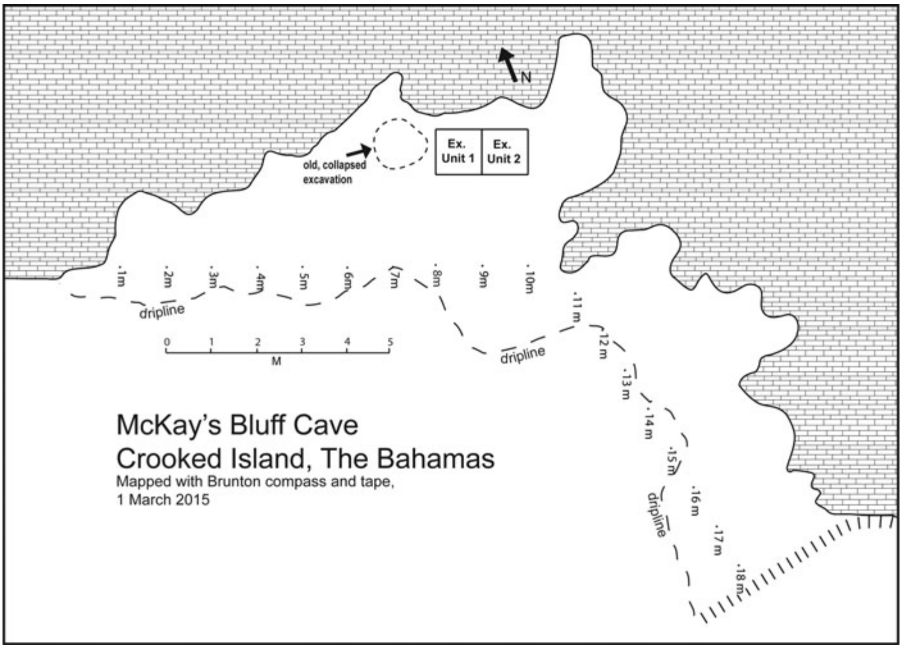

Figure 3. Plan view of McKay's Bluff Cave (site CR-5), Crooked Island, The Bahamas.

Figure 4), which were distinguished mainly by color, with Layer I being dark grayish brown and Layer II being light yellowish brown. Excavation levels 1–3 account for Layer I, whereas Layer II comprises excavation levels 4–6. Three small Palmetto ware potsherds were recovered in excavation level 2, corresponding to the middle part of Layer I, which also yielded the most bone (see Fauna section). The much younger age determinations of hutia bones vs. those of tortoise is strong evidence of vertical mixing of sediments in McKay's Bluff Cave (see Chronology section).

Fauna From McKay's Bluff Cave

Layer I at site CR-5 (excavation levels 1–3) produced 540 of the 606 identified bones (89%) of indigenous species (Table 2). Within Layer II, bones decline sequentially in excavations levels 4 and 5 until being absent in Level 6. We identified 18 taxa of indigenous vertebrates from the bones recovered at CR-5, featuring nine fish (75% of bones; all taxa extant near Crooked Island; Böhlke and Chaplin 1993), four reptiles (<1% of bones; only the tortoise extirpated, with the other three taxa extant; Buckner et al. 2012; Pregill 1982), two birds (<1% of bones; both species extant; White 1998), and three mammals (24% of bones; the hutia extirpated; both bats extant; Soto-Centeno and Steadman 2015). Of 455 fish bones, 16 (3.5%) were burned. Among the non-fish species, the only burned bones we recovered were those of the hutia (12 of 128, or 9.4%).

Bones of two non-native rodents (*Mus musculus, Rattus* sp.) were common in the upper strata at CR-5, as is the case in many cultural and non-cultural sites with loose, dry sediments on tropical islands (Pregill et al. 1994; Steadman 1986). These rodents often are the preferred prey of modern barn owls (*Tyto alba*) on West Indian islands (Buden 1974).

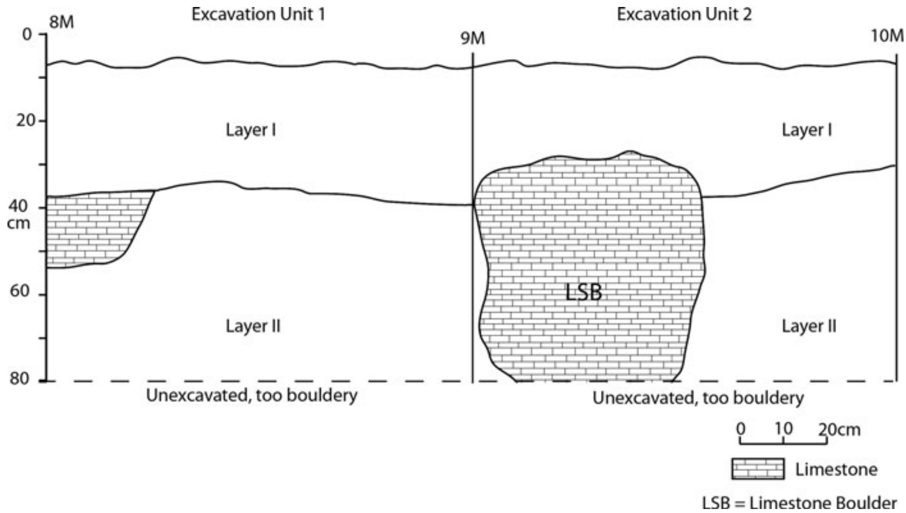

Figure 4. *Profile of sediments in the north wall of Excavation Units 1 and 2, McKay's Bluff Cave (site CR-5), Crooked Island, The Bahamas.*

DISCUSSION AND CONCLUSIONS

The vertebrate faunal composition from our excavation at McKay's Bluff Cave establishes Layer I (levels 1–3) as primarily cultural in origin, with a dominance of fish and hutia bones and the presence of Palmetto ware ceramics and marine shell. Both fish and hutia bones also were reported to be common at the pre-Columbian open (non-cave) archaeological site of Major's Landing (site CR-8; deFrance 1991). Bones of hutia were common as well on the surfaces of sites CR-25, 26, and 27 when we visited them in March 2015. Hutia bones already had been reported from the caves along Gordon Hill by Granberry (1978).

Based on four AMS ^{14}C dates from individual hutia bones (three from McKay's Bluff Cave, one from Crossbed Cave), we are confident that the hutia (*Geocapromys ingrahami*) survived on Crooked Island into post-Columbian times, most likely into the seventeenth century if not later.

Historical and archaeological research indicates that Christopher Columbus went ashore on Crooked Island near Pittstown Landing (Keegan 1988, 1992; Mitchell and Keegan 1987). In his daily log entry at this location (October 21, 1492), Columbus reported: "Thus walking around one of these lakes, I saw a serpent, which we killed; and I am bringing the skin to Your Highnesses. When it saw us it threw itself into the lake and we followed it in, because it was not very deep, until with lances we killed it. It was seven *palmos* in length" (Dunn and Kelley 1989:107). One palmo is about 24.74 cm long (Dunn and Kelley 1989:107, note 2); so the "*sierpe*" was about 173 cm in length. It has been suggested that this serpent was an iguana, but its size, behavior, and the discovery of a crocodile femur during excavations at the Pittstown Landing site point to its identification as a crocodile, although the written report of Columbus is not adequate to distinguish between the Cuban crocodile (*Crocodylus rhombifer*) or the estuarine-inhabiting American crocodile (*C. acutus*). While diagnostic characters of the recovered femur assign this bone to the Cuban rather than American crocodile (see Results section), the age of this femur precedes European contact.

Cuban crocodiles survive today only on Cuba and the Isle of Pines, although

Table 2. **Bones and other material recovered from McKay's Bluff Cave (site CR–5), Crooked Island, The Bahamas.**

		Level						
Material	**Backdirt**	**1**	**2**	**3**	**4**	**5**	**6**	****Total**
Palmetto ware potsherd	—	—	3	—	—	—	—	3
Macroscopic charcoal	—	—	+	—	+	+	—	—
Marine shell	—	+	+	—	—	—	—	—
Fish bone								
Epinephelus adscensionus — rock hind	—	2	1	—	—	—	—	3
Epinephelus striata — Nassau grouper	—	—	1	—	—	—	—	1
Haemulon sp. — grunt	—	2	—	—	—	—	—	2
Halichoeres sp. — wrass	—	—	2	—	—	—	—	2
Scarus coeruleus — blue parrotfish	—	—	3	—	—	—	—	3
**Scarus* sp. — parrotfish	—	1	—	3	—	—	—	4
Sparisoma sp. — parrotfish	—	2	—	—	—	—	—	2
*Scaridae sp. — parrotfish	—	2	—	1	—	—	—	3
Acanthurus sp. — surgeonfish	—	1	3	1	—	—	—	5
Acanthostracion sp. — cowfish	—	—	1	—	—	—	—	1
Menticirrhus sp. — kingfish	—	—	—	1	—	—	—	1
Actinopterigyii sp. — boney fish*	—	104	142	131	41	10	—	428
Reptile bone								
Chelonoidis sp. — tortoise†	—	—	2	—	—	—	—	2
Anolis sagrei — Cuban anole	—	—	—	2	—	—	—	2
Anolis brunneus — Crooked Island anole	—	1	—	—	—	—	—	1
Leiocephalus punctatus — Crooked Island curly—tailed lizard	—	—	—	1	—	—	—	1
Bird bone								
Gallinago delicata — Wilson's snipe	1	—	—	—	—	—	—	—
Mimus gundlachii — Bahama Mockingbird	4	—	1	—	—	—	—	1
Mammal bone								
Macrotus waterhousii — Waterhouse's leaf—nosed bat	1	2	1	—	—	—	—	3
Erophylla sezekorni — Buffy flower bat	—	1	—	—	—	—	—	1
Chiroptera sp. — unidentified bat*	1	7	1	—	2	2	—	12
Geocapromys ingrahami — Bahama hutia†	23	44	61	12	10	1	—	128
Mus musculus — house mouse (nn)	8	6	5	6	2	1	—	20
Rattus sp. — rat (nn)	11	5	16	9	1	1	—	32
Total (all indigenous species)**	30	169	219	152	53	13	0	606
Total fish**	0	114	153	137	41	10	0	455
Total non—fish**	30	55	66	15	12	3	0	151

*Taxon not necessarily different from one identified more precisely.

**Row totals do not include materials from the backdirt; column totals do not include non—native species (nn). †Species no longer occurs on Crooked Island.

they once were much more widespread in the West Indies (Morgan and Albury 2013). Data from stable isotopes of carbon and nitrogen establish the Cuban crocodile as a terrestrial predator on Abaco (northern Bahamas) that fed primarily on tortoises, iguanas, and hutias (Hastings et al. 2014); our stable isotope data (Table 1) suggest a slightly more marine/estuarine-derived component in the prehistoric terrestrial food web on Crooked Island than on Abaco. A similar trend of decreasingly terrestrial dietary preference on small islands has been documented in pre-Columbian human food webs in the West Indies (Stokes 2005).

The extirpated Cuban crocodile survived for a longer time after human colonization on Crooked Island than on Abaco, which is the only other Bahamian island with a chronology of extirpation based on direct AMS ^{14}C dating of individual crocodile bones. The evidence from Abaco suggests that Cuban crocodiles may have been lost within as little as a century of the arrival of Lucayan peoples at Cal AD ~1000 (Hastings et al. 2014; Steadman et al. 2014). Our AMS ^{14}C date from 1702 Cave suggests survival of the Cuban crocodile for at least several centuries later on Crooked Island, until AD ~1300 to 1400. This late survival is supported further, to some extent, by the historic evidence in the previous paragraph. Nevertheless, the AMS ^{14}C date on the Cuban crocodile femur from Pittstown Landing (Beta-445997; AD ~1050 to 1250; Table 1) points to the initial occupation of that site well before the arrival of Europeans. We note as well that a single incomplete tooth of a crocodile (not identified to species) was recovered from an undated pre-Columbian site (AC-14) on nearby Acklins Island (deFrance 1991). In a blue hole near AC-14, an osteoderm and a rib of a crocodile were found by divers in 2008 (N.A.A., pers. comm.).

For the undescribed species of tortoise (*Chelonoidis* sp.) on Crooked Island, our youngest AMS ^{14}C date is similar to the more extensively studied situation on Abaco, where extinction of the tortoise *Chelonoidis alburyorum* took place at AD ~1000 to 1100 (Franz and Franz 2009; Hastings et al. 2014; Steadman et al. 2014). On Grand Turk, the extinction of an undescribed species of *Chelonoidis* took place at a similar time (AD ~1100; Carlson 1999; Carlson and Keegan 2004). In each case, it seems likely that tortoises were lost within one to several centuries of human arrival.

To summarize, our goal in this study was to estimate the timing of faunal change, particularly extirpation, on Crooked Island. Evidence from eight radiocarbon dates on identified bones demonstrates that the loss of hutias, Cuban crocodiles, and tortoises on Crooked Island post-dates prehistoric human arrival. Hutias were subjected to considerable pre-Columbian human predation, yet probably survived several centuries longer than the crocodiles and tortoises. This may reflect the much higher population of the herbivorous hutias versus that of the much larger crocodiles and tortoises.

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