American Crocodile *Crocodylus acutus*

Thomas R. Rainwater[1], Steven G. Platt[2], Pierre Charruau[3], Sergio A. Balaguera-Reina[4], Luis Sigler[5], J. Rogelio Cedeño-Vázquez[6] and John B. Thorbjarnarson[7]

[1] Tom Yawkey Wildlife Center & Belle W. Baruch Institute of Coastal Ecology and Forest Science, Clemson University, P.O. Box 596, Georgetown, South Carolina 29442, USA
[2] Wildlife Conservation Society - Myanmar Program, No. 12, Nanrattaw Street, Kamayut Township, Yangon, Myanmar
[3] Centro del Cambio Global y la Sustentabilidad en el Sureste AC, CP 86080, Villahermosa, Tabasco, México
[4] Programa de Biología Ambiental, Facultad de Ciencias Naturales y Matemáticas, Universidad de Ibagué, Carrera 22 Calle 67, Ibagué 730001, Colombia
[5] The Dallas World Aquarium, 1801 N Griffin Street, Dallas, Texas 75202, USA
[6] Departamento de Sistemática y Ecología Acuática. El Colegio de la Frontera Sur, Unidad Chetumal, Av. Centenario Km 5.5, Chetumal 77014, Quintana Roo, México
[7] Wildlife Conservation Society, Gainesville, Florida 32635-7625, USA (Deceased)

Common Names: American crocodile, Cocodrilo, Lagarto, Caimán de la costa, Caimán aguja, Cocodrilo de río, Lagarto real

Range: Belize, Cayman Islands (?), Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, El Salvador, Guatemala, Haiti, Honduras, Jamaica, Nicaragua, Mexico, Panama, Peru, USA, Venezuela

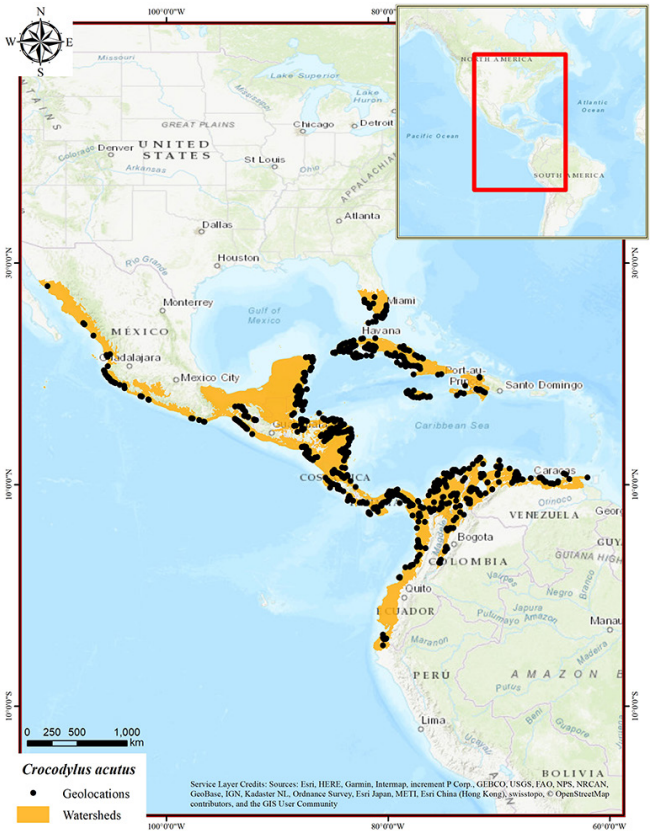

Figure 1. Distribution of *Crocodylus acutus*. Map courtesy of Sergio Balaguera-Reina.

Conservation Overview

CITES: Appendix I, Appendix II (Mexico, Cuba and Cispatá Bay population of Colombia)

CSG Action Plan:

- Availability of survey data: Moderate
- Need for wild population recovery: Moderate
- Potential for sustainable management: Moderate

2018 IUCN Red List: VU (Vulnerable. Criteria A2cd. Inferred decline of 30% in three generations (75 years), inferred from reduction in extent of occurrence (last assessed in June 2009; Ponce-Campos *et al*. 2012).

Principal Threats: Habitat loss and degradation, fishing nets, illegal hunting, hybridization (Pacific coast of Mexico and perhaps elsewhere)

Ecology and Natural History

The American crocodile is a large species of crocodilian, with males attaining maximum lengths of 5-6 m, although some individuals may reach 7 m (Schmidt 1924; Medem 1981). Adult females generally measure no more than 3-3.5 m TL, but individuals up to 4.4 m have been reported (Domínguez -Laso 2009). Sexual size dimorphism indices of 2.10, 2.13, 2.09, 2.08 and 2.13 were calculated for populations in coastal Belize and the Caribbean coast of Mexico (Platt *et al*. 2011; Labarre *et al*. 2017). Both sexes exhibit a pronounced median pre-orbital ridge (POR) on the skull, which may be sexually dimorphic and appears to vary geographically among *C. acutus* populations (Thorbjarnarson 1989; Platt and Rainwater 2005).

The American crocodile is characterized by the most reduced and irregular dorsal armor (osteoderms) of any crocodilian (Ross and Mayer 1983). Inter-populational differences in scalation likely exist in this widely ranging species (Seijas

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2002; Platt *et al*. 2012), and recent studies have also shown high intraspecific variation in the post-occipital, cervical, and dorsal scalation, allowing for individual identification (Balaguera-Reina *et al*. 2017). Population-specific size estimation models for *C*. *acutus* are available for Belize (Platt *et al*. 2011), Mexico (Labarre *et al*. 2017) and Coiba Island, Panama (Balaguera-Reina *et al*. 2018b).

Figure 2. Left: Adult male *C*. *acutus,* Banco Chinchorro Atoll, Mexico, with prominent pre-orbital ridge (Photograph: Pierre Charruau). Right: Adult male *C*. *acutus*, Turneffe Atoll, Belize, with a less-prominent pre-orbital ridge. (Photograph: Thomas Rainwater).

Figure 3. Adult female *C*. *acutus* guarding hatchlings, Chiapas, Mexico. Photograph: Belen Jimenez.

Figure 4. Adult *C*. *acutus,* Tárcoles River, Costa Rica. Photograph: Tanya Manfrediz.

The American crocodile is the most widely distributed of the New World crocodiles, ranging from the southern tip of Florida, along both the Atlantic and Pacific coasts of southern Mexico, Central America, and northern South America, as well as the Caribbean islands of Cuba, Jamaica, and Hispaniola (Groombridge 1987; Kushlan 1988; Thorbjarnarson *et al*. 2006). The habitat of *C*. *acutus* consists largely of brackish water coastal habitats such as the saltwater sections of rivers, coastal lagoons, and mangrove swamps. *Crocodylus acutus* inhabits offshore cays (islands) and atolls where it survives under true marine conditions (Platt and Thorbjarnarson 2000a; Platt *et al*. 2013; Charruau *et al*. 2005; González Cortés 2007; Venegas-Anaya *et al*. 2015).

Populations are also known from freshwater habitats located well inland, including a number of reservoirs (Medem 1981; Mandujano-Camacho and Rodas-Trejo 2010; Sigler 2010; Espinal and Escobedo-Galván 2011). A significant population inhabits Lago Enriquillo, a landlocked hypersaline lake situated 40 m below sea level in the arid southwestern Dominican Republic (Schubert 2002). A robust population also inhabits Cayo Centro, an island in Banco Chinchorro atoll located 50 km from southern coast of the Mexican state of Quintana Roo. During the dry season, lagoons on Cayo Centro can experience extremely hypersaline conditions (up to 61 ppt; Charruau *et al*. 2005).

Figure 5. Adult *C*. *acutus*, Tayrona National Natural Park, Colombia. Photograph: Nidia Farfán-Ardila.

Figure 6. Adult male *C*. *acutus* in a coastal lagoon, Cozumel Island, Mexico. Photograph: Pierre Charruau.

Knowledge of *C*. *acutus* has increased rapidly over the few past decades, and much research has been conducted on reproductive ecology (Platt and Thorbjarnarson 1997, 2000b; Mazzotti *et al*. 2007a; Charruau *et al*. 2010a, 2011, 2017a; Escobedo-Galván *et al*. 2019; Platt *et al*. 2014a; Charruau 2012; Charruau and Hénaut 2012; Balaguera-Reina *et al*. 2015a; Murray *et al*. 2015, 2016; González-Desales *et al*. 2016; Ferguson *et al*. 2017; Gómez-González *et al*. 2017), nutrition, diet, and foraging ecology (Platt *et al*. 2002, 2013a,b, 2014b;

Figure 7. Adult male *C. acutus,* Turneffe Atoll, Belize. Photograph: Thomas Rainwater.

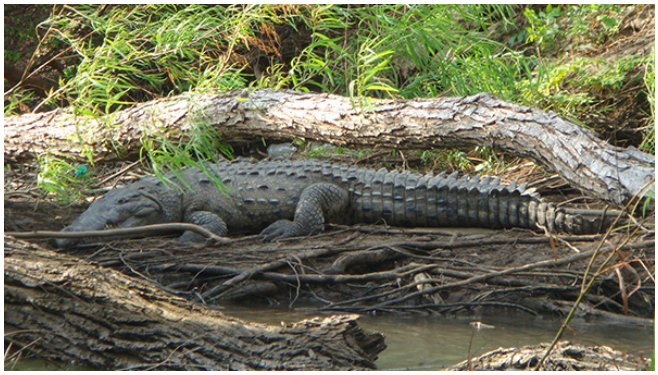

Figure 8. Adult (14-year-old) male *C. acutus,* Sumidero Canyon National Park, Mexico. Photograph: Luis Sigler.

Richards and Wasilewski 2003; Gómez Hernández 2004; Cupul-Magaña *et al*. 2008, 2015; Villegas and Schmitter-Soto 2008; Acosta-Chaves *et al*. 2016; Ávila Cervantes *et al*. 2017; Hernández-Hurtado *et al*. 2018; Balaguera-Reina *et al*. 2018a; Triminio *et al*. 2019), morphometrics (Domínguez-Laso 2009, 2017; Platt *et al*. 2011; Platt and Rainwater 2005; Rainwater *et al*. 2010; Labarre *et al*. 2017; Farlow *et al*. 2018a,b), scalation (Seijas 2002; Platt *et al*. 2012; Balaguera-Reina *et al*. 2017; Boucher *et al*. 2017; English 2017), growth (Pérez and Escobedo-Galván 2009; Charruau 2011; Charruau *et al*. 2010b; García-Grajales *et al*. 2012, Balaguera-Reina *et al*. 2015a), movement and spatial ecology (Wheatley *et al*. 2012; Cherkiss *et al*. 2014; Balaguera-Reina *et al*. 2016; Beauchamp *et al*. 2018, 2019), population genetics (Ray *et al*. 2004; Cedeño-Vázquez *et al*. 2008; Porras Murillo *et al*. 2008; Rodriguez *et al*. 2008, 2011; Weaver *et al*. 2008; Machkour-M'Rabet *et al*. 2009; Milián-García *et al*. 2011, 2015; González-Trujillo *et al*. 2012; Bashyal *et al*. 2014; Bloor *et al*. 2015, Budd *et al*. 2015; Hekkala *et al*. 2015; Pacheco-Sierra *et al*. 2016, 2018; Serrano-Gómez *et al*. 2016; Mauger *et al*. 2017; Milián-García *et al*. 2018a,b), behavior in captivity (Benko and Perc 2009), physiology and biochemistry (Merchant *et al*. 2010a,b), parasitology and bacteriology (Villegas and Gonzáles-Solís 2009; Pérez-Flores *et al*. 2011, 2017; Tellez and Paquet-Durand 2011; Charruau *et al*. 2012, 2016, 2017b; Escobedo-Galván *et al*. 2012; Charruau and González-Muñoz 2015; Rainwater *et al*. 2015; Reeves *et al*. 2019), ecotoxicology (Wu *et al*. 2000; Rainwater *et al*. 2007, 2011; Charruau *et al*. 2013; Murray *et al*. 2017), and conflict with humans (Barrantes 2010; Cupul-Magaña *et al*. 2010; Balaguera-Reina 2012, 2013; Bolaños Montero 2012; García-Grajales and Buenrostro-Silva 2013; García-Grajales *et al*. 2013; Carrillo-Rivera and Porras-Murillo 2014; Ponce-Campos 2014; Balaguera-Reina and Farfán-Ardila 2018; García-Grajales and Buenrostro-Silva 2018, 2019).

Crocodylus acutus is a hole-nesting species, but adaptable in terms of nesting ecology, in some areas creating elevated mounds of substrate into which eggs are deposited (Thorbjarnarson 1989; Platt and Thorbjarnarson 1997; Platt and Thorbjarnarson 2000b; Charruau *et al*. 2010a, 2011). Clutch size is typically 30 to 60 eggs, although in some populations mean clutch size is in the low 20s (Platt and Thorbjarnarson 2000b, Sigler 2010; Balaguera-Reina *et al*. 2015a) or less (ie <17 at Banco Chinchorro; Charruau *et al*. 2010a). As with most hole nesting species of crocodilians, *C. acutus* nests during the annual dry season, with eggs hatching around the beginning of the annual wet season (Thorbjarnarson 1989; Platt and Thorbjarnarson 2000b; Sigler 2010; Balaguera-Reina *et al*. 2015a; Casas-Andreu 2003; Charruau *et al*. 2011; González-Desales *et al*. 2016). A somewhat different pattern occurs in Banco Chinchorro Atoll where the population has adapted to local conditions. Females nest at the end of the dry season and hatching occurs during the middle of the wet season, thus representing a compromise between the risk of flooding and increasing the availability of freshwater for hatchlings (Charruau *et al*. 2010a). Most nest failures are attributed to predation, nest abandonment, desiccation, flooding, and low temperatures associated with heavy rainfall (Mazzotti 1989; Platt and Thorbjarnarson 2000b; Charruau *et al*. 2010a). The American crocodile is adept at using man-made areas for nesting, and this is one of the reasons behind population recovery in parts of its range (Mazzotti *et al*. 2007a, 2009; Ulloa-Delgado 2012; McCann *et al*. 2016; Mazzotti *et al*. 2019).

Figure 9. Hatchling *C. acutus*, Sumidero Canyon National Park, Mexico. Photograph: Luis Sigler.

Similar to most crocodilians, *C. acutus* is a dietary generalist that consumes a wide variety of prey such as invertebrates, amphibians, reptiles, birds and mammals (Platt *et al*. 2013a; Balaguera-Reina *et al*. 2018a). In offshore, marine habitats of Belize, Mexico (Quintana Roo), and Panama, the diet consists largely of marine invertebrates, particularly various species of crabs, but also corals, gastropods, and bivalves (Platt *et al*. 2013a; Ávila Cervantes *et al*. 2017; Balaguera-Reina *et*

al. 2018a). Fruit and vegetation are occasionally consumed by *C*. *acutus*, although the dietary significance of frugivory is poorly understood (Platt *et al*. 2013b, 2014b). *Crocodylus acutus* exhibits the typical ontogenetic dietary shift with smaller size-classes consuming mostly invertebrates and larger individuals taking increasing amounts of vertebrate prey (Platt *et al*. 2002, 2013a; Balaguera-Reina *et al*. 2018a).

Figure 10. Adult *C*. *acutus* feeding in the Tárcoles River, Costa Rica. Photograph: Tanya Manfrediz.

Figure 11. Adult male *C*. *acutus*, Banco Chinchorro Atoll, Mexico. Photograph: Pierre Charruau.

Studies on the population ecology of *C*. *acutus* have been carried out in Belize (Platt *et al*. 1999, 2004; Platt and Thorbjarnarson 2000a; Platt 2003; Rainwater and Platt 2009, 2013; Chenot-Rose and Rose 2013; Platt and Rainwater 2014; Tellez *et al*. 2016), Colombia (Balaguera-Reina and Gonzalez-Maya 2008; Ulloa Delgado 2011; Balaguera-Reina 2012; Balaguera-Reina *et al*. 2012, 2015b, 2016; Espinosa *et al*. 2012; Viloria-Largares *et al*. 2017), Costa Rica (Bolaños Montero 2012; Mauger *et al*. 2012), Cuba (Rodríguez Soberón *et al*. 2002), Dominican Republic (Schubert 2002; Powell and Incháustegui 2009), Ecuador (Carvajal *et al*. 2005), Haiti (Thorbjarnarson 1988), Honduras (Espinal and Escobedo-Galván 2011), Jamaica (Henriques *et al*. 2012), Mexico (Cupul-Magaña *et al*. 2004; Charruau *et al*. 2005; Cedeño-Vázquez *et al*. 2006; Hernández-Hurtado *et al*. 2006, 2011; Brandon-Pliego 2007; García-Grajales *et al*. 2007; González Cortés 2007; Sigler 2011; Garcia-Grajales and Buenrostro-Silva 2017), Panama (Venegas-Anaya *et al*. 2015; Balaguera-Reina *et al*. 2018b), the USA (Florida) (Ogden 1978; Kushlan and Mazzotti 1989a,b; Moler 1991; Moler and Abercrombie 1992; Mazzotti *et al*. 2007b; Cherkiss *et al*. 2011; Green *et al*. 2014; Lorenz 2014; Briggs-Gonzalez *et al*. 2017) and Venezuela (Seijas 1988).

Recent genetic studies have confirmed that significant hybridization is occurring between *C*. *acutus* and *C*. *moreletii* in Belize (Hekkala 2004; Ray *et al*. 2004; Hekkala *et al*. 2015) and Mexico (Cedeño-Vázquez *et al*. 2008; Rodriguez *et al*. 2008; Machkour-M'Rabet *et al*. 2009; Pacheco-Sierra *et al*. 2016) as well as with *C*. *rhombifer* in Cuba (Weaver *et al*. 2008; Milián-Garcia *et al*. 2011, 2015). The ecological and evolutionary consequences of this hybridization are poorly understood but are a priority for future work.

Conservation and Status

The American crocodile is found in 18 countries in the northern Neotropics (Thorbjarnarson *et al*. 2006). As *C*. *acutus* produces a commercially valuable skin, the principal reason for past declines in population size can be attributed to the extensive commercial overexploitation that occurred from the 1930s into the 1970s (Medem 1981; Thorbjarnarson 1989). Current threats are habitat destruction and in some areas continued, albeit illegal hunting. A review of the conservation status and distribution of *C*. *acutus* throughout its range conducted in the early 2000s (Thorbjarnarson *et al*. 2006) concluded populations were recovering in most parts of its historic range. There were a few areas where population recovery appeared to be limited (eg Colombia), or non-existent (eg Ecuador), but populations of *C*. *acutus* in areas such as Cuba, USA, Mexico, and Costa Rica appear to be healthy and robust.

It was estimated that by 2002 *C*. *acutus* had been extirpated from 8.9% of its historical range (Thorbjarnarson *et al*. 2006), but there is also evidence that the species is re-colonizing the one country from which it had been extirpated (Cayman Islands), with three individuals being sighted over a period of 12 months in 2008 and 2009 (M. DaCosta-Cottam, pers. comm.). The review by Thorbjarnarson *et al*. (2006) quantified the information available at the time and classified 69 areas in eight distinct crocodile bioregions as Crocodile Conservation Units (CCUs), defined as the most important areas for the conservation of *C*. *acutus*. The relative importance of the CCUs in each bioregion was quantified using an algorithm that weighted factors that experts on *C*. *acutus* considered to be most important for the long-term conservation of viable populations. Two bioregions in particular were identified where the creation of protected areas should be given a high priority: 1) Dry Pacific South America (northern Peru and southern Ecuador) and 2) Northwest and Central Pacific Mexico.

North America

In the USA, *C*. *acutus* is restricted to the southernmost, subtropical tip of the state of Florida. Since the 1970s, when

it was first listed as Endangered under the US Endangered Species Act, the population has steadily increased (Mazzotti *et al*. 2007a,b) and in 2007 *C. acutus* was officially reclassified as Threatened (Stansell 2007) reflecting the successful population recovery. Today, one of the most significant sources of mortality for crocodiles in Florida is road mortality (Brien *et al*. 2008). In addition, a significant mortality event involving *C. acutus* occurred in Florida in 2010 as a result of an unprecedented period of cold weather (Mazzotti *et al*. 2016).

American crocodiles are found in areas of suitable habitat along the Pacific coast of Mexico from the Guatemala border to the State of Sinaloa (Alvarez del Toro 1974; Sigler 2002; Muñiz 2004). Specific reports are available from Jalisco (Huerta Ortega *et al*. 2002; Cupul-Magaña *et al*. 2002), Sinaloa (Navarro Serment 2003), and Oaxaca (Brandon-Pliego 2007). The three top priority CCUs in this bioregion were either coastal habitats characterized by relatively small mangrove areas that are typically associated with the mouths of rivers (Jalisco-Colima coast), or coastal lagoon/mangrove complexes with very seasonal inputs of freshwater (Bahía de Petacalco and Costa de Oaxaca) (Thorbjarnarson *et al*. 2006). Crocodiles are widespread in these patchy habitats, with animals being found in 38 of 52 water bodies along the Jalisco coast (P. Ponce-Campos and S. Huerta-Ortega, pers. comm.). Crocodiles are also known from inland reservoirs (Presa Adolfo López Mateos, also identified as CCU) as well as in freshwater sections of some of the region's larger rivers (Rio Santiago CCU). Human-crocodile conflict (HCC) is a growing problem in the Pacific region (Huerta Ortega and Ponce Campos 2002; Cupul-Magaña *et al*. 2010; García-Grajales and Buenrostro-Silva 2018, 2019). An initiative from the Mexican government through the National Environmental Agency (SEMARNAT) called "SOS crocodile" has identified a team in each region in the country to respond to incidents of HCC, gather information on the event, and take action to mitigate the problem (SEMARNAT 2018).

Hybridization with non-native *C. moreletii* that became established after escaping from commercial crocodile farms potentially threatens the genetic integrity of *C. acutus* in some areas along the Pacific Coast (Serrano-Gómez *et al*. 2016; Pacheco-Sierra *et al*. 2018). Along the Yucatan mainland of Mexico there is extensive hybridization between *C. moreletii* and *C. acutus* (Cedeño-Vázquez *et al*. 2008; Rodriguez *et al*. 2008; Machkour-M'Rabet *et al*. 2009; Pacheco-Sierra *et al*. 2016, 2018), while the island populations on Cozumel and Banco Chinchorro remain genetically pure (Machkour-M'Rabet *et al*. 2009; Pacheco-Sierra *et al*. 2016). An isolated population of *C. acutus* occurs in the Rio Grijalva, the only known Gulf of Mexico drainage where the species is present. In the Grijalva drainage, crocodiles inhabit a series of freshwater reservoirs, as well as riverine habitats between reservoirs (Sigler 2002; Mandujano Camacho 2003).

On the island of Hispaniola, a few small coastal populations of crocodiles were reported in Haiti by Thorbjarnarson (1988), but by far the largest populations were in two landlocked lakes, Lago Enriquillo in the Dominican Republic and Étang Saumâtre in Haiti. Lago Enriquillo is an unusual habitat, a hypersaline lake well below sea level, and crocodile populations have fluctuated widely since the 1980s as a result of changes in lake salinity and illegal hunting (Schubert and Santana 1996). Thorbjarnarson (1989) reported on the population in Étang Saumâtre in Haiti and some other coastal locations, but systematic surveys were last conducted in Haiti during the mid-1980s. More recent informal surveys indicate the population in Étang Saumâtre is greatly reduced (A. Schubert, pers. comm.).

Up until the late 2000s, American crocodiles in Jamaica were reasonably abundant in areas along the southern coast. However, since that time coastal development appears to have destroyed many of the fragile wetland habitats and nesting areas used by crocodiles, and the situation regarding *C. acutus* in Jamaica now appears dire (Henriques *et al*. 2012). As of 2012, crocodiles remained in small numbers, widely distributed among small and isolated habitat patches primarily in the Black River Morass, central southern coast, and far eastern marshes and canals (Henriques *et al*. 2012). Crocodile numbers are declining due to continued habitat loss, persecution and illegal harvest for meat (Henriques *et al*. 2012). Real potential for the extirpation of *C. acutus* in Jamaica exists in the foreseeable future if current trends continue and more effective intervention is not developed (Henriques *et al*. 2012).

Populations of *C. acutus* in Cuba are widespread and locally abundant (Rodríguez Soberón *et al*. 2006; ; Milián-García *et al*. 2018b). In 2007 Cuba became the first country to successfully petition CITES for a transfer of its *C. acutus* population to Appendix II, based on a program of managed use that includes ranching and closed-cycle captive breeding.

Central America

The American crocodile in Belize is largely competitively excluded from inland, freshwater habitats by the sympatric *C. moreletii* and therefore restricted to the coastal zone (Platt and Thorbjarnarson 1997, 2000a,c). The most important populations are found on offshore islands, particularly the Turneffe and Lighthouse atolls (Platt *et al*. 1999, 2004; Platt and Thorbjarnarson 2000a; Platt 2003; Rainwater and Platt 2009, 2013; Chenot-Rose and Rose 2013; Platt and Rainwater 2014; Tellez and Boucher 2018). Hybridization between *C. acutus* and *C. moreletii* appears common along the coast of mainland Belize (Hekkala 2004; Ray *et al*. 2004; Hekkala *et al*. 2015).

In the 1980s and 1990s *C. acutus* populations were reported to be greatly depleted in Guatemala (Enrique Fernández, pers. comm.) but there is little new information from this country. Crocodiles are similarly rare in El Salvador; spotlight surveys by Escobedo Galván *et al*. (2004) in some of the best remaining coastal habitats observed 28 crocodiles, mostly juveniles, over a total of 157.5 km (encounter rate= 0.17 crocodiles/km). In Honduras, most of the major rivers of the Atlantic drainage support small populations, although most appear depleted (King *et al*. 1990). Surveys by Cerrato (2002)

Figure 12. Sign on protected *C. acutus* nesting beach, Turneffe Atoll, Belize. Photograph: Thomas Rainwater.

in northern coastal Honduras in wetlands associated with the Laguna Guaimoreto, Rio Chapagua, Laguna El Lirio and the lower 15 km of the Rio Aguan reported a mean encounter rate of 2 crocodiles/km, which represent an increase from similar surveys conducted in the same area in 1989. Perhaps the largest crocodile population in Honduras is located in the El Cajon Reservoir where 1082 crocodiles were counted, with a large number of hatchlings (536) confirming successful reproduction (Espinal 2005; Espinal and Escobedo-Galván 2011). Crocodiles are also known to be breeding in some of the Bay Islands off the northern coast of Honduras (Kaiser *et al*. 2001).

Surveys in Nicaragua by King *et al*. (1994) reported *C. acutus* as rare but persisting in the Atlantic drainage, and several viable populations were identified on the Pacific coast (Estero Real, Las Salinas) and near Managua. A similar conclusion was made by Buitrago (2000, 2001). Incidental illegal take of crocodiles in association with the legal caiman harvest is a problem (Buitrago 2001). In Costa Rica, a low density of crocodiles is found in wetlands along the Atlantic coast, and larger ones reported from mangroves swamps and rivers along the Pacific coast (Bolaños Montero, 2012). A population of over 300 individuals was reported from the Rio Grande de Tarcoles (Sasa and Chaves 1992) and another of about 35 individuals in Estero Roto (Chaves Cordero 1993). Moderate encounter rates (crocodiles/km of survey route) were recorded in the Rio Chirripó at La Rambla de Sarapiquí (2.33), Golfo de Nicoya (1.93) and mangrove wetlands associated with the Terraba and Sierpe rivers (2.28) (Bolaños Montero *et al*. 1997). Substantial populations of crocodiles are also known from the Rio Tempisque (Sánchez 2001; Bolaños Montero 2012) and the vicinity of the Osa Peninsula (Boston *et al*. 2005), and it is likely that crocodiles occupying habitat patches along the Pacific coast function as a metapopulation (Porras 2007). Growing populations of crocodiles and people have resulted in several instances of human-crocodile conflict, including fatal attacks (Ross and Larriera 2001; Bolaños Montero 2012). In Panama, a long-term study on Coiba Island has revealed new information on the population genetics (Bashyal *et al*. 2014) as well as reproductive (Balaguera-Reina *et al*. 2015), spatial (Balaguera-Reina *et al*. 2016), trophic (Balaguera-Reina *et al*. 2018a), and population (Balaguera-Reina *et al*. 2018b) ecology of American crocodiles inhabiting insular areas. An estimated population size of ~200 non-hatchlings on the southern tip of the island (Balaguera-Reina *et al*. 2018b) highlights the importance of Coiba Island as an American crocodile hotspot and fertile locality for research on the natural history of the species.

In the regional analysis carried out by Thorbjarnarson *et al*. (2006), the highest priority CCUs in the Caribbean drainage of Central America are three very different habitats: 1) an extensive region of eastern Nicaragua containing a vast complex of coastal lagoons and rivers that extend inland (Costa Miskito and Rio Coco), 2) a section of the largest lake in Central America (Lago de Nicaragua), and 3) a region of central Caribbean Panama that includes the enormous Gatun Lake Reservoir (Bahía de Panama-Este). The second level of priority CCUs is represented by a large river (Rio San Juan, Nicaragua), an extensive coastal lagoon complex (Laguna de Chiriqui, Panama), and a large reservoir (Embalse El Cajón, Honduras). Along the Pacific coast the highest priority CCUs are patches of coastal mangrove and short sections of estuarine rivers. Puerto Sandino is a tidal mangrove complex that receives fresh water from the Izapa and Tamarindo Rivers. The Estero Real is the largest estuarine system of the Golfo de Fonseca and is in the driest region of Nicaragua, receiving less than 500 mm of rain annually. This CCU is comprised principally of a mangrove forest within which a number of commercial shrimp farms have been established, causing significant damage to the ecosystem. Isla Coiba in Panama is a national park comprised of 40 islands in Veraguas Province. There are also robust populations of *C. acutus* associated with rivers and coastal mangroves on the Pacific coast of Costa Rica (Rio Terraba, Rio Tempisque) that were rated at the second CCU priority level.

South America

American crocodile numbers in Colombia are increasing and new populations have been discovered throughout the country. This facilitated the down-listing of the species from "Critically Endangered" to "Endangered" in the most recent local assessment (Morales-Betancourt *et al*. 2015). Healthy populations have been reported in Portete and Cispatá Bay, Puerto Badel (Arjona Municipality), Dibulla, Tayrona Natural National Park, and in the Sardinata, San Miguel, Nuevo Presidente and Tibu Rivers of the Caribbean region. However, a paucity of information still exists for areas such as the Pacific and Andean regions with only 37% of the national territories included in ecological studies during the last decade (Balaguera-Reina *et al*. 2015).

Community-based conservation programs in two areas of the Colombian Caribbean coast have provided the most detailed information on the conservation status of *C. acutus*. In the Cispatá Bay region (Ulloa Delgado 2004, 2005; Ulloa Delgado and Sierra Díaz 2002, 2006), a group of 15 ex-hunters, known as "caimaneros" are active participants in a program for the conservation of *C. acutus*. This community group formed ASOCAIMAN (Asociación para la Conservación de los Caimanes de la Bahía de Cispatá), with its main objective being the conservation of *C. acutus*. Aside from increasing

the protection of crocodiles, the project has included the creation of artificial nesting beaches in the mangroves of Cispatá Bay, and coupled with the head-starting of juvenile crocodiles. A somewhat similar community-based program to protect crocodiles, crocodile nests, and head-start crocodiles is underway in the Portete Bay in northeastern Colombia (Gómez *et al*. 2009).

In Venezuela, crocodiles are known from a number of coastal areas and river systems along the Caribbean coast. Restocking with ranched stock has been conducted in Falcon Province in the northeast of the country (Arteaga 1993; Velasco 2004; Velasco and Lander 1998) and in Aragua Province (Lander *et al*. 1994; Velasco 2004). These are the most important populations, with an active conservation program that includes surveys and monitoring. Comparative surveys between 1986 and 1993 suggest that populations in several locations are stable or growing as a result of protection and restocking, although residual problems of illegal killing for medicinal products is reported (Arteaga 1994). De Sola *et al*. (2004) and Lander and Bermudez (2005) reported on surveys around the Venezuelan coast and demonstrated that in some areas the status of populations have improved since previous surveys. Velasco *et al*. (2000) prepared a National Recovery Plan for *C. acutus* in Venezuela, and Villarroel *et al*. (2005) presented the results of a workshop evaluating the Venezuelan *C. acutus* population and habitats, and proposed 11 CCUs for the country. All three highest priority CCUs along the Caribbean coast of Venezuela and Colombia are coastal lagoon systems (Thorbjarnarson *et al*. 2006). Two of the three proposed CCUs are mangrove systems in seasonally dry areas, one in Colombia (Alta Guajira, comprised of the Bahía Portete and Bahía Hondita), and one in Venezuela (Laguna Tacarigua). The Cispatá Bay CCU is an extensive mangrove swamp associated with the old delta of the Rio Sinú. The second priority level of CCUs includes additional habitat types such as an inland, freshwater riverine site in dry forest habitat (Bache River, Colombia) over 1200 km from the coast, a coastal river/lagoon/reservoir complex (Yaracuy and Aroa Rivers), as well a reservoir (Embalse Pueblo Viejo).

One of the areas where populations of *C. acutus* are most threatened is along the Pacific coast of South America. In Ecuador, crocodiles were formerly abundant in the Rio Guayas system but appear to have been all but extirpated (although population surveys are needed for confirmation). A small number of crocodiles remain in the coastal region of the Gulf of Guayaquil (Carvajal *et al*. 2005; Carvajal and Alava 2005) but coastal mangrove destruction for the construction of shrimp aquaculture facilities is removing critical crocodile habitat. A small population remains in the Rio Tumbes region of northern Peru, at the southernmost limit of the species' range (Trelancia 2001). Two areas were identified as CCUs (Thorbjarnarson *et al*. 2006), both associated with the Rio Tumbes drainage forming the geopolitical boundary between Peru and Ecuador. The Amotape CCU is a freshwater section of the Tumbes in a region of dry forest with few human pressures. The Estero Corrales is a tidal mangrove system associated with the Tumbes delta complex and adjacent to a protected area (Santuario de los Manglares), but nonetheless threatened by shrimp aquaculture and rice farming.

As *C. acutus* produces a commercially valuable skin, there has been interest in commercial utilization programs. Commercial farms in Honduras and Colombia have been registered with CITES as captive breeding operations (one and seven, respectively). Commercial global exports of *C. acutus* have increased from 120 in 2006 to 3403 in 2015 (Caldwell 2017). With the recent down-listing of its *C. acutus* population to CITES Appendix II, Cuba and Cispatá Bay in Colombia are developing plans for exports based on commercial farming and ranching.

Figure 13. Hatchling *C. acutus* basking, Banco Chinchorro Atoll, Mexico. Photograph: Pierre Charruau.

Priority Projects

Thorbjarnarson *et al*. (2006) listed a number of specific areas containing some of the most important populations of *C. acutus*, and where greater habitat protection is needed. From this list three areas have been selected here as the highest priority for conservation action.

<u>High priority</u>

1. **Conservation in Peru and Ecuador**. The Guayas River system in Ecuador historically supported a large population of *C. acutus*, which appears to have all but disappeared following intensive commercial hunting and habitat destruction in the 20th century. Surveys are needed to determine if crocodiles still remain in the Guayas River, and to develop population recovery plans. The small population in the Tumbes area of northern Peru is also extremely vulnerable. Preliminary studies suggest that the *C. acutus* in Ecuador/Peru are genetically distinct from other populations (M. Anaya-Venegas, pers. comm.). Therefore, the genetic status of these populations merits further investigation.

2. **Population evaluation and conservation in the Magdalena/Cauca River basin**. Crocodiles are reported from several areas in the Magdalena/Cauca River basin up to 1200 km from the coast. This area is considered a high priority not only due to the lack of information and apparent endangered population status, but also because

of the extraordinary riverine nature of the crocodiles. In a 2004 review by the CSG (Larriera *et al*. 2005), the implementation of a national program for rebuilding depleted populations of *C. acutus* was seen as a major priority, and could be promoted by better linkage of commercial crocodile farming operations in Colombia with ex-situ conservation efforts (Larriera *et al*. 2005). However, these actions have not yet been carried out in Colombia, threatening the future of these populations.

3. **Development of a conservation program in Jamaica**. American crocodile numbers continue to decline in Jamaica due to habitat loss, persecution, and illegal harvest for meat consumption (Henriques *et al*. 2012). Extirpation of the species in the country is likely unless effective conservation measures are taken (Henriques *et al*. 2012). A continued nation-wide population evaluation, habitat assessment, and monitoring and education program is needed as a foundation towards developing a crocodile conservation plan for Jamaica.

Moderate priority

4. **Genetic evaluations.** The American crocodile is a wide-ranging and ecologically plastic species. Genetic evidence to date suggests there are substantial genetic differences among populations in different parts of the species' range. American crocodiles are known to hybridize with *C. moreletii* and *C. rhombifer*; however, the evolutionary implications of this hybridization are poorly understood, and further investigation is warranted.

5. **Population status in the Cayman Islands, El Salvador, Guatemala and Haiti.** Recent information on the status of *C. acutus* in the Cayman Islands, El Salvador, Guatemala, and Haiti is sparse or lacking. Crocodile surveys in these countries are needed to assess population numbers, availability and quality of habitat, and current threats so that appropriate conservation and management plans can be developed.

6. **Investigations on ecology and population biology.** Although the American crocodile has been well-studied in certain areas of its range, we still know relatively little about its ecology, population dynamics and behavior in the wild. Information on these and other aspects of the life history of *C. acutus* (eg genetic diversity, movement patterns, habitat use, physiology) would benefit the overall management of the species and assist decision-makers dealing with problem animals and human-crocodile conflict.

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